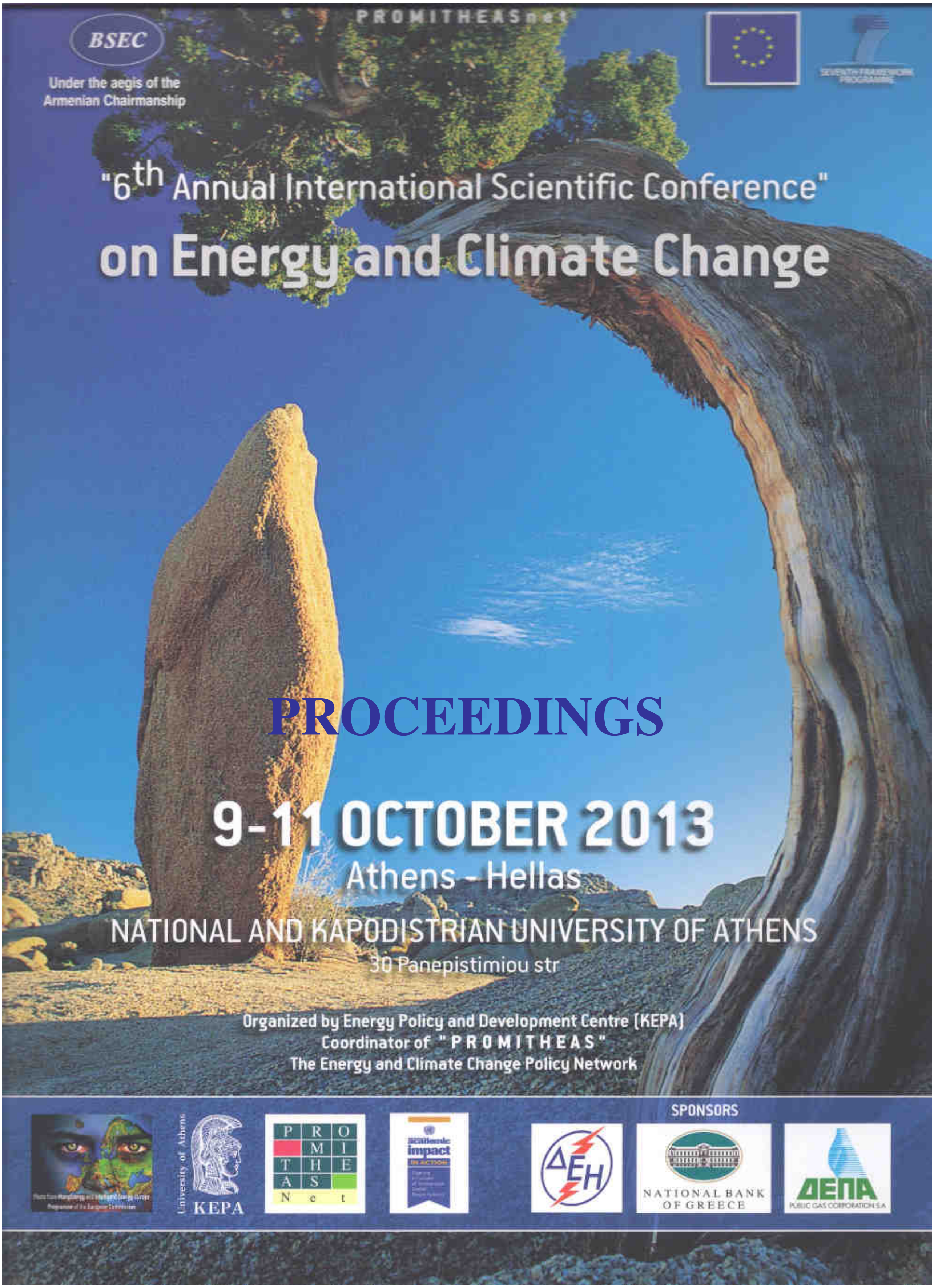
PROMITHEASnet
BSEC
Under the aegis of the Armenian Chairmanship
SEVENTH FRAMEWORK PROGRAMME
"6th Annual International Scientific Conference"
on Energy and Climate Change
PROCEEDINGS
9-11 OCTOBER 2013
Athens - Hellas
NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS
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Coordinator of "PROMITHEAS"
The Energy and Climate Change Policy Network
University of Athens
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Agenda
6th Annual International Scientific Conference on Energy and Climate Change

Day 1 **9 October 2013**

Venue:	**"Kostis Palamas" building**
9:00 – 9:30	**Registration**
9:30 – 11:00	**Opening**

CHAIR

AMB. TRAIAN CHEBELEU
Deputy Secretary General of the Black Sea Economic Cooperation, Permanent International Secretariat (BSEC-PERMIS).

Dr. VAHAN SARGSYAN
Energy Strategy Center (ESC) of Scientific Research Institute of Energy (SRIE) - ARMENIA.

PROF. DIMITRIOS MAVRAKIS
Director of Energy Policy and Development Centre (KEPA), National and Kapodistrian University of Athens (NKUA) – HELLAS.

ADDRESSES

PROF. THEODOSIS PELEGRINIS
Rector of the National and Kapodistrian University of Athens.

Dr. SIMON PAPYAN
First Deputy Minister of Nature Protection – Armenia Acting Chairmanship of BSEC.

AMB. TRAIAN CHEBELEU
Deputy Secretary General BSEC-PERMIS.

Mr. YADIGAR MAMMADOV
Secretary of the Economic, Commercial, Technological and Environmental Affairs Committee, of the Parliamentary Assembly (PABSEC) of the BSEC countries.

AMB. EMILIA KRALEVA
Ambassador Extraordinary and Plenipotentiary of the Republic of Bulgaria to the Hellenic Republic.

AMB. MARGUS RAVA
Ambassador Extraordinary and Plenipotentiary of Estonia to the Hellenic Republic.

AMB. LUCIAN FATU
Ambassador Extraordinary and Plenipotentiary of the Republic of Romania to the Hellenic Republic.

Mr. DAVID J. LIPPEATT
Economic Counselor, USA Embassy in Athens.

Ms. ELENI MANOLI
European Commission DG – Research.

PROF. JORGAQ KACANI
President of BSUN, Rector of Polytechnic University of Tirana (PUT) – ALBANIA.

Mr. KONSTANTINOS THEOFYLAKTOS
President of Centre for Renewable Energy Sources and Saving (CRES) - HELLAS.

PROMITHEAS-4: "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"

		PROMITHEAS-4, PAVING GREEN PATHWAYS IN 12 COUNTRIES **BY PROF. DIMITRIOS MAVRAKIS, DIRECTOR OF KEPA,** NKUA – HELLAS.
	11:00 – 11:30	*Family photo - Coffee break*
	11:30 – 13:30	**CLIMATE CHANGE POLICY MIXTURES – 1** **CHAIR** **PROF. HAJI MALIKOV** Geotechnological Problems of Oil, Gas and Chemistry (GPOGC) of the Azerbaijan State Oil Academy (ASOA) – AZERBAIJAN. **PROF. EVGENIJ INSHEKOV** Institute for Energy Saving and Energy Management of the National Technical University of Ukraine (ESEMI-NTUU) - UKRAINE. **PROF. EVANGELOS DIALYNAS** National Technical University of Athens (NTUA) – HELLAS. **NATIONAL REPORTS** **ALBANIA** by Prof. Andonaq LAMANI, PUT. **ARMENIA** by Dr. Vahan SARGSYAN, ESC of SRIE. **AZERBAIJAN** by Prof. HAJI MALIKOV, GPOGC of ASOA. **BULGARIA** by Dr. Lulin RADULOV, Black Sea Regional Energy Centre (BSREC) **ESTONIA** by Dr. NADEZDA DEMENTJEVA, Technical University of Tallinn. (TUT) **KAZAKHSTAN** by Prof. Sergey INYUTIN, Scientific Research Company Kazhiminvest
	13:30 – 15:00	*Break*
	15:00 – 17.00	**CLIMATE CHANGE POLICY MIXTURES – 2** **CHAIR** **PROF. ALEXANDER ILYINSKY** Financial Univercity under the Goverment of the Russian Federation (FA) - RUSSIA. **PROF. JORGAQ KACANI** PUT - ALBANIA. **Dr. LULIN RADULOV** Director of BSREC - BULGARIA. **NATIONAL REPORTS** **MOLDOVA** by Dr. Ion COMENDANT, Institute of Power Engineering (IPE) of the Academy of Sciences of Moldova (ASM) **ROMANIA** by Ms. Camelia VASILE, Institute for Studies and Power Engineering (ISPE)

PROMITHEAS-4: "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"

	RUSSIAN FEDERATION by Prof. Alexander ILYINSKY, FA
	SERBIA by Mr. Aleksandar MADZAREVIC, Faculty of Mining and Geology of University of Belgrade (UB-FMG)
	TURKEY by Prof. Bilgin HILMIOGLU, TUBITAK Marmara Research Center
	UKRAINE by Prof. Evgenij INSHEKOV, ESEMI-NTUU
17:00-18:00	**NEEDS AND GAPS** by Dr. LULIN RADULOV Director of BSREC – BULGARIA
	DISCUSSION
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Day 2 — 10 October 2013

Venue:	**"Kostis Palamas" building**
9:30–12:30	**ENVIRONMENT - CLIMATE CHANGE**
	CHAIR
	PROF. BILGIN HILMIOGLU TUBITAK Marmara Research Center – TURKEY
	Dr. VAHAN SARGSYAN ESC of SRIE – ARMENIA
	PROF. MILTON TYPAS NKUA - HELLAS
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	THE CAPTURE OF CO2 FROM FLUE GAS USING ADSORPTION COMBINED WITH MEMBRANE SEPARATION by PROF. KRZYSZTOF WARMUZINSKI, Institute of Chemical Engineering – POLAND
	THE EFFECT OF GOVERNMENT EXPENDITURE ON THE ENVIRONMENT by PROF. GEORGE E. HALKOS, University of Thessaly (UTH) – HELLAS
	APPROPRIATE MCDA METHODS FOR CLIMATE CHANGE POLICY EVALUATIONS by Dr. POPI KONIDARI, KEPA of NKUA – HELLAS

[1] Only the name of the speaker is mentioned in the agenda, while the names of the co-authors are quoted in the web-site and the book of abstracts

PROMITHEAS-4: "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"

CHAIR

PROF. ALVINA REIHAN
TUT – ESTONIA.

PROF. ANCA POPESCU
ISPE – Romania.

PROF. SERGEY INYUTIN
Turan – Astana University - Kazakhstan.

SUSTAINABLE ENERGY ACTION PLANS FOR CITIES: THE POTENTIAL OF THE BUILDING SECTOR
by **Dr. EFROSINI GIAMA**, Aristotle University of Thessaloniki (AUTH) – HELLAS.

TRANSITION TO GREEN ECONOMY – A NEW VECTOR OF KAZAKHSTAN'S INNOVATIVE DEVELOPMENT
by **PROF. SERGEY INYUTIN**, Turan-Astana University-KAZAKHSTAN.

AZERBAIJAN: TRANSITION TO CLEAN ENERGY IN THE CONDITION OF CLIMATE CHANGES
by **Dr. ROVSHAN KARIMOV**, Institute of Geography of Azerbaijan – National Academy of Sciences – AZERBAIJAN.

THE ASSESSMENT OF ROMANIA'S PROGRESS TOWARDS 2020 GREENHOUSE GAS TARGETS TAKING INTO ACCOUNT CLIMATE CHANGE MIDICATION AND ENERGY POLICY OBJECTIVES
by **PROF. ANCA POPESCU**, ISPE - Romania.

12:30–15:30 *Visit to National Archeological Museum*

15:30 –17:30

ENERGY POLICY

CHAIR

PROF. NIKOLA KALOYANOV
Technical University of Sofia (TUS) - BULGARIA.

Dr. ION COMENDANT
IPE of ASM - MOLDOVA.

PROF. CON. KARAGIANNOPOULOS
NTUA - HELLAS.

SPEAKERS

KEYNOTE SPEAKER: NEARLY ZERO ENERGY BUILDINGS
by **PROF. NIKOLA KALOYANOV**, TUS - Bulgaria.

SENSITIVITY OF EMISSIONS AND THEIR DRIVERS TO ECONOMIC GROWTH AND FOSSIL FUEL AVAILABILITY: A REGIONAL ANALYSIS
by **Dr. IOANNA MOURATIADOU**, Potsdam Institute for Climate Impact Research – GERMANY.

A NEGAWATT MARKET FOR SUSTAINABLE ENERGY SERVICES SECURITY
by **Mrs. REEM YUSUF**, World Bank – UK.

SIGNIFICANCE OF DEPENDABILITY CONCEPT FOR ELECTRICITY SECURITY OF SUPPLY
by **PROF. MILOS TANASIJEVIC**, UB-FMG – SERBIA.

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by **PROF. CHIEN-TE FAN**, The Institute of Law for Science and Technology, National Tsing Hua University (NTHU) – TAIWAN.

PROMITHEAS-4: "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"

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by Mr. SETYAWAN DHANI, Ministry of Finance – INDONESIA.

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CHAIR

PROF. CHIEN-TE FAN
The Institute of Law for Science and Technology, NTHU – TAIWAN.

PROF. ANDONAQ LAMANI
PUT – ALBANIA.

PROF. GEORGE E. HALKOS
UTH – HELLAS.

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by Dr. ANTON MING-ZHI GAO, The Institute of Law for Science and Technology, NTHU–TAIWAN.

LCOE AS A POLICY TOOL FOR RES-E SUPPORT SCHEMES
by Dr. CHRISTOS TOURKOLIAS, CRES - HELLAS.

THE IMPACT OF RENEWABLE ENERGY PROJECT IN NEPAL
by Dr. ALEXANDER SPACHIS, Delegation of the European Union to Nepal - NEPAL.

OBSTACLES FOR THE PROMOTION OF SMALL HYDRO IN KAZAKHSTAN: ANALYSIS OF THE BARRIERS TO TECHNOLOGY TRANSFER
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by PROF. GEORGE E. HALKOS, UTH of Thessaly - HELLAS.

COMBINATION OF HYBRID WAVE AND WIND ENERGY CONVERSION APPLIED TO AN OFFSHORE PLATFORM
by Ms. AFROKOMI AFROULA STEFANAKOU, University of Aegean – HELLAS.

Day 3 — 11 October 2013

Venue: **"Kostis Palamas" building**

9:30–13:30 **PROGRAMS AND PROJECTS**

CHAIR

PROF. EDOARDO CROCI
IEFE – Bocconi University – ITALY.

PROF. OLGA EFIMOVA
FA - RUSSIA.

PROF. KATHERINE M. PAPPAS
NKUA - HELLAS.

PROMITHEAS-4: "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"

SPEAKERS[1]

NEW MARKET-BASED MECHANISM UNDER UNFCC
by **PROF. EDOARDO CROCI**, IEFE – Bocconi University – ITALY.

ENERGY & CLIMATE CHANGE – THE BSTDB EXPERIENCE
by **Mr. ROMAN MATKIWSKY**, Director for Energy and Infrastructure of the Black Sea Trade and Development Bank (BSTDB).

ARMENIAN ENERGY SYSTEM DEVELOPMENT STUDY USING THE MARKAL-ARMENIA INTEGRATED ENERGY SYSTEM MODEL
by **Dr. VAHAN SARGSYAN**, ESC of SRIE – ARMENIA.

INTEGRATING DISTRIBUTED POWER UNITS IN A VIRTUAL POWER PLANT
by **Mrs. ANNA FLESSA, MSc.**, KEPA of NKUA - HELLAS.

PROMOTING LOW EMISSION URBAN DEVELOPMENT STRATEGIES IN EMERGING ECONOMY COUNTRIES (URBAN-LEDS)
by **Mr. LUCAS DE MONCUIT**, ICLEI-Local Governments for Sustainability – GERMANY.

COGENERATION IN SOUTH EAST EUROPE. TRENDS AND PERSPECTIVES
by **Mr. THEODORE CHRONIS**, Hellenic Association for Cogeneration of Heat and Power–HELLAS.

BRIEF REVIEW OF IMPLEMENTATION OF RES IN EUROPEAN COUNTRIES
by **Mrs. KARINE SARGSYAN**, ESC of SRIE – ARMENIA.

IMPACT OF RES IMPLEMENTATION ON TECHNICAL AND ECONOMIC CHARACTERISTICS OF REGIONALLY INTEGRATED ARMENIAN ENERGY SYSTEM
by **Dr. VAHAN SARGSYAN**, ESC of SRIE – ARMENIA.

THE FFCC TOOL FOR CLIMATE CHANGE POLICY MAKERS
by **Ms. ELENI-DANAI MAVRAKI, MSc.**, Development and Assessment Midication/Adaptation Tool (MADAT) KEPA of NKUA – HELLAS.

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by **Mrs. VASSO TSIAUSSI**, The Goulandris Natural History Museum – HELLAS.

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by **Mr. CHRISTOS NAKOS**, CRES – HELLAS.

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by **PROF. OLGA EFIMOVA**, FA - RUSSIA.

ENERGY AUDIT METHODOLOGY TESTING OF THE PILOTE ENERGY EFFICIENT RESIDENTIAL BUILDING IN ARMENIA
by **Mr. ARTUR TSUGHUNYAN**, United Nations Development Programme (UNDP) – ARMENIA.

CAPACITY BUILDING ACTIVITIES FOR MITIGATION/ ADAPTATION MIXTURES
by **Ms. ALIKI-NEFELI MAVRAKI, MSC.**, KEPA of NKUA - HELLAS.

HOW THE C-ENERGY-NETWORK CAN HELP YOU
by **Mr. HENRY SCOTT**, National Documentation Centre – HELLAS.

[1] Only the name of the speaker is mentioned in the agenda; while the names of the co-authors are quoted in the web-site and the book of abstracts

List of Participants

A/A	Title	First Name	Last Name	Organization
1	Mrs.	Nuray Guler	Akalin	Tubitak Marmara Research Center, Turkey
2	Dr.	Safaa	Baydoun	Beirut Arab University, Lebanon
3	Amb.	Traian	Chebeleu	Black Sea Economic Cooperation-PERMIS
4	Mr.	Theodore	Chronis	Hellenic Association for Cogeneration of Heat and Power, Hellas
5	Prof.	Edoardo	Croci	IEFE - Bocconi University, Italy
6	Dr.	Ion	Comendant	Institute of Power Engineering, Academy of Sciences of Moldova
7	Dr.	Nadezda	Dementjeva	Tallin University of Technology, Estonia
8	Mr.	Lucas	de Moncuit	ICLEI - Local Governments for Sustainability, Germany
9	Mr.	Setyawan	Dhani	Ministry of Finance, Indonesia
10	Prof.	Evangelos	Dialynas	National Technical University of Athens, Hellas
11	Prof.	Olga	Efimova	Finance University under the Government of Russian Federation, Russia
12	Prof.	Chien-Te	Fan	National Tsing Hua University, Taiwan
13	Prof.	Marina	Fedotova	Finance University under the Government of Russian Federation- Russia
14	Mrs.	Anna	Flessa MS.c.	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA), Hellas
15	Prof.	Anton Ming-Zhi	Gao	The Institute of Law for Science and Technology (ILST), National Tsing Hua University, Taiwan
16	Mrs.	Ewa	Gasiorowska	Vattenfall - Environmental Strategic Development
17	Dr.	Efrosini	Giama	Aristotle University of Thessaloniki, Hellas
18	Ms.	Elena	Gova	Associate EM Consulting, Hellas
19	Prof.	George	Halkos	University of Thessali, Hellas
20	Dr.	Bilgin	Hilmioglu	Tubitak Marmara Research Center, Turkey

21	Prof.	Alexander	Ilyinsky	Finance University under the Government of Russian Federation- Russia
22	Prof.	Evgenij	Inshekov	National Technical University of Ukraine - Institute for Energy Saving and Energy Management
23	Prof.	Sergey	Inyutin	Turan-Astana University, Kazakhstan
24	Prof.	Lyubov	Inyutina	Turan-Astana University, Kazakhstan
25	Mr.	Igor	Ivanchenko	Embassy of Ukraine in Athens, Hellas
26	Prof.	Jorgaq	Kacani	President of BSUN
27	Mr.	Baris	Kalkavan	Embassy of Turkey in Athens, Hellas
28	Prof.	Nikola	Kaloyanov	Technical University of Sofia, Bulgaria
29	Prof.	Constantinos	Karagiannopoulos	National Technical University of Athens, Hellas
30	Dr.	Rovshan	Karimov	Institute of Geography, Azerbaijan
31	Mrs.	Natalia	Klimenko-Rampias	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA)
32	Dr.	Popi	Konidari	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA)
33	Amb.	Emilia	Kraleva	Embassy of Bulgaria in Athens, Hellas
34	Prof.	Andonaq	Lamani	Polytechnic University of Tirana, Albania
35	Mr.	Stamatis	Laskaris	Associate EM Consulting, Hellas
36	Prof.	Jui-Chu	Lin	National Taiwan University of Science and Technology, Taiwan
37	Amb.	Lucian	Fatu	Embassy of Romania in Athens, Hellas
38	Mr.	Aleksander	Madzarevic	University of Belgrade, Serbia
39	Prof.	Haji	Malikov	GPOGC, Azerbaijan
40	Mr.	Yadigar	Mammadov	PABSEC
41	Mrs.	Eleni	Manoli	European Commission DG - Research
42	Mr.	Emilios	Margaritis	Infrastructure Projects and Business Development Consultant (EM), Hellas

43	Amb.	Minas	Martikian	Embassy of Armenia in Athens, Hellas
44	Mr.	Roman	Matkiwsky	BSTDB
45	Ms.	Aliki-Nefeli	Mavraki MS.c.	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA), Hellas
46	Ms.	Eleni-Danai	Mavraki MS.c.	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA), Hellas
47	Prof.	Dimitrios	Mavrakis	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA), Hellas
48	Dr.	Ioanna	Mouratiadou	Potsdam Institute for Climate Impact Research, Germany
49	Ms.	Alexandra	Moysidou MS.c.	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA), Hellas
50	Ms.	Khafira	Museybova	Embassy of Azerbaijan in Athens, Hellas
51	Mr.	Chistos	Nakos	Center for Renewable Energy Sources and Saving, Hellas
52	Prof.	Katherine	Pappas	National and Kapodistrian University of Athens, Hellas
53	Dr.	Simon	Papyan	Ministry of Nature Protection of the Republic of Armenia
54	Prof.	Theodosis	Pelegrinis	National and Kapodistrian University of Athens, Hellas
55	Dr.	Ariel Macaspac	Penetrante	University of Leipzig, Germany
56	Prof.	Anca	Popescu	ISPE, Romania
57	Dr.	Lulin	Radulov	Black Sea Regional Energy centre, Bulgaria
58	Prof.	Alvina	Reihan	Tallin University of Technology, Estonia
59	Mrs.	Karine	Sargsyan	SRIE-ESC, Armenia
60	Dr.	Vahan	Sargsyan	SRIE-ESC, Armenia
61	Mr.	Henry	Scott	National Documentation Centre, Hellas
62	Dr.	Vladimir	Shtivelman	The Geophysical Institute of Israel
63	Amb.	Alexander	Spachis	EU Delegation in Nepal
64	Mr.	Afrokomi Afroula	Stefanakou	University of Aegean, Hellas
65	Prof.	Milos	Tanasijevic	University of Belgrade, Serbia
66	Mr.	Konstantinos	Theofylaktos	Center for Renewable Energy Sources and Saving, Hellas
67	Dr.	Christos	Tourkolias	Center for Renewable Energy Sources and Saving, Hellas

68	Mr.	Artur	Tsughunyan	UNDP Armenia, Armenia
69	Mrs.	Vasiliki	Tsiaoussi	The Goulandris Natural History Museum - Greek Biotope Wetland Centre, Hellas
70	Prof.	Milton A.	Typas	National and Kapodistrian University of Athens, Hellas
71	Mrs.	Alexandra	Vasila	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA), Hellas
72	Mrs.	Camelia	Vasile	ISPE, Romania
73	Prof.	Krzysztof	Warmuzinski	Institute of Chemical Engineerging, Poland
74	Ms.	Reem	Yusuf	The World Bank

Opening

Introductory comments to the 6th Scientific International Conference on Energy and Climate Change by Prof. Dimitrios MAVRAKIS

- ☐ Dr. Simon Papian, 1st Deputy Minister of Nature and Protection of the Armenian Republic that is chairing the BSEC organization

- ☐ Excellencies from international organizations and embassies in Athens, ladies and gentlemen, dear Colleagues

- ☐ On behalf of the Rector of our University and personally I welcome you to the 6th International Scientific Conference on Energy and Climate change.

- ☐ The conference is a small contribution to the worldwide efforts to promote the concept of Green Energy through the development of converging green pathways based on the specific characteristics of the countries and the regions of our planet.

- ☐ For more than 10 years, under the auspices of BSEC and with the support of its Permanent International Secretariat (PERMIS), our PROMITHEASnet, consisting of academic institutions from the countries of BSEC, EU, Asia and Eastern Mediterranean promotes the establishment of a "Green Alliance" between the Academic Institutions, the Governments and the Market Forces in our countries with the aim to promote the concept of green economy among them.

- ☐ It is important to inform you that in close cooperation with the "Task Force on Green energy Development of BSEC" we hope that this aim will be further promoted in the context of the New Market Mechanisms under the UNFCCC, as I will present you later on.

- ☐ In this framework and in the context of PROMITHEAS – 4, an EU – FP7 financed project, we have been working the last three (3) years with the aim to transfer knowledge in 12 countries on how to develop, assess, and optimize mitigation /adaptation policy mixtures, based on their policies and characteristics

- ☐ All intermediate reports and outcomes were communicated to the governments and market stakeholders of the beneficiary countries, mainly through BSEC – PERMIS requesting their comments.

- ☐ In addition in three BSEC Ministerial Meetings and a number of successive meetings of the BSEC working groups (including the Task Force for the Green energy development) we have also presented the progress of our work requesting their active participation.

- ☐ Unfortunately we have failed, so far, to engage the Business Council and the Black Sea Trade and Development Bank of BSEC in a structured cooperation. But we are optimistic that in close cooperation with PERMIS we will convince them to modify their practices so as to be benefited from the emerging opportunities of green economy especially in the frame of the efforts to upgrade the content of aforementioned Task Force.

- ☐ Knowledge transfer was a key challenge in our efforts and in order to meet it we have organized four intensive training courses, free of charges, encouraging more than 100 decision makers and young scientists to participate to them.

- From the beginning of 2013 we have organized 12 national conferences in the beneficiary countries where we presented the draft final national reports to the governmental authorities and national market stakeholders requesting their comments

- But the knowledge gap still exists and we have decided to organize two annual seminars for beginners and advanced participants (starting from next month) on how to develop and assess M/A policy mixtures, one market oriented workshop in cooperation with our Albanian Colleagues on energy efficiency and smart networks which we will try to upgrade to a regional importance event and hopefully one high level meeting for members of BSEC parliaments and governmental authorities, with the aim to update them on green economy topics.

- In the session that follows all 12 national reports prepared by the teams of the most famous institutions of our region will be presented by the distinguished colleagues coming from them.

- You are invited to attend it and participate actively.

- As I have already mentioned at the beginning we consider our work as a contribution to the efforts to pave pathways of green development in our region and this explains the title and the contents of the presentation that follows later on

Opening speech to the 6th Scientific International Conference on Energy and Climate Change by Amb. Traian CHEBELEU

Mr. Chairman,
Distinguished Professor Mavrakis,
Distinguished Participants,

I am very honoured to represent the Black Sea Economic Cooperation Organization at this 6th International Scientific Conference on Energy and Climate Change, organized by *Promitheas* Network, directed by the Energy Policy and Development Centre (KEPA) and hosted by the National and Kapodistrian University of Athens.

We are always glad to remind that our Organization was at the origin of the *Promitheas* Network, which consists today of prestigious academic and research institutions from all the Member States, with a project supported by the Project Development Fund of BSEC. Later the project expanded with funds from the European Union and with generous contributions of the Hellenic Government. The interest of our Organization in the follow-up of this project is also confirmed by the fact that all the previous five *Promitheas* Scientific Conferences were held under the auspices of the successive BSEC Chairmanships-in-Office, currently the Armenian BSEC Chairmanship-in-Office.

Since 2008, when it started, this conference has developed into one of the well established discussion fora in the Black Sea Region for energy and climate change issues, that has gained a very much deserved prestige at international level, benefiting from the participation of scientists, researchers and policy makers from all over the world.

Over the years, these scientific conferences and, more generally, the activities of he *Promitheas* Network have made significant contributions to the knowledge transfer and development on energy and climate change issues in the BSEC Region. The papers and discussions of the scientific conferences and the publications you prepared have been very valuable for us, providing food for thought as to where and what BSEC should focus on, so that it could bring added value and act really in support of the needs and interests of its 12 Member States in these fields.

Energy and environment protection are major areas of action of BSEC – an organization established 20 years ago with the purpose to promote a lasting and closer cooperation among the States in the region. Our region is at cross-roads of energy transportation routes and has a major role to play in ensuring the energy security not only of the States in the region but of many other States in Europe and other neighbouring areas.

Energy and environment protection are essential elements for the sustainable development of the BSEC Member States. The *Economic Agenda Towards an Enhanced BSEC Partnership*, endorsed by the BSEC Summit Meeting held in Istanbul on 26 June 2012, which is a strategic document guiding the BSEC activities in the years to come, includes the goals of Sustainable Energy and Development of the Black Sea Energy Market and of Environmental Protection and Conservation among the priority areas of action of the Organization.

Among the actions in order to advance towards these goals, the *BSEC Economic Agenda* envisages:
- Taking gradual steps to materialize the vision of transforming the BSEC Region into a model for clean energy by the year 2050.
- Encouraging cooperation among the Member States to define a Green Energy Strategy with the view to promoting renewable energy sources, clean technologies and energy efficiency.

In this context, a significant part of our efforts are focused on the development of the BSEC regional cooperation in Green Energy. The meeting of the Task Force on Green Energy Development, scheduled for 13 November 2013, will start working a BSEC Green Energy Strategy Paper. We count very much on the professional advice and contribution of Professor Mavrakis and his team in the process of the elaboration of this Strategy Paper.

As a matter of fact, our efforts to deepen regional cooperation in the energy and climate sector are usefully complemented by activities undertaken with the contribution and the support from countries and institutions having Observer or Sectoral Dialogue Partner statuses. Among the most prominent ones are precisely those developed by the *Promitheas* Energy and Climate Change Network, which is a good example of BSEC-EU collaboration, as the EU Commission has the status of Observer to our Organization.

We look forward to the activities of *Promitheas* Network to continue to contribute to bringing our Member States closer together, and to providing valuable input to our activities within the institutional framework of BSEC aimed at enhancing the regional cooperation in the fields of energy and environmental protection.

We need strengthening the interaction between the academic sector and energy stakeholders for an efficient cooperation in the BSEC framework in energy and environment fields. Such interaction always produces ideas and concrete recommendations that we can use afterwards in our discussions within the BSEC Working Groups.

I would like to conclude by expressing my high appreciation and thanks for the excellent organization and warm hospitality offered by our hosts and by wishing all of you fruitful exchanges in today's and tomorrow's meetings.

Address by Bulgarian Ambassador Emilia KRALEVA at the opening of the 6th International Scientific Conference on Energy and Climate Change (October 9, 2013)

Dear Professor Mavrakis, Professor Sargasyan, Ambassador Chebeleu,

Dear Excellencies, distinguished guests, ladies and gentlemen,

I'm glad to attend today's event, which is devoted to a topic featuring high on the agenda of European and international politics but also on the different regional cooperation formats, among them the BSEC organisation.

Energy and climate issues, green energy development, are closely related and preventing dangerous climate change is a strategic priority for the European Union. Europe is working hard to cut its greenhouse gas emissions substantially while encouraging other nations and regions to do likewise.

Research and knowledge transfer are exactly the key for preparing mitigation and adaptation policy portfolios. I wish to congratulate all participants in the "PROMITHEAS-4 project for the proposals they have prepared as a result of their 3-year work for the optimization of these portfolios for the beneficiary countries.

Bulgaria is among the EU countries that contribute a lot to the common green targets being blessed with relatively rich green energy sources. But as the Bulgarian report will be presented later on by the esteemed Dr. Lulin Radulov and Professor Nikola Kaloyanov on his part will also have a key role in the energy policy discussions of the conference, permit me to have the role to stress the importance of the political framework that facilitated the success of the PROMITHEAS Conference. I will also not miss the opportunity to highlight the fact that it has developed over the years as an annual conference due to the devoted work of the Energy Policy and Development Centre to the National and Kapodistrian University of Athens.

It worths mentioning that the funds provided by the EU under its 7th Framework Program for Research are not the only support for these activities. The fight against climate change is increasingly being reflected in other policy areas of the EU. It is remarkable that the European Commission has proposed at least 20% of the EU's budget for 2014-2020 to be spent on climate-relevant measures. As the world's leading donor of development aid, the EU also provides substantial funding to help developing countries tackle climate change, including just over €7.3 billion in "fast start" financing over 2010-2012.

Let me conclude by noting that The 6th International Scientific Conference on Energy and Climate Change is one of the first events in this area after the presentation of the latest report by the United Nations Intergovernmental Panel on Climate Change (IPCC) 2 weeks ago (*27 September*). The report says it is unequivocal that climate change is occurring and confirms there is at least 95% certainty that human activities are the principal cause. This makes it all the more pressing to draw up a new global climate agreement covering all countries and which is ambitious, comprehensive and legally binding so that to keep global warming below 2°C compared to the pre-industrial times.

I wish every success to this conference and hope it will contribute to a large extent to the international efforts to finalise this global agreement by 2015, by proving the importance of mitigation and adaptation actions and thus persuading all the beneficiary countries to be at the forefront of climate actions worldwide.

Thank you.

Address by Romanian Ambassador Lucian FĂTU at the opening of the 6th International Scientific Conference on Energy and Climate Change (October 9, 2013)

Distinguished audience,

It is with pleasure and gratitude that I address this select event. I am confident that the proceedings will advance a valuable scientific, as well as practical contribution on the vital link between energy and climate change, between growth and environmental sustainability.

I would like to open with short professional consideration. Traditional diplomacy, involving skilled rhetoric and hushed meetings between a chosen few is a thing of the past. Current diplomacy, and especially European affairs, cannot be conducted without sound scientific arguments and cannot succeed unless it is well disseminated by means of mass-communication. Economic diplomacy, public and cultural diplomacy, as well as a thorough understanding of the *acquis communautaire* are crucial items of the toolbox of any modern diplomat, within or outside the EU. Energy diplomacy, formulated as a distinct EU policy with a Charter dating back to the end of the Cold War, stands in its own class.

Recognising these realities, the Romanian Government has outlined an ambitious program for 2013-2016 focusing on:

- Energy security
- Energy efficiency and environment protection
- Enhancing competitiveness
- Encouraging investments, especially in renewable energy generation
- Energy consumer protection
- Romania – regional energy hub

The actions outlined within the second pillar of this program include:

- Building high efficiency co-generation applications
- Rehabilitating, modernizing or replacing existing ones
- Promoting European standards on minimal levels of energy efficiency
- Improving energy efficiency based on financing from relevant EU funds
- Providing financial and fiscal incentives to energy efficiency enhancing projects
- Launching a national program of education on energy saving and renewable resources
- Completing the legislative framework for a competitive energy services market
- Promoting the use of *white certificates* for boosting investment in energy efficient programs
- Including environment costs in the price of energy
- Harnessing the opportunities created by the flexible mechanisms of the Kyoto Protocol.

I would like to wish you all fruitful exchanges and productive networking.

Thank you.

Adreessing Speech by Ms.Eleni MANOLI

It is my pleasure to be here, as representative of the Environment Directorate of the Directorate General for Research and Innovation of the European Commission, at the closing conference of PROMITHEAS-4.

During the past three years, this project has focused on building capacity for achieving the much needed climate change mitigation goals. It is now well understood, and broadly acknowledged that the reduction of Greenhouse Gas Emissions is the only way through which we can ensure a sustainable future for us and for our planet. The key findings of the Working Group I of the Intergovernmental Panel of Climate Change summarise well the situation:

1. Warming of the climate system is undisputable. Global surface temperature has risen about 0.8°C since 1880.
2. There is 95% probability that this temperature rise is due to human activities
3. With no action there is a 62% chance that by 2081-2100 the temperature could be more than 4°C higher than in pre-industrial times.

It is obvious that the impacts of such an increase would be significant – if not devastating – for our economies, our societies and the environment. A drastic reduction in Greenhouse Gas Emissions is needed, if we are to limit the increase in surface temperature, as well as sea level rise.

In this context, enhanced awareness among planners, decision and policy-makers is a significant instrument for ensuring that new policy options are put in place to combat climate change. Climate change mitigation and the reduction of greenhouse gas emissions should not be viewed a restriction to national economic development. They also represent an opportunity for a greener future, a future that also brings new development opportunities, growth and jobs, and at the same time ensures a more sustainable future.

It is along this line of thinking that PROMITHEAS-4 was launched. The initial call of the 7th Framework Programme called for exploring climate policy scenarios for emerging or developing economies. It was particularly aimed at identifying knowledge gaps and research needs in such economies, and at exploring the appropriate policy mix for climate change adaptation, mitigation and economic development in post-2012 climate regimes.

Although I have followed Promitheas-4 only for a limited period of time, it is my impression that the project through its capacity building and modelling activities delivered on those aims. And throughout its duration, PROMITHEAS-4 has managed to mobilise resources and reach out to key policy makers in the 12 emerging economies that were the focus of the project.

Of course, PROMITHEAS-4 is not the only FP7 project in this field. Through the 7th Framework Programme several other research projects have and are still focusing on modelling the impact of different policy instruments, with a focus on economic tools and consumer behavior changes. The aim is to investigate the potential for the decarbonisation of the energy sector in the EU and beyond. This research effort will not stop with end of FP7.

Throughout the Framework Programmes, it has been well understood that research and innovation play a crucial role in addressing the climate-energy challenge. Recent prospective analyses show that the decarbonisation of the energy sector is feasible and that the key to achieving it is rooted in the accelerated development of innovation and technology.

The forthcoming Framework Programme for Research for the 2014-2020 period, Horizon 2020, will strongly support research, innovation and technological developments in the area of energy and climate change, as well as the shift towards a green economy.

The relevant actions will span the entire research and innovation cycle extending from frontier research through large-scale demonstration and market uptake. It has been stated by the previous speakers that 20% of the EU budget for 2014-2020 will be devoted to climate-related expenditure. This percentage, in Horizon 2020 should exceed 35%. This is considerable, given that the total budget for Horizon 2020 is currently proposed to be around 70 billion €. The above proposal indicates the importance that the EU and the Member States place on climate change mitigation and adaptation objectives, climate resilience. The Horizon 2020 research themes, in addition to innovation, new technologies and models, will also target the development of the necessary knowledge base, methods and tools in order to design efficient and cost-effective mitigation policies. They will further aim to support the international climate negotiations under the UNFCCC umbrella.

Having said the above, I would like to stress the importance of the conference of the PROMITHEAS network as a forum that brings together knowledge and developments in the countries of the Baltic Sea and disseminates these to policy-makers. It is extremely important to us that results are widely communicated and provide policy support.

Thank you again for this invitation, and I would like to wish for a stimulating conference and debate.

Adreessing Speech by Mr. Konstantinos THEOFYLAKTOS

Dear Delegates,

Energy and climate change are assessed as the main challenges for this century and a vast set of policies, targets, measures and instruments have been designed, developed and implemented in order to create sustainable scenarios for the next day in favor of our societies and economies and, more important, of future generations of this planet.

Moreover, energy has an additional role to play since it is linked with geopolitics, national security and long-term economic competitiveness.

In the supply domain, research and technology focuses on developing sustainable technologies in order to exploit, in an environmental way, the indigenous resources, especially the renewable energy sources, and optimize the management of energy production and supply by incorporating storage and smart grid principles. In parallel, emphasis is given to the energy demand sector and, in specific, to the development of energy efficient technologies for buildings –households, tertiary and public sector - transportation, power systems and industry, which make a key component of reducing the reliance on fossil fuels and minimizing the carbon footprint. However, critical to the success of sustainable energy technologies will be the understanding and assessment of their potential social and economic impacts.

To this end, we are, nowadays, even wiser, since numerous research outputs as well as comprehensive and detailed studies have been developed at international level, describing both the implications and challenges for energy and climate change but also the instruments to be used for tackling them.

Moreover, in our days, a growing need to exploit synergies between a market based and a target driven approach to tackle climate and energy challenges is recognized as the only way to ensure success in the implemented actions. The technological advancements are also a key factor of success, whereas innovative and cutting edge technologies are to be used in order to deliver the desired outcomes in the energy and environment domain.

Renewables and Energy Efficiency technologies will continue to play a central role in this strategy and it is expected that a high growth will be observed in all the relevant economic and technological domains.

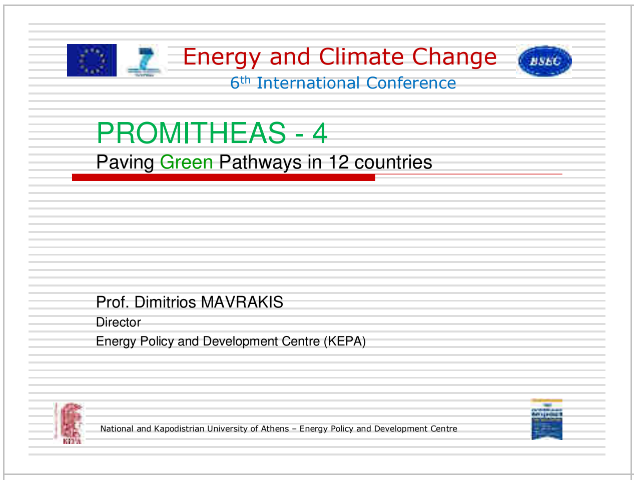
Researchers, entrepreneurs, investors, politicians must enter into a continuous dialogue and be involved in knowledge exchange in view of designing, developing and implementing the most appropriate mix for tackling climate change and achieving the various energy targets for RES penetration and energy efficiency.

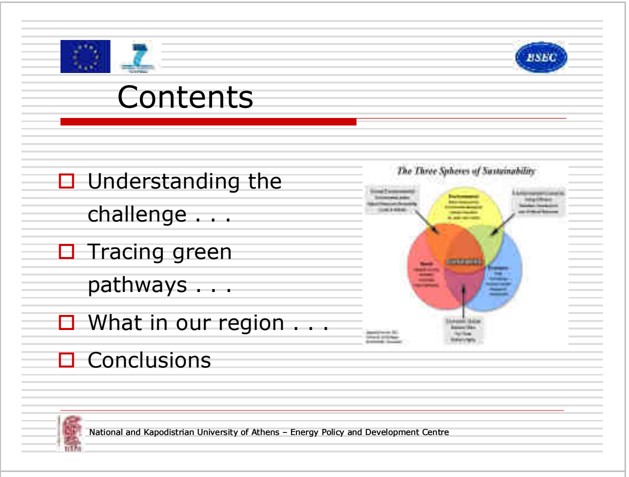
The aforementioned challenges are even higher now and especially in Greece, considering the implications of the continuous economic recession and the fact that medium and long term strategies and targets tend to be left aside. Especially in this timing, the Energy sector should become a pioneer for bring forward sustainable and innovative solutions that protect the environment and the consumers, and also support the transition to an economic growth.

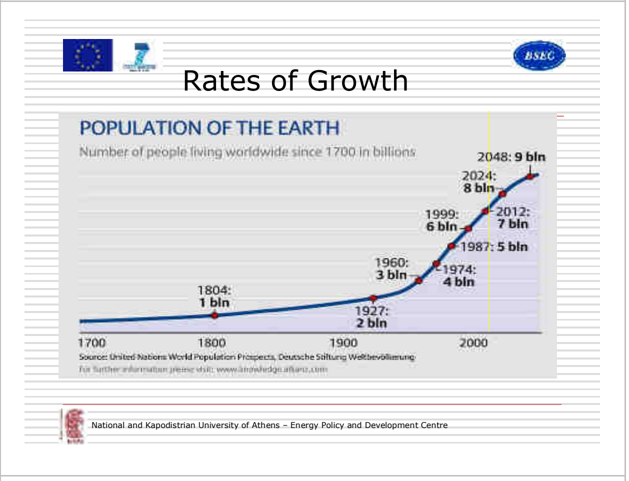
The Greek Centre for Renewable Energy Sources and Energy Efficiency- CRES, under its dual role as the national energy centre for RES and EE as well as an energy research centre, will continue to follow the technology and policy evolution in the field of energy, aiming to deliver state of the art services by integrating all the appropriate developments and elements, while ensuring the economic, social and environmental sustainability.

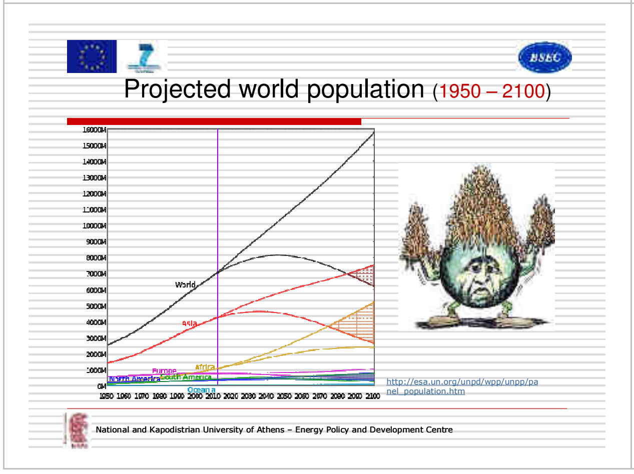
Thank you for your attention and best wishes for a fruitful Congress.

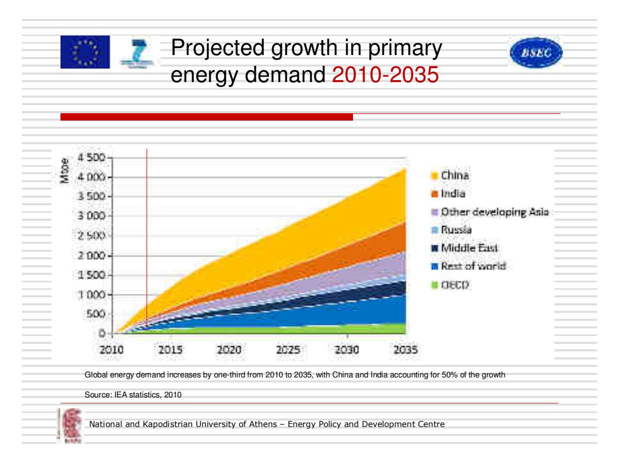
PROMITHEAS-4, Paving green pathways in 12 countries by Prof. Dimitrios MAVRAKIS



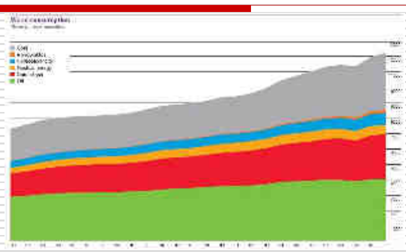








World primary energy consumption 1986-2011



Source: BP statistical review of world energy – June 2012

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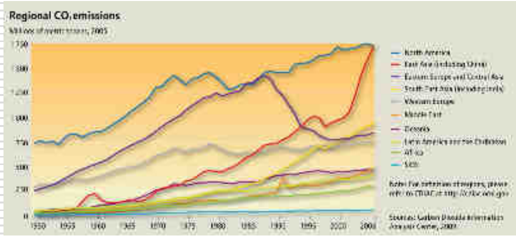
Trends in CO_2 emissions



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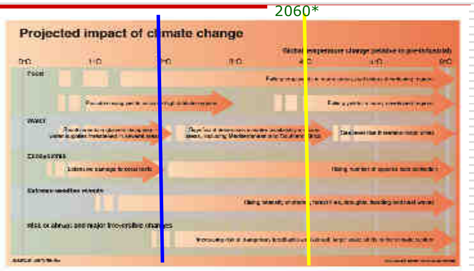
Beyond the 2^0 C level

2060*



* World Economic Forum

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Tracing green pathways . . .

- The ultimate challenge
- The Kyoto protocol contribution
- The UNFCCC framework for various approaches

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The ultimate challenge

A Green Sustainable
and Equitable Economic Development
Capable to:

- Reduce GHG emissions – Mitigation
- Reduce Vulnerability to Climate Change – Adaptation (Agriculture, Energy sector, Water resources, Infrastructure, Tourism, Health sector, Ecosystems)
- Secure equitable economic development – Green economy

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The Kyoto protocol process

- 1st commitment period 2005 – 2012
  - Annex 1 and **non** Annex 1 countries
  - CDM, JI, ETS
  - Top to down procedure, limited success
- 2nd commitment period 2013 – 2020
  - Part of Annex 1(15% of global emissions)
  - CCS* under CDM (Durban)
  - Less parties with binding targets

*CCS : Carbon Capture Storage

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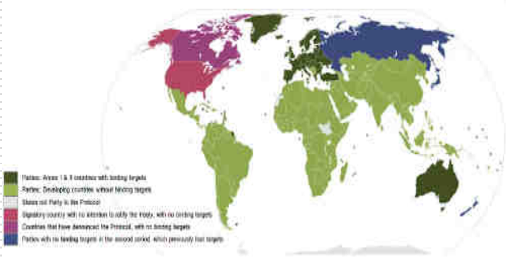
Kyoto protocol
(Present state of world actual commitment)



Carbon Pricing Scenarios July 2013 PROMETHIUM

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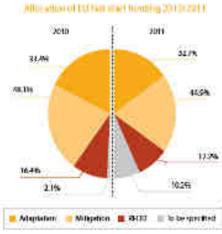
Copenhagen Accord

Assist developing countries in
- Adaptation
- Mitigation
- Reducing Emissions from Deforestation and forest Degradation (REDD+)

☐ $ 100 bl /year up to 2020
(2.34 bn € mobilized by EU in 2011 still pending)



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A promising perspective

The Framework[1] for various approaches under UNFCCC[2]

With the aim to promote cost effectiveness of mitigation actions:

Parties may individually or jointly develop and implement such approaches in accordance with their national circumstances which may include the following:

☐ Bilateral, domestic, voluntary offset programs
☐ Sub-national, national and regional trading systems
☐ Other market and non market approaches

1. 1/cp 17-Preamble of Section E
2. UNFCCC :United Nations Framework Convention on Climate Change

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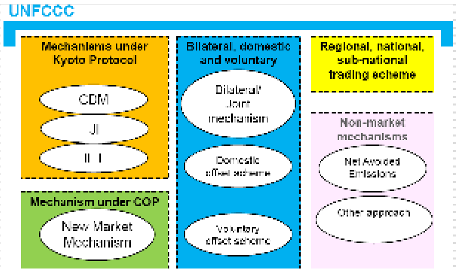
Framework for various approaches



NMMs in Charts IGES - JAPAN

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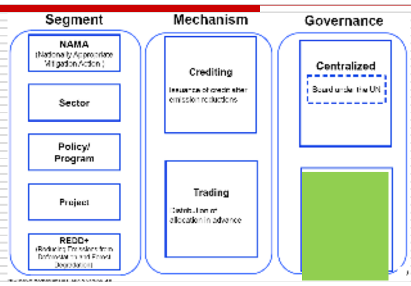
New Market Mechanisms (NMMs) Components



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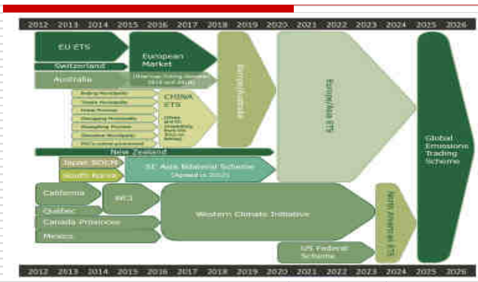
Expected evolution of ETS



Carbon Pricing Scenarios July 2013 PROMETHIUM

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What in our region . . .

- PROMITHEAS – 4
- Developing policy mixtures
- Mapping the region
- Reviewing policies
- Trends and consequences

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PROMITHEAS – 4 (General information)

- Title: "Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"
- Type: EU – FP7 (ENV – Cooperation, Contract No. 265182)
- Duration: Three (3) years (2011-2013)
- Budget: One (1) Mil. Euros (Approx.)
- Partners: 16 Institutes - 14 countries
- Beneficiaries: 12 emerging economies

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Developing M/A policy mixtures

- Review the climate change policies of beneficiaries
- Collect and develop databases and scenarios (BAU, PES, OPT)
- Run LEAP model
- Assess policy mixtures (AMS)
- Comment policy mixtures in national conferences
- Develop and implement intensive knowledge transfer procedures
- Keep informed the governmental authorities

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State of implementation of "Kyoto" in the region

	Ratification of Kyoto protocol	Registered CDM projects	Emission trading	Adaptation policy
Albania	01.04.2005	3	–	–
Armenia	25.04.2003	6	–	–
Azerbaijan	28.09.2000	5	–	√**
Bulgaria	15.08.2002	*Annex B country*	EU-ETS,JI, GIS	√*
Georgia	16.06.1999	6	–	–
Greece	31.05.2002	*Annex B country*	EU-ETS	√*
Kazakhstan	19.06.2009	*Annex B country*	National ETS (2014)	–
Moldova	22.04.2003	8	–	–
Romania	19.03.2001	*Annex B country*	EU-ETS,JI,GIS	√*
Russia	18.11.2004	*Annex B country*	JI, GIS	–
Serbia	19.10.2007	6	–	–
Turkey	28.05.2009	-	voluntary carbon market	–
Ukraine	12.04.2004	*Annex B country*	JI, GIS	–

* Transposition of Directive 2007/60/EC on assessment and management of flood risks, ** Water management & fees (2003, 2011)

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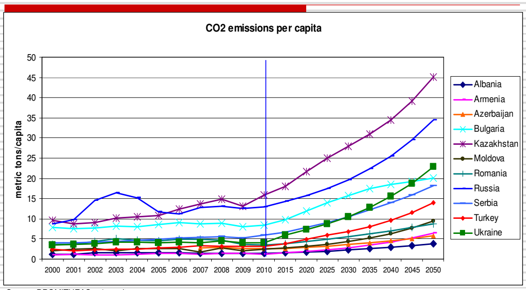
CO_2 emissions (Metric tons eq./capita)



Source: PROMITHEAS – 4 results

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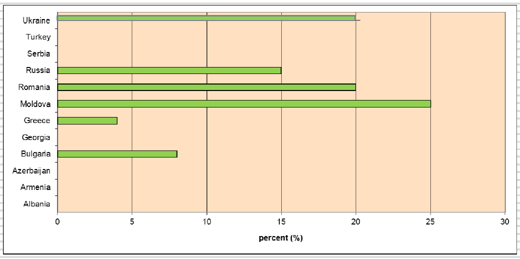
CO_2 emission reduction targets until 2020



Note: Target of Bulgaria (8%) refers to 2012.

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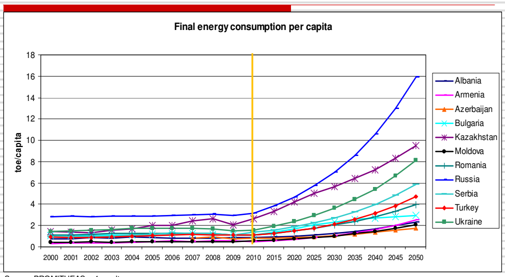
Final energy consumption per capita



Source: PROMITHEAS – 4 results

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Energy efficiency policies

	Appliances	Buildings*	Energy sector	Industry
Albania	With policy instruments	With policy instruments	No policy instruments	No policy instruments
Armenia	No policy instruments	No policy instruments	No policy instruments	No policy instruments
Azerbaijan	No policy instruments	No policy instruments	With policy instruments	No policy instruments
Bulgaria	With policy instruments	With policy instruments	No policy instruments	With policy instruments
Kazakhstan	No policy instruments	No policy instruments	No policy instruments	No policy instruments
Moldova	No policy instruments	With policy instruments	With policy instruments	No policy instruments
Romania	No policy instruments	With policy instruments	With policy instruments	No policy instruments
Russia	With policy instruments	With policy instruments	No policy instruments	No policy instruments
Serbia	No policy instruments	With policy instruments	No policy instruments	No policy instruments
Turkey	No policy instruments	With policy instruments	With policy instruments	With policy instruments
Ukraine	With policy instruments	With policy instruments	No policy instruments	No policy instruments

With policy instruments

No policy instruments

* Heat conservation, energy and insulation standards, energy management, etc.

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Conclusions

- There is a knowledge gap in developing, implementing and assessing M/A policy mixtures
- The countries of the region do not participate (…so far)
  - In the formation of the Global ETS
  - In the development of regional NMMs
- There is a considerable potential in reducing energy intensity (Nationally and Regionally)

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Conclusions (Knowledge needs)

- Reliable data bases (Development and maintenance in both national and regional level)
- Expertise in
  - Scenarios development (Assumptions, modifications)
  - Models and assessment methods
  - M/A policy mixtures (Implementation, modification)
- Social awareness among
  - Policy and decision makers
  - Market stakeholders
  - Simple people

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Conclusions (Paving green pathways)

- National Emission Trade Schemes (ETS) can be developed and converge regionally and globally, until 2030
- Converging national NMMs, based on M/A policies, can provide economic benefits for the economies of the region
- Countries with emerging economies can be benefited from the green fund of the Copenhagen accord

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Conclusions (decreasing energy intensity)

- Increase the energy efficiency standards
- Encourage the use green technologies and smart networks
- Establish tradable certificates for all avoided emissions
- Enhance energy supply companies with energy saving services

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Thank you for your attention

KEPA in Athens - Greece

E-mail: epgsec@kepa.uoa.gr.
Tel. + 30 210 727 5732

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National reports

Albania

6-th Annual International Conference on "Energy and Climate Change". Athens, Greece, October 09th 2013

"Climate change policy mixtures and assessment of different scenarios for Albania"

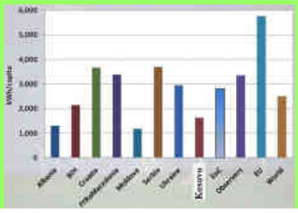
Prof. Dr.-Ing. Andonaq LAMANI

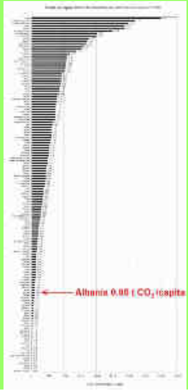
Department of Energy, Faculty of Mechanical Engineering, Polytechnic University of Tirana, "Mother Teresa" Square, No. 4, Tirana, Albania, e-mail: alondo@fim.edu.al

Introduction

Levels of CO_2 emissions in Albania are about 5-times lower than average international levels (WRI 2011).

This is because (EC 2008):
- a high percentage of electricity is produced by hydro power plants;
- energy consumption per capita is low, and
- industrial productivity has continued to fall.





Spectrum of climate change mitigation options for Albania

Furthermore, the Albanian energy sector is facing the following problems which may be an obstacle to further economic development:

i) high dependence on hydropower (World Bank, 2010);

ii) limited regional electricity interconnections at present (World Bank, 2010);

iii) high level of energy import dependence (2.538 TWh or 33.3% at 2012) (ERE, 2012);

iv) high technical and commercial losses from the distribution system (3.346 TWh or 43.9% at 2012) (ERE, 2012);

v) (10-20)% of water resources are lost in the irrigation system (UNDP, 2012).

Spectrum of adaptation needs in Albania

The future climate scenario for Albania predicts (GEF, 2006):
- increased temperatures;
- decreased precipitation, and
- reduction of arable land and water resources.

The most vulnerable area is Albania's coastal zone, while the most vulnerable sectors are expected to be (GEF, 2006):
- water resources;
- agriculture;
- energy, and
- tourism.

Scenarios

BUSINESS – AS – USUAL SCENARIO (2000 – 2050)

BAU scenario description

The BAU scenario is structured by:
i.Laws, regulations, Ministerial Decisions or presidential Degrees which are related with the climate change problem, were included;
ii.The mitigation/adaptation policy instruments that Albania has set into force **before** 1st January 2011.

Scenarios

OPTIMISTIC SCENARIO (2000 – 2050)

Optimistic scenario description

The Optimistic scenario is structured by:

i)the mitigation/adaptation policy instruments that Albania has set into force **after** 1st January 2011;

ii)additional policy instruments in line with the EU climate change policy that can be adjusted to the needs and priorities of Albania, and

iii)the **maximum exploitation** of the potential of Albania in energy efficiency and renewable energy sources.

Scenarios

PESSIMISTIC SCENARIO (2000 – 2050)

Pessimistic scenario description

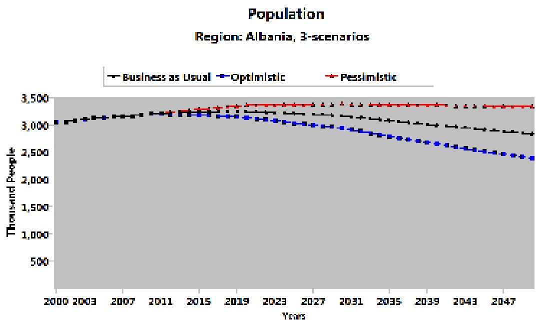
The *Pessimistic scenario* is structured by:
i)the mitigation/adaptation policy instruments that Albania has set into force **after** 1st January 2011;
ii)no other additional policy instruments apart from those already decided to be implemented and in line with the EU climate change policy, which will be adjusted to the needs and priorities of Albania, and
iii)the **minimum exploitation** of the potential of Albania in energy efficiency and renewable energy sources.

Official data sources

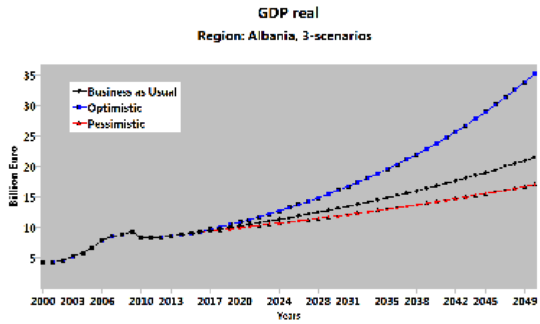
Albanian institutions which are involved in the data collecting process, are:
- INSTAT- Institute of Statistics www.instat.gov.al
- ERE- Albanian Energy Regulatory Authority www.ere.gov.al
- APC- Albanian Power Corporation www.kesh.com.al
- OST- Transmission System Operator www.ost.al
- CEZ Distribution www.cez.al
- Bank of Albania www.bankofalbania.al
- Ministry of Economy, Trade, and Energy www.mete.gov.al
- Ministry of Environment, Forest, and Water Administration www.moef.gov.al
- Ministry of Finance www.minfin.gov.al
- Ministry of Agriculture, Food, and Consumer Protection http://www.mbumk.gov.al/
- National Agency of Natural Resources www.akbn.gov.al

Other International Institutions are:
World Bank www.worldbank.org, International Monetary Fund www.imf.org
Energy Community http://www.energy-community.org, USAID www.usaid.gov
UN Development Programme www.undp.org, International Energy Agency www.iea.org, Energy Charter http://www.encharter.org, etc.

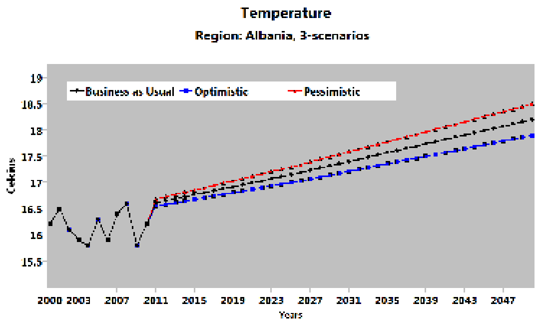
Demographics: Population



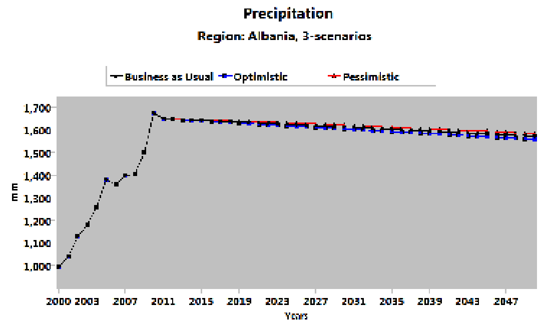
Economy: Gross Domestic Product

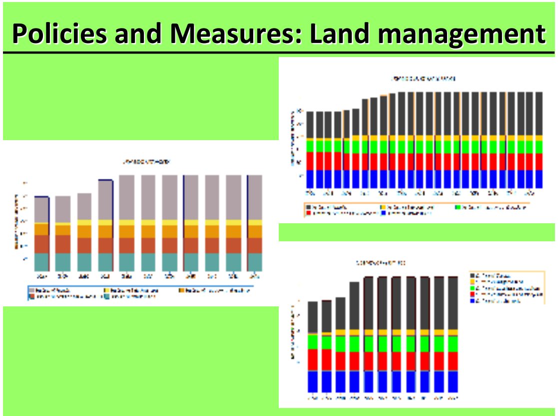


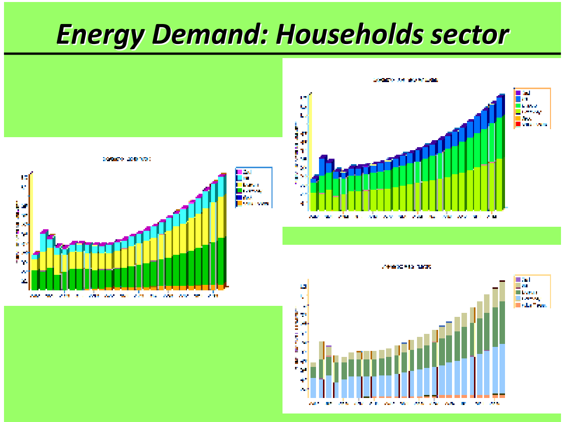
Climate statistics: Temperature

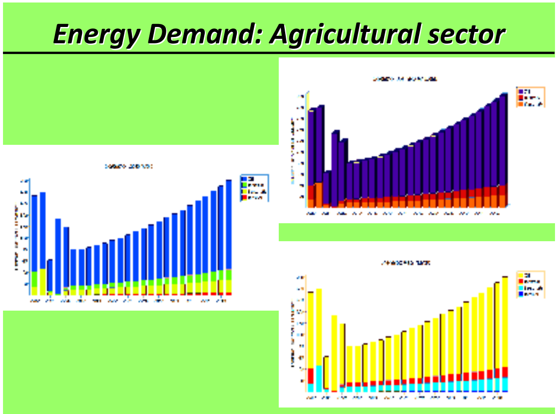


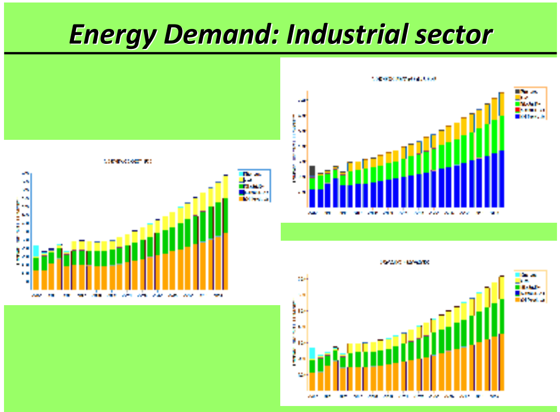
Climate statistics: Precipitation

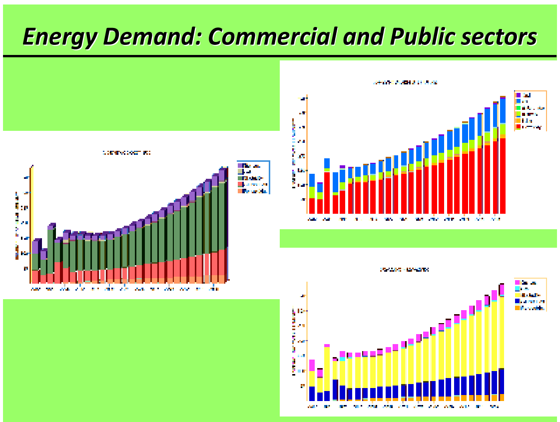


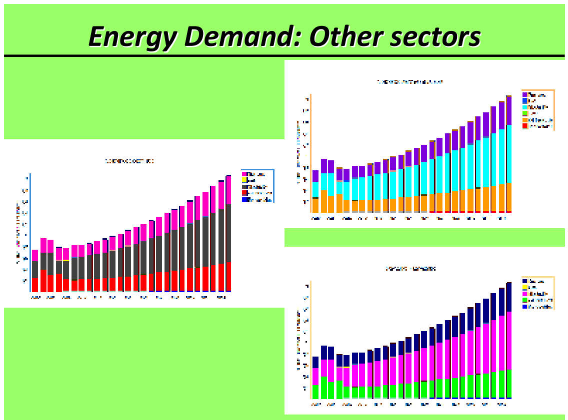

Policies and Measures: Land management


Energy Demand: Households sector

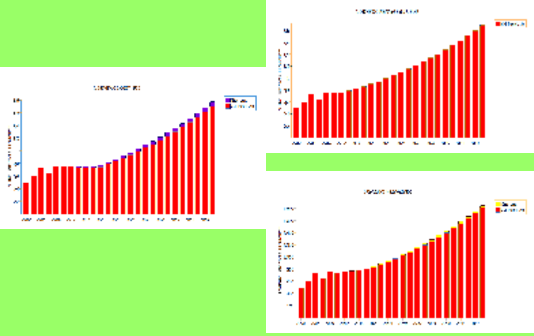

Energy Demand: Agricultural sector


Energy Demand: Industrial sector

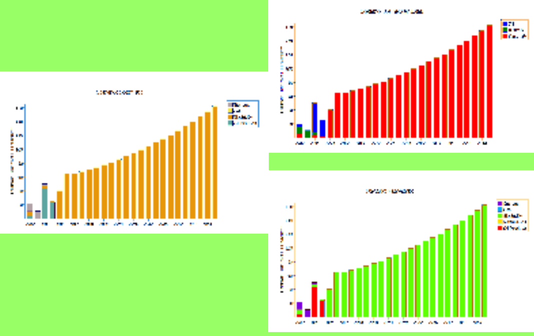

Energy Demand: Commercial and Public sectors


Energy Demand: Other sectors

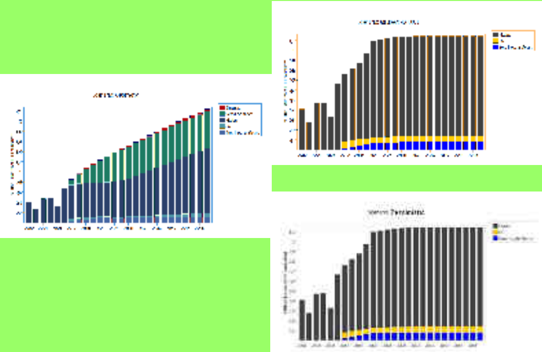
Energy Demand: Transport sector



Energy Demand: Non-specified sectors

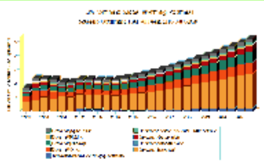


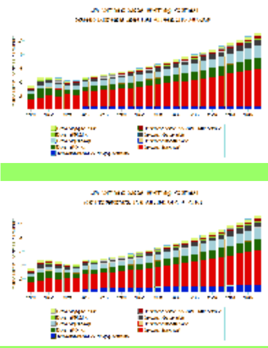
Transformation: All plants



Global warming potential (GHG emissions)

All sectors





Assessment of the three developed scenarios

The multi - criteria method AMS is used for the assessment of the 3-developed scenarios for Albania.

The AMS method

Each scenario is assessed for its performance under the criteria/sub-criteria of the AMS method. This method is a combination of three standard multi-criteria methods:

- ❑ the Analytical Hierarchy Process (AHP),
- ❑ the Multi-Attribute Utility Theory (MAUT), and
- ❑ the Simple Multi-Attribute Ranking Technique (SMART).

Assessment of the three developed scenarios

1-Criteria: Environmental Performance (16.8 %)

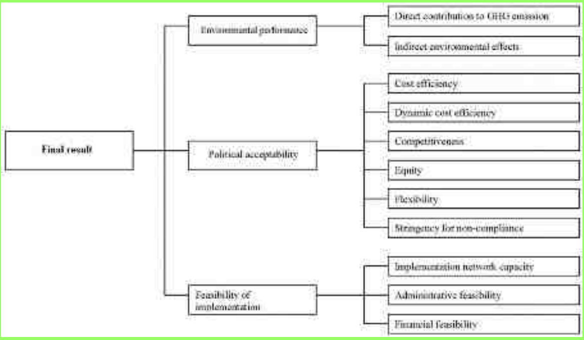
2-Criteria: Political acceptability (73.8 %)

3-Criteria: Feasibility of implementation (9.4 %)

Result: The best scenario

Assessment of the three developed scenarios

The structure



Assessment of the three developed scenarios

Total emissions in Albania

Scenario	Total GHG emissions (in $MtCO_{2eq}$)		
	2000	2020	2050
BAU	3.664	5.816	11.939
Optimistic	3.664	4.942	11.212
Pessimistic	3.664	5.808	12.111

Assessment of the three developed scenarios

Emissions per each sector in Albania

Scenario	GHG emissions (in $MtCO_{2eq}$)		
	2000	2020	2050
Households			
BAU	0.178	0.380	0.860
Optimistic	0.178	0.316	0.796
Pessimistic	0.178	0.348	0.828
Agriculture			
BAU	0.413	0.235	0.493
Optimistic	0.413	0.230	0.482
Pessimistic	0.413	0.232	0.487
Services			
BAU	0.150	0.145	0.304
Optimistic	0.150	0.121	0.280
Pessimistic	0.150	0.133	0.292
Industry			
BAU	0.394	0.835	1.752
Optimistic	0.394	0.687	1.604
Pessimistic	0.394	0.762	1.678
Transport			
BAU	1.438	2.601	5.457
Optimistic	1.438	2.148	4.938
Pessimistic	1.438	2.393	5.240
Electricity generation			
BAU	0.000	0.381	0.477
Optimistic	0.000	0.203	0.517
Pessimistic	0.000	0.702	0.990

Assessment of the three developed scenarios

Other environmental effects in Albania under each scenario

Scenario	In $MtCO_2$ eq		
	2000	2020	2050
Environmental effects (Carbon Monoxide (CO)- Nitrogen Oxides (NOx)- Non Methane Volatile Organic Compounds- Sulfur Dioxide)			
BAU	0.297	0.471	0.994
Optimistic	0.297	0.395	0.914
Pessimistic	0.297	0.439	0.963

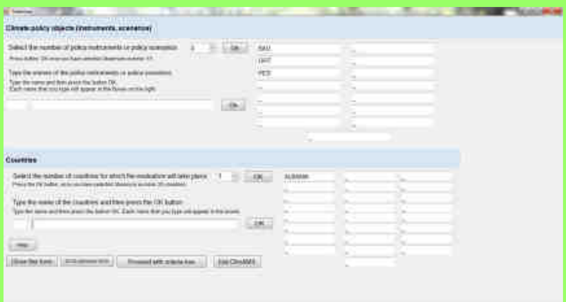
Assessment of the three developed scenarios

Water use in Albania

Scenario	In billion m^3		
	2000	2020	2050
Household water use			
BAU	1.760	1.830	1.830
Optimistic	1.760	1.880	1.740
Pessimistic	1.760	1.880	1.740
Industrial water use			
BAU	0.211	0.217	0.217
Optimistic	0.211	0.263	0.551
Pessimistic	0.211	0.263	0.551
Agricultural water use			
BAU	1.040	1.045	1.045
Optimistic	1.040	1.086	1.155
Pessimistic	1.040	1.102	1.193

Assessment of the three developed scenarios

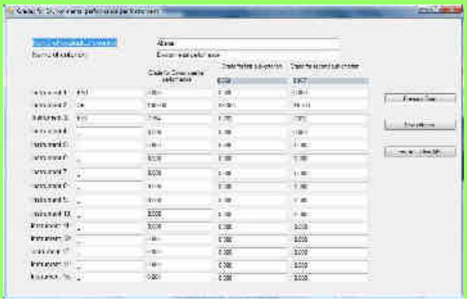
Initial settings for the 3-scenarios in ClimAMS-2012



Assessment of the three developed scenarios

Criterion 1: Environmental performance

1) The first sub-criterion "**Direct contribution to GHG emission reductions**";
2) The second sub-criterion "**Indirect environmental effects**".

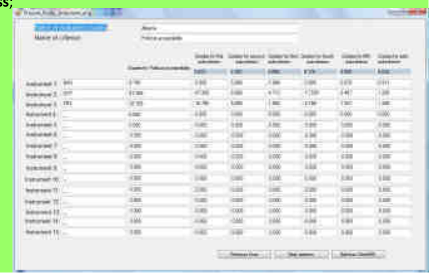


Assessment of the three developed scenarios

Criterion 2: Political acceptability

Results for each sub-criterion:

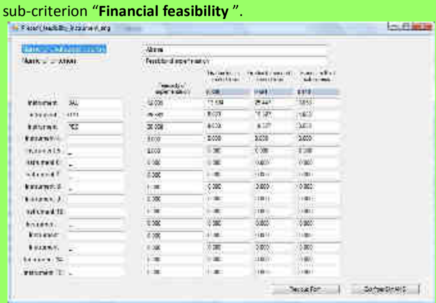
1) **Cost efficiency;**
2) **Dynamic cost efficiency ;**
3) **Competitiveness;**
4) **Equity;**
5) **Flexibility;**
6) **Stringency for non-compliance** ".



Assessment of the three developed scenarios

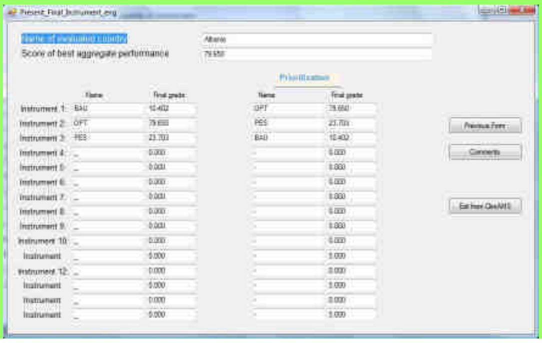
Criterion 3: Feasibility of implementation

1) First sub-criterion "**Implementation network capacity** ";
2) Second sub-criterion "**Administrative feasibility** ";
3) Third sub-criterion "**Financial feasibility** ".



Assessment of the three developed scenarios

Results of AMS method



Assessment of the three developed scenarios

AMS results for each scenario for Albania

Criteria	Scenarios		
	BAU	Optimistic	Pessimistic
Direct contribution to GHG emission reductions (0.833)	0.000	83.300	0.762
Indirect environmental effects (0.167)	0.000	16.700	7.032
Environmental performance (0.168) - A	**0.000**	**100.000**	**7.794**
Cost efficiency (0.474)	0.000	47.300	16.765
Dynamic cost efficiency (0.183)	5.060	8.080	5.060
Competitiveness (0.085)	1.894	4.713	1.894
Equity (0.175)	0.000	17.500	0.198
Flexibility (0.051)	0.975	2.467	1.557
Stringency for non-compliance (0.032)	0.811	1.295	1.295
Political acceptability (0.738) - B	**8.740**	**81.355**	**26.768**
Implementation network capacity (0.309)	13.534	8.683	8.683
Administrative feasibility (0.581)	25.447	16.327	16.327
Financial feasibility (0.110)	3.058	4.883	3.058
Feasibility of implementation (0.094) - C	**42.039**	**29.893**	**28.068**
Total (A+B+C)	**10.402**	**79.650**	**23.703**

The final grades demonstrate that **OPTIMISTIC scenario** has the best performance in achieving the objectives of the Albanian climate change policy taking into consideration the national framework. However, it has specific weaknesses under the criterion "feasibility of implementation".

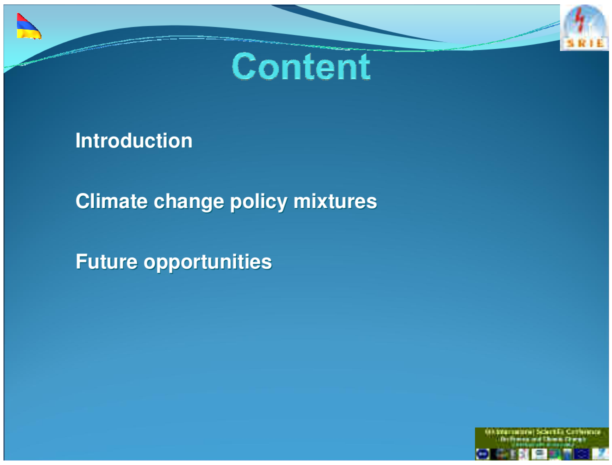
Scodra town during 2010 heavy floods www.gazeta-shqip.com

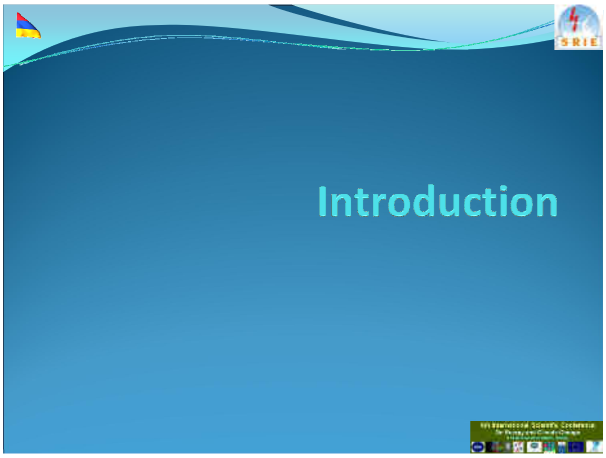
Thank You For Your Attention!

Prof.Dr.-Ing. Andonaq LAMANI
Department of Energy, F.M.E.-P.U.T.
e-mail: alondo@fim.edu.al

Armenia

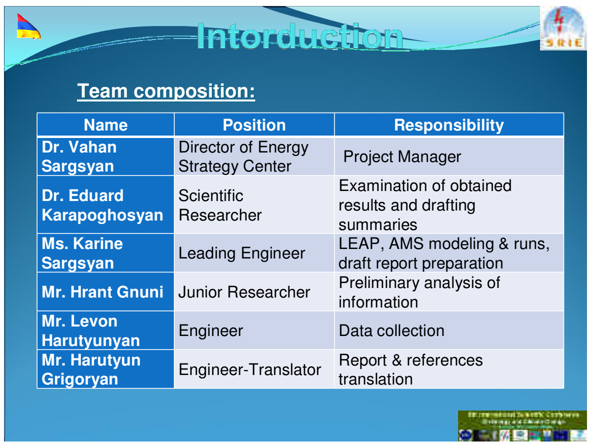

6th International Scientific Conference
on Energy and Climate Change
9-11 October 2013, Athens (Hellas)
PROJECT: Knowledge Transfer and Research Needs for Preparing Mitigation / Adaptation Policy Portfolios (Contract No. 265182)
Development and assessment of Mitigation/ Adaptation Climate Change policy portfolios for Armenia
Dr. Vahan Sargsyan
Energy Strategy Center of
Scientific Research Institute of Energy


Content
Introduction
Climate change policy mixtures
Future opportunities


Introduction


Scientific Research Institute of Energy
Energy Strategy Center
✓ Scientific Research Institute of Energy (SRIE) as an independent organization has been established in 1961
✓ In 1998 under the TACIS support the Energy Strategy Center (ESC) has been established as the branch of SRIE
✓ ESC assists the RA Government in the field of:
Energy sector strategy and policy development,
Energy efficiency, Energy saving implementation and Renewable energy development issues,
Energy balance elaboration,
National Communications on Climate Change (Energy part) preparation, etc.


PROMITHEAS 4 Conference: "Development and assessment of Mitigation and Adaptation Climate Change policy portfolios for Armenia"
"Oval" Hall
Golden Tulip Yerevan Hotel
Yerevan, Armenia
23rd of May 2013
Representatives from:
Ministry of Energy and Natural Resources of RA
EU Delegation
Ambassador of Greece in Armenia
NKUA-KEPA
UNFCCC National Focal Point
UNDP Climate Change Program
USAID
Asian Development Bank
Alliance to Save Energy
UNDP-GEF
Armenia R2E2 Fund
…and other


Intorduction
Team composition:
Name | Position | Responsibility
Dr. Vahan Sargsyan | Director of Energy Strategy Center | Project Manager
Dr. Eduard Karapoghosyan | Scientific Researcher | Examination of obtained results and drafting summaries
Ms. Karine Sargsyan | Leading Engineer | LEAP, AMS modeling & runs, draft report preparation
Mr. Hrant Gnuni | Junior Researcher | Preliminary analysis of information
Mr. Levon Harutyunyan | Engineer | Data collection
Mr. Harutyun Grigoryan | Engineer-Translator | Report & references translation

Climate Change Policy Mixtures

Climate Change Policy Mixtures

Data Collection:

✓Armenia RES Roadmap (2011)

✓National Energy Efficiency Action Plan 2010 (2010)

✓Action Plan for the Ministry of Energy of the Republic of Armenia Stipulated by the Provisions of the National Security Strategies of the Republic of Armenia (2007)

✓Overview, Implementation of the Kyoto Protocol's Clean Development Mechanism in Armenia (EBRD, 2009)

✓Sustainable Energy Sector Development Strategy of Armenia (2005)

Climate Change Policy Mixtures

Base Parameters for all Scenarios:

✓**Base Year: 2010**

✓**Historical Period: 2000-2010**

✓**Planning Period: 2010-2050**

Climate Change Policy Mixtures

Developing BAU – Key Assumptions:

✓*Demographics:* UN projections for Armenian population

✓*Economy:* GDP Average Annual Growth – 4.5%

✓*Climate Statistics:*

- Annual Change of Precipitation: -0.8%
- Annual Increase of Temperature: 1 %
- Surface Waters Decrease: -0.53%

✓Land Management – 1530 km² of arable land during whole planning period

Climate Change Policy Mixtures

Developing BAU – Energy Demand:

✓*Households:*

- Natural Gas – from 471 to 2410 million m³
- Electricity – up to 8.8 billion kWh
- Heat – up to 244 billion kcal

✓*Agriculture*

- Electricity – 4%/year (up to 604 million kWh)

✓*Industry*

- Natural Gas – up to 1.9 million m³
- Electricity – 5 billion kWh
- Heat – 288 billion kcal in 2050

✓*Transport*

- Energy Demand – 4% annually
- ✓ *Non Specified*
- Average Annual Growth – 2%

Climate Change Policy Mixtures

Developing OPT – Key Assumptions:

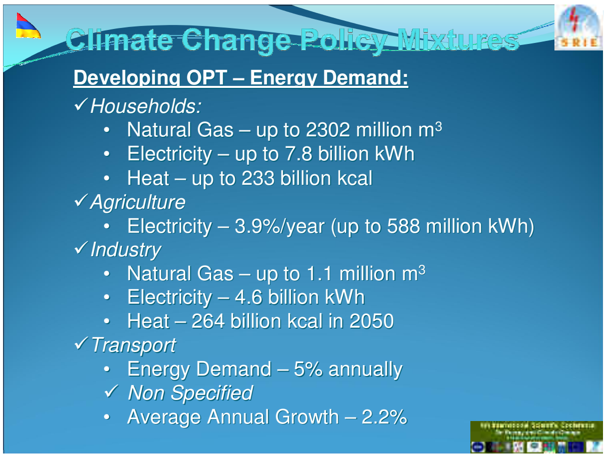
✓*Demographics:* UN projections for Armenian population

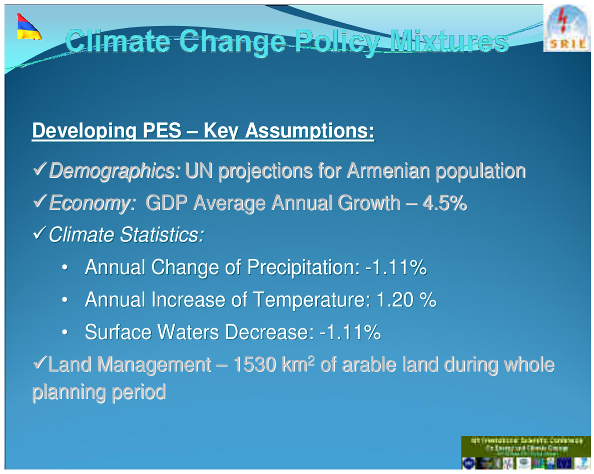
✓*Economy:* GDP Average Annual Growth – 4.5%

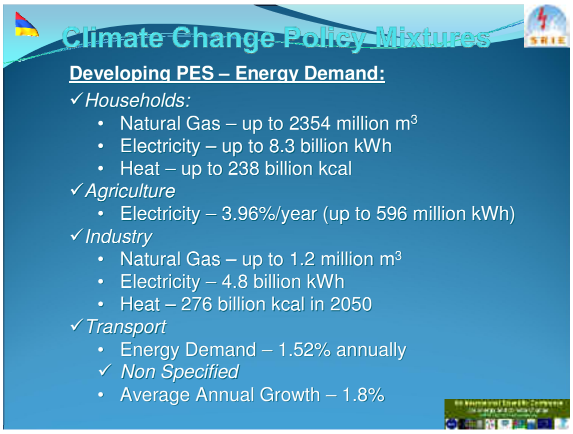
✓*Climate Statistics:*

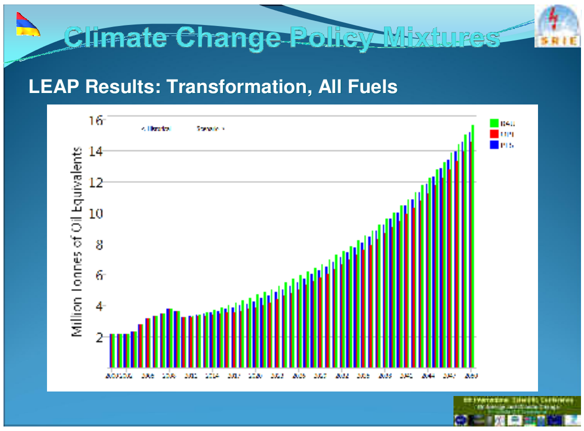
- Annual Change of Precipitation: -0.26%
- Annual Increase of Temperature: 1.02 %
- Surface Waters Decrease: -0.26%

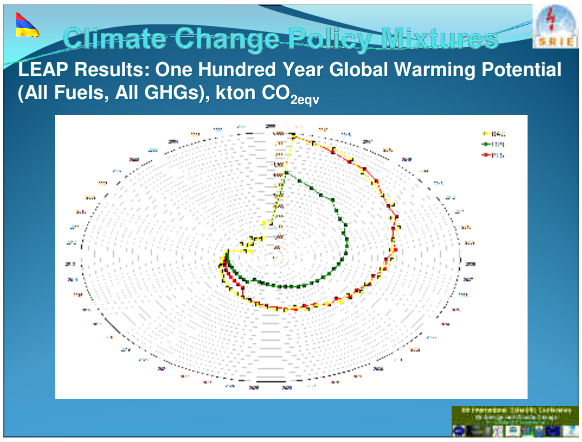
✓Land Management – 1530 km² of arable land during whole planning period

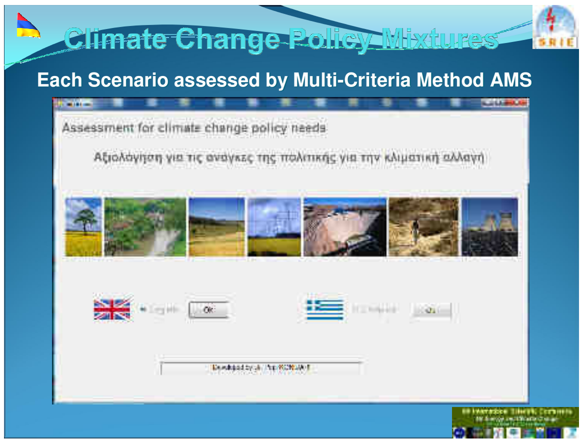

Climate Change Policy Mixtures
Developing OPT – Energy Demand:
✓Households:
• Natural Gas – up to 2302 million m³
• Electricity – up to 7.8 billion kWh
• Heat – up to 233 billion kcal
✓Agriculture
• Electricity – 3.9%/year (up to 588 million kWh)
✓Industry
• Natural Gas – up to 1.1 million m³
• Electricity – 4.6 billion kWh
• Heat – 264 billion kcal in 2050
✓Transport
• Energy Demand – 5% annually
✓ Non Specified
• Average Annual Growth – 2.2%


Climate Change Policy Mixtures
Developing PES – Key Assumptions:
✓Demographics: UN projections for Armenian population
✓Economy: GDP Average Annual Growth – 4.5%
✓Climate Statistics:
• Annual Change of Precipitation: -1.11%
• Annual Increase of Temperature: 1.20 %
• Surface Waters Decrease: -1.11%
✓Land Management – 1530 km² of arable land during whole planning period


Climate Change Policy Mixtures
Developing PES – Energy Demand:
✓Households:
• Natural Gas – up to 2354 million m³
• Electricity – up to 8.3 billion kWh
• Heat – up to 238 billion kcal
✓Agriculture
• Electricity – 3.96%/year (up to 596 million kWh)
✓Industry
• Natural Gas – up to 1.2 million m³
• Electricity – 4.8 billion kWh
• Heat – 276 billion kcal in 2050
✓Transport
• Energy Demand – 1.52% annually
✓ Non Specified
• Average Annual Growth – 1.8%


Climate Change Policy Mixtures
LEAP Results: Transformation, All Fuels
Million Tonnes of Oil Equivalents
16
14
12
10
8
6
4
2


Climate Change Policy Mixtures
LEAP Results: One Hundred Year Global Warming Potential (All Fuels, All GHGs), kton CO2eqv


Climate Change Policy Mixtures
Each Scenario assessed by Multi-Criteria Method AMS
Assessment for climate change policy needs
Αξιολόγηση για τις ανάγκες της πολιτικής για την κλιματική αλλαγή

Climate Change Policy Mixtures

Best policy mixture: policy portfolio in OPT is the best in terms of overall performance. The policy portfolio in BAU is the worst one.

Criteria	Scenarios		
	BAU	OPT	PES
Direct contribution to GHG emission reductions (0,833)	0,000	83,300	42,513
Indirect environmental effects (0,167)	16,700	0,000	6,661
Environmental performance (0,168) – A	**16,700**	**83,300**	**49,174**
Cost efficiency (0,474)	0,000	47,300	23,586
Dynamic cost efficiency (0,183)	4,018	10,164	4,018
Competitiveness (0,085)	2,066	5,141	1,293
Equity (0,175)	0,000	17,500	8,922
Flexibility (0,051)	0,991	2,465	1,544
Stringency for non-compliance (0,032)	1,133	1,133	1,133
Political acceptability (0,738) – B	**8,208**	**87,704**	**40,496**
Implementation network capacity (0,309)	15,123	6,074	9,703
Administrative feasibility (0,581)	28,436	11,420	18,244
Financial feasibility (0,110)	4,580	1,839	4,580
Feasibility of implementation (0,094) – C	**48,139**	**19,333**	**32,528**
Total (A+B+C)	13,388	77,585	41,205

Future Opportunities

Future Opportunities

Needs & Gaps:

✓Demography: no national long-term (up to 2050) forecasts
✓GDP: no national long-term GDP and its distribution forecasts
✓Water use by sectors: only regional forecast is available
✓Energy Demand: simplified forecast
✓Energy transformation: lack of future technology specifications

Comprehensive studies related to long-term (50-100 years) projections of demographic situation, economic development (GDP), energy demand, energy/water use, new technologies etc. are strongly required

Future Opportunities

Future cooperation:

✓Information and data exchange

✓Consultancies

✓Study-tours for students & young specialists

✓Training in different areas of energy and climate issues

✓Providing of Expertise

✓Etc.

Thank You!

Energy Strategy Center of
Scientific Research Institute of Energy
5/1 Myasnikyan avenue, 0025 Yerevan, Armenia
Phone/Fax: +374-10 559-664
E-mail: piuesc@energinst.am
Vahan.sargsyan@energinst.am

Azerbaijan

Development and Assessment of Mitigation / Adaptation Climate Change policy portfolios for Azerbaijan

Scientific Research Institute "Geotechnological problems of oil, gas and Chemistry" (GPOGC)
under
Azerbaijan State Oil Academy

CONFERENCE of PROMITHEAS – 4
Development and Assessment of Mitigation / Adaptation Climate Change policy portfolios for Azerbaijan

Was held on 11th of June 2013
JW Marriott Absheron Baku

Chairman: Prof.D.Mavrakis
Co-chairman: Prof. E.Ramazanova

Governmental Participants:
The Government of Azerbaijan, Ministry of Education, Ministry of Ecology and National resources, Azerbaijan National Academy of Sciences, Institute of Radiation Problems, State Oil Company of Azerbaijan Republic, State Agency on Alternative and Renewable Energy Resources, UNDP, National aerospace agency, International Ecoenergy Academy

Prof. Elmira Ramazanova, Dr.Haji Malikov, Enver Shirinbayli, Aynura Huseynova, Aysel Sadiqli

Scientific Research Institute "Geotechnological Problems of Oil, Gas and Chemistry" was established under decree of Cabinet of Ministers in 1992

Director - Professor Elmira Ramazanova, Vice-president of National Oil Committee of Azerbaijan Republic, corresponding-member of Azerbaijan National Academy of Sciences

The main directions of of the Scientific Research Institute are:

- fundamental scientific research projects in the field of engineering, chemical sciences and applied directions;
- carrying out technological processes in order to meet the highest standards set in science and technology;
- Improving scientific qualifications of scientific and teaching staff and post-graduate students;

Objectives of the Azerbaijan climate change policy

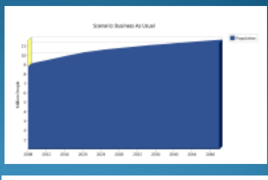
Azerbaijan ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and the Kyoto Protocol in 2000. As a non-Annex I Party to the UNFCCC, Azerbaijan does not have quantitative commitments for reducing GHG emissions. The country has not undertaken so far any quantitative objectives in Renewable Energy Sources (RES) or in Energy Efficiency (EE). The first programme relevant to climate change policy issues was the State Program *"On utilization of Alternative and Renewable Energy Sources in Azerbaijan Republic"* October 21, 2004

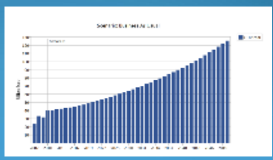
Data collection

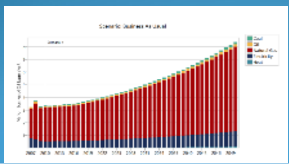
Azerbaijan, as a key strategic energy partner for EU both as a producer and transit country received as assistance a 14 million EUR budget support programme to reform its energy market and legislative framework, improve energy efficiency and promote new and renewable energy sources (RES) (EC, 2012; EC, 2010).
The harmonization of the Azeri legislation with EU law is an important component of their cooperation, initiated by signing the MoU on Strategic Partnership between the European Union and Republic of Azerbaijan in the field of Energy in 2007 (UNECE, 2007).
Many EU directives in environmental areas have already been translated into Azeri (UNECE, 2011). In 2010 Azerbaijan confirmed at high political level its commitment and policy priority to engage the country more forcefully into the development of RES (notably wind, solar and hydro), and of Energy efficiency (EC, 2010).

Business – As – Usual scenario description

The State Program *"On utilization of Alternative and Renewable Energy Sources in Azerbaijan Republic* and State Programme on *"Socioeconomic Development of the Regions of Azerbaijan for the period 2009–2013"* attracted considerable resources for the development of energy, water and sanitation infrastructure in the country since the first Environmental Progress Report (EPR) (UNECE, 2011).

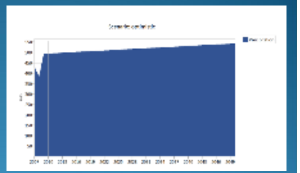


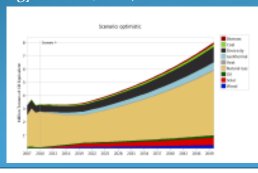


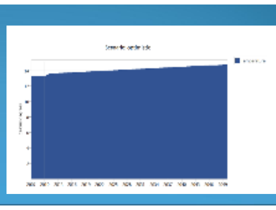


Optimistic scenario description

This scenario is consistent with the intention of the country to promote its RES and support the efficient use of energy. A first step towards these Azeri climate policy components was the Presidential Order "On preparation of National Strategy on the use of Alternative and RES for 2012-2020" (29 December 2011) (State Agency for Alternative and Renewable Energy Sources, 2012).



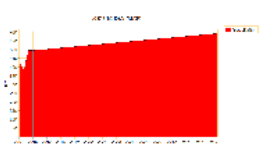


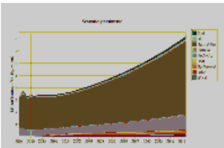


Pessimistic scenario description

The Pes scenario is structured by:

- the mitigation/adaptation policy instruments that the country has set into force after 1st January 2011;
- no other additional policy instruments apart from those already decided to be implemented and in line with the EU climate change policy; the EU policy instruments will be adjusted to the needs and priorities of the examined country and
- the minimum exploitation of the potential of Azerbaijan in energy efficiency and renewable energy sources by limiting the possible technological options only to the energy and residential sector and to hydropower and solar power.





Conclusions:

BAU scenario

The BAU scenario concerns evolution of the already implemented mitigation and adaptation policy instruments in Azerbaijan until the year 2050 and serves as the reference against which the outcomes of the other scenarios are compared.

The currently implemented Azeri mitigation climate policy has only one main component, the promotion of RES. There are no specific obligations to purchase renewable energy, only defined tariffs exist for the generating companies so as to sell energy in the wholesale market The adaptation climate policy concerns water management with only one policy instrument implemented, that of water fees.

OPT scenario

The Optimistic scenario concerns the time evolution of an enhanced mitigation/adaptation policy portfolio that Azerbaijan will implement during the time interval 2011 - 2050. This enhanced policy portfolio takes into account the policy instruments adopted after 1st January 2011 as well as plans of the country and supports:

- efficient technologies targeting to the maximum reduction of GHG emissions
- infrastructure for the adaptation towards the minimum – in size and extent - expected climate change impacts.

PES scenario

The Pessimistic scenario concerns the time evolution of a mitigation/adaptation policy portfolio that the country will implement up to 2050 without exploiting fully the national potential in energy efficiency and renewable energy sources and by facing the worse expected impacts of climate change, taking into account the policy instruments adopted after 1st January 2011.

This scenario assumes less ambitious mitigation policy by limiting the possible technological options only to a selected number of sectors with the highest energy efficiency potential and the most promising for the country types of RES.

Given that the country has not approved any policies beyond 2020, it will be assumed under this scenario that the ones adopted before 2020 will be extended until 2050, as well as that minimum additional policies will be enforced after 2020.

ASSESSMENT OF THE THREE DEVELOPED SCENARIOS FOR AZERBAIJAN, THROUGH THE MULTI - CRITERIA METHOD AMS

General comments

The three scenarios have been assessed trough the multi criteria method AMS. This method is combines three multi-criteria methods: Analytical Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT) and Simple Multi-Attribute Ranking Technique (SMART) (Konidari and Mavrakis, 2007; 2006). AMS is developed for evaluating climate policy instruments (PI) or relevant Policy Mixes (PM) and with suitable modification for evaluating their interactions as well.

Scenario	Total GHG emissions (in $MtCO_{2eq}$)		
	2000	**2020**	**2050**
BAU	-	29,802	65,546
OPT	-	23,712	55,596
PES	-	25,834	59,220

Mean CEI for each sector depending on the policy instruments of the BAU scenario

Scen.	Sector	Technological options	Policy instrument	CEI	Mean CEI
Mitigation					
BAU	Buildings	-	-	-	
	Industry	-	-	-	
	Transport	Energy efficiency	Regulatory standards (emission limits of cars (Decree No. 45/2010))	-1,75	(-1,75-0,25)/2 = -2/2 = -1
			Economic instruments (tax exemptions)	-0,25	
	Energy	Promotion of RES technologies	Subsidy (Feed-in-tariffs) (Presidential Decree No. 341/2005. Resolution of the cabinet of Ministers No. 247/2005)	-0,25	(-0,25-0,25)/2 = - 0,25
		Energy efficiency	Tradable permits (Presidential Decree No. 727/2005)	-0,25	
Adaptation					
	Water management		Economic instruments (water fees)	-0,25	-0,25

Results

The overall final score for each policy portfolio is presented in figure 30. The results for each scenario are presented in Table 13.

AMS results for each scenario.

Criteria	Scenarios		
	BAU	OPT	PES
Direct contribution to GHG emission reductions (0,833)	0,000	83,300	54,275
Indirect environmental effects (0,167)	0,000	16,700	8,654
Environmental performance (0,675) - A	**0,000**	**100.00**	**62.929**
Cost efficiency (0,390)	0,000	47,300	15,912
Dynamic cost efficiency (0,227)	3,550	8,981	5,669
Competitiveness (0,103)	2,371	3,757	2,371
Equity (0,188)	0,000	17,500	11,398
Flexibility (0,056)	0,982	2,464	1,555
Stringency for non-compliance (0,036)	1,133	1,133	1,133
Political acceptability (0,259) - B	**8,036**	**81,135**	**38,039**
Implementation network capacity (0,228)	13,534	8,683	8,683
Administrative feasibility (0,685)	19,367	19,367	19,367
Financial feasibility (0,088)	3,091	4,818	3,091
Feasibility of implementation (0,065) - C	**35,991**	**32,868**	**31,141**
Total (A+B+C)	**9,314**	**79,767**	**41,572**

In Azerbaijan is used still the old system of USSR on inventory of emissions of polluting substances in atmosphere is used. (A management under the control of pollution of atmosphere, Reference: GIDROMETISDAT, 1979).

•For preparation of national inventories and national data on emissions creation in the countries of the special groups, prosecuting these subjects on the basis of official bodies is expedient:
•To carry out actions for training of experts for improvement of the account of emissions;
•There will be useful an establishment of constant contacts of national groups on emissions with similar groups of other countries, participation in seminars, courses on training and an exchange of experience;
•The reporting on emissions of the enterprises to make opened;
To make accessible data of gaugings of concentration of components in emissions at the enterprises that will help accumulation of the information for working out of issue factors

Several documents are already in the preparation process and include the following:

-Timely action to improve weather forecasts, food security, freshwater resources, a rapid response to an emergency or disaster, early warning systems and insurance coverage can reduce damage from future climate change and bring many immediate practical benefits.

-The ability of Azerbaijan to adaptation (and most CIS countries), it is particularly important because the economy is heavily dependent on climate-sensitive sectors such as agriculture. They are also less able to adapt in comparison with more industrialized countries.

- Avoid economic losses. Without adaptive temperature increase of 2,5 º C may reduce the gross domestic product at 0.5-2%, with losses in most developing countries will be high

- Methods of adaptation are vital. Adaptation at the national level include the development of effective implementation of adaptation strategies

Thank You for Your attention!

Bulgaria

Promitheas-4: Knowledge transfer and research needs for preparing mitigation / adaptation policy portfolios

CLIMATE CHANGE POLICY SCENARIOS - BULGARIA

L. Radulov, A. Nikolaev
Black Sea Regional Energy Centre

22.10.2013 г. ATHENS

BULGARIAN CLIMATE CHANGE MITIGATION POLICY (1)

- Bulgaria is committed to EU 20-20-20 targets:
  - 20% reduction of primary energy consumption
  - 20% share of renewable energies
  - 20% reduction of GHG emissions
- Bulgarian Energy Strategy:
  - 16% share of RES by 2020 (based on 9,6% share in 2005), of which 10% RES in the transport sector
  - 50% reduction of GDP energy intensity in 2020 compared to 2005
  - increase of the energy efficiency by 25% by 2020

22.10.2013 г. ATHENS 2

BULGARIAN CLIMATE CHANGE MITIGATION POLICY (2)

- National Energy Efficiency Action Plan of Bulgaria:
  - 9% reduction of the energy consumption for the period 2008 – 2016
  - includes numerous measures (by sectors) to reach this target
  - estimates the energy saving effect and costs of the existing and planned measures by 2020
- National Renewable Energy Action Plan:
  - National 2020 target and estimated trajectory of renewable energy in heating and cooling, electricity, and transport
  - Includes numerous measures promoting renewable energy development by 2020

22.10.2013 г. ATHENS 3

BULGARIAN CLIMATE CHANGE MITIGATION POLICY (3)

- Third National Action Plan for Climate Change 2013-2020:
  - 21% reduction of GHG emissions in 2020 compared to 2005 for the sectors covered by the Emission Trading Scheme (ETS)
  - 20% increase of GHG emissions in 2020 compared to 2005 for sectors outside ETS
  - Specifies GHG emission reduction measures and estimates their effects in terms of GHG reduction and cost

22.10.2013 г. ATHENS 4

BULGARIAN ADAPTATION POLICY

- There are only few studies assessing the climate change impact on forestry and agriculture
- Adaptation needs are stated only generally in the 5th National Communication and 3rd National Action Plan for Climate Change
- There are neither a national adaptation strategy nor any planned adaptation measures

22.10.2013 г. ATHENS 5

THREE M/A POLICY SCENARIOS

- Business as usual (BAU)
- Optimistic (OPT) – ambitious M/A policies
- Pessimistic (PES) –M/A policies with average ambitions

22.10.2013 г. ATHENS 6

BUSINESS-AS-USUAL SCENARIO
Assumptions

- The energy intensity of all economic sectors remains unchanged
- In households, the energy consumption is proportionate to both the number of households and the average household income
- In the energy production, only the planned (as of 31.12.2010) changes are considered – increase of renewable energy capacities, shut down of existing plants, etc
- High adaptation needs, but minimum adaptation measures

22.10.2013 г. ATHENS 7

OPTIMISTIC SCENARIO
Assumptions

- Energy end-use efficiency: until 2020 the measures specified in the 2nd NEEAP (2011); in 2021–2050 additional ambitious EE measures
- Gradual improvement of the efficiency of all power plants, except for NPP and HPP, and lower transmission and distribution losses
- Change of the energy demand structure: e.g. gradual shift of the transport sector to electricity, reaching 65% electricity in 2050
- Change in the energy production sources' structure: e.g. quick expansion of renewable energy, slow expansion of the natural gas share, substantial decrease of coal share
- Low adaptation needs, but these needs are seriously addressed

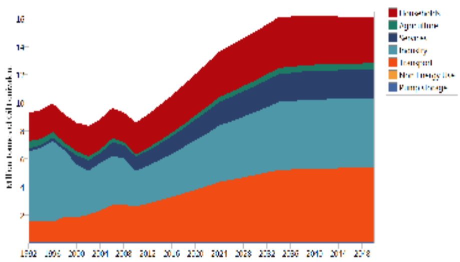
22.10.2013 г. ATHENS 8

PESSIMISTIC SCENARIO
Assumptions

- Additional M/A measures compared to the Business-As-Usual scenario, but less than the Optimistic scenario
- The additional measures are limited to the most cost-effective ones

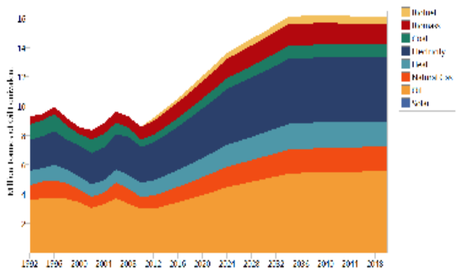
22.10.2013 г. ATHENS 9

BS: ENERGY CONSUMPTION BY SECTORS



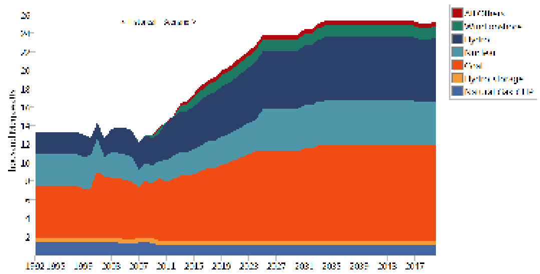
22.10.2013 г. ATHENS 10

BS: final energy consumption by fuel



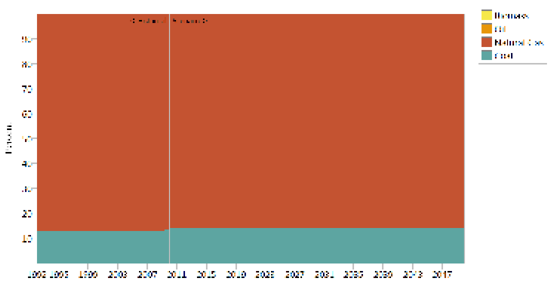
22.10.2013 г. ATHENS 11

BS: Electricity capacities



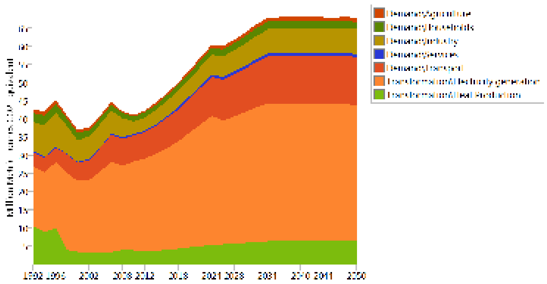
22.10.2013 г. ATHENS 12

BS: DISTRICT HEATING BY FUEL



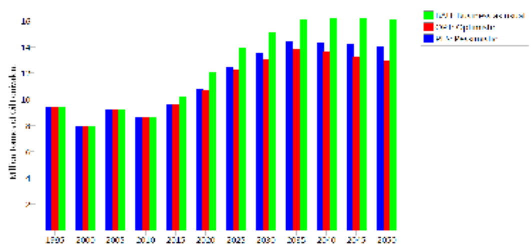
22.10.2013 г. ATHENS 13

BS – GHG emissions (CO2 eq.)



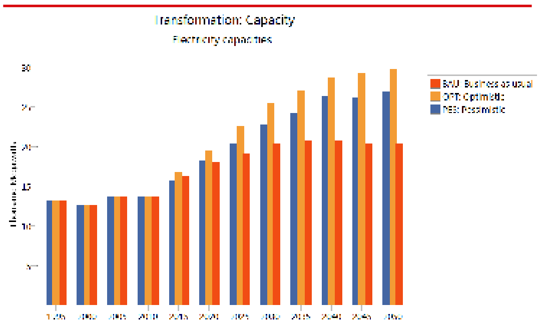
27.10.2013 г. ATHENS 14

Energy consumption in the 3 scenarios



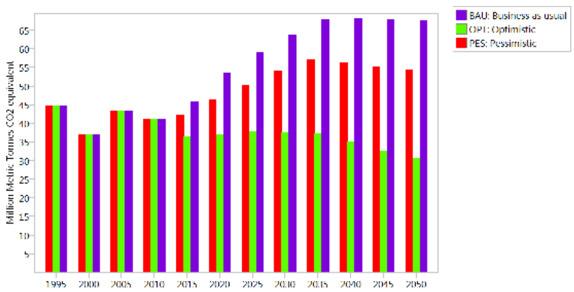
27.10.2013 г. ATHENS 15

Electricity capacities in the 3 scenarios



27.10.2013 г. ATHENS 16

GHG emissions in the 3 scenarios



27.10.2013 г. ATHENS 17

Scenario evaluation

Criteria	Highest score	Lowest score
GHG emission reduction	OPT	BAU
Indirect environmental effects	OPT	BAU
Cost effectiveness	OPT	BAU
Dynamic cost efficiency	OPT	BAU
Competitiveness	OPT	BAU
Equity	OPT	BAU
Flexibility	BAU	OPT, PES
Stringency for non compliance	all equal	
Implementation network capacity	BAU	OPT, PES
Administrative feasibility	BAU	OPT
Financial feasibility	BAU	OPT

27.10.2013 г. ATHENS 18

AGGREGATE SCORE OF SCENARIOS

BAU	OPT	PES
11,9	78,2	41,5

- OPT has the highest score
- BAU has the lowest score

27.10.2013 r. ATHENS 19

Promitheas-4: Knowledge transfer and research needs for preparing mitigation / adaptation policy portfolios

THANK YOU FOR YOUR ATTENTION !

L. Radulov, A. Nikolaev
Black Sea Regional Energy Centre

27.10.2013 r. ATHENS 20

Estonia

PROMITHEAS – 4

Development and Assessment of Mitigation / Adaptation Climate Change policy portfolios for Estonia

Assoc.Prof. Alvina Reihan
Tallinn University of Technology
Department of Environmental Engineering

Dr. Nadežda Dementjeva
Eesti Energia AS
Energy Trading Department

6th International Scientific Conference
Energy and Climate Change
9 – 11 October 2013
Athens, Greece

PROMITHEAS - 4

Outline

- Introduction
- Climate change policy mixtures
  - Data collection
  - BAU, OPT,PES scenarios developing
  - Results
- Needs and gaps
- Future opportunities

6th International Scientific Conference Energy and Climate Change
9 – 11 October 2013 Athens, Greece

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Area = 45 226 km^2
Population –
1 287 000 inhab.
Capital - Tallinn
(population 360 000)

6th International Scientific Conference Energy and Climate Change
9 – 11 October 2013 Athens, Greece

PROMITHEAS - 4

Tallinn University of Technology

- The provision of education -1918
- University since 1936
- Second largest (public) university
- Diploma, bachelor, master and doctorate programs
- Budget 2012 – 36,3 mlj eur.(9,7mlj–state)
- From 2013 ~ higher education in Estonia for free
- ~14,000 students, ~ 2,400 (1300 R&D)staff
- Total area – 150 000 m^2 - 72 buildings
- TUT key areas for R/D up to 2015 include:
  - Changing climate and environment and sustainable technologies

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9 – 11 October 2013 Athens, Greece

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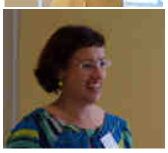
Our PROMITHEAS-4 team

Me – Alvina Reihan, PhD - TUT, Partner 16 – management, reporting

Tanel Laasma, MSc – Environmental Research Center – database, modelling



Nadezda Dementjeva, PhD – Eesti Energia – modelling, AMS

PROMITHEAS - 4

Workshop in Tallinn, 8 May 2013

Development and assessment of Mitigation / Adaptation Climate Change policy portfolios for Estonia

To identify all posible needs and gaps related to
- Established national procedures (for GHG inventory), sources, reporting forms, available data and information
- Database for the LEAP (Created in EXEL-form)
- Policy mitigation/adaptation instruments

A pathway to M/A policy portfolios
Scenarios and policy portfolios, up to 2050
A tool for policy makers

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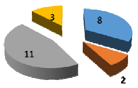
PROMITHEAS - 4

Workshop in Tallinn, 8 May 2013

Gender	Participants	%
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

The gender dispersion – slightly larger proportion of women (58%) than men (42%)



Introduction of CELA Network of CC Technology Transfer Centres in Europe and Latin America

PROMITHEAS - 4

Comments received

- Estonian Renewable Energy Association
  - Assumptions of energy consumption;
  - EUA and ERU prices;
  - Transnational network connections and its impact on the local energy market;
  - District heating and local heating ratio;
  - Newest regulations, reports and directives (after late 2011)

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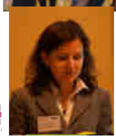
Workshop in Tallinn, 8 May 2013

6th International Scientific Conference E n e r g y and C l i



Waste to Energy!!!

PROMITHEAS - 4

Objectives

The national objectives:

- 8% GHG emissions reduction by 2012 compared to year 1990;
- 25% share of RES in the gross final energy consumption by 2020;
- 9% reduction of final energy consumption by 2016 in comparison to the period 2001–2005.

The additional objectives:

- "Estonian Electricity Sector Development Plan until 2018"
- "Estonian Environmental Strategy 2030"
- "Estonia's National Renewable Energy Action Plan 2020"

Mitigation options	Adaptation needs
Exploitation of RES	Energy sector
Energy efficiency	Agricultural sector
Mitigation through JI and GIS	Forestry sector
	Water resources

PROMITHEAS - 4

Data collection

- Sources:
  - Statistics Estonia;
  - Eurostat;
  - Estonian Environmental Information Centre;
  - Elering (Estonian Transmission System Operator);
  - National Inventory Report (NIR) on Greenhouse Gas Emissions in Estonia (1990-2010).
- Problems:
  - the lack of reliable data: GDP distribution per sector, energy efficiency in sectors, initial data in tourism and health service, transport sector, etc.
  - significant gaps and uncertainties in the available data;
  - the component of adaptation in climate change policy is not fully developed, it requires data related to the frequency of extreme events, water resources and use, low-income groups, biodiversity, etc.
  - Estonian unique situation using oil shale as a feedstock for shale oil production

PROMITHEAS - 4

Business-As-Usual Scenario

- Mitigation and adaptation policy instruments were implemented before 31.12.2010;
- The Estonian BAU scenario is mainly a mitigation policy portfolio:
  - penetration of RES in the gross final energy consumption,
  - support to increase energy efficiency;
  - GHG emission reductions through JI and EU-ETS;
  - selling of AAUs though the GIS;
  - adaptation policy oriented towards water and forest management

PROMITHEAS - 4

BAU - Key Assumptions

- Demographics: “medium variant” of the population projections are used for all 3 scenarios (BAU, OPT, PES);
- Economy: GDP growth rate is assumed to be 4% by 2050 based on IMF projections for all 3 scenarios;
- Climate statistics:
  - precipitation will increase between 1 and 2% per decade;
  - average air temperature will be 8,35 ℃ by 2050;
  - surface water will increase as 7% by 2020 and 15,5% by 2050;
  - the increase of ground water is 10% average for the region by 2050.
- T&D losses is assumed to decrease by 0,3% annually;
- 1000 MW of wind farms would be in operation by 2050;
- Feed-in-tariffs follow their historical trends;
- Environmental charge rates are in place until 2015;
- Projections for the global trends prices are provided by KEPA.

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9 – 11 October 2013 Athens, Greece

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Optimistic Scenario

- Mitigation/adaptation policy instruments Estonia has set into force after 01.01.2011;
- Maximum exploitation of the potential of the country in energy efficiency and renewable energy sources;
- Wider range of policy instruments:
  - performance standards;
  - financial policy instruments (subsidies and grants);
  - dissemination policy instruments.
- Adaptation policy instruments are foreseen for the agricultural sector

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PROMITHEAS - 4

OPT - Key Assumptions

- OPT policy portfolio sets stringent mitigation targets in all sectors;
- Climate statistics:
  - precipitation is increased by an annual growth rate of 7,5%;
  - average air temperature is assumed to be 7,4 ℃ by 2050;
  - increase in the frequency of the heat waves follows the increase of the temperature in the same scenario;
  - increasing of surface water is assumed to be the maximum 5% by 2020 and 9% by 2050, groundwater is estimated at 5% by 2050;
- T&D losses is assumed to decrease by 0,6% annually;
- New oil shale based units would be built with capacity 300MW;
- The extension of RES in heat generation in boiler stations;
- Nuclear power plant with capacity 600MW by 2023;
- 2000 MW of wind farms would be in operation by 2050;
- Cutting of feed-in-tariffs almost by 30%;
- Increase in the environmental charges;
- The additional policies concerning the transport and agriculture sectors.

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PROMITHEAS - 4

Pessimistic Scenario

- Mitigation/adaptation policy instruments Estonia has set into force after 01.01.2011;
- No other additional policy instruments apart from those already decided to be implemented and in line with the EU climate change policy;
- Minimum exploitation of the potential of Estonia in energy efficiency and RES.

PES - Key Assumption

- Climate statistics:
  - precipitation is increased by an annual growth rate of 24%;
  - average air temperature is assumed to be 9,9 ℃ by 2050;
  - increase in the frequency of the heat waves follows the increase of the temperature in the same scenario;
  - increasing of surface water is assumed to be the maximum 15% by 2020 and 22% by 2050, groundwater is estimated at 15% by 2050;
- T&D losses is assumed to decrease by 0,15% annually
- No other new power units or plants would be built and only planned capacities would operate;
- Cutting of feed-in-tariffs almost by 50%;
- Increase in the environmental charges;
- Biofuels will not reach the 5,75% in agricultural sector.

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PROMITHEAS - 4

Results of LEAP – Global Warming

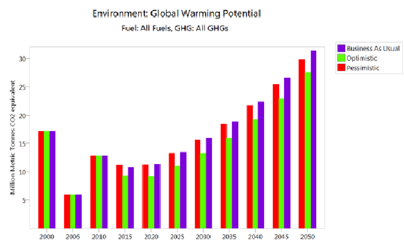

Figure 1: GHG emissions

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PROMITHEAS - 4

Results of AMS - Assessment of scenarios

Criteria	Scenarios		
	BAU	OPT	PES
Direct contribution to GHG emission reductions (0,833)	0,000	53,300	3,324
Indirect environmental effects (0,167)	0,000	16,700	10,020
Environmental performance (0,475) - A	0,000	100,00	13,344
Cost efficiency (0,390)	0,000	47,300	35,063
Dynamic cost efficiency ([illegible])	11,688	4,616	[illegible]
Competitiveness (0,103)	2,175	5,459	0,866
Equity (0,188)	0,000	[illegible]	[illegible]
Flexibility (0,050)	1,764	2,795	0,440
Stringency for non compliance (0,016)	[illegible]	[illegible]	[illegible]
Political acceptability (0,253) - B	16,761	78,844	40,061
Implementation network capacity ([illegible])	10,300	10,300	[illegible]
Administrative feasibility (0,055)	[illegible]	[illegible]	19,367
Financial feasibility ([illegible])	3,667	3,667	[illegible]
Feasibility of implementation (0,063) - C	33,333	33,333	33,333
Total (A+B+C)	15,503	78,120	34,040

Table 1: AMS results for each scenario

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Modelling Results

- BAU scenario:
  - GHG emissions will be reduced by 35% in 2020 compared to year 2000;
  - RES share will be 0% in the transport sector and 20,6% in EG in 2020 .
- OPT scenario:
  - GHG emissions will be reduced by 46% in 2020 compared to year 2000;
  - RES share will be 11,25% in the transport sector and 32% in EG in 2020.
  - The final energy consumption will be reduced by 9% in 2020 compared to BAU.
- PES scenario:
  - GHG emissions will be reduced by 34% in 2020 compared to 2000;
  - RES share will be 5,6% in the transport sector and 25,5% in EG in 2020;
  - The final energy consumption will be reduced by 4% in 2020 compared to BAU.
- AMS assessment:
  - the mitigation/adaptation policy portfolio in the Optimistic scenario is the best one in terms of overall performance;
  - but requires the encouragement of business investments in RES and energy efficiency projects, the continuation of the demonstrated effectiveness of the implementation network and more stringent frame for non-compliance.

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Needs and gaps

- General needs:
  - improvement of data integration and sharing;
  - to provide more adequate information for generating research in climate policy;
  - to realize and estimate climate change potential and risks etc.
- Research needs:
  - Scenarios and policy portfolios up to 2050;
  - Future climate change estimation;
  - Direct and indirect impacts on to Estonian sectors of activities;
  - Measures to reduce the impact of climate change;
  - The cooperation way between countries for reducing impact of climate change.
- Gaps:
  - lack of knowledge on methods and approaches how to analyze adaptation options and chose possible actions and adaptation measures;
  - lack of transfer of innovative technologies ;
  - lack of human resources;
  - lack of financial support for climate change research.

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Possible future cooperation and training

Needs to:

❖future research of existing policies and measures on greenhouse gases (GHG) emissions;

❖future research related to the potential of economic sectors to reduce GHG emissions and reduction measures, and the projected impact by the year 2020, with a view to 2030, 2040 and the 2050th.

❖organize special educational programs on climate change in the Estonian universities and/or cooperation with other universities;

❖organize/improve cooperation with/between Statistics Office of Estonia, Governmental/nongovernmental agencies, Estonian Renewable Energy Association etc in term of sharing not only data and technical information but also in the exchange of the best knowledge and experience in this area.

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Thank you very much for your attention!

www.ttu.ee

Dr. Alvina Reihan
Tel.: +372 620 2506
E-mail: alvina.reihan@ttu.ee

Dr. Nadežda Dementjeva
Tel.: +372 539 67 467
E-mail: nadezda.dementjeva@energia.ee

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Kazakhstan

6th International Scientific Conference on Energy and Climate Change

PROMITHEAS – 4

Kazakhstan Climate Change policy mixtures of PROMITHEAS-4 project: key issues of national report

Prof. Sergey INYUTIN,
Head of the PROMITHEAS-4 Project in Kazakhstan

Athens 9-11 October 2013

PROMITHEAS - 4

Content

1. Introduction
2. Climate Change policy mixtures in Kazakhstan
   - Developing three scenario(BAU,OPT and PES) with LEAP
   - Results, assessment of the policy mixtures
   - Best policy mixture
3. Future opportunities

- 2 -

PROMITHEAS - 4

SRC KAZHIMIMVEST, Team members

- JSC Scientific Production Firm (1992). The Department of scientific research and innovative clean environment technologies (DSRICET) deals with scientific research and consultancy in optimization of technological processes taking into account innovations, environment saving, technologies in various areas of Energy Conservation and Climate Change.
- The institution leads the collaboration of partners such as Scientific-Research Institute of Economy, Information, Transport, Telecommunications (EITT), Turan-Astana University, Aulie-Ata State University of Taraz City, Kaz Scientific Reseach Institute for Ecology and Climate (KAZNIIEK) and established the Climate Change Working Group (CCWG) to contribute in the development of reliable policy portfolios for effective adaptation/mitigation actions in support of the implementation of Climate Change Policy on national and regional levels
- The members of CCWG has broad experience in providing analytical works, international coordination, project activities, education ,knowledge dissemination, Legislative activities, sc
- scientific research, logistics, work in close cooperation with key ministries on related issues.
- **Key Team members:**
- **Dr. Y.Kalashnikov** -President of SRC KAHIMINVEST
- **Prof. S. Inyutin-** Head of the Project in Kazakhstan ,Member of SC PROMITHEAS-4,Head of CCWG
- **Dr.I. Yesserkepova-** member of CCWG, Deputy Director of "KAZNIIEK"under MEP
- **Dr.L. Inyutina**-member of CCWG, Head o the Department DSRICET, KAZHIMINVEST

Other Young scientists: Salyutina, Sultankulova, etc.

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PROMITHEAS - 4

National Workshop "Development of Mitigation/Adaptation Climate Change Policy Portfolios for Kazakhstan" 14 June 2013, Astana

- 4 -

PROMITHEAS - 4

National Workshop "Development of Mitigation/Adaptation Climate Change Policy Portfolios for Kazakhstan"

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PROMITHEAS - 4

Kazakhstan nominators in PROMITHEAS-4

- The Seminar on "Developing National Climate Change policy mixtures – Case Study" is the second part of the Training process of PROMITHEAS – 4.(December 2012)
- Kaz participant: Sultankulova Aygoz, MS, Turan-Astana University Teacher
- The Training session on LEAP organized by IHS was successfully completed in Vienna. Instructor was Dr. Charlie HEAPS and representatives from all the 12 beneficiary countries, as well as from Greece and Austria participated.(Viena, September 2011)
- Kaz participant: Salyutina Yekaterina, MS, Turan-Astana University

- Inna Kim ("Institute Energya"), MS, engineer, has received Certificate on Training Course (E-learning) in 2012

PROMITHEAS - 4

National Workshop "Development of Mitigation/Adaptation Climate Change Policy Portfolios for Kazakhstan"

- Session on National report **"Development and assessment of Mitigation/Adaptation climate change policy portfolios for Republic of Kazakhstan"**
- PROMITHEAS-4 project in Kazakhstan: goal, tasks, implementation"
- *Ass.Prof.,S. Inyutin, Scientific Head of the Project, Turan-Astana University* A pathway to Mitigation/Adaptation policy portfolios
- PROMITHEAS – 4 A pathway to M/A policy portfolios
- *Ms. Eleni-Danai Mavraki, MSc. Project Manager, KEPA, Hellas*
- Spectrum of CC policy measures and instruments, model and key assumptions
- *L. Inyutina Head of experts group, MSc.,KAZHIMINVEST*
- Interpretation of three scenarios developed with LEAP
- *A. Sultankulova, MSc., teacher of Turan-Astana University*
- Conclusions, observed needs and gaps
- *L. Inyutina, KAZHIMINVEST, I.Yesserkepova, Deputy Head of KAZNIIEK, MEP*
- PROMITHEAS – 4 as a tool for policy makers
- *Eleni-Danai Mavraki, MSc. Project Manager, KEPA, Hellas*
- Round table discussions

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PROMITHEAS - 4

Kazakhstan Climate Change Policy

Kazakhstan's CC Policy is based on the Strategic Development Plan of the Republic of Kazakhstan 2020;The Intersectoral Program "Zhasyl Damu 2010-2014"; The MEP Concept" Green Economy"

Voluntary CC obligations to reduce GHG emissions 15% by 2015 and 25% by 2050

RES support law(2009)

National ETS in place since 2013 (Ecological Code 2011)

Reducing excessive dependency on primary industries and commodity exports, mainly oil & gas

National oil resrve of 39.8 billion barrels (2010), the country's major revenue generator, is estimated to last for only 63 years.

Addressing lack of capacity and institutional structure, especially in the water and energy sectors

Has significant gaps in energy and infrastructure sector, esp. on appropriate policies, markets and institutional frameworks to allow efficient development of those sectors.

Protecting its fragile ecology (semi-desert geography) from the adverse impacts of climate change

Kazakhstan has been identified as one of the countries with high vulnerability and low adaptation potential for climate change effects.

BASIC FACTS

Official name	Republic of Kazakhstan
Capital	Astana
Official language	Kazakh and Russian
Type of government	dominant-party, unitary presidential state
Leadership (Pres.)	Nursultan Nazarbayev
GDP (2011)	\$186 billion (total) \$11,167 (per capita)
Population	16,911,900 (Jan. 1, 2013 est.)
Major Industries	crude oil, base metals, chemicals, food , agriculture

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Kazakhstan CC Policy: Status in KP-CP2

Country	Base year emissions (1990 for most countries) (MtCO2eq.)	[illegible]	[illegible]	[illegible]
Australia	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Liechtenstein	0.2	-16%	-16%	-22%
Monaco	0.1	[illegible]	[illegible]	[illegible]
Norway	[illegible]	[illegible]	[illegible]	[illegible]
Switzerland	[illegible]	-15.0%	-15.0%	[illegible]
Ukraine	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL excl EIT[5]	[illegible]	[illegible]	[illegible]	[illegible]

Source : CDC Climate Research

Kazakhstan emitted 290 Mt CO2 eq. in 2009 (6% of the EU total output; 23% below 1990 country level)

KP was ratified in 2009; Law on Amendments (2010) enhanced the country's ability to participate in carbon markets (facilitates JI by excluding from environmental licensing procedures; GHG emissions inventory on annual basis.

Notes: Carrying-over calculation is based on 2008-2010 emissions.

[1]A positive percentage indicates that the average annual emissions for the 2008-2010 period (including credits and debits under LULUCF) are above the permitted emissions under the KP-CP2. The year 2010 is the latest year for which data have been validated in the framework of the UNFCCC.

[2]Amendments including Belarus and Kazakhstan for the KP-CP1 have not been ratified so far.

[3] Croatia and Iceland will fulfill their commitments jointly with the EU in accordance with Article 4 of the Kyoto Protocol.

[4]The EU-27 countries have differentiated commitments under the KP-CP1. The provided data therefore aggregates those of the concerned countries. According to the European Climate and Energy Package, countries are not allowed to use their surplus of AAUs for 2013-2020.

[5]EIT: Economies in transition. Here, only non-European countries are included: Belarus, Kazakhstan and Ukraine

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PROMITHEAS - 4

Data collection

- ***Economic data:*** national statistics, forecast MEDT RK, protocol No.29 dated 28.08.2012, http://www.minplan.gov.kz/economya; GDP growth: according to the IMF, 2011, World Economic Outlook, http://www.imf.org/external/pubs/ft/weo/2011/01/pdf/text.pdf ; growth of the population of Kazakhstan, according to the "2010 World Population Prospects" of the United Nations (http://esa.un.org/wpp/unpp/p2k0data.asp)
- ***Energy data:*** UN statistics (energy balances and energy profiles of countries, adapted from the national statistics, including by sector. http:// un.org / UNSD / energy / balance / ebep_pdf.htm, http://unstats.un.org/unsd/pubs
- **National LEAP Model Construction:** given the general approaches and requirements for all countries and national characteristics
- **National characteristics, taken for consideration for the model:** climate (temperature, precipitation, etc.), water resources, land / forests, the potential renewable energy sources; energy efficiency, global trends (fuel prices), national (the price of electricity, heat), measures national policies (subsidies, the price of carbon, etc.), types and costs of technology

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Developing of BAU scenario

- **Climate** is continental; in the North, winter-summer from -18 °C to -19 °C
  in the South, winter-summer -3 °C to 29 °C (Source: SNC 2,2009)
- **Precipitation** 2000-2010: from 200 mm(2000) to 369mm (2003,2004) and 120 mm(2010), (Source: MEP Newsletter / Kazgidromet, 2011)
- **Floods** - according to the Ministry of Emergency operational data (2010), an increase to 2050 of up to 3 per year
- **Hot days**: from 21(2000) to 15(2010) (source: MEP operational data), the trend continues
- Frost- varies greatly depending on the location of construction, in particular in Astana the five-day temperature is -35 °C, and the average annual temperature is 1.8 °C (source : local regulation) Warming is assumed and decrease the number of frost days per year.
- **Policy and measures**: Fix-in-Tariff, ETS are expected to come in 2013, the subsidies-according to legislation (source: governmetal operational data) .
- **Desertification**: according to Program "Zhasyl Damu" , land degradation by 2014 is expected to 0.05 ha; afforestation to increase to 65 hectares (an increase of at least 1% per year), source: MEP Program "Zhasyl Damu"
- **Fuel prices** (coal, gas oil) and **carbon prices-** according to the IEA Outlook 2010
- **Water use** : in general, the trend will continue, for irrigation of 10 years was reduced by 17% (MEP operational data)
- Policy portfolio does not include measures for adaptation

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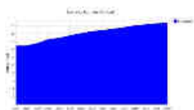
PROMITHEAS - 4

KAZAKHSTAN: BAU (2000 – 2050)
POPULATION, GDP REAL, INCOME- GROWTH



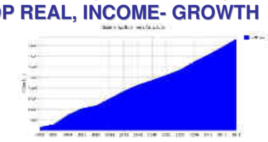
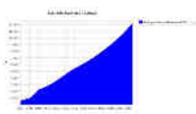


Table 1: United Nations projections for Kazakhstan population (UN, 2010) http://esa.un.org/wpp/unpp/p2k0data.asp

Variant	Average annual rate of change (%)							
	2005-2010	2010-2015	2015-2020	2020-2025	2030-2035	2040-2045	2045-2050	2050-2055
Medium	1.10	1.05	0.92	0.73	0.58	0.61	0.61	0.41

Table 2: Projection for the Kazakhstan GDP (IFM, 2011)

Year	**2011**	**2012**	**2013**	**2014**
Annual percent change of GDP (%)	5.9	5.6	6.5	6.4



GDP growth rate until 2050 remains at this level, the structure by sector varies according MEBP assumptions, in particular the growth of the manufacturing sector will reach 13% of GDP by 2017, the growth of the mining industry will grow from 19% (2012-2014) to 48% after 2017.

The growth of income received similar GDP growth / capita

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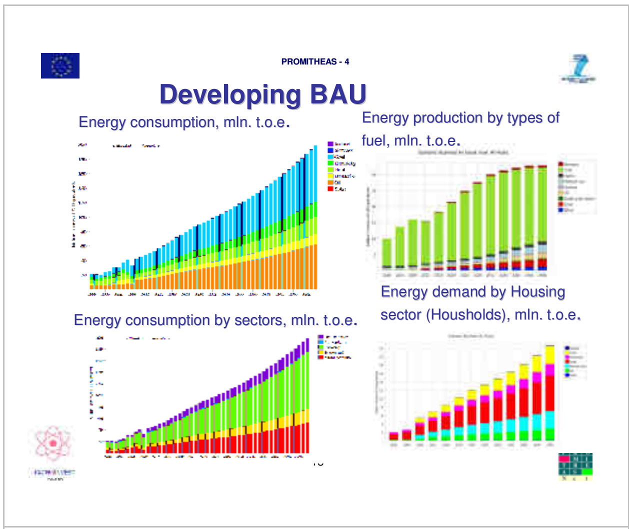
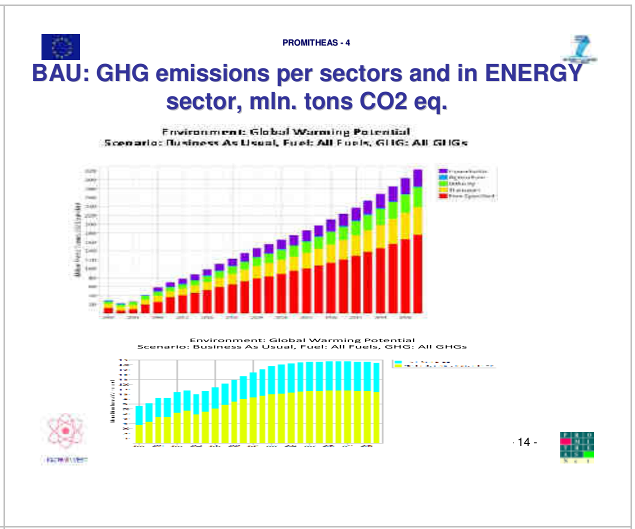

PROMITHEAS - 4
Developing BAU
Energy consumption, mln. t.o.e.
Energy production by types of fuel, mln. t.o.e.
Energy demand by Housing sector (Housholds), mln. t.o.e.
Energy consumption by sectors, mln. t.o.e.


PROMITHEAS - 4
BAU: GHG emissions per sectors and in ENERGY sector, mln. tons CO2 eq.
Environment: Global Warming Potential
Scenario: Business As Usual, Fuel: All Fuels, GHG: All GHGs
Environment: Global Warming Potential
Scenario: Business As Usual, Fuel: All Fuels, GHG: All GHGs
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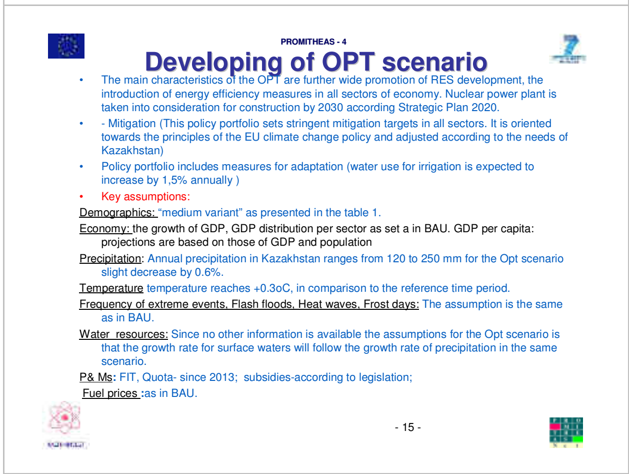
PROMITHEAS - 4
Developing of OPT scenario
The main characteristics of the OPT are further wide promotion of RES development, the introduction of energy efficiency measures in all sectors of economy. Nuclear power plant is taken into consideration for construction by 2030 according Strategic Plan 2020.
- Mitigation (This policy portfolio sets stringent mitigation targets in all sectors. It is oriented towards the principles of the EU climate change policy and adjusted according to the needs of Kazakhstan)
Policy portfolio includes measures for adaptation (water use for irrigation is expected to increase by 1,5% annually)
Key assumptions:
Demographics: "medium variant" as presented in the table 1.
Economy: the growth of GDP, GDP distribution per sector as set a in BAU. GDP per capita: projections are based on those of GDP and population
Precipitation: Annual precipitation in Kazakhstan ranges from 120 to 250 mm for the Opt scenario slight decrease by 0.6%.
Temperature temperature reaches +0.3oC, in comparison to the reference time period.
Frequency of extreme events, Flash floods, Heat waves, Frost days: The assumption is the same as in BAU.
Water resources: Since no other information is available the assumptions for the Opt scenario is that the growth rate for surface waters will follow the growth rate of precipitation in the same scenario.
P& Ms: FIT, Quota- since 2013; subsidies-according to legislation;
Fuel prices :as in BAU.
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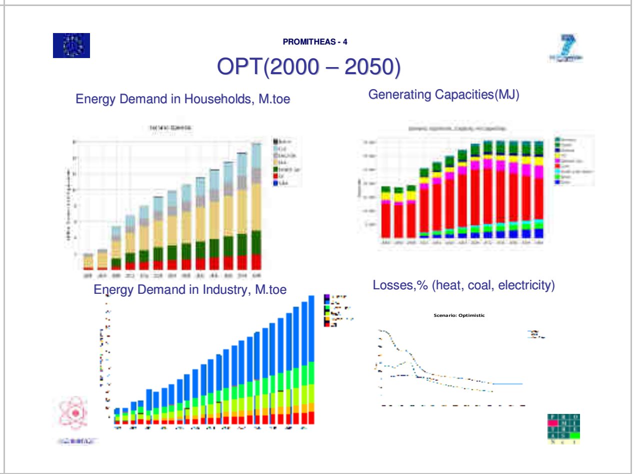
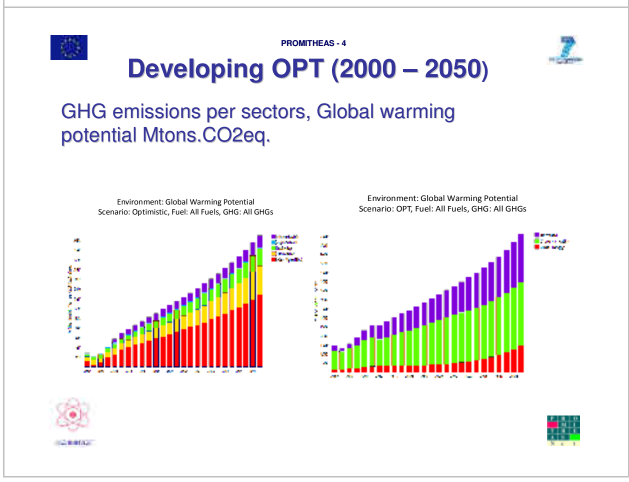
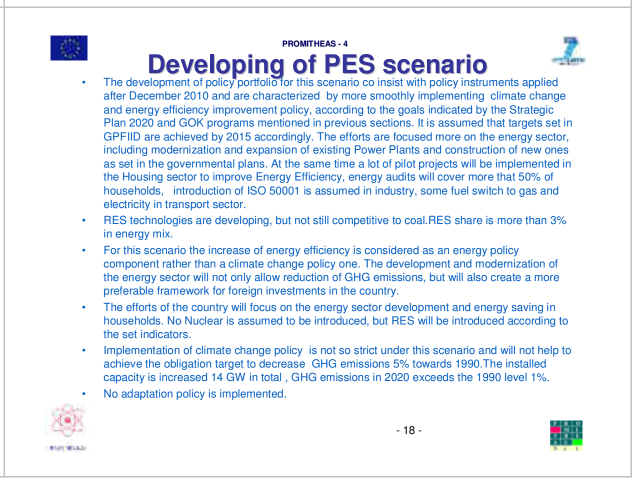

PROMITHEAS - 4
OPT(2000 – 2050)
Energy Demand in Households, M.toe
Generating Capacities(MJ)
Energy Demand in Industry, M.toe
Losses,% (heat, coal, electricity)
Scenario: Optimistic


PROMITHEAS - 4
Developing OPT (2000 – 2050)
GHG emissions per sectors, Global warming potential Mtons.CO2eq.
Environment: Global Warming Potential
Scenario: Optimistic, Fuel: All Fuels, GHG: All GHGs
Environment: Global Warming Potential
Scenario: OPT, Fuel: All Fuels, GHG: All GHGs


PROMITHEAS - 4
Developing of PES scenario
The development of policy portfolio for this scenario co insist with policy instruments applied after December 2010 and are characterized by more smoothly implementing climate change and energy efficiency improvement policy, according to the goals indicated by the Strategic Plan 2020 and GOK programs mentioned in previous sections. It is assumed that targets set in GPFIID are achieved by 2015 accordingly. The efforts are focused more on the energy sector, including modernization and expansion of existing Power Plants and construction of new ones as set in the governmental plans. At the same time a lot of pilot projects will be implemented in the Housing sector to improve Energy Efficiency, energy audits will cover more that 50% of households, introduction of ISO 50001 is assumed in industry, some fuel switch to gas and electricity in transport sector.
RES technologies are developing, but not still competitive to coal.RES share is more than 3% in energy mix.
For this scenario the increase of energy efficiency is considered as an energy policy component rather than a climate change policy one. The development and modernization of the energy sector will not only allow reduction of GHG emissions, but will also create a more preferable framework for foreign investments in the country.
The efforts of the country will focus on the energy sector development and energy saving in households. No Nuclear is assumed to be introduced, but RES will be introduced according to the set indicators.
Implementation of climate change policy is not so strict under this scenario and will not help to achieve the obligation target to decrease GHG emissions 5% towards 1990.The installed capacity is increased 14 GW in total , GHG emissions in 2020 exceeds the 1990 level 1%.
No adaptation policy is implemented.
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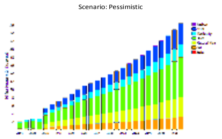
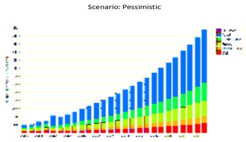
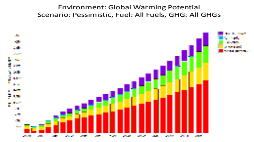
Developing of PES scenario

Final energy demand In households

Final energy demand in Industry







GHG emissions per sectors, Mton CO2 eq.

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PROMITHEAS - 4

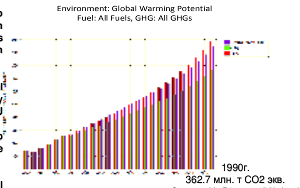
Results of 3 scenarios according to LEAP

RESULTS of LEA modeling:

for the BAU in 2020 GHG emissions amounted to 386,1 MtCO2eq., Total primary energy consumption by 75.56 Mtoe (2020), an increase of 2.2 times compared with a year 2009.Dolya renewable energy in the total energy mix to 2020 0.28%.

for OPT in 2020 share of RES - 10.1% in the total energy mix by 2020. Total primary energy consumption is reduced by 7, 5% compared with BAU in 2020 due to the measures implemented. GHG emissions with direct effect in 2020 amounted to 335,8 MtCO2eq, a decrease of 50,3 MtCO2eq relative to BAU (13%)

For PES in 2020 share of RES - 3.5% in the total energy mix in 2020, and 2.07 times increase in the total primary energy consumption in comparison with 2009 (74.34 million tons of oil equivalent by the result LEAP). GHG emissions in 2020 - 372,4 MtCO2eq (more OPT, less than BAU by 13.7 Mt CO2 eq)



1990г.
362.7 млн. т CO2 экв.
Source: table P3, page 15,National Report on GHG emissions inventory for 1990-2009 (NIR), available at : http://www.eco.gov.kz, eco.gov.kz/files/o_kadastre.doc

Scenario	Total GHG emissions (in MtCO2eq)		
	2000	2020	2050
BAU	143.7	386.1	945.6
Opt	143.7	335.8	763.4
Pes	143.7	372.4	988.8

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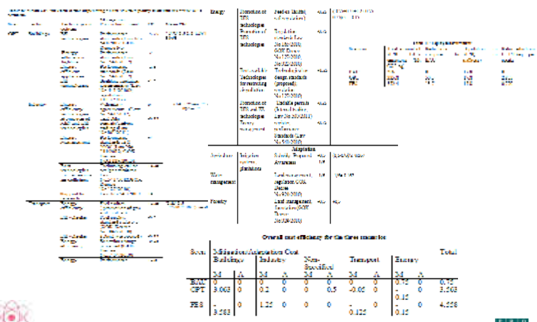
Assessment of the policy mixtures in OPT



Overall cost efficiency for the three scenarios

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: Score of best aggregate performance.

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Kazakhstan: Best policy mixture

Criteria	Env.Perf.	Polit./Accept.	Feas. Impl.	Row sum	Weight coefficient
Env.Perform.	0.154	0.149	0.200	0.503	0.168
Polit.Accept.	0.769	0.745	0.700	2.214	0.738
Feas/Implem.	0.077	0.106	0.100	0.283	0.094

Criteria	Scenarios BAU	Opt	Pes
[illegible]	[illegible]	[illegible]	[illegible]
Environmental performance - A	[illegible]	[illegible]	[illegible]
Dynamic cost efficiency	[illegible]	[illegible]	[illegible]
Flexibility	[illegible]	[illegible]	[illegible]
Political acceptability - B	[illegible]	[illegible]	[illegible]
Financial feasibility	[illegible]	[illegible]	[illegible]
Feasibility of implementation - C	[illegible]	[illegible]	[illegible]
Total (A+B+C)	[illegible]	[illegible]	[illegible]

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PROMITHEAS - 4

Future opportunities

1. Comments received (next slide)
2. Needs and gaps observed
3. Future cooperation with GOK for policy mix improvement
4. Possibilities for cooperation(ADB project on CC)
5. Need for further training on CC policy, assessment, business and investments

(transition to "Green economy" assessment is about 2% of GDP, during 2010-2049-av.0.7% of GDP)

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PROMITHEAS - 4

Goal on transmission to Green Economy is added to existing goals (MEP)

Additional goals

Sector	Goal description	2020	2030	2050
Water resources	* Decrease of water deficit on national level	By 2020 water supply providing of population	By 2020 provide water to agriculture	Solve water problems
	* Water resources deficit decrease in the basin	Max provide water to the basin(by 2025)	By 2030 absence of water deficit in the basin	
Agriculture	* Productivity	3-4 times increase		
	* Crops (ton./ha)	1,4	2,0	2,0
	* Irigation costs (m3/ton)	450	330	250
Energy Efficiency	* Energy intensity of GDP decrease towards 2010 level	25% (10% by 2015)	30%	50%
Power Sector	* Share of alternative resources for power production:	Солнечных и ветряных: не менее 3% к 2017 г.	~30%	50%
	* Alternative sources, * Gas power plants	20%[2]	25%[2]	30%
	* Gasification o regions	Akmola, Karaganda	Northen and East Oblasts	
	* GHG emissions decrease in Power sector towards recent level	2012 level	-15%	-40%
Air contamination	* Pollutants SOX, NOX into environment		EU level	
Wastes utilization	* Solid Wastes disposal		100%	100%
	* Landfields		~95%	100%
	* Share of utilized wastes		40%	50%

1 Solar, Wind, hydro, Nuclear
2 CHP fuel switch to gas
Source: MEP WG

PROMITHEAS - 4

THANK YOU FOR ATTENTION!

S.inyutin@mail.ru
KAZHIMINVEST

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Moldova

6th International Scientific Conference
Policy portfolios for emerging economies

EU FP-7 ROMITHEAS -4 Project
"Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios"

Development and Assessment of M/A Climate Change policy portfolios for R. of Moldova

Dr. Ion Comendant,
Institute of Power Engineering ASM

Content

Institute of Power Engineering

- **IPE ASM was founded in 1991**, public institution:
  - 28 scientific researchers: including 2 Full Member of the Academy of Sciences, 8 Doctors of sciences and 9 PhDs.
  - Laboratories&Departments: controlled power transmission lines; simulation and diagnostics of power equipment; Electric-power equipment and power electronics; Energy efficiency and RES
- **Research Domain**:
  - Energy system development planning and optimal operation
  - Elaboration of new methods, devices, tools and equipment for increasing energy efficiency and RES promotion
- **IPE Scientific Journal:** Regional Energy Problems
  - http://ieasm.webart.md/home_ro/

Moldova National Workshop

- On **May 14, 2013** in the framework of PROMITHEAS-4 Project the **National Workshop** „Development and evaluation of the M/A policy portfolios for the R. of Moldova" was organized by IPE in **Chisinau,** Hotel "Codru"
  - 48 participants, including: Gheorghe Salaru, Ministry of Environment; Victor TVIRCUN, Ambassador, BSEC-PERMIS General Secretary; Vladimir Berzan, IPE Director; Prof. Dimitris Mavrakis, Project Coordinator; Dr. Popi Konidari

The Workshop agreed on the following conclusions:

1. **The Workshop was very helpful for audience by new results obtained in the domain the project PROMITHEAS-4 was devoted.**
2. **As a result of trainings devoted to scenarios calculation using LEAP model, the last was tailored to correspond Moldova specific conditions, where 96% of energy sources are from import.**
3. **The list of research needs and gaps identified would help to ensure pragmatic platform for more accurate outcomes on GHG emissions calculation in the future.**
4. **The Workshop recognize that for the purpose of renewable electricity involvement into the climate change scenarios calculation the lack of effective balancing power on country territory should be taken into consideration, their share being put in compliance with this shortage.**

PROMITHEAS-4 Moldova Team

- **Total number of Moldova team in the PROMITHEAS-4 project – 6:**

- **Prof. Mihai Chiorsac**, Moldova team general coordinator, tel. 373 69095046, e-mail: kiorsak@mail.ru
- **Dr. Ion Comendant**, Scientific coordinator, management, Evaluation of policy portfolios, tel. 373 69217004, e-mail: icomendant@gmail.com
- **Dr. Vasile Scorpan**, Scenarios and policy portfolios, tel. 373 79469883, e-mail: v.scorpan@yahoo.com
- **Marius Taranu**, Evaluation of available data and information, tel. 373 69684528, e-mail: tsaranu@yahoo.com
- **Sergiu Robu**, Choice and implementation of models, tel. 373 79477978, e-mail: sergiu.robu@asm.md
- **Iulia Panfilchina**, Choice and implementation of models, tel. 373 68277550, e-mail: panfilchina@hotmail.com

Data collection

- National Bureau of Statistics, Statistical Yearbooks of the R. Moldova and Energy Balance for 1990 – 2011;
- National Bank of Moldova;
- State Hydrometeorological Service of Moldova;
- Government Decisions;
- Ministry of Environment and Natural Resources;
- National Agency for Energy Regulation;
- Climate Change Office;
- World Energy Outlook 2010, IEA;
- World Bank;
- UNDP;
- United Nations Economic Commission for Europe;
- UNEP/Ministry of Environment and Natural Resources;
- IPCC, Climate Change.

Moldova climate change policies applied

- No specific climate change policies documents are approved up to now. The existing normative acts are oriented to resolve country priorities, M/A impact is considered as tangible result.
- In 2013 both the Low Emission Development Strategy and Climate Change Adaptation Strategy are planned to be approved. They gather the actions from all existing first level legal documents that have M/A impact as well.
- The main climate mitigation impact is expected to have from the realization of Energy Strategy up to 2030 approved in 2012, that promote energy efficiency and RES, including to reach by 2020:
  - energy intensity reduction by **10%**;
  - grid electricity losses reduction up to **11%**, grid gas losses by **39%**, grid heat losses by **5%**;
  - energy consumption reduction in buildings by **20%**;
  - **10%** of public buildings renovated;
  - the share of annual electricity from renewable energy sources up to **10%**.
  - the use of energy from renewable sources relative to total gross domestic consumption: **20%** ;
  - the share of biofuels in total transport fuel consumption: **10%**.

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Scenarios developed

- **Three Scenarios**
  - Business as Usual (BAU);
  - Optimistic (OPT);
  - Pessimistic (PES).

Model is applied for calculation

- **Time horizon: 2000-2050**
- **OPT and PES scenarios are oriented to the following national objectives:**
  - **20%** share of RES in the total energy mix by 2020
  - **20%** reduction of the total primary energy consumption by 2020, compared to that of year 2009.
- **Only the territory of right bank of river Nistru is considered in calculation**

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Sectors Review

Key Assumptions	Resource	Transformation	Demand
- Population - GDP - GDP per capita - GDP real growth - GDP per Sector - Annual Household Income - Climate Statistic - World Prices for Resources	PRIMARY: - Coal - Gasoline, Dieel - Fuel Oil, LPG - Hydro SECONDARY: - Electricity - Heat - Natural Gas	- Electricity Generation - District Heating - Losses	- Agriculture - Household - Industry - Transport - Non Specified

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Key Assumptions for the BAU Scenario

- Population: -0.69% by 2050;
- GDP: +5.0% by 2030;
- GDP distribution for Industry Sector: 2.5% by 2050;
- GDP distribution for Agriculture Sector: 1.5% by 2050;
- Import electricity from Ukraine and Transnistria (76%);
- No intensification of renewable energy resources usage;
- No energy efficiency policy;
- Excessive dependence (100%) on natural gas imported from a single supplier. Natural gas is widely used for electricity generation;
- Energy dependence will grow;
- Emissions of greenhouse gases and oxides will increase;
- The BAU scenario is only a mitigation policy portfolio.

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Key Assumptions for the OPT Scenario

- Population and GDP as in BAU Scenario;
- GDP distribution for Industry Sector: 3.5% by 2050;
- GDP distribution for Agriculture Sector: 2.0% by 2050;
- Energy reduction in buildings up to 10% until 2020;
- The share of biofuel consumption is expected to reach the level of 4% in the transport sector by 2015 and by 10% in 2020;
- Rehabilitation of existing CHPs with electricity generation growth;
- Electricity imported from Ukraine and Transnistria will decrease
- Electricity, heat and natural gas losses in T&D will decrease
- Mini hydro stations with a capacity of 1.2 MW are planned to be built on the Reut River;
- Effective energy efficiency policy promotion.

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Key Assumptions for the PES Scenario

- Population and GDP as in BAU Scenario;
- GDP distribution for Industry Sector: 2.0% by 2050;
- GDP distribution for Agriculture Sector: 1.5% by 2050;
- Partial rehabilitation of existing CHPs and growth of electricity generation;
- Electricity imported from Ukraine and Transnistria will decrease;
- Electricity, heat and natural gas losses in T&D will decrease;
- Developing renewable energy resources for own needs (small HPP, wind, biogas and solar power).

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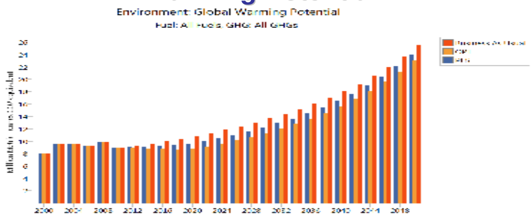
LEAP Results: Evolution of the Global Warming Potential



Scenario	Growth of Total GHG emissions, % from 2000		
	2000	2020	2050
BAU	_	36	221
Opt	_	10	191
Pes	_	15	201

Scenario	Total GHG emissions reduction, % from BAU		
	2000	2020	2050
BAU	_	_	_
Opt	_	19	9
Pes	_	15	6

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Assessment of the policy mixtures

Results of AMS Method applied:

Criteria	Scenarios		
	BAU	OPT	PES
Direct contribution to GHG emission reductions (0,833)	0	83,300	65,822
Indirect environmental effects (0,167)	16,700	0	9,342
Environmental performance (0,168) - A	**16,700**	**83,300**	**75,164**
Cost efficiency (0,474)	0	47,300	7,837
Dynamic cost efficiency (0,183)	5,060	8,080	5,060
Competitiveness (0,085)	2,363	3,774	2,363
Equity (0,175)	0	17,500	13,810
Flexibility (0,051)	1,390	2,220	1,390
Stringency for non-compliance (0,032)	1,133	1,133	1,133
Political acceptability (0,738) - B	**9,947**	**80,007**	**31,593**
Implementation network capacity (0,309)	13,534	8,683	8,683
Administrative feasibility (0,581)	19,367	19,367	19,367
Financial feasibility (0,110)	2,179	5,424	3,397
Feasibility of implementation (0,094) - C	**35,080**	**33,474**	**3[illegible],447**
Total (A+B+C)	**13,444**	**76,186**	**38,899**

- OPT is distinguished by a better performance (grade) in responding to the climate change policy needs of the country taking into consideration the national framework.

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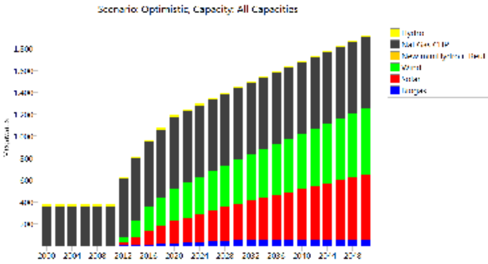
OPT: Best Policy Mixture



- It is assumed that the share of RES in the electricity generation will be the following:
  Wind – 600MW by 2050;
  Solar – 600MW by 2050;
  Biogas – 50MW by 2050.
- The total efficiency of the cogeneration power plant will not be less than 80% and for electricity production efficiency 45-50%

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Needs and gaps observed: *MITIGATION & ADAPTATION POLICY DATA*

- To develop country specific emission factors and methodologies, specifically for key source and sink categories;
- To reduce the inventory uncertainties by improving the statistical data collection system;
- To Enhance quality assurance (QA), quality control (QC) and verification activities, by setting-up a sustainable MRV system;
- RM needs to develop data collection forms and detailed procedures to establish the legal foundation, guidelines and procedures for annual preparation of energy balances and other statistic datasets, required for MARKAL and LEAP models application, according to International Energy Agency (IEA) and Eurostat guidelines;
- RM should develop the required legislation to require the electricity and natural gas distribution companies to include NACE codes in customer records for non-residential customers and report energy consumption to National Bureau of Statistics (NBS) and Ministry of Economy (MoE) by NACE categories;
- For the following sectors the data are not available and need extra analyses: "Frequency of extreme events" index; GDP for the 1990-1998 periods is not available; "Energy water use (km³)" index is not covered by RM statistical system; Information about financial incentives, Carbon Taxes, Feed in tariffs, Penalties are not available for the whole studied period; energy demand cost (in EUR) is not available; Primary and Secondary fuels lack for the years 1990-1999; a lot of data is lack for Transformation

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Needs and gaps observed: *MITIGATION & ADAPTATION SCENARIOS AND POLICY PORTFOLIOS*

- As the country is distinguished by low energy security (70% electricity import) and low capacity to pay for energy consumed specific studies are needed to demonstrate the share of affordable renewable electricity to cover power demand during the years;
- The potential for CHP promotion should be determined on country territory taking into consideration that 4500 hours of high and constant heat demand is needed to make such PP economical;
- Centralize heating demand for the years up to 2050 needs to be revised because of persisting factors leading the consumers to select autonomous heating systems;
- The total energy demand in BAU scenario is easily estimated, as it is proportionate to the GDP per capita in the Household sector and to GDP in all other sectors. However, this estimation is much more complicated in OPT and PES scenarios, as the effect of specific mitigation measures has to be added. According to the Energy Strategy up to 2030 the shares of renewable energies, energy losses and power capacities are pre-established in the national balance by 2020, but neither the time horizon is sufficient, nor these shares are differentiated per economic sector;
- there is no studies that would show the limits of sectors technologies dissemination and what may be the speed of their implementation during the years up to 2050, Other

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Needs and gaps observed: *EVALUATION OF MITIGATION & ADAPTATION POLICY INSTRUMENTS*

- Because of big import of energy resources in the RM, the case study developed with LEAP model was refined in order to obtain correct outputs:
  It was needed to fix the negative production problem in the energy balance, to add a new "Transformation" module for oil production; the capacity variable was used in that module to limit the domestic production and set the module to use gap filling imports for any demand not met by domestic production; the data that specifies natural gas imports have been removed, etc.
- Build capacities for gathering, analyzing and disseminating climate risk information, including weather data, climate modeling and impact assessment.
  Needs: Study tours and research stays organized with relevant international centers for climate assessment; Risk maps generated for the three regions of the country (South, Centre, North), and by sector; High-risk areas identified and prioritized.
- Develop regional climate change scenarios in the Republic of Moldova for mid (2020s) and long term (2050s and 2080s) based on Atmosphere Ocean General Circulation Models (AOGCMs) and Regional Climate Models (RCMs)
- Assess risks/opportunities to sustainable development of certain sectors (agriculture, livestock, water resources, forestry, human health, energy and transport sectors) due to the increased number and intensity of extremes events as result of climate change

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Future opportunities

- The results obtained will be used in the preparation of National Communication: LEAP Model, Data collected, Gaps and Needs observed, AMS Method, etc.;
- The list of research needs and gaps identified would help the national experts to promote new studies and works, in order to ensure pragmatic platform for more accurate outcomes on GHG emissions calculation in the future;
- The data based compiled will be useful in the process of restructuring of national official statistical system, in order the last be in compliance with the EU one

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Thank you for your attention

icomendant@gmail.com

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Status of renewable electricity promotion

- **Wind Farms (WF) in the world and Moldova:**
  - 24GW în 2001 ⟹ 97 GW în 2010; 37,6 GW in 2010 → 42 GW in 2011
  - In Moldova no WF electricity generated to the grid is recorded until now
- **WF promotion in Moldova:**
  - To reach 10% renewable electricity by 2020, i.e. around 200MW
  - Renewable electricity produced is mandatory for buying on the market
  - Renewable electricity tariff calculation is regulated by the appropriate Tariff Methodology published in 2009
  - Until now WF investors have requested access to the grid for around 800MW
  - Wind technical reserves are around 600-1000MW

Wind Farm promotion challenges

- **WF main challenges in Moldova:**
  - May the consumers support the WF electricity price?

    (See: Ion Comendant. The identification of solutions to cover energy demand from renewables. Regional Energy Problems, no. 2(16), 2011, IPE ASM, pages 39-52)
  - What is the impact of WF promotion for National Power Sector Development and Operation?

Is WF contributing to fuel consumption reduction when operating in the power system? If yes, how much?

If fuel reduction is recorded how it influences the price for electricity produced?

How much WF contributes to energy security increase?

WF main features

- **WFs are distinguished by:**
  - very low credit power for the conditions of the R. of Moldova, where the territory is small and spaces for feasible wind is limited
  - limited interval of working wind speed : 2.5 - 25 m/s. If the speed is higher than 25 m/s WF is disconnected from the grid, producing power imbalance in the system
  - for one WF the error for wind forecast is 10-20% for a forecast horizon of 48 hours and reach up to 100% if the horizon is higher than 48 h
  - when the wind is lack, another PP should replace WF power, so that the implementation of WF in Moldova require to ensure such compensation:

In short term

In medium and long term

WF operation in time horizon

- **Short term impact:**
  - WF power Imbalance provoked can be covered by balancing power, that is mainly from import or, partially, from MGRES; The price for balancing power is very expensive: in 2011 the balancing power higher than 50 MW cost twice more than predicted power.

CONCLUTION: in short term WFs neither contribute to electricity price decreasing nor to energy security increase. Even more, WFs construction leads to decreasing of existing small level of country energy security

- **Medium and Long term impact:**
  - The impact depends on how power sources development will follow:

    Two way: 1. Energy strategy way: it establish CHP mainly be built. Lack of heat demand and practical difficulties to implement cogeneration PPs impede to realize Energy Strategy option

    2. IPE ASM scenario: it combines the construction of diverse PPs

(See: I. Comendant, A. Sula. Impactul factorilor de influență asupra scenariilor de dezvoltarea a surselor de energie electrică. Analele Institutului de Energetică al AȘM. Fascicola 2. Ch.: TAȘM, 2010..207-231. ISSN 1853-9247. www.ie.asm.md)

What the PPs should be built to cover WF imbalance?

- **Gas turbines and combine cycle – the most appropriate PPs:**

PPs prioritization to overcome WFs imbalance challenge

Type of fuel	Tehnology	Start up time parametres			Start up costs	Ramp rate		Minimum stable generation	
		Hot start up time	Cold start up time	Relative flexibility**	Relative flexibility **	(% of total capacity/ minute)	Relative flexibility **	Value	Relative flexibility**
Natural gas	Gas turbines	10-40 minute	10-40 minute	++	++	20%-30%	++	25%-30%	++
	Combined cycle	10-40 minute*	10-40 minute*	++	+	5%-10%	+	40%	+
Coal	Steam boilers	40-60 minute	1-10 hours	-	-	1%-5%	-	40%-50%	-
Nuclear	Steam boilers	60-120 minute	13-24 hours	- -	- -	1%-5%	-	50%-60%	- -

* After this period a CCGT only has its turbine capacity available.
**The symbols show the relative flexibility of the different technologies; the ++ shows the most flexible least flexible unit technology, the - - shows the least flexible unit

Combined Cycle in tandem with WFs

- **The results obtained:**

Items	units	CCPP 200 MW	WF 200MW[1]	CCPP+WF, 400MW
Efficiency	%	52	-	43
Natural gas reduction	mil. M3	0	110[2]	64
Price of electricity produced	US$ c/kWh	12,20	13,60[1]	14,75
Investments	mil. US$	130	300	430
CO2 reduction	mii CO2	0	209[2]	121
Energy Security	-	Ensure	Not ensure[3]	Ensure

Notes
1)Examined without taking into consideration balancing power for WF capacity variation
2) At a PP with 52% efficiency
3) For the Republic of Moldova WF crediting power is taken equal to zero

WF+CCPP verses Coal PP

- **The results obtained:**
- Investment effort:

from 1500 US$/kW **(WF)** **+**650 US$/kW **(CCPP)** → **to** 2150 US$/kW **Performant Coal PP of 200MW**

- Coal PP has higher CO2 emissions then WF+CCPP tandem, **But it:**
  - leads to diversification of the fuel used in the country
  - Diminish significantly natural gas consumption, coming from one source
  - Ensure a price for electricity 24% lower than tandem WF+CCPP
  - Increase country energy security, as coal can be bought around the world and the reserves are enough for the following 200 years

WF+CCPP verses Coal PP (CPP)

- **Coal PP CO2 emission problem**
- CPP emits 1304 th. tone CO2 versus 507 th. tone CO2 of CCPP+SE
- Moldova has the obligation to diminish by 25% CO2 emissions in 2020 in comparison with 1990. In order to be in compliance with the engagement:

To Build capturing CO2 installation at CPP **To Buy CO2 on the world market**

- **Question:** At what price for CO2 the price of CPP=price WF+CCPP

Answer: 57 US$/tCO2 while on the world market it is **8,6 US$/tCO2**

Conclusions

- **For Moldova actual conditions it is much reasonable to develop Coal PP than to promote Wind Farms or Photovoltaic Power Plant**
- **Only when own electricity production will reach around 100% of demand capacity WF promotion should become a goal for country energy strategy**

Conclusions (2)

	BAU	OPT	PES
Total primary energy consumption compared to that of year 2009	Increases by 43%	**Reduced by 4%**	Increases by 13%
The share of RES in the total energy mix by 2020	5%	**13%**	2%
The GHG emissions in 2020, $MtCO_2eq$	10.8	**8.7**	9.6

In the OPT scenario the total primary energy consumption is reduced only by 4%. This low percentage is attributed to the following reasons:
- there is limited information within the country regarding energy efficient technologies and practices that does not allow the achievement of the required amount of energy savings;
- aged equipment and infrastructure are responsible for losses and without the necessary amount of investments there will be gradually higher losses;
- there are not yet official reports concerning the estimation of the potential in energy savings per sector and activity.

The GHG emissions in 2020 are 8,7$MtCO_2eq$, which is less compared to those of the BAU scenario.

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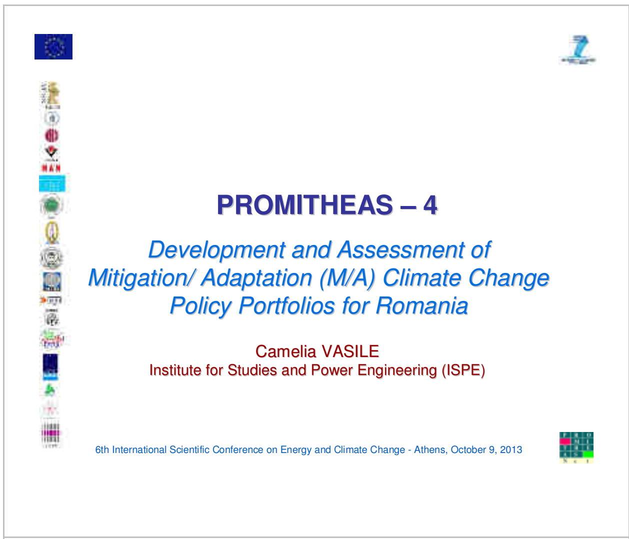
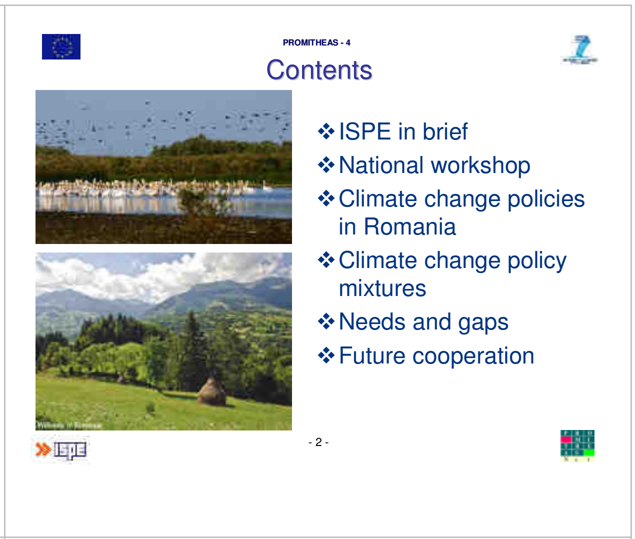
Romania


PROMITHEAS – 4
Development and Assessment of Mitigation/ Adaptation (M/A) Climate Change Policy Portfolios for Romania
Camelia VASILE
Institute for Studies and Power Engineering (ISPE)
6th International Scientific Conference on Energy and Climate Change - Athens, October 9, 2013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Contents
❖ISPE in brief
❖National workshop
❖Climate change policies in Romania
❖Climate change policy mixtures
❖Needs and gaps
❖Future cooperation
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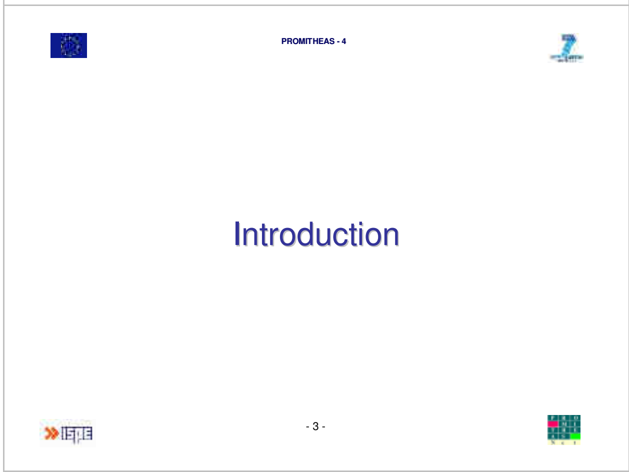
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Introduction
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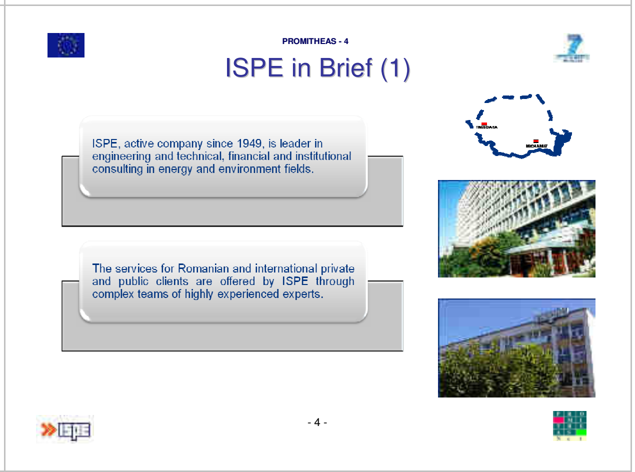
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ISPE in Brief (1)
ISPE, active company since 1949, is leader in engineering and technical, financial and institutional consulting in energy and environment fields.
The services for Romanian and international private and public clients are offered by ISPE through complex teams of highly experienced experts.
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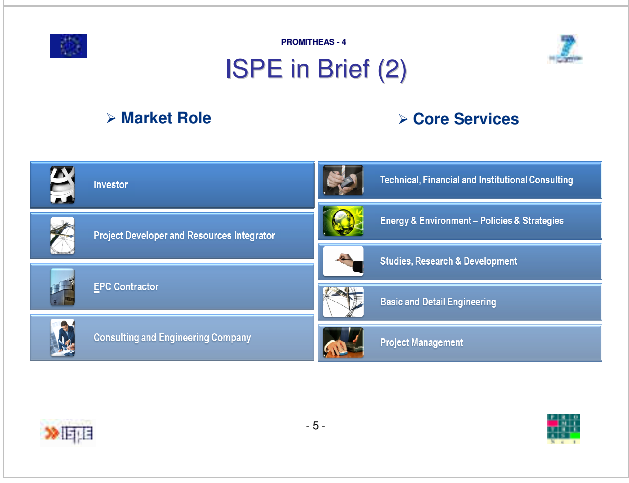
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ISPE in Brief (2)
Market Role
Core Services
Investor
Project Developer and Resources Integrator
EPC Contractor
Consulting and Engineering Company
Technical, Financial and Institutional Consulting
Energy & Environment – Policies & Strategies
Studies, Research & Development
Basic and Detail Engineering
Project Management
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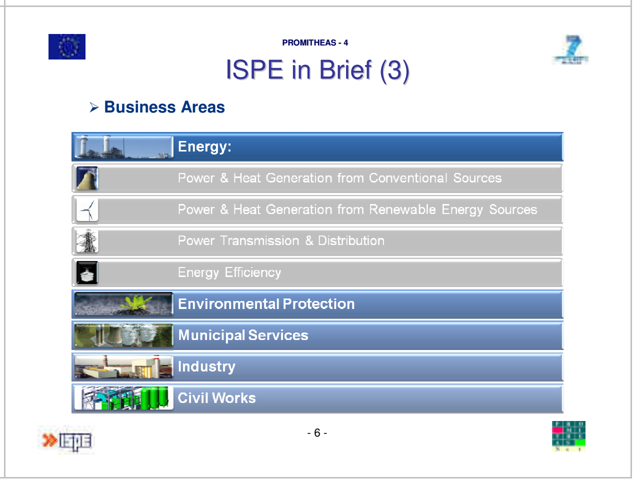
PROMITHEAS - 4
ISPE in Brief (3)
Business Areas
Energy:
Power & Heat Generation from Conventional Sources
Power & Heat Generation from Renewable Energy Sources
Power Transmission & Distribution
Energy Efficiency
Environmental Protection
Municipal Services
Industry
Civil Works
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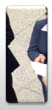
PROMITHEAS - 4

ISPE in Brief (4)

- Clients

Public

- Governmental Authorities
- Regulatory Authorities (ANRE(Romanian Energy Regulatory Authority), ANPM (Romanian Environmental Protection Agency), ANRM (Romanian Agency for Mineral Resources) etc.)
- Local Authorities
- Research-Development-Innovation Agencies
- National Utilities (Nuclearelectrica, Hidroelectrica,Transelectrica, Oltenia Energy Holding, Hunedoara Energy Holding, Romgaz, Transgaz, etc.)
- Universities
- NGOs



Private

- Utilities (ENEL, EON, CEE, GDF, Petrom etc.)
- International Organizations and Financing Bodies
- Industrial Project Developers (energy, oil and gas, metallurgy, transport, chemistry, cement industry etc.)
- Investors
- Consulting companies
- EPC contractors

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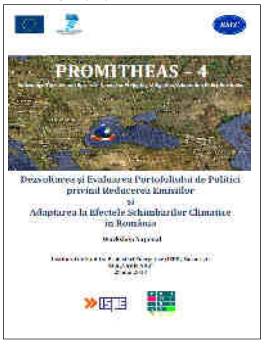
PROMITHEAS - 4

National Workshop (1)

- Date and location: May 28 2013, ISPE HQ
- Participants from:
  - BSEC
  - Embassy of Greece: Economic and Commercial Affairs Office
  - Romanian Government:
  - Business environment and industry:
  - Education and research institutes:
  - NGOs
  - WEC-Romanian Member Committee



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PROMITHEAS - 4

National Workshop (2)

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PROMITHEAS - 4

Climate change policies in Romania

- In July 2013 the Romanian Government adopted through DG 529/2013 the second National Strategy on Climate Change (NSCC) 2013 – 2020.
- NSCC focuses on two directions:
  - mitigation of GHG emissions and increasing the capacity of carbon sequestration by natural absorbing tanks for reaching the national targets;
  - adaptation to the effects unavoidable negative of climate change on natural and human systems
- National policy for GHG mitigation follows the European approach:
  - on one side by implementing the EU-ETS scheme, and
  - on the other side, by adopting policies and measures at sector level.

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PROMITHEAS - 4

Climate Change Policy Mixtures

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Data collection (1)

Main data sources used for activity data:

Sector	Official National Data Sources
Energy	1. National Institute for Statistics - Energy Balance 2. Energy producers 3. Ministry of Economy 4. Romanian Civil Aviation Authority 5. Transgaz SA 6. National Authority on Regulating in Energy and Heat 7. National Agency for Mineral Resources
Industrial - Processes	1. National Institute for Statistics - Statistical Yearbook and other additional data 2. Industrial operators through 42 Local/Regional Environmental Protection Agencies 3. Direct information from industrial operators
Solvent and other product use	1. National Institute for Statistics 2. Industrial operators through 42 Local/Regional Environmental Protection Agencies
Agriculture	1. National Institute for Statistics
LULUCF	1. National Institute for Statistics through Statistical Yearbook 2. Ministry of Agriculture, Forests and Rural Development (MADR) - Forests General Directorate (2007-2008); Ministry of Environment and Forests-Forests General Directorate (2009-2010) 3. National Forest Administration (RNP)
Waste	1. National Institute for Statistics 2. National Environmental Protection Agency 3. Public Health Institute 4. National Administration "Romanian Waters" 5. Food and Agriculture Organization 6. Landfill operators through 42 Local/Regional Environmental Protection Agencies

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Data collection (2)

International Data Sources:

- Eurostat website: http://epp.eurostat.ec.europa.eu, offers a whole range of important and useful data that governments, businesses, the education sector, journalists and the public can use for their activities;
- EEA website: http://www.eea.europa.eu, are available a series of data and maps item which contain a very large amount of data from all the sector;
- International Monetary Fund IMF website: www.imf.org;
- World Bank website: http://data.worldbank.org;
- IEA website: www.iea.org, and printed publications;
- UNFCCC website: http://unfccc.int, and publications.

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Scenarios description (1)

BAU

BAU

- RES legislative framework - in force;
- High investments in RES / rapid developing tendency;
- Energy efficiency legislative framework- in force;
- From 2007, Romania participates in the EU-ETS;
- Romania successfully participate in the development of JI project - 16 JI projects approved;
- Adaptation measures are not yet implemented.

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Scenarios description (2)

OPT

OPT scenario is structured by:

- the mitigation/adaptation policy instruments that the country has set into force after 1st January 2011;
- additional policy instruments in line with the EU climate change policy that can be adjusted to the needs and priorities of country;
- the maximum exploitation of the potential of the country in energy efficiency and renewable energy sources.

PES

PES scenario is structure by:

- the mitigation/adaptation policy instruments that the country has set into force after 1st January 2011;
- no other additional policy instruments apart from those already decided to be implemented and in line with the EU climate change policy;
- the minimum exploitation of the potential of Romania in energy efficiency and renewable energy sources by limiting the possible technological options only to the energy and transport sector and to wind and hydropower.

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Scenarios description (3)

OPT

- the promotion of Renewable Energy Sources;
- the introduction of energy efficiency measures in all sectors;
- the continuation of the nuclear program (the finalization of the Unit 3 and 4 of the Cernavoda Nuclear Power Plant with an installed capacity of about 1400 MW both until 2020;
- the realization of the National Investment Plan;
- the use of domestic resources in order to assure the security of supply;
- the encouragement of investments through the JI Mechanism, GIS and EU – ETS;
- the implementation of adaptation activities.

PES

- the promotion of Renewable Energy Sources;
- the introduction of energy efficiency measures in all sectors;
- the encouragement of investments through the JI Mechanism and EU – ETS;
- the implementation of adaptation activities.

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Main characteristics of the policy portfolio (1)

For BAU Scenario

The key drivers are assumed to develop based on their historical trends.

- Use of RES for energy purposes is very intense in Romania.
- The promotion of RES on the Romanian market not only requires legislative, but also financial and economical support. Promotion of RES-e - mandatory quota system, combined with the use of GC.
- The biodiesel industry in Romania is still at its inception compared with other EU markets, but shows over the last year one of the highest growth rates.
- Romania successfully participates in the development of “Joint Implementation” projects.
- Romania participated in the EU-ETS in the last year of Phase I of the scheme (2007) although several malfunctions at the level of GHG Registry prevented the companies to actively trade EUAs. Currently (second phase of the EU ETS) all malfunctions have been solved and companies included in the EU-ETS may actively benefit from the rules of the ETS.

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Main characteristics of the policy portfolio (2)

For OPT Scenario

This policy portfolio established mitigation targets in all sectors. Its ambitious targets can be achieved with an intense recovery of the economy after the economic and financial crisis and with GDP growth rates over 5%/year.

Main characteristics:

- penetration of all types of RES;
- achieving the nuclear program;
- continuing use of national coal (lignite) but in modernized and new capabilities with high performances;
- import of natural gas / hard coal for new power plants with high performance for the closure of the energy and power balance;
- promotion of energy efficiency in all sectors,
- adoption of all expected technological improvements.

For PES Scenario

- The key drivers are assumed to be developed based on their historical trends towards the EU energy policy. ⇒ For this scenario all EU Directives not implemented before January 1st, 2011 have been considered;
- The low economic development leads to lack of funds for investment in hydropower and biomass;
- Energy demand will be lower so that the existing capabilities will meet this demand, without the need for investment in new capacity;
- The low growth rate of the economy will also cause a lack of necessary funds for adaptation to climate change mainly for the energy, industry and agriculture sectors.

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Key assumptions for OPT/PES scenarios

OPT / PES

- GDP growth rate – as in BAU scenario;
- Population - as in BAU scenario;
- GDP distribution per sector – assumed to follow the GDP growth rate;
- Average annual household income growth rate - assumed to be equal to the growth rate of GDP per capita.
- Policies and measures - RES promotion, energy efficiency, technological development;

OPT	PES
For all industry the demand will follow the growth rate of GDP real, adjusted with energy saving measures;	For all industry the demand will follow the growth rate of GDP real, adjusted with the energy savings measures;
Precipitation - assumed to decrease with 3% until 2050;	Precipitation – assumed to decrease with 5% until 2050;
Temperature - assumption was an increasing at 15,5°C by 2050;	Temperature - assumption was an increasing at 15,5°C by 2050;

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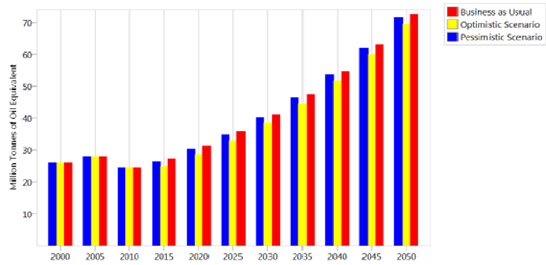
Results – BAU/OPT/PES

Energy demand evolution



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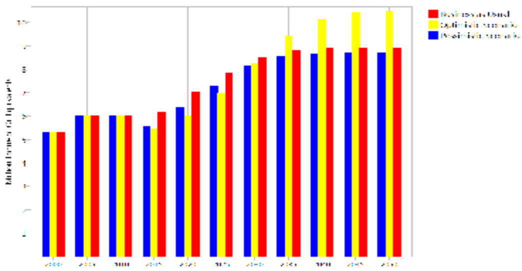
Results – BAU/OPT/PES

Electricity generation evolution



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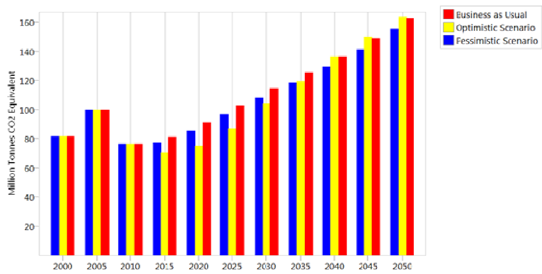
Results – BAU/OPT/PES

GHG emissions evolution



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Scenario evaluation with the AMS method

- BAU, OPT and PES were assessed with the AMS multicriteria method, against three criteria:
  - environmental performance (amount of GHG emissions and secondary environmental effects);
  - political acceptability (attitude of the involved entities – target groups)
  - feasibility of implementation (applicability of the policy portfolio from the point of the governmental and national pertinent entities).

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AMS results for each scenario

Criteria	Scenarios		
	BAU	**Opt**	**Pes**
Direct contribution to GHG emission reductions (0,833)	0	83,300	28,651
Indirect environmental effects (0,167)	0	16,700	5.899
Environmental performance (0,168) - A	**0**	**100,00**	**34,549**
Cost efficiency (0,474)	0	47,300	16,878
Dynamic cost efficiency (0,183)	3,029	12,141	3,029
Competitiveness (0,085)	1,885	4,731	1,885
Equity (0,175)	0	17,500	6,008
Flexibility (0,051)	1.395	2,210	1,395
Stringency for non-compliance (0,032)	1,133	1,133	1,133
Political acceptability (0,738) - B	**7,442**	**85,015**	**30,329**
Implementation network capacity (0,309)	6,065	15,225	9,610
Administrative feasibility (0,581)	19,367	19,367	19,367
Financial feasibility (0,110)	2,439	6,122	2,439
Feasibility of implementation (0,094) - C	**27,871**	**40,713**	**31,416**
Total (A+B+C)	**8,571**	**83,368**	**31,140**

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Best policy mixture

2020
Energy demand
Transformation Sector
GHG emissions

OPT – The lowest level
BAU – The highest level

24% share of RES in the final energy consumption

20% GHG emission reductions

19% increase of the energy efficiency

OPT- is the best scenario to achieve the targets;
BAU does not achieve sufficiently the Romanian national targets;
PES – reaches the targets, but it is has less political acceptability and more difficulties to be implemented compared to the OPT scenario.

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Needs and Gaps

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National procedures, sources, available data and information (1)

Inventory

- Gaps:
  - lack of cooperation between ministries and delays in the creation of the legal framework required to use the surplus certificates;
  - lack of experience in trading these certificates with respect to the procedures at local and international level
- Needs:
  - strengthen cooperation between the public authorities with environment-related functions and impacts;
  - establish climate-change-related working groups in relevant areas such as energy efficiency, transport or waste emissions;
  - reinforce and maintain the institutional, legal and procedural arrangements between all involved participants;
  - implement measures for enhancing the institutional capacity.

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National procedures, sources, available data and information (2)

Reporting

- Specific needs for improving the country's report:
  - calculation of specific emission factors / other parameters relevant to NGHGI for energy sectors, industrial processes, agriculture and waste to allow the use of higher tier calculation methods;
  - improvement of methodology used for Land use, Land Use Change and Forestry;
  - improvement of the structure and differentiation of the information collected, processed and provided by the INS for better correlation with the reporting requirements;
  - improvement of the methodological issues (data collection, emissions estimation) on GHG emissions recovery within the Industrial Processes and Waste activities;
  - improvement of data disaggregation considering the IPCC classification;

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National procedures, sources, available data and information (3)

Verification

- Needs identified for improving the verification procedure:
  - improvement of transparency at sector level by providing a cumulative table on the status of emissions/removals estimation for every sub-sector;
  - improvement of the NGHGI archiving structure;
  - improving the quality of the uncertainty assessment;
  - better documentation and use of electronic links and automated procedures for data entry and storage of sources and references;
  - improving the use of data specific to other reporting mechanisms, such as use of ETS data, at the GHG inventory level;

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Database development for M&A policy portfolios

- Information gaps concerning Key Assumptions, Energy Demand and Energy Transformation
- Needed studies that can lead to the required data:
  - **Households** - the number of households, the mean area of a household, the number of electrical devices, the efficiency of these devices, the energy consumptions, etc.;
  - **Primary energy resources** - studies presenting the reserves, resources and availability of energy resources;
  - **The National Power System** - need of a centralized database of the NPS on all types of power plants, all types of primary resources used to contain all costs required in the database;
  - **The transformation sector** - the inventory of the large energy consumers by industry branches in order to identify the energy consumption and the main measures to conduct to the primary energy savings and to increase the energy efficiency;
  - **Transport sector** - identification of the possibilities to introduce new type of vehicles for goods and passengers transport; creation of a database with the energy consumption/energy efficiency of the mean of transports used;

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M&A scenarios and policy portfolios (1)

Key assumptions

- Research needs:
  - analysis of scenarios of socio-economic and technological development of Romania, in the context of new European energy-environment policies;
  - multi-criteria analysis for prioritizing the scenarios, taking into account economic, environmental, security and social criteria;
  - GDP growth forecast till 2050 that takes into account the economic crisis effects;
  - research efforts on climate forecast;
  - water use in households, agriculture, industry, and energy by 2050;
  - forecasts for surface waters, groundwater or total renewable freshwater resources

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M&A scenarios and policy portfolios (2)

Policies and measures

- Gaps:
  - lack of hierarchy of options for reducing GHG emissions in line with the average cost for reducing these emissions;
  - lack of assessments regarding the affordability by population and enterprises when selecting specific reduction measures;
  - lack of clear policies on taxes.
- Needed studies for the energy sector:
  - evolution of fuel costs in Romania and the world market;
  - impact of environmental policies on the Romanian economy competitiveness;
  - rates, fees, support schemes for promoting clean and efficient technologies;
  - reduction of energy consumption in the residential and services sectors, etc.

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Evaluation of M&A policy instruments

Policies and measures

- Gaps:
  - information on the costs that the government has to pay for implementing the Romanian policy instruments;
  - information on how the Romanian climate policy affects the national competitiveness;
- Research needs:
  - the impact of public investments in energy infrastructure over the environment;
  - the impact of the support scheme for RES and energy efficiency over the consumers (industrial and residential ones);
  - the use of revenue from emission trading (JI/CDM, GIS, ETS), penalties, fees for investments in new and efficient technologies to reduce the negative impact of climate change;
  - the total amount of administrative costs needed for exerting the national M/A climate change policy (planning, management, verification, monitoring etc).

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Future cooperations

Cooperation with Romanian Government

- ISPE participated to the preparation of the Report on Forecasted Progress under Article 3.2 of “Decision 280/2004/EC concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol”
  - General objective of ISPE contribution - to develop a methodology for drawing up quantitative projections of GHG emissions and removals by sinks, by sectors and gas types, as required in the guidelines and instructions for national inventory preparation for the period 2013 – 2030.
- ISPE participates to the tender for the preparation of the 6th National Communication of Romania as a Party to the UNFCCC and the Biennial Report Nr.1“

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Thank you

Camelia Vasile
camelia.vasile@ispe.ro

ISPE SA
1-3, Lacul Tei Blvd.
020371 Bucharest, Romania
Tel: +40-21-2061331
www.ispe.ro

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Russia

Development and assessment of Mitigatiion / Adaptation Climate Change policy portfolios for Russian Federation

Prof. Alexander ILYINSKY
Financial University, Moscow
Dr. Popi KONIDARI, Anna FLESSA M.Sc.
National and Kapodistrian University of Athens

PROMITHEAS-4 **Final Conference** and **PROMITHEASnet** 6th International Scientific Conference, Athens 9-11 Oct. 2013

Promitheas 4 National Workshop - 1st International Conference Climate Policy, Sustainable Development and Green Finance 20-21 May 2013, Moscow, Russia

(Financial University)

Agenda
20-21 May 2013
Financial University – Hall No. 213
49 Leningradsky Prospect
Moscow

Day 1

09:30-10:00	Registration	
Opening		
Chair	Prof. A. Ilyinsky	Dean of IFF
Co-chair	Prof. D. Mavrakis	Director of KEPA, National and Kapodistrian University of Athens, Greece
10:00-10:10	Welcome address	
	Prof. M. ESKINDAROV	Rector of Fin. University
	Opening Speeches:	
10:10-10:20	Mr.Spinelis;	Ambassador of Greece
10:20-10:30	Mr. Siluanov;	Minister of Finance
10:30-10:40	Mr. Tvircun;	General Secretary of BSEC
10:40-11:00	Prof. D. Mavrakis	Director of KEPA, National and Kapodistrian University of Athens, Greece
11:00-11:20	*Coffee break*	
Session 1a:	**Climate Change Policies**	
Chair	Mr. Bedritsky;	Advisor to President of RF
Co-chair	Mr. Aksakov	Deputies of the State Duma
11:00-11:10	Speakers: Mr. Aksakov	Deputies of the State Duma
11:10-11:20	Mr. Yulkin;	Head of RSPP
11:20-11:30	Mr. Fedorov;	Deputies of the State Duma
11:30-11:45	Mrs. Anna Flessa, MSc.	Fellow researcher of KEPA
11:45-12:30	Prof. A. Ilyinsky	Dean of IFF
12:30-12:45	Mrs. Anna Flessa, MSc.	Fellow researcher of KEPA
12:45-14:30	*Other reports;*	
	Comments – Discussion	

International IFF-KEPA team members

- Prof. Alexander Ilyinsky
- Dr. Alexander Didenko
- Dr. Sergei Petropavlovsky
- Dr. Popi Konidari
- MSc. Inna Lukashenko
- MSc. Anna Flessa

Russia: facts and figures

- Area: 17,098,242 sq. km
- Population: 142,500,482 (July 2013 est.)
- GDP (purchasing power parity): $2.555 trillion (2012 est.)
- Climate: ranges from steppes in the south through humid continental in much of European Russia; subarctic in Siberia to tundra climate in the polar north; winters vary from cool along Black Sea coast to frigid in Siberia; summers vary from warm in the steppes to cool along Arctic coast

Russian energy: facts and figures (2012 est.)

Electricity - production: 1.064 trillion kWh	4
Electricity - exports: 19.14 billion kWh	8
Electricity - installed generating capacity: 223.1 million kW	4
Electricity - from nuclear fuels: 17.2% of total installed capacity	14
Electricity - from RES: 0,5% of total installed capacity	179
Crude oil - production: 10.37 million bbl/day	1
Crude oil - exports: 4.69 million bbl/day	2
Natural gas - production: 653 billion cu m	1
Natural gas - exports: 200.1 billion cu m	1
CO_2 emissions from consumption of energy: 1.634 bln. Mt	4

Data collection – how we collected and our sources

- Roshydromet
- Federal State Statistics Service
- ERI RAS/REA
- EBRD
- European Commission
- UNDP
- UNEP
- UNFCCC
- World Bank
- IFC
- FAO
- IEA
- WWF

Developing BAU scenario

- Focus on energy efficiency and less on Renewable Energy Sources
- Remove all remaining cross - subsidies from electricity pricing
- Electricity tariffs for households will remain regulated
- Increasing nuclear energy to 25% of energy production

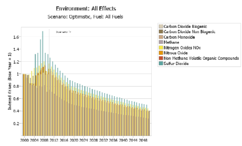
Developing OPT scenario

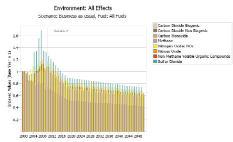
- Reduce energy intensity in 2020 by 40% of 2007 level
- Target to double GDP in ten years
- Goal to add at least 20000 MW of new generating capacity
- Cooperation bonds between EU and Russia especially in the area of energy
- Environmental issues

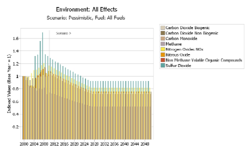
Developing PES scenario

- Slower implementation of innovations,
- Low GDP growth rate,
- Severe climate change,
- Bad demography
- Reflect augmented set of Governmental policies, which implemented slower with worse results.

Results of the 3 scenarios according to LEAP







AMS assessment of the policy mixtures

Criteria	Scenarios		
	BAU	OPT	PES
Direct contribution to GHG emission reductions (0,833)	0,000	83,300	[illegible]
Indirect environmental effects (0,167)	0,000	16,700	8,302
Environmental performance (0,675) - A	0,000	100,00	45,674
Cost efficiency (0,390)	0,000	47,309	22,407
Dynamic cost efficiency (0,227)	5,573	8,968	5,660
Competitiveness (0,101)	1,178	1,510	[illegible]
Equity (0,188)	0,000	17,909	3,904
Feasibility (0,056)	1,293	2,210	1,397
Stringency for non compliance (0,038)	1,133	1,125	1,137
Political acceptability (0,259) - B	7,229	81,674	41,251
Implementation network capacity (0,228)	11,407	7,305	11,697
Administrative feasibility (0,685)	[illegible]	10,112	21,094
Financial feasibility (0,088)	3,667	3,667	3,667
Feasibility of implementation (0,067) - C	46,498	25,283	39,568
Total (A+B+C)	8,846	79,420	41,628

Best policy mixture

- For criterion of environmental performance, OPT offers better grade of all scenarios;
- This could be interpreted as lack of regulation (driven, perhaps, by lack of motivation) of regulatory bodies to decrease environmental impact of Russian economy.
- There is definitely great leeway for improving environmental performance of the economy through implementation of new policies, many of which are currently discussed.

Thank you for your attention and cooperation!

Serbia

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Knowledge transfer and research needs for preparing mitigation/adaptation policy portfolios

- Serbian National Report -

Aleksandar Madžarević

University of Belgrade – Faculty of Mining and Geology

9-11 October 2013, Athens, Greece

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Objectives

- M/A policy portfolios development and assessment
- Identification of Needs and Gaps
- Knowledge transfer procedures
- Dissemination

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Strategy

- Development
  - Evaluation of available data and information
  - Choice and implementation of models
  - Scenarios and policy portfolios
- Implementation
  - Scenarios and policy portfolios
- Evaluation
  - Evaluation of policy portfolios
- Knowledge transfer towards scientists and decision makers of both public and private sectors
  - Training Dissemination
- Identification of scientific research needs and gaps
  - Prioritization of research gaps and needs

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Serbian climate change policy - Objectives

- Serbia signed the United Nations Framework Convention on Climate Change in June 2001.
- The country ratified the Kyoto Protocol and signed it in January 2008.
- The signing of the protocol does not oblige Serbia to reduce its GHG emissions.
- Serbia signed the Treaty that establishes the Energy Community of Southeast Europe and EU in 2006.

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Spectrum of climate change mitigation options / adaptation needs for Serbia

- Exploitation of RES
- Energy efficiency
- Fuel switch
- Mitigation through CDM
- Other mitigation options

- Energy sector
- Agricultural sector
- Forestry sector
- Water resources
- Others

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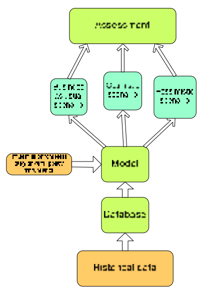
Policy mixtures and possible scenarios for Serbia



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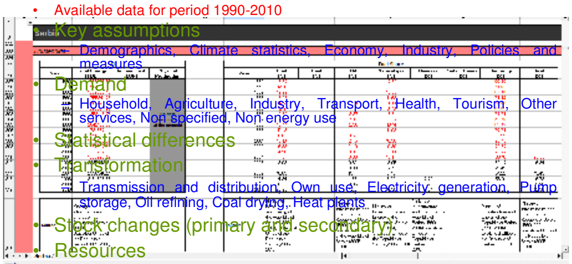
Database

- Available data for period 1990-2010
- Key assumptions
  - Demographics, Climate statistics, Economy, Industry, Policies and measures
- Demand
  - Household, Agriculture, Industry, Transport, Health, Tourism, Other services, Non specified, Non energy use
- Statistical differences
- Transformation
  - Transmission and distribution, Own use, Electricity generation, Pump storage, Oil refining, Coal drying, Heat plants
- Stock changes (primary and secondary)
- Resources
- Non energy sector
  - Land use, change and forestry, Agriculture, Waste, Cement manufacture, Lime production.



Part of the database

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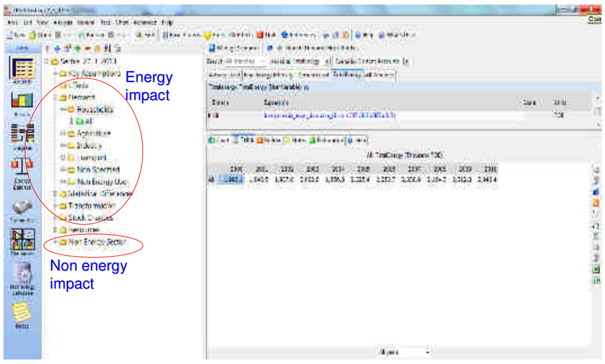
LEAP model for Serbia



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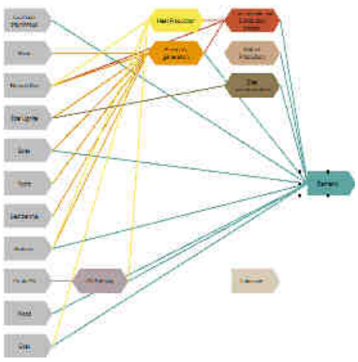
LEAP model for Serbia



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Possible scenarios

- Database is linked with LEAP- open and dynamic model
- Base year 2010
- Scenario development
- Three possible scenarios:
  - Business as usual,
  - Optimistic and
  - Pessimistic

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Business as usual scenario

- Key drivers are assumed to develop based on their historical trends
- Utilization of RES is limited to hydropower plants and non-commercial use of biomass and geothermal energy
- Despite the introduction of the FITs, renewable energy sources have not been promoted. There are rare examples of individual solar thermal building systems and small solar Photovoltaic roof maintained units.
- 19 privately owned small hydro power plants were connected in 2010 to the distribution system of Public Enterprise “Electric Power Industry of Serbia”

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Business as usual scenario

- ***GDP distribution per sector***
  - based on the trend of the historical data.
- ***Precipitation***
  - For the BAU scenario a negative growth rate of 0,25% is assumed based on the historical data of the decade 2000-2010
- ***Temperature***
  - temperature will increase by approximately 1,2^{o}C in 2020 compared to that of year 2010
- ***Policies and Measures***
  - Feed – in – tariff system

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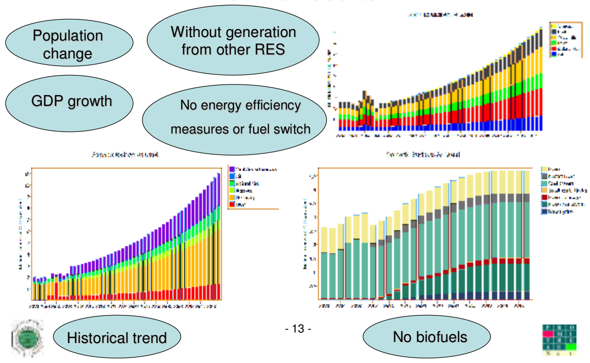
Business as usual scenario - some results



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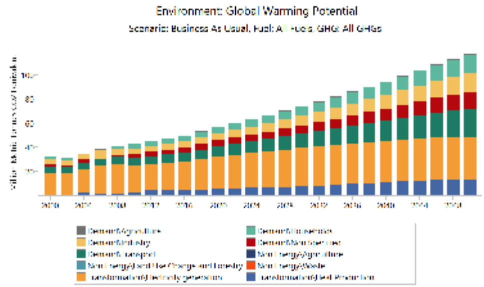
Business as usual scenario – some results



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Optimistic scenario

- The Optimistic scenario concerns the time evolution of an enhanced mitigation/adaptation policy portfolio that the country will implement during the time interval 2011 - 2050.
- This scenario is linked with stringent climate policy options and relatively high need for adaptation policy instruments to handle minimum climate change impacts for Serbia.

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Optimistic scenario

- The main characteristics of this policy portfolio is:
  - the promotion of RES,
  - the introduction of energy efficiency measures in all sectors,
  - the implementation of adaptation activities towards the minimum – in size and extent - expected climate change impacts,
  - the adoption of all expected technological improvements.

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Optimistic scenario

- The Optimistic scenario concerns:
  - the mitigation/adaptation policy instruments that the country has set into force after 1st January 2011;
  - additional policy instruments in line with the EU climate change policy that can be adjusted to the needs and priorities of the examined country* aiming to the maximum exploitation of the potential of the country in energy efficiency and RES.

- *Albania, Moldova, Serbia and Ukraine are Contracting Parties of the Energy Community and have committed to comply with the EU energy policy (http://www.energy-community.org/portal/page/portal/ENC_HOME). This commitment concerns also climate change policy due to policy instruments that support the usage of technologies for energy efficiency and renewable energy sources.

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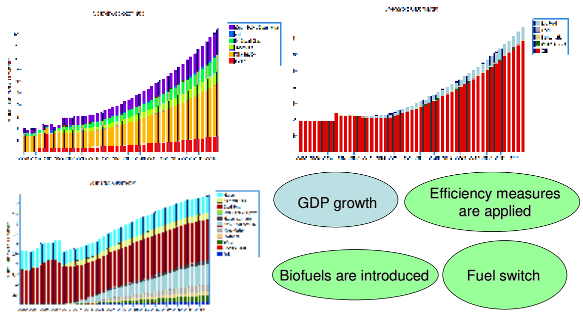
Optimistic scenario - some results



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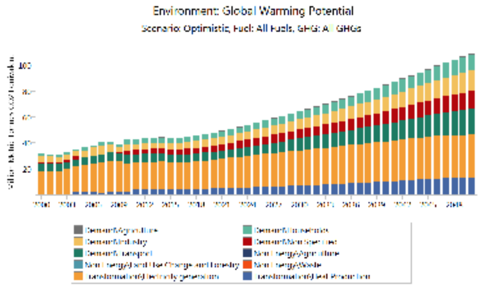
Optimistic scenario - some results



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Pessimistic scenario

- This scenario is a non-climate policy scenario. The priorities are not in mitigation activities and adaptation needs, but in energy supply and security for ensuring economic growth in higher rates than those of this scenario
- The penetration of RES technologies for this scenario concerns mainly biomass and hydropower
- Efforts for energy efficiency will concern mainly the energy sector and the residential sector

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Pessimistic scenario

- **Mitigation**
- ***Existing policy instruments***
  - *Updated Energy law*
  - *Law on Construction and Spatial planning*
- ***Additional policy instruments***
  - *Policy instruments for the promotion of RES*
    - Increase in electricity prices for allowing investments in the power sector.
    - Lower and constant feed-in-tariffs for RES.
    - Tax exemptions and subsidies for the encouragement of investments in the energy and mining sector.

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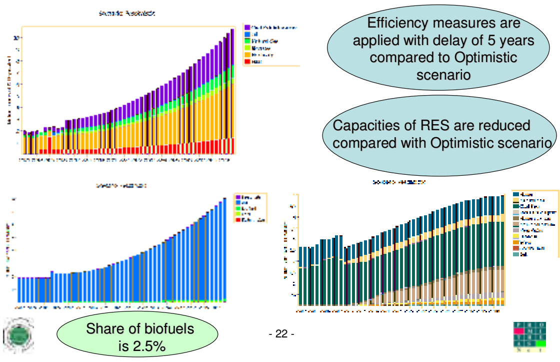
Pessimistic scenario – some results



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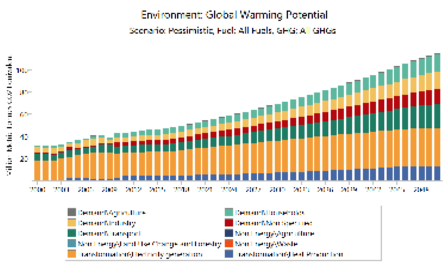
Pessimistic scenario – some results



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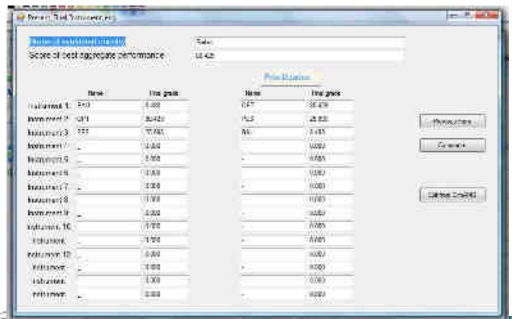
Results of AMS



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Comments

- OPT has higher political acceptability due to its higher performance in cost efficiency.
- In feasibility of implementation the OPT scenario has the lowest performance compared to the other two.
- The implementation network does not have the necessary capacity, skills and experience to apply such a strict climate policy mixture.

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Comments

- The administrative feasibility needs to be improved considerably so as to incorporate the EU legislation and meet the requirement of the EU acquits in this policy area.
- Significant disadvantage for this policy mixture is the insurance of the necessary financial resources so as to be effective.

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Conclusions

- This report concerns the development and assessment of three climate change mitigation and adaptation policy portfolios for Serbia.
- Each of them is characterized by a different policy mixture and is named after it as Business As Usual (BAU), Optimistic (OPT) and Pessimistic (PES).
- Serbia as a non-Annex I country has no obligation to reduce its GHG emissions under the Kyoto Protocol.

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Assessment outcomes

- The BAU scenario has the largest amount of GHG emissions, followed by the PES scenario.
- The policy portfolio of the OPT scenario has the best performance in political acceptability since it is the most cost effective for the target groups (residential, industrial, energy and transport sectors).
- It offers more flexibility for the target groups in complying with their obligations.

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Assessment outcomes

- The most promising mitigation/adaptation policy portfolio is the one which characterizes the Optimistic scenario.
- The success of this policy portfolio requires the appropriate implementation network, the necessary financial means and a more stringent frame for non-compliance.

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Research needs and gaps

1. Research needs and gaps related to M&A policy data
   - Established national procedures, sources, available data and information
   - Database development for M&A policy portfolios
2. Research needs and gaps related to M&A scenarios and policy portfolios
3. Research needs and gaps related to the evaluation of M&A policy instruments

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Research needs and gaps

- There is no systematic database at the level of the country.
- Some of the required data were not collected at all.
- For the analyzed period even energy balances of the country can not be found (except 2007-2010).
- The Initial National Communication of the Republic of Serbia (Ministry of Environment and Spatial Planning, 2010)
- "Report on the State of the Environment in Republic of Serbia" (Serbian Environmental Protection Agency (SEPA)) covers land–use change and forestry.

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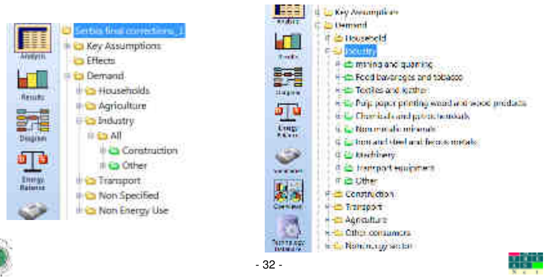
Research needs and gaps

- There is no systematic collecting, analyzing, systemizing and reporting of data nether by RHMSS, SORS nor SEPA for national GHG inventory.



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Thank you !

Aleksandar MADŽAREVIĆ
University of Belgrade – Faculty of Mining and Geology
Centre for Energy
amadzarevic@rgf.bg.ac.rs

Turkey

TÜBİTAK

Development and Assessment of Mitigation / Adaptation Climate Change Policy Portfolios for Turkey

Nuray AKALIN
TUBİTAK-Marmara Research Center

9 October 2013
Athens

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Objectives of the Turkish CC Policy

- Turkey became a party to UNFCCC on 24 May 2004.
- Decision (26/CP.7) of Conference of the Parties-7 (COP7) that was held in Marrakech in 2001 deleted Turkey from Annex II - but the country remained as an Annex-I Party of the UNFCCC - and recognized the special circumstances of the country as being different from that of the other Annex I countries of the Convention.
- Turkey ratified Kyoto Protocol on August 26th, 2009.
- Turkey does not have a quantified emission limits or reduction commitments for the first commitment period (2008-2012) under the Protocol.

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Objectives of the Turkish CC Policy

- Turkey is an observer to the Energy Community. Countries with full membership will apply European Union (EU) directives related to the use of Renewable energy sources (RES) and the promotion of energy efficiency.
- Turkey is a candidate country for EU membership.

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Objectives of the Turkish CC Policy

- Main plans/strategies related with climate change in Turkey,
  - *National Climate Change Strategy, 2010-2020*
  - *National Climate Change Action Plan, 2011-2023*
  - *Strategic Plan of the Ministry of Energy and Natural Resources, 2010-2014*
  - *Electricity Energy Market and Supply Security Strategy*
  - *Energy Efficiency Strategy, 2012-2023*

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CC Mitigation Options for Turkey

- Explotation of RES
  - *Hydropower*: 36.000 MW
  - *Wind*: 20.000 MW
  - *Solar*: 3.000 MW
  - *Geothermal*: 600 MW
  - *Biomass*: 2.000 MW
  - İncentives
- Energy Efficiency
  - Energy-saving potential of
    - 30% in the building sector
    - 20% in the industry sector
    - 15% in the transport sector
  - Increase capacity and efficiency of existing thermal plants by rehabilitation activities
  - Reduce nationwide electricity distribution losses
  - Incentives and awareness-raising campaigns

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CC Mitigation Options for Turkey

- Fuel switch
  - 5% biofuel can be added to other types of fuel in the country.
  - Increase use of RES for electricity production,
  - Start use of nuclear energy for electricity production.
- Mitigation through emission trading
  - Estimated annual CO_2 reduction by voluntary market projects was 12 million ton by 2012,
  - Other mechanisms for future.

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Adaptation Needs in Turkey

The following sectors will effected from the changes in temperature and precipitation caused by climate change:

- Energy sector
  - Temperature rise
  - Fluctuations in water resources
  - Hydropower is directly related with amount of water resources
- Water resouces
- Agriculture
- Forestry

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Business As Usual (BAU) Scenario

- The policy portfolio of BAU includes the implemented policy instruments related with climate change issues before 31 December 2010,
- RES applications, notably hydro and wind, increased considerably after old RES Law entered into force in 2005,
- Turkey does not have an organized commercial and domestic photovoltaic program,
- Also, tariffs were low compared to other EU countries, although multiple tariffs were envisaged by the amended RES Law. But, the Law entered into force after 31 December 2010, so, it is not considered in BAU.

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Business As Usual (BAU) Scenario

- In the framework of The Energy Efficiency Law, rehabilitation of thermal power plants, decrease of losses, incentives and awareness raising are considered in BAU,
- No CDM projects are completed, because Turkey cannot participate in the flexible mechanisms of the Kyoto Protocol,
- In BAU, only projects in the Voluntary Carbon Market are taking into account,
- No adaptation measures are implemented.

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Optimistic (OPT) Scenario

- The mitigation/adaptation policy instruments that the country has set into force after 1st January 2011,
- Additional policy instruments in line with the EU climate change policy that can be adjusted to the needs and priorities of the examined country,
- The maximum exploitation of the potential of the country in energy efficiency and renewable energy sources,
- Improvement of network capacity.

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Optimistic (OPT) Scenario

- The policy instruments used in OPT:
  - *Amended RES Law: Law on Utilization of Renewable Energy Sources for the Purpose of Generating Electricity (Official Gazette No: 27809, 8 January 2011)*
  - *Regulation on increasing efficiency in the use of energy resources and energy (Official Gazette No: 28097, 27 October 2011)*
- Additional policy instruments in OPT:
  - RES incentives should be increased to provide usage of max RES potential,
  - Additional policy instruments should be added so as to reinforce the up to now set of policy instruments for the promotion of EE,
  - Development of new policies for emission trade.

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Pessimistic (PES) Scenario

- The mitigation/adaptation policy instruments that the country has set into force after 1st January,
- No other additional policy instruments apart from those already decided to be implemented and in line with the EU climate change,
- The minimum exploitation of the potential of the country in energy efficiency and renewable energy sources by limiting the possible technological options to the sectors.

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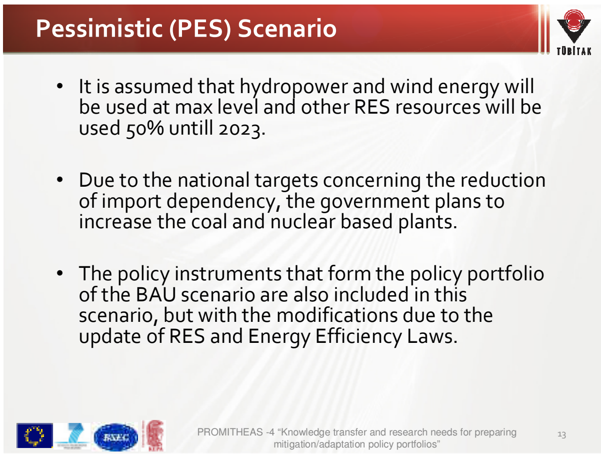
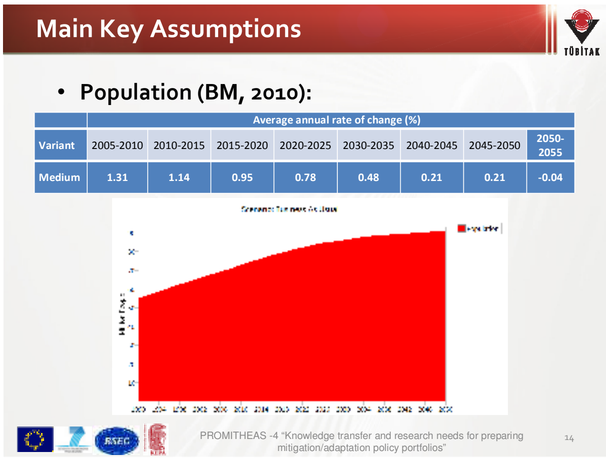
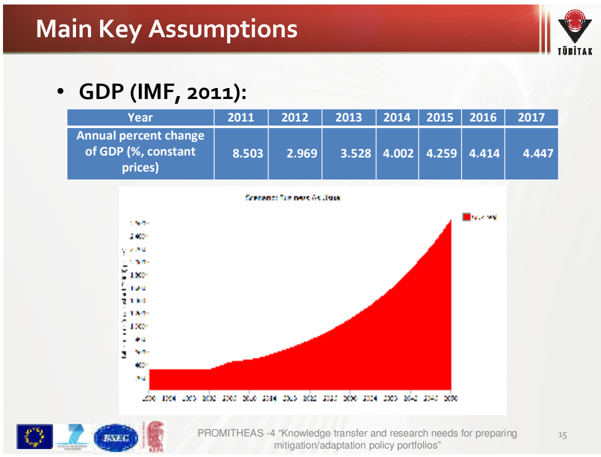
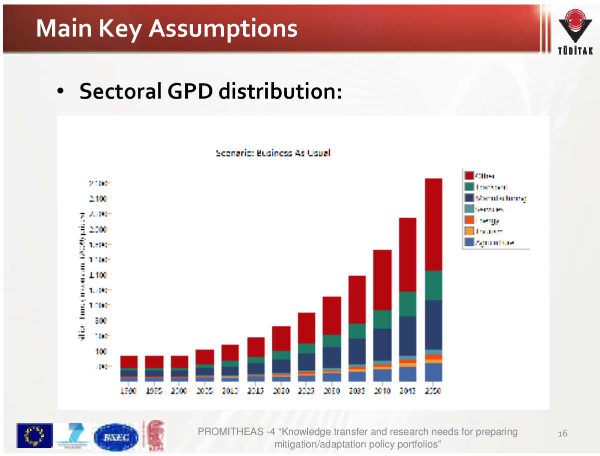


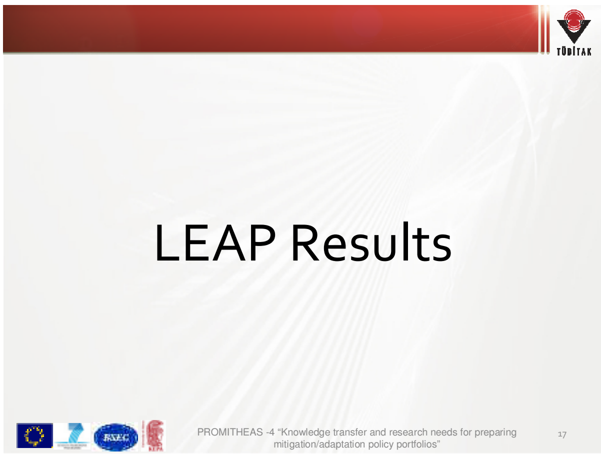


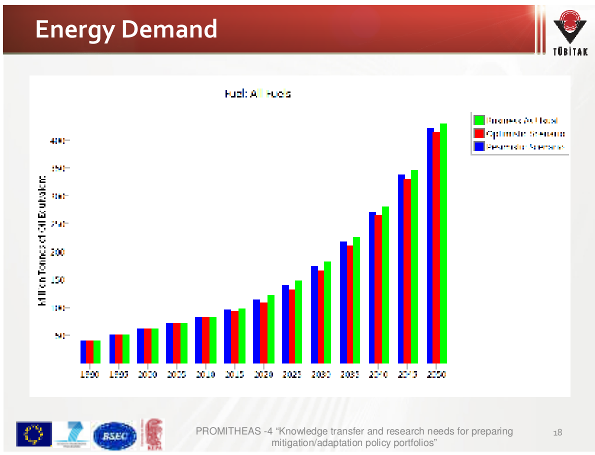
	Average annual rate of change (%)							
Variant	2005-2010	2010-2015	2015-2020	2020-2025	2030-2035	2040-2045	2045-2050	2050-2055
Medium	1.31	1.14	0.95	0.78	0.48	0.21	0.21	-0.04



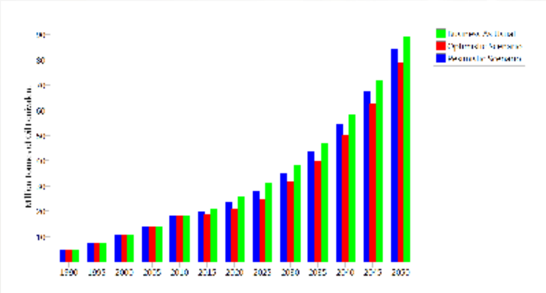
Year	2011	2012	2013	2014	2015	2016	2017
Annual percent change of GDP (%, constant prices)	8.503	2.969	3.528	4.002	4.259	4.414	4.447



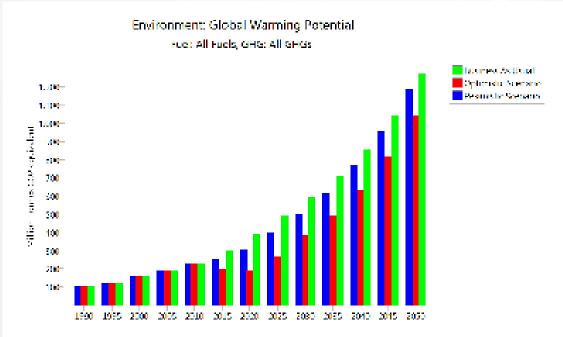




Electrcity Generation



GHG Emissions



LEAP Results for BAU

- Energy demand as well as GHG emissions overdoubled within the 20-year period 1990-2010.
- For the BAU scenario, GHG emissions in Turkey will increase by 269% in 2020 and by 1104% in 2050 compared to the year 1990. Compared to the year 2010, the emissions will increase by 70.13% and by 455% respectively.
- The share of RES in electricity generation in 2023 will be 26.5%.

LEAP Results for OPT

- For the OPT scenario, GHG emissions in Turkey will increase by 78.62% in 2020 and by 882.8% in 2050 compared to the year 1990, while compared to the year 2010, there will be a decrease of 17.66% and an increase of 353.05% respectively.
- The share of RES in electricity generation in 2023 will be 47.7%, almost 20% more than BAU because of the introduction of solar and the increased penetration of wind, hydro and geothermal in electricity generation through the reinforced feed-in tariff system and the increased amount of subsidies.

LEAP Results for PES

- According to the outcomes of the LEAP model for the PES scenario, GHG emissions in Turkey will increase by 191.4% in 2020 and by 1023% in 2050 compared to the year 1990 while compared to the year 2010, they will increase by 34.35% and by 417.7% respectively.
- The share of RES in electricity generation in 2023 will be 46.9%.

AMS Results

Criteria	Scenarios		
	BAU	Opt	Pes
Direct contribution to GHG emission reductions (0.833)	0	83.300	33.949
Indirect environmental effects (0.167)	0	16.700	8.787
Environmental performance (0.168) - A	0	100.00	42.736
Cost efficiency (0.473)	0	47.300	12.969
Dynamic cost efficiency (0.183)	5.060	8.080	5.060
Competitiveness (0.085)	3.539	3.539	1.422
Equity (0.175)	0	17.500	7.138
Flexibility (0.050)	0.975	2.467	1.557
Stringency for non-compliance (0.034)	1.133	1.133	1.133
Political acceptability (0.738) - B	10.708	80.019	29.280
Implementation network capacity (0.309)	13.718	8.591	8.591
Administrative feasibility (0.581)	19.367	19.367	19.367
Financial feasibility (0.110)	3.058	4.883	3.058
Feasibility of implementation (0.094) - C	36.143	32.841	31.016
Total (A+B+C)	**11.300**	**78.941**	**31.704**

AMS Results

- The BAU scenario is characterized by the highest final energy consumption and the worst environmental performance, compared to the other scenarios, which results from the limited number of mitigation and adaptation policy instruments.
- PES is characterized by moderate environmental performance.
- OPT has the lowest amount of GHG emissions and the lowest energy consumption.

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AMS Results

- The policy portfolio of the OPT scenario is overall the most promising scenario
  - the best performance towards the reduction of GHG emissions,
  - it ends up as the most cost effective, especially for certain target groups (buildings, industrial sector)
  - the most fair towards the contribution of the sectors to emission reductions offering more incentives and options (subsidies, feed in tariffs)

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Needs and Gaps

- Historical data limitations:
  - No projections for GDP were in national level.
  - The historical GDP data was available from 1998. There is a forecast for GDP growth till 2017– the one by IMF. Therefore, a recent GDP growth forecast till 2050 is needed.
  - Limited data for water use
  - No data about heat waves and frost days are available.
  - No historical data about surface, ground and renewable fresh waters are available and overlap separately.

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Needs and Gaps

- Information gaps concerning historical data for energy demand:
  - Although there are many small CHP and bio-fuel production plants, they are not included separately in Energy Balance Tables.
  - For all transport modes (road, rail, air and maritime), the separate energy use are not available as passenger and freight. There are some emission reduction targets for passenger and freight transports at different transportation modes. It is not possible to figure out the policies & measures in LEAP.
  - The output fuel data by type in Refining Process is not open due to national interest.

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Needs and Gaps

- Turkey has many mitigation and adaptation policies and measures in the Strategy Document and Action Plans which were approved by the Government.
- But these measures are expressed as percentage and overlapped measures.
- To use these measures in the LEAP, it is needed to convert the percentage data to exact energy use reductions or emission reductions.
- The effects of the measures should be monitored systematically. This is very important for modeling the measures in LEAP and justifying in AMS.

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National Workshop

National workshop held on 31 May 2013 in Ankara

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Thank you for your attention…

Nuray AKALIN
nuray.guler@tubitak.gov.tr
Environmental and Cleaner Production Institute
TÜBİTAK MAM
www.mam.gov.tr

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Ukraine

PROMITHEAS – 4

Development and Assessment of Mitigation / Adaptation Climate Change policy portfolios for Ukraine

Policy mixtures and Assessments

Evgenij Inshekov, Mariia Kokorina
Institute for Energy Saving and Energy Management
National Technical University of Ukraine "KPI"

Athens, 9 October 2013

Outline

- Introduction
- Business-as-usual scenario
- Optimistic scenario
- Pessimistic scenario
- Assessment of scenarios using AMS method
- Conclusion
- Needs and gaps

Introduction

- Objectives of the Ukrainian climate change policy
- Spectrum of climate change mitigation options for Ukraine
- Spectrum of adaptation needs in Ukraine

Objectives

National objectives:

–Ensure reduction of annual energy consumption by 318 mtce until year 2030
–Increase the percentage of coal in the energy balance from 22% in 2005 to 33% by 2030
–Decrease the share of the imported fuels in the energy balance from 54,8% of the total primary energy supply to 11,7%
–Reduce natural gas consumption by 18,8% of primary energy needs in 2030
–Increase the share of renewables by 9,5 Mtoe during the period 2004-2020 and for the period 2020-2030 by 26,1 Mtoe (12% of Ukraine's primary energy needs)
–Achieve a contribution of biomass to the total primary energy consumption by 5% in 2020 and 10% in 2030, including 10% target for the share of biofuels in transport by 2020
–Reduction of energy consumption by 30,95 million tons of equivalent fuel in 2015.

Documents:

–Energy Strategy of Ukraine until 2030
–Updated Energy Strategy until 2030
–Biomass Action Plan for Ukraine
–State Target Economic Program on energy efficiency and the development of energy production from renewable energy sources and alternative fuels for 2010-2015

Mitigation options

- Exploitation of RES
- Energy efficiency
- Mitigation through JI and GIS

Adaptation needs

- Energy sector
- Agricultural sector
- Forestry sector
- Water resources

Scenarios

- Business-As-Usual
- Optimistic
- Pessimistic

Business-As-Usual Scenario

Mitigation and adaptation policy instruments were implemented before 31.12.2010;

The Ukrainian BAU scenario is mainly a mitigation policy portfolio:

— penetration of RES in the gross final energy consumption,

— support to increase energy efficiency;

— GHG emission reductions through JI and GIS

BAU - Key Assumptions

- Demographics: "medium variant" of the population projections are used for all 3 scenarios (BAU, OPT, PES);
- Economy: GDP growth rate is assumed to be 3,5% based on IMF projections for all 3 scenarios;
- Climate statistics:
  — the annual precipitation change was considered to follow its historical growth;
  — the average air temperature change following historical trends by 2020;
- T&D losses is assumed to reach level of 0,6%. For natural gas, oil and heat 0,5% and for coal 1%;
- Feed-in-tariffs follow their historical trends;
- Projections for the global trends prices are provided by KEPA.

BAU – Energy Demand

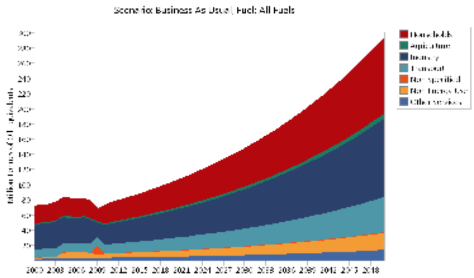

Figure 1: Final Energy Demand per sector

BAU – Energy Demand

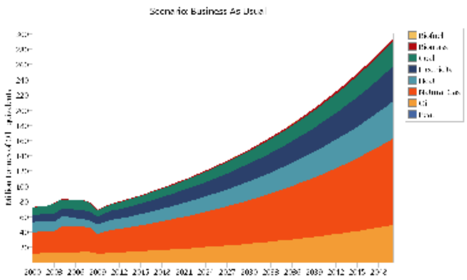

Figure 2: Final Energy Demand per fuel

BAU – Transformation

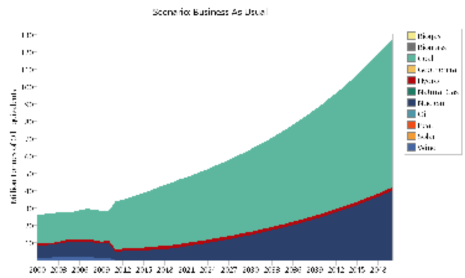

Figure 3: Transformation: Electricity Generation

BAU – Transformation

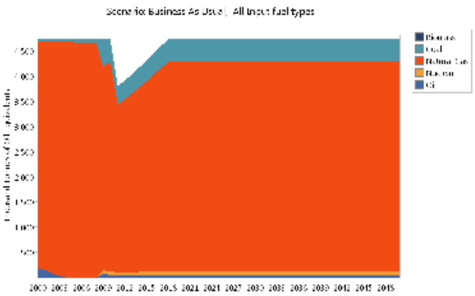

Figure 4: Share of Heat Production by fuel type

Optimistic Scenario

- Mitigation/adaptation policy instruments Estonia has set into force after 01.01.2011;
- Maximum exploitation of the potential of the country in energy efficiency and renewable energy sources;
- Wider range of policy instruments:
  - performance standards;
  - financial policy instruments (subsidies and grants);
- Additional instruments in accordance with EU climate change policy, which can be adapted to the needs and priorities of the country
- Additional legislation regarding energy efficiency in residential and public buildings

OPT - Key Assumptions

- OPT policy portfolio sets stringent mitigation targets in all sectors;
- Climate statistics:
  - the annual precipitation growth rate amounts 1,5%;
  - the average air temperature is assumed to be 11,5 ˚C by 2020
- T&D losses is assumed to decrease by 0,4% annually;
- RES target capacity by 2030 will count at least 10% of installed capacity
- Households: reduction of natural gas consumption from 52% in 2015 to 40% in 2030, increase of biomass use up to 6% by year 2020, as a result increase of coal share in the total energy consumption;
- Technological improvements in the road branch are foreseen, resulting to 20% energy savings by 2015 and to 40% by 2030.

OPT – Energy Demand

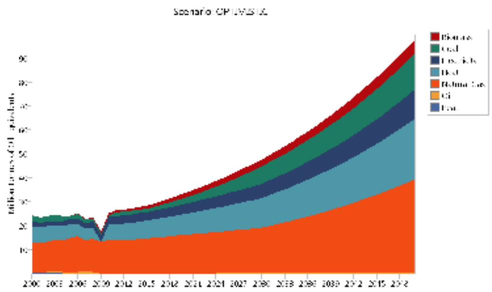

Figure 5: Final Energy Demand in Household Sector

OPT – Energy Demand

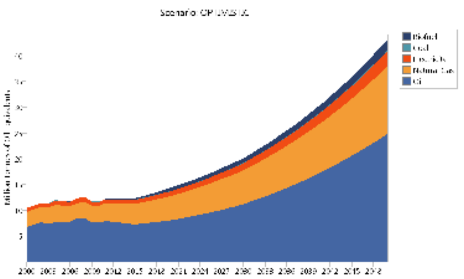

Figure 6: Final Energy Demand in Transport Sector

OPT – Transformation

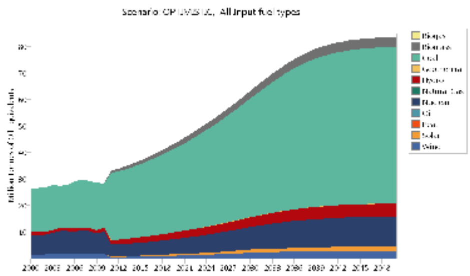

Figure 7: Transformation: Electricity Generation

Pessimistic Scenario

- Mitigation/adaptation policy instruments Ukraine has set into force after 01.01.2011;
- No other additional policy instruments apart from those already decided to be implemented and in line with the EU climate change policy;
- The minimum exploitation of the potential of Ukraine in energy efficiency and RES by limiting the possible technological options only to the promotion of the most promising for Ukraine RES i.e. biomass and wind power.

PES - Key Assumption

- Climate statistics:
  - precipitation is increased by an annual growth rate of 0,75%
  - the average air temperature is assumed to be 13,5 ˚C
- T&D losses for electricity is assumed to be 0,8% and for heat 0,6%
- Increase of biomass use in households up to 3 % by year 2020
- Technological improvements in agriculture are assumed, resulting to 1,25% energy savings in 2020 compared to the amount of year 2009
- Technological improvements in the industry are assumed, resulting to 2,5% energy savings compared to the respective amount for each branch of year 2010
- Technological improvements in the road branch are foreseen, resulting to 10% energy savings by 2015 and to 20% by 2030.

PES – Energy Demand

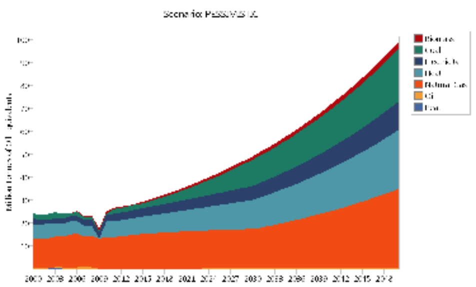

Figure 8: Final Energy Demand in Household Sector

Results of LEAP - Demand

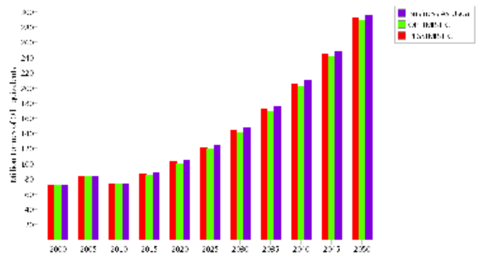

Figure 9: Comparison of energy demand for the 3 scenarios.

Results of LEAP - Transformation

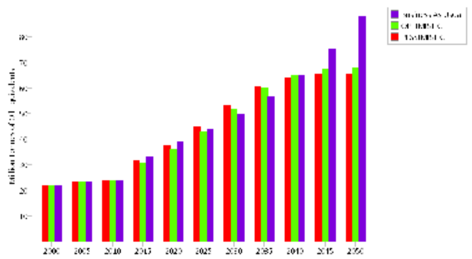

Figure 10: Comparison of the electricity generation results for 3 scenarios

Results of LEAP – Global Warming

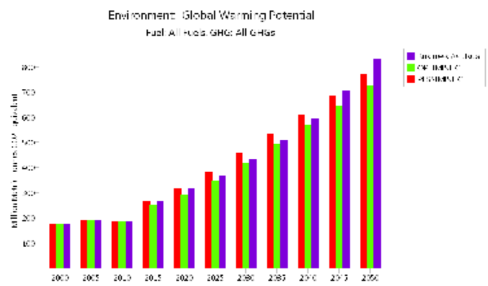

Figure 11: GHG emissions for Ukraine till 2050 for 3 scenarios

Assessment of scenarios using AMS method – General comments

- AMS - multi criteria method;
- AMS method combines three multi-criteria methods:
  - Analytical Hierarchy Process (AHP)
  - Multi-Attribute Utility Theory (MAUT)
  - Simple Multi-Attribute Ranking Technique (SMART)
- AMS is developed for evaluating climate policy instruments, relevant policy mixes and their interactions;
- Three criteria are applied in AMS:
  - environmental performance
  - political acceptability
  - feasibility of implementation

Assessment of scenarios using AMS method – Required data

- Total emissions for the country
- Emissions per sector for the country
- Other environmental effects for the country under each scenario
- Water use for cooling (Energy sector)

Table 6: Total emissions for the country.

Scenario	Total GHG emissions (in $MtCO_{2eq}$)		
	2000	2020	2050
BAU	173,2	317,4	832,2
OPT	173,2	289,5	727,7
PES	173,2	317,9	772,0

Table 1: Total emissions for Ukraine

AMS method - Results

Criteria	Scenarios		
	BAU	OPT	PES
Direct contribution to GHG emission reductions (0,833)	1,467	83,300	0,000
Indirect environmental effects (0,167)	0,000	16,700	0,000
Environmental performance (0,675) - A	**1,467**	**100,00**	**0,000**
Cost efficiency (0,390)	0,000	47,300	9,466
Dynamic cost efficiency (0,227)	5,078	8,044	5,078
Competitiveness (0,103)	3,775	3,775	0,949
Equity (0,188)	0,295	17,500	0,000
Flexibility (0,056)	1,555	2,464	0,981
Stringency for non-compliance (0,036)	1,133	1,133	1,133
Political acceptability (0,259) - B	**11,837**	**80,217**	**17,608**
Implementation network capacity (0,228)	11,743	7,413	11,743
Administrative feasibility (0,685)	21,994	14,112	21,994
Financial feasibility (0,088)	2,639	4,181	4,181
Feasibility of implementation (0,065) - C	**36,376**	**25,705**	**37,918**
Total (A+B+C)	**12,401**	**78,416**	**16,559**

Table 2: AMS results for each scenario

Conclusions

- **BAU scenario:**
  - GHG emissions will be increased compared to those of year 2005 by almost 65%.
  - The RES share in the transport sector for year 2020 is 5% (due to the absence of supportive mechanisms)
- **OPT scenario:**
  - GHG emissions in Ukraine will increase by 51% in 2020 compared to those of year 2005
  - The share of RES in the transport sector in 2020 will be 4,7% (biofuels), and 11,2% in electricity production.
  - The final energy consumption in 2020 will be reduced by 5% compared to that of BAU for the same year.
- **PES scenario:**
  - GHG emissions in Ukraine will increase by 65% in 2020 compared to those of year 2005
  - The share of RES in the transport sector in 2020 will be 2,4% and in the electricity generation it will be 7,35%
  - The final energy consumption in 2020 will reduced by 2% compared to that of BAU for the same year.

Conclusions

- **AMS assessment:**
  - the mitigation/adaptation policy portfolio in the Optimistic scenario is the best one in terms of overall performance;
  - but requires the encouragement of business investments in RES and energy efficiency projects, the continuation of the demonstrated effectiveness of the implementation network and more stringent frame for non-compliance.
- **Problems:**
  - the lack of several reliable data: GDP distribution per sector, energy efficiency in sectors, energy balance of the EU standards, initial data in tourism and health service, transport sector, etc.
  - significant gaps and uncertainties in the available data;
  - the component of adaptation in climate change policy is not fully developed, it requires data related to the frequency of extreme events, water resources and use, low-income groups, biodiversity, etc.
- **Future work:**
  - the report should include more scenarios with the combinations of population and GDP growth.

Needs and gaps

Information gaps concerning Historical data for Key assumptions:

•No data is available in climate statistics for frequency of extreme events (more specifically - heat waves per year, frost days per year) for any year in the studied period. As far as territory of Ukraine can be divided into four different climatic regions: cool snow forest climate, steppe climate, Mediterranean climate and mountain tundra climate, calculation of the previously mentioned parameters is almost impossible. All the climate statistics in Ukraine collected by Central Geophysical Observatory.

•No data is available for GDP Deflator with the reference year 2009 to the whole studied period.

•No data is available for the manufacturing value added for all the industrial sectors. The lack of data applies to the whole studied period. The State Statistic Service of Ukraine (SSSU) has available the primary data needed to calculate the added value for all the sectors.

• No data is available for a volume of water for cooling in energy water use for any year in the studied period. State Statistic Service of Ukraine is responsible for all statistical data and should include this indicators to the list.

Needs and gaps (2)

Information gaps concerning Historical data for Energy Demand

•No energy demand cost data is collected for the all specific sectors of the Ukrainian economy (Households, Agriculture, Services, Industry, and Non-Energy Use) and their sub-sectors. This applies to the whole studied period. This indicator could be calculated for all the sectors mentioned above based on the data provided by energy companies and SSSU.
•There are no available data for energy demand, consumption and costs , final energy intensity for the particular Service sub-sectors, such as Tourism and Health Services. This applies to the whole period 1990-2010. These sectors included to the common branch Other by SSSU.
•In Transport sector, the energy demand data in each type of transport (Road, Rail, Air, and Water) is available, but it is not further broken down into Passenger transport and Freight transport. This applies to the whole studied period.
•There are no data for final energy intensity and demand cost (including per fuel) for all Transport subsectors.

Needs and gaps (3)

Information gaps concerning Historical data for Energy Transformation:
•All financial data required in this section of the database are not available. In particular, there is no available data about the Capital Costs, Fixed OM Costs, Variable OM Costs, and Salvage Value of the energy capacities in the Transformation branches.
•There are no data about the Maximum Availability, Capacity Credit, and Process Efficiency of any Transformation process.
•There are no available data for import and export targets for all transformation branches for the whole studied period.
•No data for potential , efficiency and raw losses available for all transformation branches. This applies to the whole studied period. This data available only at the individual energy production companies.
General information gaps:
•Ukrainian statistic reports have different structure, branches and content compared to Eurostat. Only 3 energy balances (years 2009-2011) published by SSSU respond to the requirements of the Eurostat.
•Most data (such as branches and sub-branches of energy demand, transformation and production) for the period of 1990-2000 is not available that is why all calculations done using data form year 2000. Because of a different statistic collecting system previously mentioned data were collected and provided by IEA.

National Workshop

Development and Assessment of Mitigation / Adaptation (M/A) Climate Change policy portfolios for Ukraine

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Monday 10 June 2013

Venue: *Academic Council Hall of National Technical University of Ukraine "Kiev Polytechnic Institute", 37, Peremogy Avenue, Kiev 03056, Ukraine*

Thank you for your attention!

Needs and gaps

By Dr. Lulin RADULOV

Promitheas-4: Knowledge transfer and research needs for preparing mitigation / adaptation policy portfolios

Research needs and gaps related to the development and evaluation of M/A policy portfolios

L. Radulov, A. Nikolaev
Black Sea Regional Energy Centre

24.10.2013 г. ATHENS

OBJECTIVES

- To summarize the research needs and gaps encountered during the work on Promitheas-4 project, in relation to the development and evaluation of M/A policy portfolios
- Coverage: 12 project beneficiary countries:
  - Albania, Armenia, Azerbaijan, Bulgaria, Estonia, Kazakhstan, Moldova, Romania, Russia, Serbia, Turkey and Ukraine

24.10.2013 г. ATHENS 2

SCOPE

- Research gaps and needs are identified in the following fields:
  - National procedures, sources, and data for M/A policy portfolios, including national GHG inventory, reporting, verification
  - Availability of historical data (1990 – 2010) needed as a basis for the scenario development: demographics, economy, climate, policies and measures, energy demand, energy transformation
  - Availability of modeling tools to simulate the M/A policy effects
  - Availability of information for 2011-2050 for the development of M/A policy scenarios, i.e. climate, demographics, economy, policies, energy demand, energy transformation forecasts
  - Availability of information to carry out scenario evaluation

24.10.2013 г. ATHENS 3

National procedures, sources, and data : Needs (1)

- Strengthening of institutional, legal and procedural arrangements, as well as the capacity and coordination of participating bodies
- Improving the transparency of the inventory and data consistency
- In non-Annex I countries, the regulatory framework concerning organizational, administrative, and informational issues needs improvement, energy balances need to become more reliable and complete, standard Eurostat NACE codes need to be implemented
- Improving the completeness of reporting

24.10.2013 г. ATHENS 4

National procedures, sources, and data: Needs (2)

- Quality assurance (QA), quality control (QC), and verification activities need to be enhanced by setting-up a sustainable MRV system
- Using electronic links and automated procedures for data entry and storage of sources and references, further automation of the emission calculation
- Improvement and enrichment of the capacity of national statistics
- Research on development of country specific emission factors

24.10.2013 г. ATHENS 5

HISTORICAL DATA: GENERAL PROBLEMS

- The collection of historical data since 1990 proved to be impossible and/or irrelevant for most of the countries because several countries underwent major restructuring
- Substantial changes in the data classification took place, due to transition to Eurostat methodology
- In almost all countries there are no available data in electronic format for the period 1990 – 1999
- Some data are available only upon request to the responsible authority

24.10.2013 г. ATHENS 6

HISTORICAL DATA: NEEDS

- To integrate data about frequency of extreme events, availability and use of water resources, land management, and added value of industrial sub-sectors into the national statistical system
- To make available energy demand data, both in energy and financial units, not only for each sector of economy (transport, industry, services), but also for their sub-sectors
- To make available economic and technical data about energy capacities
- To make available official information about the M/A policies and measures, mainly regarding financial incentives (soft loans and subsidies) and land management

24.10.2013 г. ATHENS 7

AVAILABILITY OF MODELING TOOLS

- Adaptation policies and their effects on the economy and the environment are not directly integrated in the models; their integration is needed
- Some energy models reflect well the situation in more developed countries but need to be adapted to the characteristics of economies in transition
- Tools need to better reflect the economic functions, such as utility, agents' time horizon, heterogeneous demand structure, discounting rate, and consideration of environmental costs and benefits

24.10.2013 г. ATHENS 8

Availability of information for 2011-2050: Needs (1)

- Development of long-term (e.g. by 2050) national GDP forecasts, considering how the GDP share of each sector and sub-sector is expected to evolve over the time
- Development of reliable long-term climate forecasts, possibly in scenarios, depending on the anthropogenic GHG emissions. Forecasts of extreme events and water resources are missing in almost all countries
- Assessment of the climate change effects on each of the vulnerable sectors, identification of the adaptation needs, and design of policies and measures to address these needs

24.10.2013 г. ATHENS 9

Availability of information for 2011-2050: Needs (2)

- Development of energy demand forecasts by 2050, broken down by sector / sub-sector and by fuel consumed in each sector / sub-sector. These forecasts include assessment of the energy efficiency potential and renewable energy potential
- Development of long-term forecasts for the energy transformation capacities, including construction of new and phasing-out of existing capacities, expected cost and technical parameters (efficiency, availability, etc.) of each type of capacity
- Assessment of the effects (energy, emissions, costs) of the current and planned M/A policies

24.10.2013 г. ATHENS 10

Scenarios evaluation: Needs

- Ex-ante evaluation of policies, including feasibility of implementation and effects on the environment, costs, competitiveness, equity, etc. (a similar need was identified in the development of M/A scenarios – see above)
- Establishment of policy monitoring and evaluation procedures to better understand the performance of the already implemented policies; publication of the monitoring and evaluation results
- Development of the capacity to apply a multi-criteria evaluation method – in most of the countries there is no experience with the method

24.10.2013 г. ATHENS 11

Promitheas-4: Knowledge transfer and research needs for preparing mitigation / adaptation policy portfolios

THANK YOU FOR YOUR ATTENTION!

L. Radulov, A. Nikolaev
Black Sea Regional Energy Centre

24.10.2013 г. ATHENS 12

PART II

DAY 2 – 10 OCTOBER 2013

Environment – Climate Change

Conceptualizing equitable access to sustainable development – developing countries and technology transfer in climate change negotiations

Dr. Ariel Macaspac PENETRANTE
Institute for Infrastructure and Resources Management
University of Leipzig, Germany
Email: penetrante@wifa.uni-leipzig.de

Abstract

Climate change negotiations require conceptual underpinnings to provide a robust foundation for the whole negotiation system. Principles such as the "common but differentiated responsibilities" or "polluter pays" serve as "political formula" to guide negotiators to achieve mutually acceptable outcomes. Negotiations on technical issues such as emissions reduction often fail due to the lack of guiding principles. After decades of negotiations, the climate change negotiation system is still searching for principles particularly when the negotiators have realized that the principle of common but differentiated responsibilities seems to be itself preventing countries to reach an international agreement to reduce Greenhouse gas emissions as it is increasingly seen to promote free-riding.

As the United Nations Framework for Climate Change Convention (UNFCCC) looks for completing principles, it has asked international experts to come up with ideas how the newly agreed principle of "*equitable access to sustainable development*" can facilitate the negotiation process, by providing guidelines to overcome the divide between developed and developing countries. This paper aims to contribute its understanding of this principle by looking at the fifteen simulation games of the climate change negotiations that the author has conducted to derive ideas on how principles can be used to reach an agreement. Furthermore, this paper concentrates on a case study of how technology transfer in the energy sector can be conducted by states to support the principle of equitable access to sustainable development.

"To go beyond is as wrong as to fall short" (Confucius)

Introduction

One of the most challenging activities when identifying stumbling blocks (and finding ways to cope with them) is that these stumbling blocks are usually obscured by human subjectivity. Academic debates on principles such as equity, fairness and justice inevitable touch on experiential values, whereas attempts to quantify such values may produce further negative consequences that would delegitimize any "noble" goal. As national governments are represented by humans, policies are consequently determined through various individual cognitive processes, which follow specific experiential trajectories. Paradigms, as historical constructs, build "mental anchors" which continuously produce, maintain and enhance perceptions (see Cedarbaum, 1983; Kuhn, 1996). Perceptions, in turn, define preferences and expectations that subsequently frame actions.

As the theory of path dependence suggests, norms, rules and procedures slip away from the awareness of actors as the decision-making process unfolds, and escape any form of self-criticism. Such mental anchors are "paradigms" that may "paralyze" cognitive processes leading to the inability or refusal to look outside the current model of thinking (see Kuhn, 1996). A mental anchor is a lock-in situation where the potential for change or further movement remains low (David, 1988). The internalization of these norms, rules and procedures determine cognitive thinking to the point that it may hinder flexibility.

Paradigms or "cognitive constructs" have the purpose of containing contingencies to enhance decision-making. They allow the development of expectations and incentives through which goals and actions are precisely constituted. These paradigms involve routines that enable actors to focus resources on other important areas; thus, paradigms enhance efficiency. For instance, the concept of 'territoriality' is a paradigm developed after the Westphalian peace that purports state sovereignty, elucidating independent decision-making within that specific territory. As a paradigm, territoriality/sovereignty is close to becoming a quasi-dogma or even a legal doctrine: the sanctity of the current boundaries in Africa, for example, has determined international foreign policy around civil unrest in the region. Challenges to existing boundaries, whether through rebel groups or neighboring countries, tend to be considered pejorative to the principle of sovereignty, leading to various sanctions being implemented.

That a paradigm can be shifted is not a new idea (see Handa, 1986; Kuhn, 1996; Hoyningen-Heune, 2011). Paradigm shifts are necessary when mental anchors no longer serve the contingencies they are supposed to address. In some cases, actors may realize that existing (and dominant) values and social institutions are no longer efficient, and no longer fit the changing conditions of that time. Although paradigmatic shifts may cause enormous transition costs in order to move from one paradigm to the next, and although they may face fierce objection by powerful societal actors, actors may still manage to shift the way they think. As paradigms are frequently established within existing power structures and reproduced by power asymmetries, initiatives to change such paradigms may be easily regarded as threats to the entire system and to the powerful groups that sponsor them. A "paradigm economy" - where specific actors actively profit or enjoy positive externalities from existing phenomena - is understood to imply contestation processes when paradigm shifts are sought. Shifts will be most likely challenged by actors profiting from the status quo. In similar cases, actors may realize that it is impossible to shift paradigms as there is no credible alternative available, and that shifting may materialize unknown risks, such as unanticipated power vacuums ("paradigm shift dilemma"). Therefore, they may merely resort to the transparent identification of such paradigms and the development of strategies designed to prevent "paralysis,", rather than attempting to genuinely resolve the conflicts caused by obsolete ways of understanding social subjects. Nevertheless, shifting paradigms is not done for the sake of shifting. A paradigm, as described above, has a distinct purpose particularly in decision making.

In various complex cases, such as in the global environmental context, actors may realize that there is a plurality of paradigms among them. Ideally, deciding on specific problems such as climate change requires that decision makers think the same way, especially when looking at various conceptual issues. The plurality of paradigms may, for example, lead to the failure to reach consensus on what the real problem is. As the complexity of climate change leads to the multidimensionality of rationales and perspectives, climate policy makers may be confronted with complementing and/or competing paradigms. In this matter, no paradigm shift is needed, but rather a "consensus" on which paradigm should be employed at all.

The diversity of models of thinking leads to great diversity in how the problem is viewed. This may inhibit decision making as deliberations may not come up to consensual solutions. As paradigms may determine negotiation formulas or formulate the agenda for the talks, multilateral negotiation processes should start by ascertaining whether there is consensus on paradigms – they should deconstruct the construct. Because global climate negotiation is confronted by the lack of consensus on paradigms, particularly on justice and fairness, a kind of "consensus diplomacy" becomes indispensable.

The Parties to the United Nations Framework Convention on Climate Change (UNFCCC) introduced the notion of equitable access to sustainable development in the Cancun agreements, in the context of a timeframe for global greenhouse gas emissions. They have identified the overarching priorities of developing countries as being social and economic development and poverty eradication; in light of this developing countries will need more time to reach their peaks than developed nations (UNFCCC, 2012).

The centrality of the principle of equity is not new to the UNFCCC. It deals not only with conventional issues relating to mitigation and adaptation, but it also involves the decision-making process itself. The difficulty of reaching consensus can be attributed to the lack of agreement on which analytical level equity should be defined. An example of this is equitable burden-sharing, that is, resource-sharing or sharing the available carbon budget in accordance with the principles of equity vs. effort sharing, or sharing the necessary effort (costs) in accordance with the principles of equity (UNFCCC, 2012). At the Conference of the Parties (COP) 17 in Durban, South Africa, the UNFCCC secretariat and related bodies started conducting informal consultations on EASD. This led to a workshop at the fifteenth session of the Ad hoc Working Group on Long-term Cooperative Action under the Convention, which was held on 16 May 2012 in Bonn, Germany (UNFCCC, 2012). The workshop initiated a public discourse on EASD; in particular, the context for equity and EASD, the definition of equity and the application of the equity principle. This paper intends to contribute to this academic discourse and seeks to deliver insights into how equity and EASD can be defined, operationalized and implemented from the perspective of the negotiation process.

Notions of Justice and Fairness – The North-South Consensus Diplomacy

The entanglement of the climate change negotiations in the North-South divide is an immediate implication of competing interests between developed and developing countries (see Penetrante, 2010, 2013). The definition of relations between the "North" (developed countries) and the "South" (developing countries) inform not only which results are viable, but also which procedures are acceptable, particularly when existing decision-making structures are perceived as favoring developed countries and inhibiting the equal participation of developing countries. The North-South conflict cleavage moves along the contestation line of how countries understand justice and fairness (Penetrante, 2010, 2013). Focusing on perspectives provides insights into the differences between how justice and fairness are defined by actors.

While academic literature tends to use 'justice' and 'fairness' as interchangeable, this research project makes a clear distinction between these two terms. The notions of fairness and justice among countries are attributed to past experiences (backward-looking) and to future expectations (forward-looking). Thus, relating narratives to the negotiation process provides the distinction of fairness from justice. While fairness pertains to the procedure by which decisions are made, justice refers to whether an outcome satisfies the needs of the actors and whether it addresses their capabilities. Cecilia Albin (2001, p. 264) follows a similar distinction between what is just and what is fair. She notes that agreements (as the outcome of the negotiation process) are just if these agreements are based on principles that the parties themselves consensually agreed. An agreement is fair, she continues, if the circumstances leading to the agreement are reasonable. If, for example, the parties to the UNFCCC have agreed to the principle of sustainable development, an agreement is just if it does not undermine sustainable development. However, this just agreement can be unfair when the methods applied to reach this agreement do not consider the various diverging capacities of actors.

Negotiation studies looks at the negotiation perspective of decision-making, wherein accurate descriptions of negotiation counterparts (with regards to their positions, interests, behavior, goals and actions) are considered useful in formulating strategies to resolve conflict cleavages (Luce and Raiffa, 1957; Schelling, 1960; Fisher and Ury, 1981; Raiffa, 1982). The entanglement of climate change negotiations in the North-South divide implies conflicts, making the negotiation perspective highly useful. Negotiation studies is usually concerned with methods of dispute resolution, and focuses on three types of justice: procedural justice, distributive justice and retributive justice. Procedural justice is concerned with fairness in the dispute resolution and resource-allocation processes, such as the equal participation of developing countries in all parallel meetings. Distributive justice, in contrast, focuses on fairness in the distribution of rights and resources, such as basing emission rights on levels of economic development. Finally retributive justice is concerned with fairness in the rectification of wrongs, for instance, through compensation payments to countries highly affected by climate change (see Rawls, 1971; Albin, 2001; Müller, 2001; Bone, 2003; Vanderheiden, 2008).

The simulation games on climate change negotiations (see Penetrante, 2012) confirmed the tendency of these various types of justice and fairness – procedural, distributive and retributive - to compete among each other. The author of this paper has conducted several simulation games, both with students and scientists between 2009 and 2012. The results of the games are preliminary interpretations of various concepts that may be relevant in the global climate talks. The games showed that these types of justice may actually undermine each other, which raises questions around, which kind of justice should be prioritized. Nevertheless, prioritizing one type of justice over the others might unintentionally produce new injustices, as this prioritization is itself a decision that requires normative assessments. Furthermore, a fair procedure can diminish the effectiveness of a potential outcome. It cannot always be assumed, for example, that the democratic process is always the fairest, as involving all countries in a decision making process for the mere sake of comprehensive representative democracy may disproportionately affect specific countries.

For instance, developing countries, particularly those with the largest emerging economies such as China and India, may demand retributive justice by seeking exceptions from legally binding GHG emission reduction schemes by arguing that developed countries are held historically and morally responsible for the current concentration of GHGs in the atmosphere. This demand may however be in opposition to the distributive justice demanded by developed countries, particularly when certain developing nations such as China and India are projected to bypass developed countries in terms of GHG emissions in the next few years or decades. Efforts to reconcile these two positions may however undermine procedural justice/fairness, as LDCs with very low emissions may opt out of negotiations over this issue in favor of bilateral negotiations.

When the negotiation process deals with the distribution of benefits and costs, it tends to create power struggles, as the negotiation process has become zero-sum. This tendency has been confirmed by the participants of the simulation games. The participants who played individual countries noted that it was almost impossible to understand the perspectives of the others in a competitive (distributive) negotiation process. This implies that pursuing distributive justice inevitably reduces the bargaining process to a power struggle. It suggests that notions of justice and fairness are merely instrumentalized to enhance bargaining power. Therefore, the political instrumentalization of the principles of justice and fairness may effectively inhibit perspective change.

The boundary between the North and the South has been mainly determined by countries' positions around who should pay for the costs of mitigating and adapting to climate change, and how much should be paid (see Beyerlin, 2006; Penetrante, 2010, 2013). Such mitigation costs include direct investments into low emission technologies, technology transfer, and the opportunity costs brought by abandoning cheaper, higher emission technologies. These positions are products of how countries understand the concepts of justice and fairness following deliberations on their national circumstances. Nevertheless, as described above, the multidimensionality of climate change as well as the diversity of experiences among actors leads to a diversity of paradigms, implicating, among other things, differences in notions of justice and fairness. As Zartman (2003: 34) notes, "relevant principles of justice [are] likely to be loose, contentious, tentative, and fluctuating".

For the North, a fair and just mitigation measure employs mandatory cuts that would not distort sound competition between future generations of actors from developed and (formerly) developing countries (Schelling, 1995; Meyer, 2004; Posner and Sunstein, 2010; Posner and Weisbach, 2010). Therefore, mitigation should not be shouldered by developed countries alone, and developing countries, must also adopt concrete GHG emission reduction policies. It is of particular importance that those emerging economies projected to be responsible for future growth in the level of emissions (such as China and India), should employ GHG emission reduction policies, which may or may not be complemented by various flexibility mechanisms.

For the South, a fair and just mitigation measure addresses historical responsibilities and diverging vulnerabilities as well as capabilities (Agarwal and Narain, 1991; Müller, 1999; Najam, 2005). Compensatory actions should complement global climate policies to ensure that historical wrongs are addressed (Müller, 2001). Reduction schemes should be complemented by capacity building and technology transfer, which does not compete with the Official Development Assistance (ODA). Developed countries are obliged to provide concessional assistance of at least 0.7% of their Gross National Product (GNP) to developing countries as affirmed by several international agreements reached in various meetings (such as the 1970 General Assembly, the 2002 International Conference on Financing for Development in Monterrey, Mexico, and the 2002 World Summit on Sustainable Development in Johannesburg (UN Milliennium Project, 2013)). With only five countries - Sweden (1.12%), Norway (1.06%), Luxembourg (1.04%), Denmark (0.88%) and the Netherlands (0.82%) - currently fulfilling their ODA obligations, additional subtractions from the ODA for climate funds is seen as inequitable, as climate projects tend to favor developing countries with emerging economies (see Silayan, 2005; IGES, 2011). Furthermore, fairness and justice should be reflected in the processes through which decisions are made. Therefore, institutional capacity building that would allow weaker parties to effectively participate in various parallel meetings should be considered part of any fair measure that aims to address climate change.

The diversity of paradigms on equity, fairness and justice requires the apparent bridging of competing notions and the recognition that each conceptual understanding is legitimate. However, the terms 'fairness' and 'justice' may be abused to legitimize one's position and increase one's bargaining strength. In this perspective, an agreement is fair and just if it serves one's own interests. Such an attitude renders fairness and justice useless. Nevertheless, as this research project argues, while global climate change negotiations presuppose a consensus on how justice and fairness should be understood, the concerns of each individual country should be recognized and adequately addressed. If individual concerns are taken as legitimate, countries may relax their defensive mode, allowing global climate talks to move forward.

While justice is directed to the outcome and fairness to the procedure, equity pertains to participation. Equity demands that the various background conditions and diverging departure points confronting each actor are appropriately addressed when assessing the "quality" of one actor's participation at the negotiation process. As the global climate change context shows, focusing on allocations of resources through the negotiation process requires complementing the notion of fairness and justice with the notion of equity. The preference to participate is determined by one actor's assessment of equity during the negotiation process. Any sustainable outcome of global climate talks will need not only to adhere to fair procedures and just outcomes, but should also adequately recognize different contributions of individual countries, as well as the differing benefits and rewards under conditions of uncertainty and diminishing resources.

The following section provides a focused analysis of equity in the global climate change negotiation context.

Equity in Climate Change Negotiations – Questions of Compliance and Global Common Goods

There is consensus among developed and developing countries that issues of equity are of central importance in global climate talks (see Grübler and Fujii, 1991; Ott et al., 2004; Buchner and Lehmann, 2005; Heyward, 2007). Any climate regime must reflect the equity concerns of all countries if the regime is to be resilient and sustainable. As Katherine Richardson et al. (2011) note, response strategies to deal with climate change will invariably confront equity issues. These include the allocation of emission rights and emission reduction obligations, as well as the responsibility for funding adaptation and distribution of adaptation funds. The principle of equity has been most frequently applied to the allocation of mitigation costs among countries. Furthermore, dealing with the equity aspects of climate change will depend on the relational structures in the decision making process, whereas power asymmetries will tend to reinforce existing power relations.

The perceived abandonment of equity principles of the UNFCCC and the Kyoto Protocol, as claimed by many experts in developing countries (Najam, 2005; BASIC Experts, 2011), requires the reconsideration of equity questions. The UNFCCC does not clearly articulate the quantified meaning of equity, but rather has identified only the categories of developed and developing countries. 'Equity' has become a diffuse term, and its interpretation has been subordinated to national interests (see Heyward, 2007; Kals and Maes, 2011). In light of this, the UNFCCC secretariat has openly invited the academic community to participate in a discussion around equity, to initiate attempts at specifying possible standards of equity, and to explore how equity issues should be pursued in global climate talks. This deliberation should complement current climate talks, particularly if post-Kyoto mechanisms to reduce GHG emissions are to be achieved. From the negotiation perspective, questions of how equity can ensure compliance should be additional topics of public deliberation.

Equity is a theoretical concept through which actors orient their own behavior when interacting with the others. John Stacey Adams (1965) suggests that actors seek equity before and during contacts with others. The equitable condition is considered as the optimal situation (equilibrium), as actors will no longer experience distress in situations where they are convinced that the ratio of what they contribute (input) and what they earn (output) is generally acceptable. Inputs are each participant's contribution to the relational exchange, which entitles one actor to rewards or benefits. Examples of inputs are time, effort, resources, ability, commitment and various forms of liabilities (see Walster et al., 1978). Outputs are positive and negative externalities incurred as a consequence of this relational exchange when achieving a common goal. Examples of outputs are financial gains, recognition and the achievement of predetermined goals (see Walster et al., 1978). It is assuming that actors seek to maximize outputs, and that a failure to do so brings distress. As such, when actors encounter distress (for instance, when negotiating with the others), efforts are conducted to restore equity within that relationship.

The theory of equity is only applicable in a social context, as the acceptability of a specific situation or of a specific outcome highly depends on one's assessment of how much input the others have contributed. Equity is measured by comparing one's ratio of inputs and outputs to that of others. Similar ratios manifest equity, whereas actors do not need to contribute equal amounts of inputs in absolute terms. nor do they need to receive equal rewards (see Guerrero et al., 2010). Equity also covers individual capacities in contributing inputs. Distress occurs when one actor sees another actor with similar capacities but lower contributions receiving similar or greater outputs from the common project. More distress arises when non-contributing free-riders harvest common benefits. Distress inevitably leads to actions.

The social component of equity delivers the identification of equity issues as actors constantly compare their actions with those of the others (see Adams, 1965; Guerrero et al., 2010). Additional efforts are needed to restore equity in global climate talks, where differentiated inputs are expected among countries - depending on their level of economic development (capability) as well as their historical responsibility - and where benefits and rewards (stabilization of GHG emissions leading to the achievement of 2°C) are considered global common goods (under conditions of non-exclusivity and yet rivalry).

Actors, when seeking equity in their relationships, establish institutions and mechanisms that "equitably" apportion rewards and sanctions among members (see Walster et al., 1973, 1978) to allow alterations of inputs and outputs in order to restore "actual equity" (Walster et al., 1973, p. 6). Various issues of equity are embedded in the UNFCCC (1992) as well as in the Kyoto Protocol to ensure that the outcomes of these rigid and tedious compromises will remain robust against future challenges. The principle of common but differentiated responsibility (as highlighted in Article 2 of the convention) recognizes that while all countries should protect the climate system, developed countries should take the lead in combating climate change, because they bear the greater burden of historical responsibility and possess a superior capacity to respond (see Oppenheimer and Petsonk, 2005).

Nevertheless, the presence of some forms of equity was quickly abandoned, particularly by developed countries (see Huq and Sokona, 2001; Najam et al., 2003; BASIC Experts, 2011) raising the question of whether equity can ever be achieved. Doubts become imminent around whether inputs and outputs of countries are in any way commensurable, particularly when the expected output is calculated in relational terms (for example, when dividing the benefits of stabilizing GHG emissions in the atmosphere among all countries). For instance, if the United States would accept legally binding mitigation targets as its input, can it compare this input with that of smaller countries with very low emissions (such as the Fijian Islands or Mali), especially when the preferences for equity between these countries are very different? As the vulnerabilities to climate change are different, the stakes at the negotiation table and the expected liabilities when doing nothing are also different. While for some countries, it is a matter of ensuring economic competitiveness in a globalized world, for others, it is a matter of national survival and the continued existence of their citizens.

Especially when it is not possible to exclude other big polluters from harvesting benefits (the non-exclusion principle of global common goods), and when emission reductions may even encourage emission growths among developing countries through various forms of leakage effects (Finus, 2001; IPCC, 2007, p. 53) undermining just outcomes, equity is only possible under four conditions. These are: 1) when inputs and outputs are comparable, 2) when fair procedures are present when establishing mechanisms for compliance and verification, 3) when equitable behavior is more profitable than inequitable behavior, and 4) when there is no free-riding to ensure just (and therefore effective) outcomes.

In addition to looking for insights into how inputs and outputs are comparable, the next step for the analysis of equity is to find strategies to increase negative externalities of free-riding compared to the benefits of doing nothing (or "business as usual"), while ensuring fair procedures and just outcomes. The following section introduces a concept of equitable access to sustainable development, wherein countries realize that non-compliance (or non-equity) is less profitable than compliance.

Internalizing Externalities in a Power Game – Call for Lock-in Climate Standards

As the secretariat of the UNFCCC and its parties prepare for the upcoming COP meetings, with the intention of putting in place a post-Kyoto emission regime, international experts have been asked to come up with ideas around how the newly agreed principle of "equitable access to sustainable development" (EASD), which would be used by parties to guide their climate policies and their preferences in the next negotiation rounds, should be conceptualized in a way that parties can overcome various North-South conflict cleavages without undermining the effectiveness of the outcome in addressing climate change. This research project argues that any principle of equity should fulfill the above mentioned conditions: commensurability of inputs and outputs, procedural justice (fairness), and profitability of participation through additional negative externalities for free-riding.

The reconciliation of tension between "global climate optimum," and the "national climate optimum," is a huge challenge for the global climate talks (see Endres, 2008, pp. 350–352). The global climate optimum refers to a situation where the total marginal costs of preventing global temperature change from surpassing 2°C correspond to the total marginal costs caused by climate damages. The national climate optimum, in contrast, is a situation where the marginal costs of national climate protection measures match the total marginal costs of climate damages in one specific country Due to the asymmetrical distribution of vulnerabilities to climate change, as well as the proposed asymmetrical allocation of emission targets dealing with global common goods, formulating global decisions within the global climate optimum remains a huge challenge.

As global decisions are made through a national lens, the national climate optimum dominates the bargaining table, as the paradigm of sovereignty has been locked into the negotiation process. Moving from the national to the global optimum requires, besides the unknown amount of transition costs, an increase in the benefits of committing to a global climate optimum. As climate is a global common good, some national governments are convinced that their total marginal costs for climate protection measures are higher than the total marginal costs of preventing climate damages, not only because they may be less vulnerable, but because they have the capacity to free-ride. As the expected costs of rejecting a contribution for global protection measures are often less than complete participation in the global emission regime, free-riding behavior flourishes. Therefore, a country seeking a global climate optimum expects deterioration of welfare as well as of economic competitiveness, for example through the relocation of high emitting companies to countries with more relaxed climate policies (see Finus, 2001). In instances such as these, free-riding is the most rational behavior.

There already exist propositions to bridge the gap between marginal social costs and marginal private costs (see Barthold, 1994; Varian, 1994;

Farzin, 1996). Internalizing negative (and positive) externalities is seen to prevent this free-riding problem by allocating (monetary) values to common goods, through which the attractiveness of doing nothing diminishes. Examples of internalizing externalities include Pigovian tax directed to the actors either causing the externalities or positively affected by externalities, combined with direct and indirect forms of subsidies to actors affected by negative externalities, where subsidies are shouldered by tax revenues. Internalizing externalities primarily aims to increase the marginal private costs and to compensate those shouldering social costs. Other forms of internalization include environmental pricing schemes such as ecotaxes and trading pollution permits.

Nevertheless, internalizing externalities is confronted by various challenges. For instance, it is not always possible to convert externalities to monetary values. When the value of carbon permits is too low, participating actors may be discouraged from changing their behavior, as the internalizing measure may not really increase marginal private costs and polluting may promise more dividends. Internalizing externalities can only be effective if the measures taken would increase marginal private costs to a level that surpasses marginal private benefits under the ‘business as usual’ scenario, and that they are made to shoulder more marginal social costs.

Another challenge refers to the exact attribution of costs to those actors causing the externalities. Under conditions of complexity, externalities may not always be relatable to those actors causing externalities. The attribution of externalities becomes the subject of fairness, justice and equity deliberations when a specific externality is caused by a collectivity within a specific (long) time period, and that this externality is only materialized after a specific number, degree or level has been reached.

For instance, several experts claim that European countries have regularly contributed up to 80 per cent of the global GHG concentration in the last centuries (Müller, 1999; Pachauri and Reisinger, 2007). However, when global temperature rise surpasses 2°C, and the ‘tipping point’ is reached by additional emissions from developing countries, the damages may be easily attributed to the latter emitting countries. Particularly, when past emissions are considered as sunk costs, there is tendency to over-value present costs and disregard sunk costs in the calculation of marginal private costs. This leads to an imbalance of attribution. Additionally, in order to internalize externalities through legally binding measures, a government, legal framework and legislation must already exist at a global level in order to ensure effectiveness. This is presently not the case.

Because the internalization of externalities has a compensatory character, it may be a subject of political interest, moving it away from an economic to a political paradigm. In contrast to an economic paradigm, where decisions are made according to costs and benefits, political paradigms foster power struggles, which may favor powerful parties. When powerful parties are considered as the “entrepreneurs of externalities”, an underestimation of externalities may occur. Further, when powerful parties are considered to be “recipients of externalities,” compensatory payments may be overestimated. This power game debars the logic of internalizing externalities, as the matching of marginal private costs with marginal social costs will more than likely be distorted.

Nevertheless, the profitability of free-riding may be diminished by using the insights of path dependence. According to path dependence, the adoption of a specific standard becomes more attractive to the participants when alternative standards become more expensive, for instance, through network effects. When the majority of participants adhere to a specific standard, this standard becomes “locked-in” and this is then reflected in other technologies and future decisions. A locked-in standard implies that other (competing) standards become more expensive, for instance, when opportunity costs arise by not adopting the lock-in standard.

In the climate change context, when the majority of countries have adopted climate protection standards, other (high-emission) standards (e.g. business as usual) will eventually be more expensive, particularly when standards related to low emission technologies have been asserted in subsequent technological development. For instance, when adhering to the climate protection standard produces additional and niche markets such as the carbon market, or when this standard leads to the type of technological development in related fields that could not have been reached in a ‘business as usual’ situation, countries are motivated - if not forced - to rethink their paradigms if they are to prevent further loss in competitiveness. As countries realize that unacceptable opportunity costs are arising and that their economic competitiveness is undermined by missed opportunities, they will be motivated to follow the majority in adopting the climate protection standard. New pressure groups that benefit and support energy policies and that promote climate protection measures may later on outweigh those that hinder climate protection policies. Groups of this kind represent companies in the renewable energy sector, and forward proposals such as increasing the share of renewables in a country’s energy portfolio. With new environmental standards inevitable, governmental agencies and business communities may be more readily prepared to commit to further climate friendly investments. Free-riding becomes irrelevant, as business as usual is translated into diminishing economic competitiveness when the lock-in standard is not adopted. In this case, compliance becomes optimal as non-compliance means unacceptable additional costs and additional economic disadvantages.

A fundamental question then arises: How can most of the countries be motivated to adopt climate protection standards, particularly when adoption causes short-term economic disadvantages as caused by various leakage effects? As path dependence argues, these short term economic disadvantages when adopting new standards are merely transition costs, that is, the costs of changing pathways. For example, leadership can be tapped in order to facilitate this transition when leaders are willing to shoulder short-term transition or switching costs. This is however only feasible when leading countries see long-term benefits under conditions of uncertainty. By anticipating long-term benefits, including economic advantages as "first movers", major countries may be motivated to initiate ambitious policies and investments that only yield rewards in the long-term.

A Principle of "Equitable Access to Sustainable Development" (EASD)

After resolving the question of how a specific paradigm or a principle may ensure compliance, the next step involves finding an understanding of the principle "equitable access to sustainable development" that can be locked-in. Resolving equity issues is just one face of the "trinity" of the principle of "equitable access to sustainable development." Besides equity, the principle deals with "access" and "sustainable development" which are, similar to equity, loose concepts with diverging possibilities of understanding and operationalizing. The EASD principle involves various conflict cleavages that are identifiable as moving within the North-South relations. The various definitions of sustainable development as well as many divergent interpretations and practical applications (Gibson, 2005) make public deliberation necessary. Comprehensively understanding the EASD principle may lead to insights into possible strategies, and to designs for a future climate regime by exploring opportunities created by synergies between equity, procedural fairness (access) and sustainable development.

Relating the EASD principle to the global climate talks moves the focus not only to the fairness of procedures but to the providing the basis for just outcomes. Equitable access builds on the distribution of means that enable actors to use available resources to achieve a specific goal, that may or may not correspond with collective goals. As the IPCC Second Assessment Report (SAR) (1995) has maintained its focus on equity and sustainable development, the report noted that a climate regime cannot be equitable in its structure and implementation if it does not follow a legitimate process that empowers all actors to effectively participate as social peers (see Fraser, 2003). The capacities of weaker parties should also be enhanced through compensatory mechanisms. Access to resources is equitable when individual conditions that inhibit inclusions are identified and remedied in a compensatory manner.

'Sustainable development' is a concept that incorporates the understanding that an optimal (sustainable growth) policy is a policy that seeks to maintain an "acceptable" growth of income without depleting the natural environmental stock (Turner, 1988, p. 12; see Gibson, 2005). It asserts that "development that meets the needs of the present generation [is possible] without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). The analysis looks at how climate protection measures such as GHG emission reduction can produce benefits for sustainable development, particularly when tensions between sustainability and development arise. It also addresses how the link between sustainable development and climate protection can become self-evident (see Jabareen, 2006).

The global climate talks have been confronted by developmental concerns of parties when climate and developmental agendas have been merged (UNEP, 1992; see African Development Bank, 2003; UNDP, 2007; World Bank, 2010). Recent calls to decouple emissions from development (UNFCCC, 2012) have become prominent as a feasible strategy to resolve some North-South issues. However, insights are still needed how such a decoupling could and should be conducted in a very complex and interdependent system. Further, the classification of developed countries to the Annex list and of the developing countries to the Non-Annex list may have institutionalized the North-South conflict cleavages in the negotiation process. Climate issues, dealing with questions of population (human settlement), (urban) lifestyles and resource demand and consumption (agricultural and industrial production) involve economic and social activities that are confronted by limits on environmental resources (Ehrlich, 1968; Meadows et al., 1972; Jackson, 2008). Any climate regime that would allocate carbon limits would need to include stringency provisions that would equitably distribute limits among countries.

The drafting of the UNFCCC is part of a process following calls for putting environmental and developmental issues into the political area of international policy making. In 1984, the UN commissioned an independent body, the so-called World Commission on Environment and

Development, that published a report entitled "Our Common Future" (1987). The deliberation initiated by this commission has been used as the basis for other conferences, including the UN Conference on Environment and Development in Rio de Janeiro in 1992. This "Earth Summit" has resulted in various agreements including the 1992 Rio Declaration on Environment and Development, Agenda 21 and Forest Principles. Complementing these agreements are the three legally binding agreements: The UNFCCC (1992), the Convention to Combat Desertification (1992) and the Convention on Biological Diversity (1992). Subsequent agreements including the UN's Millennium Development Goals (2000) and Outcome document – Future We Want (2012) reached during the UN Summit "Rio+20" held in Rio de Janeiro in 2012 have secured further political commitment for sustainable development.

While there is more likely a consensus among countries that poverty is a major cause and effect of global environmental problems such as climate change, and that sustainable development is a central concern of both developed and developing countries, national governments still need to define allocation mechanisms. These would allow equitable access to resources and capacities - including carbon emissions in the case of climate change - that enable, maintain and enhance sustainable development. National governments are furthermore uncertain as to how many emission limits are tolerable to guarantee sustainable development. Because climate change poses threats to the ecosystem upon which economic, social and environmental activities of both present and future generations rely, the goals of the UNFCCC, that is, the stabilization of GHG emission concentration that prevents surpassing 2°C, have become closely linked to the goals of sustainable development. This has led to the coupling of emissions to sustainable development.

As carbon emissions are linked to industrialization and manufacturing, as well as to agricultural outputs (see Stern, 2007), setting up a carbon budget that aims to stabilize GHG concentrations is assumed to have negative effects on economic growth, the driving motor of sustainable development. Economic growth is then translated to four main areas. These include: increases per capita income that drives private consumption (Lucas, 1988; Barro, 1997; Pokrovskii, 2011); modernization processes including enhancement of human and social capital that ensure social cohesiveness (Bourdieu, 1983; Becker, 1993; Haq, 1996; Dasgupta and Serageldin, 2000); legitimacy of governance and political structures that ensure political stability (Kooiman, 1993; Fisher and Green, 2004; Ostrom, 2010); and finally technology innovation through investments and financing, which promotes the global competitiveness of individual countries (Jonas, 1984; Carraro and Siniscalco, 1994). Economic growth is therefore the foundation of human well-being.

In this sense, trade-offs between climate protection strategies and sustainable development goals may lead to grave concerns in distributing emission cuts among countries, as emission reductions may impose limitations on economic growth and development. Equally, reaching the goals of sustainable development may generate co-benefits for climate protection strategies, particularly when enhanced economic capacities may lead to diminishing vulnerabilities, or to increasing adaptability to climate change. A principle of EASD should address complex trade-offs between climate protection strategies and sustainable development.

The following table simplifies the distribution of shares and entitlements of GHG emissions. It shows the gap between the share of developed and developing countries in historical emissions (1850-2000). The UNFCCC asserts that emissions should be calculated from the beginning of the Industrial Revolution, something that has been recognized by most participating countries. It confirms that developed countries account for 878 Gt of cumulative global emissions between 1850 and 2008, with 310 Gt considered as their fair share (overuse of 568 Gt) (Khor, 2012). This poses a huge challenge for any future emission reduction regime when distributing entitlements for future GHG emissions (2000-2049).

The determination of equitable allocation of entitlements in the future carbon budget (2000-2049) between developed and developing countries is not only highly dependent on figures and calculations in the scientific literature, particularly of the IPCC, but is also vulnerable to political conditions. For instance, the identification of 2°C among possible scenarios (2°C, 3°C, 4°C) is a political decision which addresses (still) acceptable consequences of climate change with a global temperature rise of 2°C. The scientific literature notes that there are various probabilities based on not exceeding the 2°C threshold of GHG concentration. Nevertheless, as political decisions are now oriented towards the principle of equitable access to sustainable development, categories such as historical responsibility, per capita income, and national capabilities are needed to determine entitlements, carbon budget and how efforts/burdens are to be equitably distributed. However, political decisions assume that all countries require the same amount of emissions to achieve industrialization, whereas new technologies tend to produce low emissions, particularly when efficiency is coupled with less energy consumption.

As the table illustrates, entitlements to cumulative total CO_2 emissions (2000-2049) can be equally (in absolute numbers) distributed among countries (the "desert" strategy). However, equality does not always correspond with equity as equality does not always address the individual circumstances that inhibit or promote participation at the decision making process. Allocation of emission rights to countries, as several countries demand, should address the relative share of the country's population in the global population in a given specific base year. This allocation scheme is however rejected by smaller countries with smaller populations. Qatar, Kuwait and Bahrain belong to the five highest per capita emitters as a result of small populations producing high emission commodities for export. Similarly, a number of small-island states rank relatively high, including Trinidad and Tobago, Antigua and Barbuda Singapore, Palau and Nauru (Baumert et al., 2005, p. 21). Therefore, a formula that focuses on per capita emissions will be unjust as it distorts environmental integrity. Furthermore, entitlements for future emissions as conveyed by the UNFCCC will need to include not only current emissions, but also historical emissions (Grübler and Fujii, 1991; Smith, 1991). Developing countries are also expected to have large positive entitlements as a result of the negative entitlements of developed countries for the period of 2000-2049 (BASIC Experts, 2011). Developed countries are then expected to have negative emissions (baseline 1990), which to date remain politically unacceptable.

Negative entitlements for developed countries remain a highly contested issue as developed countries are not likely to find it equitable that current generations are to be "punished" for the actions of older generations. In addition, as negative entitlements for developed countries would mean positive entitlements for developing countries, contra-productive leakage effects may take place, overturning all gains from climate policies and leading to "unjust" outcomes that undermine the environmental integrity of the agreement. In addition to business companies using high emitting technologies, and relocating to (developing) countries with more relaxed climate policies (a leakage effect of 100%) (see Gerlagh and Kuik, 2007), developing countries may be motivated to increase their use of high emitting fossil fuels (more than the initially intended level) due to falling world prices following more ambitious climate policies in developed countries, thus, further increasing emissions from developing countries (see Endres, 2008). In addition, sinking prices for fossil fuels may actually inhibit investment in renewable technologies, delaying the development of more efficient and less costly renewable energy technologies. With such leakage effects, estimated by IPCC (IPCC, 2007, p. 53) to range between 5-20 percent (with Kyoto Protocol in place), the benefits of ambitious climate policies may be less than the mitigation costs. These are similarly legitimate concerns that need to be addressed.

While developed countries have contributed the most emissions in the past, developing countries are projected to produce most of future emissions, while their per capita emissions are projected to stay below the levels of developed countries (IPCC, 2007). In addition, future emissions vary in how they translate to responsibility, as various types of emissions - "survival emissions", "developmental emissions" and "luxury emissions" (Agarwal and Narain, 1991; Shue, 1993; Rao and Baer, 2012) - are to have different meanings, leading to more integrated and comprehensive political assessments. Therefore, the financing of low-emission technologies as well as the means to increase energy efficiency should become priorities for developing countries. The UNFCCC (2007) estimates that at least $65 billion is needed in additional mitigation investments by 2030 to enable developing countries to maintain their entitlement. In addition to the question of how this considerable amount for investment is to be shouldered (and by whom), additional hidden costs such as transition costs in choosing a low emission technology path may not be bearable for individual developing countries, particularly when a significant amount of financial resources are already needed to cope with the damages brought on by climate change.

Furthermore, measures are also needed to equitably distribute emission rights among developing countries, particularly when the five BASIC countries are expected to contribute the most to the increase of emissions (IPCC, 2007). This raises the question of how national conditions are to be considered in any allocation mechanism. While some countries - such as Australia, Canada and China - are highly dependent on certain high emission technologies (including coal and shale gas), others possess natural resources favoring low emission technologies, such as Norway and Russia. Thus, national conditions favoring or hindering low emission technologies should be subjects of allocation calculations.

Table 1: Analysis of Shares and Entitlements.

		Developed Countries (Annex)	Developing Countries (Non-Annex)	Total
Actors (countries)	Number of countries (percentage to total no. of countries)	41 countries	154 countries [BASIC: 5 countries (3.2% of all developing countries)]	195
	Percentage to total no. of countries	21%	79%	100%
	Share of population	25%	75%	100%
Issues	Historical Emission (1850-2000) in accumulated numbers[1], in GtC	210	55.44 [BASIC: 27]	265
	Historical Emission (1850-2000), contribution in percentage to total concentration	80%	20% [BASIC: 50% of developing countries' historical emissions]	100%
	Cumulative global emission per capita (1850-2008)[2]	878 Gt (72% of total) (fair share with 25% of global population: 310 Gt)	336 Gton (28% of total) (fair share with 75% of global population: 904 Gt)	1214 Gt
Structures	UNFCCC (legal framework)	Parties	Parties	192 parties (191 countries and 1 regional organization)
	Industry norms and standards on environmental protection	Medium or highly advanced	Low or highly advanced	
Processes	Negotiation mode (bilateral and multilateral)	No clear preference on negotiation mode	General preference on multilateral negotiation mode. Tendency for BASIC to conduct bilateral negotiations	
	Coordination	Regional organizations (e.g. EU), coalitions (G8,G20)	Regional organizations (ASEAN, MERCOSUR), coalitions (G77+China; BASIC, AOSIS)	
Outcomes (emission reduction, carbon budget)	Achievement of 67% probability of limiting temperature rise to within 2°C (2010-2050)	21% entitlement: 157.5 Gt 25% entitlement: 187.5 Gt	79% entitlement: 790 Gt 75% entitlement: 562.5 Gt	< 750 Gt
	Achievement of 67% probability of limiting temperature rise to within 2°C (2010-2050)	21% entitlement: 126 Gt 25% entitlement: 150 Gt	79% entitlement: 474 Gt 75% entitlement: 450 Gt	< 600 Gt
	Cumulative total CO_2 emissions. 2000-2049 (with 25% probability of exceeding the 2°C temp. increase limit)[3]	21% entitlement: 210 Gt 25% entitlement: 250 Gt	79% entitlement: 790 Gt 75% entitlement: 750 Gt	1000 Gt
	Cumulative total CO_2 emissions. 2000-2049 (with 50% probability of exceeding the 2°C temp. increase limit)[4]	21% entitlement: 302.4 Gt 25 % entitlement: 360 Gt	79% entitlement: 1137.6 Gt 75% entitlement: 1080 Gt	1440 Gt
	AWG-KP's wording of the level of its ambition (August 2007)[5]	25% to 40% emission reduction below 1990 levels in 2020	"Deviation from baseline"	emissions peak by 2017 to 2022 and at least 50% emission reduction of the 2000 level by 2050

[1] Starting year 1850, excluding historical LULUCF, data source: CAIT (WRI, 2009, 2012)
[2] Source: (Khor, 2012)
[3] Source: (Meinshausen, 2009)
[4] Source: (Meinshausen, 2009)
[5] Source: (Den Elzen and Höhne, 2008)

Conclusions

That developed countries have consumed four times their equitable share for the entire period of 1850-2049 (see Müller, 2001; BASIC Experts, 2011) is comprehensible. It is understandable that developing countries demand that historical responsibilities be embedded in any equitable formula when allocating entitlements to future emissions, particularly when various emission projections suggest that developed countries have already exhausted its "equitable" carbon share. Exhausted carbon share without anticipated negative emissions would mean that developing countries would need to shift its peak of emissions to an earlier period of time, implying shorter development trajectories.

It is however equally understandable that developed countries, although they recognize their historical responsibility, are having difficulty accepting that sacrifices must be made, particularly in a highly competitive global world with several developing countries projected to surpass the economic development level of current developed countries. Present concessions may potentially lead to future unfair advantages for some developing countries. When decision makers derive the legitimacy of their decisions from their national constituents, more efforts are needed to "sell" the idea that although an individual country can only manifest minimal impact (e.g. <0.5%) on a global scale, this should not prevent countries from pursue global climate protection. Mechanisms are for instance needed to reward "first movers" who are expected to shoulder higher costs as they find themselves at the beginning of the learning curve for low emission technologies.

Historical wrongs are to be corrected, especially when these have contributed to structural imbalances that favors certain countries while undermining the capability of others to genuinely participate in the decision making process. The Indian government claims that the "*over-occupation of the global* [carbon budget by developed countries] i*s so severe that most developing countries will not be able to attain their fair entitlement to carbon space.*" Nevertheless, opportunities may be found behind corrections of historical wrongs. For instance, when compensatory mechanisms are understood as flexibility mechanisms to upgrade one's own emission profile, or when efforts are linked with technological learning, developed countries may be motivated to do more; however, this would only be feasible when free-riding has been excluded as a viable option.

(Low emission) Technology transfers from developed countries to developing countries may lead to a situation of lock-in of standards that promote climate protection, when non-adoption of (low emission) standards becomes unattractive. Global climate negotiations should be complemented by sectoral level bargaining whilst new low emission standards are sought, and the resulting transaction and switching costs should be shouldered by a global climate fund. The UNFCCC and national governments should come up with concrete reward mechanisms for first movers (e.g., the first 50 countries to implement a specific standard).

A "pure" technical formula for distributing emission rights is not possible. The optimal formula can only be the negotiated formula, because the issues involved deal with values and experiences (see Penetrante, 2010). This negotiated formula must be complemented by establishing climate protection standards (irrespective of the outcomes of the current global climate negotiations) that are adopted by the majority of countries to make alternative, ('business as usual'), less-environmentally-friendly standards less profitable. A global climate agreement to regulate emissions will more likely fail when it does not match existing (locked-in) sectoral standards. Accounting for the path dependence of paradigms allows adequate preparations for paradigm shifts and transitions, while diverging switching or transition costs for individual countries are identified and equitably distributed among actors.

Both developed and developing countries would learn in a cooperative negotiation process to regularly "close one eye" when reaching compromises. Because the benefits of cooperation would in any way surpass the benefits of free-riding, compliance is no longer a matter of goodwill, but of rational calculation. Nevertheless, cooperation is influenced by various learning processes. Cooperation is almost impossible when countries have (bad) narratives that further legitimize zero-sum bargaining positions. New narratives in the public discourse are needed to maintain a cooperative stance between countries. These should be complemented by a "formula-plus" approach, whereas national conditions such as population, per-capita income, and dependency on certain technologies manifest the advantages of the formula. Particularly when structures and processes are generally accepted as fair and when the pursued outcome will not lose its environmental integrity in the maintainance of its just character, it would be easier for countries to focus on common goals, participate as peers in the decision making process and negotiate mutually acceptable decisions.

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The capture of CO_2 from flue gas using adsorption combined with membrane separation

Prof. Krzysztof WARMUZINSKI [1]

Dr. Marek TANCZYK

Dr. Manfred JASCHIK

Aleksandra JANUSZ-CYGAN, M.Sc.

Artur WOJDYLA, M.Sc.

[1] *Contact details of the corresponding author*

Tel: +48 32 234 6915
Fax: +48 32 231 0318
e-mail: kwarmuz@iich.gliwice.pl

Address: Polish Academy of Sciences, Institute of Chemical Engineering. ul. Baltycka 5, 44-100 Gliwice, Poland

Abstract

The removal of carbon dioxide from flue gas streams can be carried out using standard separation techniques, such as adsorption and membrane separation. The process presented in this paper is based on a combination of the two. Stage one includes a four-column PSA (pressure swing adsorption) unit, whereas stage two is a membrane module. In this paper simulation results are presented concerning the removal of CO_2 from ternary $CO_2/N_2/O_2$ mixtures in the hybrid process. The simulations reveal an important effect of two operating parameters – the flow rates of regeneration and purge streams – on the recovery of CO_2 and its concentration in the enriched gas. It is found that, in the hybrid process studied, it is possible to increase CO_2 content from 13 vol.% to over 97 vol.%, with an almost complete recovery. This concentration is sufficient from the standpoint of CO_2 transport and storage. For the various flow rates of the purge gas, the calculations made it possible to evaluate the limiting flow rates of the regenerating stream which lead to the maximum CO_2 concentrations in the product, with no breakthrough of this gas in the PSA unit.

Keywords: flue gas, CO_2 abatement, hybrid process, pressure swing adsorption, membrane separation

Introduction

The EU Directive 2009/31/WE concerning geological storage of carbon dioxide (the so-called CCS Directive) provided a strong incentive for the development and implementation of technologies for capturing CO_2 from various flue gas streams, especially those generated by the power industry. The separation of CO_2 from gaseous mixtures can be realized using well-known techniques, such as adsorption and membrane permeation (Metz et al., 2005). However, due to the low CO_2 concentrations in the flue gas (usually well below 20 vol.%), a reasonably high purity and recovery of this gas (above 90 vol.%) can only be obtained using staged adsorptive or membrane separations (Tanczyk et al., 2010, Zhao et al., 2008, Chou and Chen, 2004, Na et al., 2001). In two-stage systems, the high recovery is achieved by minimizing CO_2 concentration in the purified stream leaving the first stage and recycling the CO_2 remaining after the second stage to the inlet of stage one.

The hybrid process is a natural extension of two-stage adsorptive or membrane separations which, while combining the advantages of the two, mitigates the negative characteristics of these processes, namely, high energy consumption in the case of pressure swing adsorption (PSA) and considerable capital cost of membrane systems.

In an earlier paper (Tanczyk et al., 2012) a hybrid process was presented in which the first stage includes a four-column PSA installation and the second stage is a membrane unit. The principles of this process have been based on both experimental and theoretical studies concerning adsorptive and membrane separations of CO_2/N_2 mixtures, and the demonstration installation built in our laboratory draws upon this earlier experience.

The present study summarizes extensive simulations focused on the separation of CO_2 from the mixtures containing N_2 and O_2 in the hybrid installation.

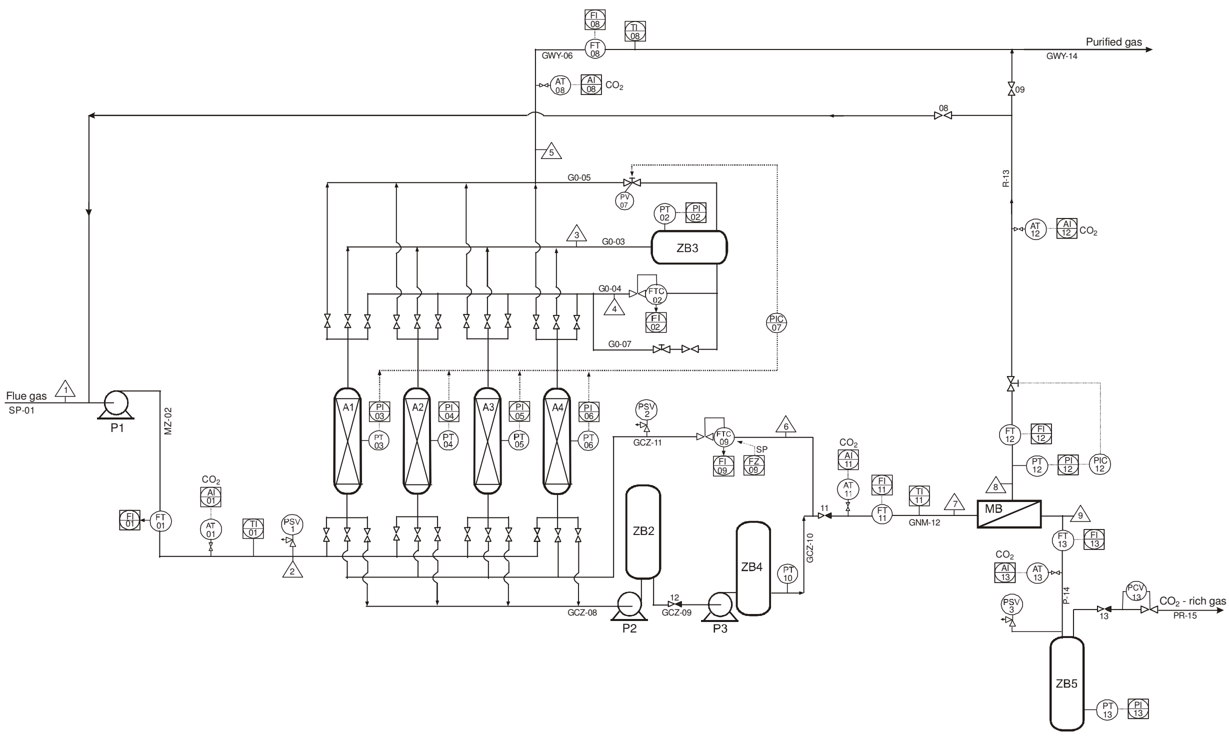

Fig. 1. Hybrid installation for the CO_2 capture from flue gases (A1-A4 – adsorbers, AT – gas composition, MB – membrane module, PT – pressure, P1 – blower, P2 – vacuum pump, P3 – compressor, TI – temperature, FT – gas flow rate, ZB2 – enriched gas tank, ZB3 – purified gas tank, ZB4 – buffer tank, ZB5 – CO_2 tank)

The objective of the simulations was to determine the principal parameters of the product streams (i.e. the purified gas stream and the CO_2-rich stream), especially from the standpoint of purity requirements associated with the transport and storage of CO_2. Also, the simulations revealed the effect of the two crucial parameters the process – gas flow rates in the regeneration and purge steps – on the recovery of CO_2 and its concentration in the enriched stream.

Hybrid installation

The hybrid installation is shown schematically in Fig. 1. The dry feed gas (a mixture containing nitrogen, oxygen and 13.3 vol.% of CO_2) is introduced into the PSA section at a pressure of 1.1 bar and with a flow rate of 7.5 m^3 (STP)/h. The PSA section yields two gas streams. The stream enriched in CO_2 is collected at the bottom of adsorbers (A1, A2, A3 and A4) via a vacuum pump (P3) and stored in a tank (ZB2). A fraction of the enriched gas is recycled to the PSA section during the cocurrent purge steps; the remainder is compressed and directed into a buffer tank (ZB4) through which the gas is supplied to a membrane module (MB). The other stream that leaves the PSA section is the purified gas, i.e., a mixture of nitrogen and oxygen collected from the top of the four adsorbers during cocurrent feed, depressurization from 1.1 bar to 1 bar and purge with the CO_2-enriched stream. A part of the purified gas stored in ZB3 is fed into the columns in which the countercurrent steps are realized (i.e. regeneration under a reduced pressure of around 0.1 bar and pressurization from 0.1 to 1.1 bar). The enriched gas supplied to the membrane section is split into two streams: the permeate (the principal product of the process), recovered at the atmospheric pressure and containing roughly over 90 vol.% of CO_2, and the retentate, collected at an elevated pressure of 2.5 bar (this stream contains 20 – 60 vol.% of CO_2 and, upon depressurization, is recycled to the inlet of a blower (P1)).

The adsorbers have a diameter of 200 mm and are packed with a zeolite molecular sieve; the height of the packing is 1.5 m. The separation properties of this adsorbent (ZMS 13X Grace) were measured in our laboratory. The equilibrium data were correlated using the multisite Langmuir equation

$$\frac{q_i^*}{q_{si}} = n_i\, b_i\; y_i\, p \left[1 - \sum_{j=1}^{n_a} \frac{q_j^*}{q_{sj}}\right]^{n_i} \qquad (1)$$

$$b_i = b_{0i} \exp(A_i/T) \qquad (1a)$$

with the numerical values of the relevant parameters shown in Table 1. The values of the mass transfer coefficients, also determined independently in our laboratory, are $1.22 \cdot 10^{-2}$ s^{-1} for CO_2, $7.01 \cdot 10^{-2}$ s^{-1} for N_2 and $7.59 \cdot 10^{-2}$ s^{-1} for O_2.

The PSA cycle studied includes the steps of feed with the flue gas, cocurrent depressurization, purge with the CO_2-enriched stream, countercurrent depressurization, vacuum regeneration with the purified gas and pressurization with the purified gas. The details of the cycle have been presented elsewhere (Warmuzinski et al., 2011), together with the separation properties of the membrane module. In the simulations the effect was analyzed of the gas flow rate during purge and vacuum regeneration on the purity and recovery of the CO_2 stream generated by the hybrid process.

Table 1. Parameters of the multisite Langmuir isotherm for CO_2, N_2 and O_2 for ZMS 13X (Grace)

Gaz	q_s mol/kg	b_0 Pa^{-1}	A K	n -
CO_2	8.20	$3.56 \cdot 10^{-11}$	4415.7	4.686
N_2	5.45	$5.77 \cdot 10^{-10}$	1909.5	1.952
O_2	5.21	$1.47 \cdot 10^{-9}$	1528.6	0.821

Model and numerical simulator

The core of the mathematical formulation describing the hybrid separation of CO_2 from flue gas streams is formed by the models of pressure swing adsorption and membrane gas permeation developed in this laboratory. The PSA model, verified based on experimental data from a two-column PSA installation, was presented in (Tanczyk et al., 2010), whereas the models of membrane permeation for the various flow patterns within the module were discussed in (Warmuzinski et al., 2008). The comprehensive model for a hybrid process was embedded in the gPROMS software package. This made it possible to carry out the simulations based on reliable and stable numerical methods and, simultaneously, to preserve the necessary degree of flexibility in defining the complex network of interconnecting components for the whole system.

Numerical simulations of the hybrid process

The effect of the gas flow rate during vacuum regeneration upon the recovery of CO_2 and its concentration in the CO_2-rich stream is shown in Fig. 2 for the various flow rates in the purge step. For each of these flow rates (6.4, 6.8 and 7.2 m^3 (STP)/h) the concentration of CO_2 first increases with an increase in the flow rate during regeneration and then, upon attaining a maximum, begins to drop. The recovery of carbon dioxide also rises with an increase in the flow rate during vacuum regeneration, to reach finally the maximum value possible, that is 100%. It should be noted that the total recovery means the absence of CO_2 in the purified gas stream. In other words, all of the carbon dioxide introduced with the feed gas leaves the installation with the CO_2-rich stream.

The maximum CO_2 concentration occurs for extreme operating conditions, namely, for the lowest possible flow rate during regeneration for which there is still no CO_2 breakthrough into the purified gas (i.e. for the flow rate that guarantees the complete CO_2 recovery). At higher flow rates of the regenerating stream more purified gas is recycled to the system, thus lowering CO_2 content at the inlet to the membrane module. This tendency is clearly seen in Fig. 3, which illustrates the relationship between CO_2 concentrations and gas flow rates on the feed and permeate sides of the membrane module. Conversely, for the flow rates of the regenerating gas below the limitizing value, the flow rate at the inlet to the module is too low relative to the membrane area. Consequently, a comparatively large amount of nitrogen passes through the membrane despite its concentration, being lower than the concentration for the limiting case. As shown in Fig. 3, in this case the permeate flow rate is around 80% of that at the inlet to the module. The limiting flow rates of the regenerating stream are 0.7, 0.9 and 1.1 m^3 (STP)/h for the flow rates of the purge gas equal to, respectively, 6.4, 6.8 and 7.2 m^3 (STP)/h.

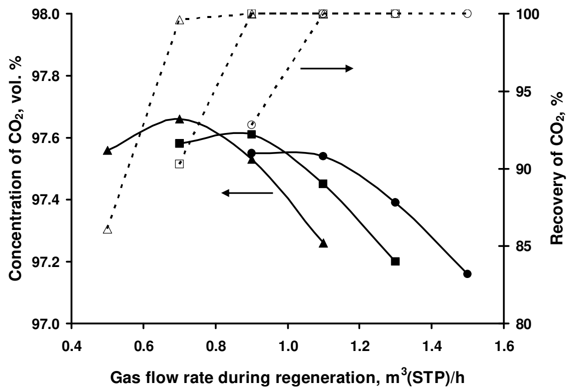

Fig. 2. Carbon dioxide recovery and its concentration in the enriched gas at the outlet of the hybrid installation for the following gas flow rates in the purge step of the PSA cycle: 6.4 (△ ▲); 6.8 (□ ■) and 7.2 (○ ●) m^3(STP)/h

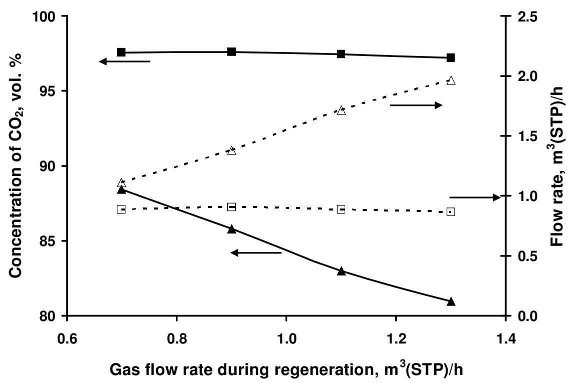

Fig. 3. CO_2 concentration and gas flow rate at the inlet to the membrane module (▲ △) and its outlet at the permeate side (■ □) for purge gas flow rate of 6.8 m^3(STP)/h

In all the cases shown in Fig. 2 the content of carbon dioxide in the CO_2-rich stream exceeds 97 vol.%, which is a value high enough for transportation and storage. It may also be noted that the variation of this content is relatively small (97.1 – 97.7 vol.%). This ensures a sufficient level of flexibility in the selection of the two crucial parameters of the process – the flow rates during regeneration and purge with, respectively, the purified gas and the CO_2-rich stream. Another favourable characteristic of the process proposed is due to the fact that higher CO_2 concentrations in the enriched stream are obtained for lower flow rates during the purge step. Therefore, the contamination of the purified gas with CO_2 can be avoided for lower flow rates of the regenerating gas. This translates into lower pumping costs in the PSA unit and a reduced compression cost at the inlet to the membrane section.

Conclusions

The process for the separation of CO_2 from flue gas streams, developed in our laboratory, is based on the combination of pressure swing adsorption and membrane permeation. Extensive modelling and simulation studies form the basis for the design and operation of a demonstration hybrid installation. The principal objective of the present study is to show the effect of two critical parameters of the process – the flow rates of the gas streams during regeneration and purge – on the recovery of carbon dioxide and its content in the enriched product. It is found that, in the process analyzed, it is possible to raise CO_2 concentration from 13.3 vol.% (i.e. from the value prevailing in the flue gas) to over 97 vol.%, at a virtually total recovery. The CO_2 concentrations obtained are sufficient from the standpoint of CO_2 transportation and storage. For three different flow rates during purge with the enriched stream (6.4, 6.8 and 7.2 m^3 (STP)/h) the limiting values were determined for the regenerating streams (0.7, 0.9 and 1.1 m^3 (STP)/h, respectively). These values lead to the maximum CO_2 concentrations in the enriched product without any CO_2 breakthrough into the purified stream (a mixture of N_2 and O_2). At present, these conclusions are being validated in the demonstration hybrid plant.

Nomenclature

A	-	coefficient of the multisite Langmuir isotherm, K
b, b_0	-	coefficients of the multisite Langmuir isotherm, 1/Pa
i	-	CO_2, N_2 or O_2
n	-	coefficient of the multisite Langmuir isotherm
p	-	pressure, bar
q^*		adsorbed phase concentration in the pellet at equilibrium, mol/kg
q_s	-	equilibrium adsorbed phase concentration at $p \rightarrow \infty$, mol/kg
y	-	mole fraction in the gas phase

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The impact of government expenditure on the environment

Professor George E. HALKOS [1]
Director of the Operations Research Laboratory, Department of Economics, University of Thessaly

Mr. Epameinondas A. PAIZANOS
PhD Candidate, Department of Economics, University of Thessaly

[1] *Contact details of corresponding author*
Tel: 0030 24210 74920
Fax: 0030 24210 74701
e-mail: halkos@uth.gr
Address: Dept of Economics, University of Thessaly Street: Korai 43, City: Volos, Country: Greece

Abstract

This paper examines the effect of government spending on the environment using a panel of countries for the time period 1980-2000. In particular, we consider a representative sample of 77 countries including those from the regions of Europe, the Black Sea and Asia. In this regard, the direct and indirect effects of government spending on pollution are estimated. The indirect effect operates through the impact of government spending on income and the subsequent effect of the income level on pollution. The dynamic nature and the potential endogeneity in the relationships examined is taken into account by the use of appropriate econometric methods. We are mainly interested in the effect on CO_2 but we also explicitly estimate the respective effects on SO_2 for reasons of comparability and to examine potential differences of the effect between consumption and production generated pollution. For example, SO_2 emissions can be decreased by reducing fossil fuel consumption, by using smoke-scrubbing equipment in power plants and by increasing energy efficiency. However, in consumption related pollutants the use and influence of environmental policies is more difficult, since the main tool to reduce these is the implementation of environmental taxes, which are often avoided as they are not politically popular. Policy implications from the results are expected to vary depending on the income level of the considered countries.

Keywords: Government expenditure; environment; direct effects; indirect effects.

1. Introduction

Government expenditure has recently expanded in many countries to alleviate the adverse effects of the 2008-2009 economic crises. A large fraction of GDP is spent by governments affecting a variety of economic variables and prosperity in particular. However, despite the important influence that public spending may have on the environment, this relationship has not been studied extensively in the literature.

The effect of government spending on the environment may be distinguished between direct and indirect effects. On the one hand, higher government expenditure is more likely to include redistributive transfers, which result to increased income equality and thus to higher demand for environmental quality. Moreover, if the environment is a luxury public good, it is likely that it will only be demanded when the demand for other public goods has been satisfied, i.e. at large levels of government size (Frederik and Lundstrom, 2001). On the other hand, government size has been found to reduce prosperity (Bajo-Rubio, 2000; Folster and Henrekson, 2001; Bergh and Karlsson, 2010; Ghali, 1998) which may in turn lead to lower pollution at some levels and to higher pollution at others, depending on the shape of the Environmental Kuznets Curve (EKC), as shown by Grossman and Krueger (1995). Therefore, the total effect of government expenditure on the environment cannot be determined a priori.

Our purpose is to investigate first how government expenditure affects pollution at given income levels and other control variables (direct effect); and then to examine the effect of government expenditure on the environment through the government expenditure impact on income (indirect effect) and to add the indirect effect to the direct effect to obtain the total effect.

The majority of the studies examining the government size–growth relationship find a negative impact of the former on the latter (Barro, 1991; Bajo-Rubio, 2000; Afonso and Furceri, 2008; Folster and Henrekson, 2001; Bergh and Karlsson, 2010; Afonso and Jalles, 2011), while others like in Ghali, 1998 report a positive effect. The estimated sign of the direct effect of government size on pollution is ambiguous in the empirical literature. Frederik and Lundstrom (2001) investigate the effect of political and economic freedom on the level of

CO_2 emissions and find that the effect of government size on levels of pollution differs according to the initial government size. They suggest that increased economic freedom, in terms of lower government size, decreases CO_2 emissions when the size of government is small but increases emissions when the size is large.

According to Bernauer and Koubi (2006) an increase in the government spending share of GDP is associated with more air pollution and this relationship is not affected by the quality of the government. However, they do not consider quadratic or cubic terms of income in their analysis and they ascribe their finding to the ambiguous hypothesis that higher income leads to both bigger government and better air quality. Recently, Lopez et al. (2011) provide a theoretical basis for determining the effect of government expenditure on pollution. Specifically, they stress the importance and estimate empirically the effect of fiscal spending composition on the environment. They argue that a reallocation of government spending composition towards social and public goods reduces pollution. Moreover, they find that increasing total government size, without changing its orientation, has a non-positive impact on environmental quality.

To the best of our knowledge the present paper is the first that distinguishes between the direct and indirect effect of fiscal spending on the environment. For that reason, a two-equation model was jointly estimated, employing a sample of 77 countries covering the period 1980-2000 for two air pollutants (sulfur dioxide, SO_2 and carbon dioxide, CO_2). In estimating the proposed model we take into account the dynamic nature of the relationships examined, by employing appropriate econometric methods for the estimation of dynamic panels for the first time in this area of research. Furthermore, appropriate GMM estimation methods are used to mitigate potential reverse causality biases of the explanatory variables.

The remainder of the paper is organized as follows: Section 2 presents the data used in the analysis and section 3 discusses the proposed econometric models. The empirical results are reported in section 4 while the final section concludes the paper.

2. Data

Our sample consists of 77 countries[6] with a full set of SO_2, CO_2, share of government expenditure, GDP/c and other explanatory variables information for the period 1980-2000. The analysis takes place up to the year 2000 because of limited availability of data on SO_2 after this period. Consequently, for reasons of comparability we also perform the analysis of CO_2 for the same time period. The database consists of 1,617 observations per variable.

An important distinction between the two pollutants that has to do with their atmospheric life characteristics is their geographical range of effect (Cole, 2007). Considering that two-thirds of SO_2 moves away from the atmosphere within 10 days after its emission, its impact is mainly local or regional and thus, historically, sulfur dioxide has been subject to regulation. In contrast, CO_2 has not been regulated by governments, since its atmospheric life varies from 50 to 200 years and hence its impact is global.

The sources of pollution vary by pollutant. The main sources of SO_2 emissions are electricity generation and industrial processes. On the other hand, apart from energy transformation and industry, an important source of CO_2 emissions is transport. Apparently SO_2 pollution is characterized as production-generated, while CO_2 emissions are a mix between production and consumption–generated pollution. This distinction is important since the mechanism by which government expenditure size affects consumption pollution is likely to differ compared to production pollution. SO_2 emissions can be decreased by reducing consumption of fossil fuels (especially high-sulfur content coal), by using smoke-scrubbing equipment in power plants and by increasing energy efficiency. However, in consumption related pollutants the use and influence of environmental policies is more difficult, since the main tool to reduce these is the implementation of environmental taxes, which are often avoided as they are not politically popular.

3. Methodology

The proposed model consists of two equations jointly estimated, one being a conventional cubic formulation of the EKC augmented by the share of government expenditure over income and the second expressing income as a function of government expenditure and other factors. Specifically,

$$\ln(P/c)_{it} = \partial_i + \zeta_t + \beta_1 \ln Govshare_{it} + \beta_2 \ln(GDP/c)_{it} + \beta_3 (\ln(GDP/c))^2_{it} + + \beta_4 (\ln(GDP/c))^3_{it} + \beta_5 X_{it} + \varepsilon_{it} \quad (1)$$

$$\ln(GDP/c) = \gamma_i + \delta_t + \alpha_1 \ln Govshare_{it} + a_2 \ln Z_{it} + u_{it} \quad (2)$$

where subscripts i and t represent country and time respectively and all variables are expressed in natural logarithms, unless otherwise stated.

The income variable and its powers in (1) control for scale effects. To control for income effect we use the household final consumption

[6] Albania, Algeria, Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada, Cape Verde, Chile, China, Colombia, Cuba, Denmark, Djibouti, Dominican Rep, Equador, Egypt, El Salvador, Finland, France, Germany, Ghana, Greece, Guatemala, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Lebanon, Liberia, Mauritius, Mexico, Morocco, Mozambique, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Sierra Leone, South Africa, South Korea, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Thailand, Togo, Trinidad, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela

expenditure, while total private investment is used as a proxy for capital stock. Institutional factors reflecting pollution regulation are taken into account by using a measure of democracy level, however this proxy is imperfect and we expect that the government variable also captures some of the unobserved environmental regulation. We also use the share of trade over GDP to examine whether involvement in international trade affects pollutants and population density, which captures part of the scale effect. Finally, ∂_i is a country effect which can be fixed or random, ζ_t is a time effect common to all countries and ε_{it} is a disturbance term with the usual desirable properties. Thus, following the terminology used to classify the pollution effects in the trade literature, the coefficient in the government expenditure variable mainly captures the composition effect and part of the technique effect.

Equation (2) is an augmented Solow model widely used in the growth literature (Mankiw et al., 1992; Barro, 1998). In particular, it is a production function based formulation and expresses income as a function of the share of government expenditure in GDP and other explanatory factors like investment and education as proxies for capital and human stock, population growth, inflation rate to consider the impact of the macroeconomic environment and a measure of openness to international trade. Finally, γ_i and δ_t represent country and time effects respectively while u_{it} is an error term.

3.1 Econometric issues and estimation

In estimating equations (1) and (2) we must take into account the unobserved heterogeneity across countries. Using the Hausman test the Random Effects model (RE) was rejected in favor of the Fixed Effects model (FE), for both equations (1) and (2). Since the balanced panel data used in this paper consists of large N and T dimensions, non-stationarity is important. We are particularly concerned about the dynamic misspecification of the pollutants equations as pointed-out by Halkos (2003). To take into account potential non-stationarity in the dynamic panel we employ the dynamic fixed effects (DFE) estimator developed by Pesaran and Smith (1995) and Pesaran et al. (1997, 2004).

Another econometric concern in estimating equations (1) and (2) is the bias occurring from the potential endogeneity between government spending with pollution and income respectively. Government spending often increases with pollution because governments implement ecological taxes. Moreover, the exact relationship between government spending and income is an active research area but there is empirical and anecdotal evidence (e.g. Lane, 2003) that governments often alter the amount and composition of fiscal spending to deal with the effects of business cycles.

To address this reverse causality problem we use the Arellano-Bond (1998) Generalized Method of Moments (GMM). GMM accounts for the inertia that is likely to exist in the determination of the dependent variables and mitigates potential reverse causality biases of the explanatory variables by using predetermined and exogenous variables as instruments in a systematic way. For both equations we assume that lagged dependent variables, as well as government expenditure and income are endogenous and treat all other explanatory variables as strictly exogenous.

Moreover, we use an additional exogenous instrumental variable for equation (1), namely the lagged weighted average of government expenditure in other countries, weighting by the inverse of the distance between the two countries. Since we use emissions rather than concentrations of pollutants, the lagged weighted average government spending in other countries is not expected to affect directly emission levels in a given country, but only through its effect on that county's government expenditure and income.

For both equations we test the validity of instruments with the Hansen test, which failed to reject the null that the instrumental variables are uncorrelated with the residuals. We also report the Difference Hansen test for the exogenous IV subset which does not reject the null that the subset is valid.

3.2 Capturing the effects of government expenditure on pollution

Given the direct and indirect effects, the total effect of government spending on pollution can be expressed as:

$$\frac{d(P/c)}{dGovshare} = \frac{\partial(P/c)}{\partial Govshare} + \frac{\partial(P/c)}{\partial(GDP/c)}\frac{\partial(GDP/c)}{\partial Govshare} \quad (5)$$

where the first expression is the direct effect and the latter is the indirect effect via government expenditure impact on prosperity. It should be noted that while the direct effect remains constant throughout the whole income range, the indirect and hence the total effect depend on the level of per capita income, because of the inclusion of quadratic and cubic income terms in (1).

4. Results

Table 1 presents the coefficient estimates of per capita income, by applying different estimation methods. To account for autocorrelation and heteroskedasticity, all standard errors reported are robust and in particular for FE estimation we report the Huber-White-Sandwich estimates of the variance-covariance matrix. The estimated effect of the government expenditure share on GDP is negative and statistically significant, at the 1% level, regardless of the method used.

In the fourth column, applying the Arellano-Bond two-step GMM estimator, dynamics are still taken into account but government share is now treated as endogenous. We use first-differences and orthogonal-deviations GMM to control for fixed country effects. The significance of the lagged dependent variable (p-value=0.000) suggests that dynamic specifications should be preferred.

We report long-run estimates and robust standard errors are obtained by using the Windmeijer's finite-sample correction for the two-step covariance matrix. The estimated impact of government expenditure on GDP is even greater in that case, suggesting that an increase of 1% in the share of government spending of GDP, ceteris paribus, reduces per capita income by 1.809%.

The signs and significance of the coefficients associated with the other control variables are all plausible and consistent with the literature, apart from the human capital proxy which although has the expected sign, is significant only in the OLS estimates. The impact of capital stock, represented by the share of investment in GDP, is positive and significant across all estimation methods. Population growth has a consistent negative and significant effect, while the trade-openness coefficient is also significant with an expected positive sign.

The Arellano-Bond estimates are used as benchmarks, therefore subsequent analysis and the estimation of the EKC equation is based on fitted values of real per capita income from the GMM estimation. Before turning to the estimation of per capita pollution we should examine the time series properties of the main variables used. Testing for unit roots in panel data requires both the asymptotic behavior of the time-series dimension T, and the cross-section dimension N, to be taken into consideration. Performing the Phillips-Perron unit root tests on all variables of interest we find evidence against stationarity in levels, since in all cases our variables are I(1). Additionally, application of the Pedroni and the Kao (Engle based) cointegration tests for the two pollutants equations provides evidence to reject the null hypothesis of no-cointegration at the conventional statistical significance level of 0.05 for the SO_2 and CO_2 equations.

Table 2a provides estimates of per capita pollution emissions utilizing the results of GMM estimates of Eq.2. In our model, as mentioned, according to the Hausman test FE is preferred to RE. Hence, for each pollutant we report FE and DFE estimates. Based on FE estimates (columns 1 and 3) the government share of GDP has a negative and significant direct effect on SO_2/c and an insignificant negative relationship with CO_2/c. DFE estimates suggest that the government share of income possesses a negative relationship with SO_2/c and CO_2/c, which is significant at 1% and 10% significance levels respectively.

Finally, Table 2b reports GMM First-Difference and Orthogonal-Deviations estimates of the EKC equation. The estimated effect of government expenditure on the environment is similar in magnitude to the DFE estimates for both pollutants but is statistically significant only in the case of SO_2. Since GMM estimates take into account dynamics and mitigate reverse causality biases, in what follows first-differences GMM results will be used as benchmark. Both pollutants have a significant cubic relationship with per capita income in all estimates. Interestingly, taking into account endogeneity in the A-B GMM estimates produces turning points for CO_2 well within the sample. The household income effect is negative, although insignificant in all cases except for SO_2 in first-differences GMM. The share of investment is found to increase pollution, but the effect is significant only for CO_2. On the other hand, the coefficient of trade-openness is always negative, but mostly insignificant. Finally, the effect of population density is robustly positive, while the democracy index is insignificant in all specifications.

A negative direct effect of government share of income on pollution is estimated by all models, as indicated in Table 2. Concentrating on GMM results, an increase of government expenditure by 1%, ceteris paribus, may result in a 0.903% reduction of SO_2/c. However the direct effect on CO_2 is insignificant. The indirect effects are negative at the median income level, leading to a negative total effect for both pollutants. The negative sign of the indirect effect occurs from the positive relationship between income and pollution at the median income level.

Explicitly, at the sample median level of income an increase in the government share of GDP leads to a reduction in income and, as a result, to a reduction in emissions. Additionally, the estimated indirect effects are notably larger than the direct effects.

Table 3 presents the direct, indirect and total effects of government expenditure on pollution based on the estimates in Tables 2a-2b. Since the indirect and thus the total effect depend on the level of income, the effects in Table 3 are calculated at the sample median level of income.

Table 1: Estimates of the impact of government share on per capita income.

Model	OLS (1)	FE (2)	DFE (5)	GMM A-B (4)
Log government share	-0.198***	-0.210***	-0.872***	-1.809***
	(0.042)	(0.069)	(0.328)	
Log investment	0.688***	0.142***	0.430*	0.876**
	(0.039)	(0.038)	(0.227)	
Log school	0.830***	0.130	0.290	0.108
	(0.109)	(0.099)	(0.475)	
Population growth	-0.239***	-0.014**	-0.255***	-0.222***
	(0.036)	(0.006)	(0.077)	
Trade-openness	0.002***	0.003***	0.006*	0.022***
	(0.000)	(0.001)	(0.0035)	
Constant	3.383***	7.855***		
	(0.557)	(0.489)		
R^2	0.493	0.201		
F test	0.000	0.000		
Wald test				0.000
Hausman FE v. RE		0.000		
Cragg-Donald F-stat				
Hausman PMG v. DFE			1.000	
Hansen test				0.202
Hansen IV subset				0.743
A-B test of AR(1)				0.000
A-B test of AR(2)				0.092
Nobs/Countries/IVs	1,596	1,596/76	1,520/76	1,406/74/61

Note: Robust standard errors are in parentheses. All tests' values reported are probabilities.
*Significant at 10%. **Significant at 5% ***Significant at 1%.

Table 2a: Estimates of pollution emissions/c.

	SO_2/c		CO_2/c	
	FE	DFE	FE	DFE
Log(government share)	-0.292**	-0.910***	-0.096	-0.256*
	(0.134)	(0.305)	(0.101)	(0.143)
LogGDPc	-50.49***	-36.51**	-18.23***	-13.17**
	(12.56)	(17.74)	(5.370)	(6.502)
$(\text{LogGDPc})^2$	6.642***	5.136**	2.402***	1.792**
	(1.541)	(2.160)	(0.638)	(0.777)
$(\text{LogGDPc})^3$	-0.283***	-0.231***	-0.099***	-0.075**
	(0.063)	(0.088)	(0.025)	(0.031)
Log(trade-openess)	-0.157***	-0.075	-0.104	-0.071
	(0.057)	(0.143)	(0.065)	(0.058)
Log(investment)	-0.064	0.175	0.100**	0.139**
	(0.060)	(0.127)	(0.048)	(0.056)
Log(household consumption)	-0.468	-1.313	-0.377	-0.479
	(0.340)	(0.823)	(0.264)	(0.348)
Democracy level	-0.007	0.001	0.001	0.005
	(0.005)	(0.010)	(0.004)	(0.005)
Population density	1.245	8.567**	6.285***	7.283***
	(2.069)	(3.521)	(1.265)	(1.453)
Constant	123.60***		44.22***	
	(33.59)		(14.41)	
Error correction term		-0.154***		-0.272***
		(0.033)		(0.035)
Turning Points	672/9,321	369/7,406	437/24,101	314/26,370
R^2	0.317		0.495	
F test	0.000		0.000	
Hausman FEv.RE	0.001		0.000	
Hausman MGv.PMG		1.000		0.851
Hausman PMGv.DFE		0.998		1.000
Nobs/Countries	1,480/74	1,406/74	1,480/74	1,406/74

Note: Robust standard errors in parentheses. All tests' values reported are probabilities.
*Significant at 10%. **Significant at 5% ***Significant at 1%.

Table 2b: Estimates of pollution emissions/c using GMM.

	SO_2/c		CO_2/c	
	First-Differences	Orthogonal-Deviations	First-Differences	Orthogonal-Deviations
Log government share	-0.903**	-1.107***	0.193	0.005
LogGDPc	-114.27**	-127.83**	-50.13***	-44.97**
$(\text{LogGDPc})^2$	14.86***	16.38**	6.266***	5.646**
$(\text{LogGDPc})^3$	-0.627***	-0.686**	-0.253***	-0.229**
Log(trade-openess)	-0.074	-0.111	-0.082	-0.099
Log(investment)	0.067	0.111	0.087**	0.156***
Log(household consumption)	-0.760***	-0.556	-0.026	-0.301
Democracy level	-0.004	-0.005	0.001	0.002
Population density	4.545	0.693	4.935*	5.518***
Turning Points	742/9,799	944/8,691	898/16,481	880/15,678
Wald test	0.000	0.000	0.000	0.000
Hansen test	0.270	0.181	0.174	0.207
Hansen IV subset	0.173	0.042	0.086	0.080
A-B test of AR(1)	0.001	0.000	0.009	0.005
A-B test of AR(2)	0.331	0.325	0.357	0.328
Nobs/Countries/IVs	1,425/75/60	1,425/75/60	1,425/75/60	1,425/75/60

Note: Robust standard errors in parentheses. All tests' values reported are probabilities.
*Significant at 10%. **Significant at 5% ***Significant at 1%.

Table 3: Impact of government spending on pollutants (elasticities).

	SO_2/c			CO_2/c		
Effects	FE	DFE	GMM (F-D)	FE	DFE	GMM (F-D)
Direct	-0.292**	-0.910***	-0.903**	-0.096	-0.256*	0.193
Indirect	-2.063	-1.462	-4.628	-2.094	-1.899	-2.843
Total	-2.355	-2.372	-5.532	-2.094	-2.155	-2.843
Change of sign point	10,003	9,268	10,809	24,210	30,201	16,438

Note: Indirect and total effects are calculated at sample median level of per capita income ($4,669).
*Significant at 10%. **Significant at 5% ***Significant at 1%.

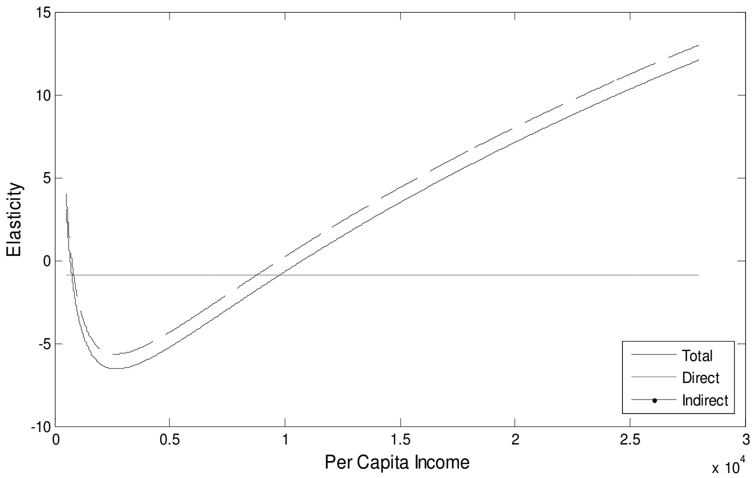

Figure 1: The effect of government share on SO_2/c.

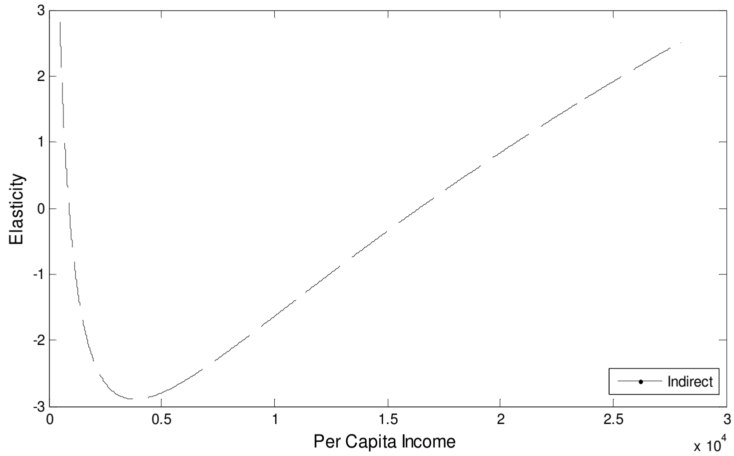

Figure 2: The effect of government share on CO_2/c.

The total effect of government share on SO_2/c is negative for low levels of per capita income and then turns to positive, while the total effect on CO_2/c is also negative but becomes positive only for very high income levels[7]. Table 3 also reports the estimated income level at which total effect changes from negative to positive. Particularly, GMM estimates indicate that this level is \$10,809 for SO_2/c and \$16,438 for CO_2/c, i.e. total effect of government share of income on CO_2/c is negative through most of the sample income range. From the figures it becomes clear that the pattern of total effect is determined by the shape of the indirect effect.

The results of Table 3 suggest that the direct effect of government spending on pollution is insignificant and considerably smaller for CO_2, in absolute values. This finding comes as no surprise if we take into consideration both pollutants' impact on human health and the technological capabilities of reducing their levels in the atmosphere. In particular, SO_2 emissions externalities are local and immediate while CO_2 emissions externalities are global and occur mostly in the future. Local environmental degradation, as in the case of SO_2, increases demand for technological improvements to diminish that impact.

Figures 1 and 2 present the direct, indirect and total effects of government share of income on emission levels against per capita income. For CO_2 the direct effect is insignificant and we do not take it into account. The indirect effect increases with per capita income, since $\frac{\partial(GDP/c)}{\partial(Govshare)}$=-1.809 and $\frac{\partial(P/c)}{\partial(GDP/c)}$ falls from 1.27 to – 7.17 for SO_2/c and from 0.22 to - 1.39 for CO_2/c throughout the sample income range. These patterns largely depend on the relationship between pollution and income levels described by the EKC.

The difference in magnitude and significance between the estimated direct effects of government expenditure on SO_2 and CO_2 could also be explained by how the different types of pollutants respond to certain policies. In particular, as already mentioned, the regulation of production generated pollutants, like SO_2, is expected to be more straightforward and this is reflected in the estimated effects.

4.2 Sensitivity analysis

If government expenditure composition is omitted then this could bias the impact of government expenditure on pollution. We perform a sensitivity analysis for the EKC equation including a government expenditure composition variable, constructed as described in Lopez et al. (2011). Interestingly, we found that composition of government spending matters only in the case of CO_2, where its sign was negative and significant at the 5% level, while the sign of the government expenditure remained unchanged compared to the main results. Additionally, we tested the existence of potential biases from omitted time-variant variables like environmental regulations using the method proposed by Krauth (2011). The results suggested that the estimated effect for SO_2/c is robust, while the same does not hold for CO_2/c, as expected.

Furthermore, a robustness check of the significance of the variables (government spending x GDP/c) and its square was performed. The interactive terms were found to be insignificant when all powers of income were included in the equation, but were significant when just the level of

[7] Notably, for both pollutants, in very low levels of income (below the 5% percentile) the total effect is positive.

GDP/c was used, thus confirming the existence of an indirect effect. Finally, we found no evidence of a quadratic relationship between income and government expenditure.

5. Conclusions

This paper, using a sample of 77 countries for the period 1980-2000 and a two equation model jointly estimated, examines the impact of government size on pollution taking into account the dynamic nature of this relationship. Our results confirm the theoretical and empirical developments on the existence of a correlation between income and pollution as well as between government size and economic performance. The reported results are not affected by biases, which may occur by omitted variables and existence of extreme observations.

The estimated direct effect of government expenditure is negative and significant for SO_2, but insignificant for CO_2. Estimation of a non-positive direct effect of government size on SO_2 is in line with recent findings by Lopez et al. (2011) and Lopez and Palacios (2010). On the other hand, the indirect effect which is considered for the first time here varies depending on income levels. The total effect is largely determined by the more dominant indirect effect. In particular, for SO_2, the total impact is negative, although decreasing in absolute value, for low levels of income and then becomes positive for more developed countries. In contrast, for CO_2 the total effect is also negative but it turns positive only for very high income levels.

We attribute these results to the different characteristics of the pollutants that may determine the effect of government expenditure on them, such as duration of their atmospheric lives, geographical and time scale of their effects on human health and on whether they are mainly production or consumption generated. Policy implications, occurring from the analysis, differ according to the level of income in a country. Results suggest that reducing government size enhances economic performance. However, cutting government expenditure should be undertaken with particular care in some levels of GDP. For SO_2 and CO_2 pollution, results suggest that reducing government size in countries with an income level less than \$10,809 and \$16,438 respectively, leads to deterioration of environmental quality. Therefore, cutting government expenditure in these countries should be accompanied by appropriate environmental regulation along with the establishment of international environmental treaties.

On the other hand, in countries with higher income levels, cutting government expenditures leads to improvements in both income and environmental quality. These implications bear some resemblance to the EKC. In particular, countries with income level at the decreasing area of the EKC are more likely to have already established the environmental legislation and to have undertaken public expenditures for the improvement of environmental quality, thus they are susceptible to diminishing returns from a further increase in government size. In that context and combining our findings with the results from Lopez et al. (2011), cutting out public spending items that increase market failure will be the most beneficial, especially for CO_2 pollution.

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Appropriate MCDA methods for climate change policy evaluations

Dr. Popi KONIDARI[1]

Head of Climate Change Policy Unit of the Energy Policy and Development Centre (KEPA)

Mrs. Anna FLESSA, MSc.

Fellow Researcher of the Energy Policy and Development Centre (KEPA)

Tel.: 0030 210 7275830
Fax: 0030 210 72 75 828
e-mail: pkonidar@kepa.uoa.gr

Address: Energy Policy and Development Centre (KEPA), National and Kapodistrian University of Athens. KEPA Building Panepistimiopolis, 157 84, Athens, Greece

Abstract

Multi-Criteria Decision Analysis (MCDA) methods are used by Decision Makers (DMs) in concluding with the optimum choice out of a set of possible solutions that will allow them to achieve a specific goal. The needs of the DMs in conducting climate change policy evaluations along with the strengths and weaknesses of the MCDA methods point out which of these methods are more suitable to be used for these decision-making problems. In this framework the most frequently used MCDA methods (AHP, fuzzy AHP, MAUT, SMART, AMS, ELECTRE and PROMETHEE) for the evaluation of climate change policy instruments or mixtures are examined. Their strengths and weaknesses are classified and compared according to the needs of DMs (governments, target groups, scientists/researchers) to: i) understand, through the set of criteria/sub-criteria, form and information of outcomes, the performance of all evaluated policy options in achieving climate change policy objectives; ii) rely with confidence on the outcomes based on the structural background and main elements of the method (mathematical and procedural background, weight coefficients, parameters, indexes, scales of assessment, sensitivity analysis) and iii) use a manageable method (flexibility in inputs, ease to use, low requirements on time and efforts, available software). The paper concludes with the more appropriate MCDA methods to be used by DMs and policy makers for climate change policy evaluations.

Key words: Comparison, climate change, mitigation, adaptation, criteria.

Introduction

During the last twenty years climate change policy issues have gained the attention of decision and policy makers. Strategies, actions, measures and policy instruments have been designed, discussed and implemented so as to mitigate greenhouse gas emissions and to adapt human activities towards the most likely expected effects of climate change. The development of such a policy mixture or even of a policy portfolio aiming to the achievement of specific national climate change mitigation/adaptation (M/A) targets raises inevitably the issue of evaluation (Mundaca L., Neij L., 2009).

Evaluation in climate change policy is performed with different approaches (monetary valuations (ie cost-benefit analysis, cost effectiveness analysis), comparing outcomes of models, MCDA methods, and qualitative comparisons) (Browne D., Ryan L., 2011; Department of Communities and Local Government: London, 2009). Out of these approaches the Multi-Criteria Decision Analysis (MCDA) methods are preferred compared to the other approaches and used progressively even more for identifying the optimum choice or set of choices out of a wider group of possible solutions for the under consideration complex problem (Kurka T., Blackwood D., 2013; Konidari P., Mavrakis D., 2007; 2006).

The aim of this paper is to identify the MCDA methods used in climate change policy evaluations, examine the most frequently selected ones, and compare them according to two elements: i) the needs of DMs and ii) their strengths and weaknesses in responding to the previous element. Their strengths and waeknesses are classified according to the evaluation needs of DMs for climate change policy issues.

The paper is divided in the three parts. The first one presents the framework under which the authors identified the most frequently used methods. The second one presents the classification according to the needs of DMs (governments, target groups, scientists/researchers) of the strengths and the weaknesses that MCDA methods of the first part have. The last session discusses the outcomes of the previous comparison and concludes with the more appropriate MCDA methods to be used by DMs and policy makers for climate change policy evaluations.

Approach

Step 1: Identifying the most frequently used multi-criteria evaluation methods

The use of MCDA methods has shown that: i) None of them is appropriate for all types of decision making problems, but certain methods fit better in assisting a DM towards a specific problem (Polatidis H. et al., 2004; Joubert A.R. et al., 1997); ii) Researchers agree that there is no single-best method for the evaluation of policy instruments/scenarios (Mundaca L., Neij L., 2009); iii) As Roy B. pointed out in 1985 the principle aim is not to discover a solution but to construct or create something, which is likely to help "*an actor taking part in a decision process to shape and/or to argue and/or to transform his preferences or to make a decision in conformity with his goals*".

Therefore, recent peer-reviewed articles published in leading scientific journals and dealing with climate change policy instruments/mixtures were sought by the authors in bibliographic databases (Science Direct, Scirus[8], Wiley Interscience and Google Scholar) during August-September 2013. The time period of publication was restricted to 2000-2014 since the Kyoto Protocol was signed in 1997, while the issue of evaluating climate change policies was set officially under discussions by the government of New Zealand and IPCC in 2001 (Konidari P., Mavrakis D., 2007). A more careful look at the content of 65 papers that correspond to the general theme of climate change policy evaluations with a MCDA method or approach resulted to the selection of 24 of them (table 1) that:

- Concerned evaluation of at least one clearly quoted climate change policy goal, strategy, instrument, action or measure with the usage of multi-criteria evaluation methods.
- Described fully the whole procedure of applying a MCDA method, oriented explicitly to climate change policy needs and concluded to results (ranking of evaluated alternatives or group of acceptable options).

The following MCDA methods have been used: Analytical Hierarchy Process (AHP), Fuzzy AHP, Multi-Attribute Utility Theory (MAUT), AMS, ELimination Et Choix Traduisant le REalité (ELECTRE), NAIADE and Preference Ranking Organization METHod of Enrichment Evaluation (PROMETHEE), REGIME. In this set of methods Simple Multi-Attribute Ranking Technique (SMART) is also included since it is part of AMS. AMS was named so being the combination of three standard multi-criteria methods: AHP, MAUT and SMART (Konidari and Mavrakis, 2006; 2007).

The most frequently used in these 24 papers are: Analytical Hierarchy Process (AHP), Preference Ranking Organization METHod of Enrichment Evaluation (PROMETHEE), AMS and ELimination Et Choix Traduisant le REalité (ELECTRE). AHP is the most popular method used in such applications, followed by PROMETHEE, AMS and ELECTRE.

Step 2: Examination and classification of strengths and weaknesses of MCDA methods according to DM's needs

In this step the needs of the DMs are quoted and then the corresponding strengths and weaknesses of the aforementioned MCDA methods are presented. Based on those needs the strengths and the weaknesses of the most frequently used MCDA methods were classified and examined on how they respond to those needs.

Need 1: Understanding the performance of all the evaluated climate change policy options

Decision makers for climate change policy issues need an evaluation method that allows them to understand how close a policy option (instrument or mixture) delivers the objectives that needs to fulfill. They need to be provided with adequate and comprehensive information on the performance of the evaluated option (Mundaca L., Neij L., 2009). This understanding is based on the: i) set of criteria/sub-criteria, ii) form and information provided from the outcomes.

Need 1.1: Set of criteria/sub-criteria

There is a need for understanding and selecting through numerous evaluation criteria that can capture and characterise the multiple attributes of policy options and the policy context in which they work (Mundaca L., Neij L., 2009). The main requirement for the set of criteria/sub-criteria of climate change policy evaluation is the same set of criteria/sub-criteria is to be used again and again (Mundaca L., Neij L., 2009).

Strengths and weaknesses of the MCDA methods to fulfill need 1.1

From all the described methods AHP presents better the problem (Kurka T., Blackwood D., 2013). Its main advantage is the decomposition of the problem into elements (Ishizaka A., Labib A., 2011; Berrittella et al., 2008). Its hierarchical structure of criteria allows users to focus better on specific

[8] http://www.scirus.com

criteria and sub-criteria when determining the respective weight coefficients through the pairwise comparisons (Ishizaka A., Labib A., 2011). Decision hierarchy in SMART can be set up in the same way as in AHP (Kangas J., Kangas A, 2005). AMS has incorporated this advantage in its methodology.

PROMETHEE does not provide the possibility of structuring the problem using a 'classical' decision tree (yet only a 'criteria hierarchy' is possible), or specific guidelines to determine the weights (Turcksin L., Bernardini A., Macharis C., 2011). In the case of many criteria, it is difficult for the DM to "*obtain a clear view of the problem and to evaluate the results*" (Wand J.J, Yang D.L., 2007).

Usually in ELECTRE all criteria or criteria of the same group are considered as of equal importance (Papadopoulos A., Karagiannidis A., 2006; Diakoulaki D., Karangelis F., 2006; Salminen P. et al., 1998).

Only AMS exhibits a complete set of criteria/subcriteria for evaluating M/A policy instruments. This was based on the preferences of three (3) different groups of stakeholders all active for climate policy issues. Blechinger P. and Shah K. (2011a; 2011b) confirmed the criteria/sub-criteria tree of the AMS method based on the preferences of policy makers whom they interviewed. The main advantage of this set is that it is common for developed and developing countries. This approach - used in AMS - is encountered in practice. Ananda J. and Gamini H. in 2003 incorporated preferences of six (6) different groups of actively involved stakeholders.

Need 1.2: Form and information of outcomes

The outcomes need to provide information without requiring further analysis before the user can make a decision (Shibl R. et al., 2013). Furthermore, the representation needs to be common for all climate policy instruments and all countries for two reasons: first, to allow a comparison among the evaluated types of policy instruments under a particular national framework; second, to allow also the comparison of the performance of the same type of instrument in different countries.

Strengths and weaknesses of the MCDA methods to fulfill need 1.2

Multi-attribute utility methods (AHP, Fuzzy AHP, MAUT, SMART, AMS) aggregate all points of view into a unique function which is to be optimized, while outranking methods (ELECTRE, PROMETHEE) construct and exploit a synthesizing relation based on the decision maker's preferences (Gamper C.D., Turcanu C., 2007).

Sometimes ELECTRE is unable to identify the preferred alternative and produces only a core of leading alternatives, due to a not necessarily complete system (regarding the use of the three thresholds) (Huang I.B., et al., 2011; Wang J.J. et al., 2009; Georgiou P. et al., 2008; Gilliam S. et al., 2005; Pohekar S.D., Ramachandran M., 2004). Some of the alternatives may remain incomparable due to an inadequate number of arguments to support the hypothesis that one alternative is as good as the other (Georgiou P. et al., 2008). The ELECTRE family methods are convenient when encountering few criteria and a large number of alternatives because they offer a clearer view of the alternatives by eliminating the less favorable ones (Wang J.J. et al., 2009; Pohekar S.D., Ramachandran M., 2004; Beccali M. et al., 2003; Georgopoulou E. et al., 2003).

PROMETHEE belongs in the same category with ELECTRE and is able for partial or full ranking of the alternatives. Its outcome is a ranking of the best to the worst alternatives showing which more are preferred if all criteria are taken into consideration (Wang J.J, Yang D.L., 2007; Diakoulaki D. et al., 2007).

AMS has been designed especially for climate change policy evaluations, concluding to a full ranking of the alternatives exhibiting strengths and weaknesses, by taking into consideration the type and level of emerging policy interactions (Konidari P., Mavrakis D., 2006).

On the other hand, AHP is often criticised with respect to the complete aggregation of the criteria which might lead to important losses of information (e.g., in case where trade-offs between good and bad scores on criteria occur) (Turcksin L., Bernardini A., Macharis C., 2011).

Need 2: Rely with confidence on the outcomes based on the structural background and main elements of the method

Policy makers do not have always the knowledge or the time to examine the structural background of a MCDA method. They need to be sure that the method is structured correctly regarding its: i) mathematical background, ii) procedural background and iii) Main elements (Weight coefficients, parameters, thresholds, indexes). This is also referred as "trust to the knowledge base" (Shibl R. et al., 2013).

Need 2.1: Mathematical and Procedural background

All methods use certain mathematical processes in concluding to their results. The minimum requirement for DMs is to have a solid method.

Strengths and weaknesses of the MCDA methods to fulfill need 2.1

All MCDA methods have their mathematical background presented and established through the respective published work.

AHP is justified mathematically (Kablan M.M., 2004). It is a mathematical theory of value, reason and judgment, based on ratio scales (Eakin H., Bojorquez-Tapia L.A., 2008).

Fuzzy AHP combines the concepts of the fuzzy set theory and the hierarchical structure analysis (Hoe et al., 2010). It is an extended AHP method with triangular or trapezoidal fuzzy numbers for handling the inherent subjectivity and ambiguity associated with human preferences and perceptions over exact numbers (Hoe et al., 2010; Tiryaki F., Ahlatcioglu B., 2009; Duran O., Aguilo J., 2008; Pan N.-F., 2008).

MAUT has the soundest theoretical structure of all the multi-criteria techniques (Van Calker K.J. et al., 2006; Gomez-Limon J.A., Martinez Y., 2006). It allows complete compensation[9] among all the attributes, while the multi-attribute utility functions incorporate preferences and uncertainties over all attributes explicitly. Although, its preferential assumptions are not generally easy to test empirically, MAUT provides satisfactory results and is less in error than any other practical alternative (Van Calker K.J. et al., 2006).

SMART is a trade-off method that can be used for up to sixteen criteria (Oltean-Dumbrava C., Ashley R., 2006). Due to its compensatory characteristic it can hide unacceptable scores for criteria. Its results are considered as robust and replicate decisions from more complex MAUT analysis with a high degree of confidence (Linkov I. et al., 2004).

ELECTRE III is a non-compensatory MCDA method, using mathematical functions to indicate the level of preference of one alternative over the others (Rogers M., Bruen M., 1998). It has a solid scientific background (Theodorou S. et al., 2010).

The basic assumptions and their consequences for the PROMETHEE method were presented in the initial paper of Brans J.P. et al. in 1986 and of Keyser De Wim, Peeters Peter in 1996. Brans J.P. et al. showed also that this method is more stable than ELECTRE. It offers a sound scientific procedure for leading to its outcomes (Theodorou S. et al., 2010).

Each method has its advantages and drawbacks. Their combination aims to make use of the strengths of the selected methods and create operational synergies or their use in parallel to get a broader decision basis for the DM (Browne D. et al., 2010; Theodorou S. et al., 2010; Ananda J., Herath G., 2009; Macharis C. et al., 2004). Furthermore, the mathematical background of each one of them is used appropriately in these combinations. Problems in AHP related with the inclusion of new alternatives and criteria can be solved when SMART is implemented (Gilliams G. et al., 2005). The combination of AHP and SMART is considered as better suited for quality evaluation, while the simple value functions are best suited for determining the scores of the alternatives (Tsvetinov P.E., 2003). The choice of a linear function as the value function is in most cases sufficient (Tsvetinov P.E., 2003). For AMS the authors used the mathematical background of all three methods (AHP, MAUT and SMART). They reduced the time for applying the procedure and the complexity that AHP exhibits when used for criteria and alternatives without affecting its credibility. The scales for the scores assigned to the alternatives for their performance against the sub-criteria are positive.

Need 2.2: Main elements (Weight coefficients, parameters, thresholds, indexes)

Not all parameters that need to be expressed as criteria/sub-criteria have the same importance for climate change policy mixtures (Blechinger P. and Shah K. 2011a; 2011b; Konidari P., Mavrakis D., 2007; 2006; Mavrakis D., Konidari P., 2003).

Strengths and weaknesses of the MCDA methods to fulfill need 2.2

A big drawback for the MAUT family is the difficulty that a DM has when trying to specify a tradeoff ratio between two different criteria such as "landscape degradation" and "employment" (Polatidis H. et al., 2004). In AMS this problem is handled. The main criteria are three; each one of which has sub-criteria that are evaluated on how much they contribute to the main one. Additionally, the preferences of three (3) main stakeholder groups are taken into consideration and through the AHP procedure the weight coefficients are determined. Psychologists argue that it is easier and more accurate to express one's opinion only on two alternatives that simultaneously on all (Ishizaka A., Lablb A., 2011).

Additionally, "*The AHP approach employs a consistency test that can screen out inconsistent judgments, which makes the results reliable.*" (Kablan M.M, 2004). Two consistency indexes are used in the AMS method. The application of both

[9] "*Compensability refers to the existence of trade-offs i.e. the possibility of offsetting a disadvantage on some criteria by a sufficiently large advantage on another criterion, whereas smaller advantages would not do the same. Thus a preference relation in non-compensatory if no trade-off occurs and is compensatory otherwise. The use of weights with intensity of preference originates compensatory multi-criteria methods and gives the meaning of trade-offs to the weights.*" (Munda G., 2006, http://www3.aegean.gr/environment/energy/mcda/library/Deliverables/del_20/A_NAIADE_based_approach_for_sustainability_benchmarking.pdf

indexes showed that the incorporation of the stakeholders' preferences regarding the assigned importance to criteria/sub-criteria is well done and reasonable. The values of both indexes are within the numerical limits specified by the developers of these indexes indicating that results are reliable.

The application of fuzzy AHP "*may produce unreliable results if: an unbalanced 9-point scale is used; the scale of fuzzification is not fully justified and an inappropriate defuzzification method is applied.*" (Srdjevic B., Medeiros Y.D.P., 2008). Most fuzzy AHP approaches use only triangular fuzzy numbers, because although trapezoid fuzzy numbers demonstrate better the situation they exhibit more uncertainty when compared to the triangular ones (Pan N.-F., 2008). Fuzzy AHP has been used in many applications, but there are very few outcomes regarding its inconsistency implying the need for further exploration of its mathematical basics (Tiryaki F., Ahlatcioglu B., 2009). Due to the absence of proven techniques for fuzzy consistency and fuzzy priority vector, some researchers used the consistency index CI and consistency ratio CR of AHP (Bulut E. et al., article in press; Heo E. et al., 2010; Kahraman C., Kaya I., 2010; Duran O., Aguilo J., 2008; Lee A.H.I. et al., 2008).

For AMS, consistency of weight coefficients is tested using two different approaches (Konidari P., Mavrakis D., 2007; 2006). The first approach is based on the consistency index of the AHP method by Saaty. The second approach was developed by Peláez J.I. and Lamata M.T. in 2002. The consistency index CI is now a function of the matrix size and not of its entries.

The main characteristic of ELECTRE TRI is the assignment of alternatives to pre-defined categories (Karakosta C. et al., 2009; Dias L. et al., 2002). Taking into consideration that some countries have not implemented climate change adaptation policy instruments, it is difficult at this phase to assign potential actions into pre-defined categories such as high, low priority or not recommended options. Furthermore, apart from the thresholds (common for all ELECTRE forms), upper and lower limits of the categories need to be defined (Malekmohammadi B. et al. 2011; Karakosta C. et al., 2009). This process is usually difficult – not only for ELECTRE TRI, but for the other types of the ELECTRE family as well - particularly when decision makers are unsure of which values each parameter (thresholds and limits for the categories) should take (Malekmohammadi B. et al. 2011; Dias L. et al., 2002).

PROMETHEE does not have a certain mathematical procedure for defining weight coefficients (Wang J.J, Yang D.L., 2007; Brans et al., 1986). Indifference and/or preference thresholds can be defined by the DM for each criterion (Diakoulaki D. et al., 2007). This procedure may be difficult to be completed particularly by an inexperienced DM (Patlitzianas K.D. et al., 2007; Wang J.J, Yang D.L, 2007).

Need 3: Use a manageable method

Need 3.1: Flexibility in inputs

In most developing countries and Small Island developing states there is an absence of quantitative data related with GHG emission registry, the potential of renewable energy sources or energy efficiency impeding multi-criteria evaluations (Konidari P., 2010; 2009; 2008; Blechinger P. and Shah K., 2011a; 2011b).

Strengths and weaknesses of the MCDA methods to fulfill need 3.1

Depending on the set of criteria/subcriteria that is to be used, the outcomes of an energy model can be incorporated appropriately. Almost all National Communications, submitted to the United Nations Framework Convention for Climate Change (UNFCCC), included the outcomes of models such as MARKAL/TIMES, LEAP and ENPEP showing projections and trends of GHG emissions in several sectors of their economy and reduction costs as well (UNFCCC, 2011).

There are cases at which an energy model was combined with a multi-criteria evaluation method particularly for M/A policy issues. The combination of AHP and MAUT has been used in evaluating a number of developed through the LEAP model policy scenarios (Phdungsilp A., 2010; 2006). AMS has been used in combination with the Green-X model for evaluating policy scenarios regarding the penetration of RES-E in Greece (Kampezidis H. et al., 2011). No other combination between any of the particular seven multi-criteria evaluation methods and energy models has been mentioned (Ishizaka A., Labib A., 2011; Behzadian M. et al., 2010).

AHP allows qualitative and quantitative approaches for solving a problem (Kilincci O., Onal S.A., 2011; Wong J.K.W., Li H., 2008; Duran O., Aguilo J., 2008). It can handle uncertain, imprecise and subjective data (Srdjevic B., Medeiros Y.D.P., 2008). The usage of pairwise comparisons does not require the explicit definition of a measurement scale for each attribute (Bozdura F.T. et al., 2007).

Some of the input data for the method are possible to come from the energy model that the country has used for its energy and climate change planning. LEAP has been used in combination with MCDA methods, such as AMS. For the other sub-criteria that no model outcomes are available, information and data from national reports and databases can be used with the MAUT and SMART procedures during the AMS application.

In order to apply ELECTRE III a detailed knowledge of energy and economic background of the examined countries is necessary which is not all the time available (Papadopoulos A., Karagiannidis A., 2008).

PROMETHEE methods can handle data with a reasonable degree of accuracy and fixed numerical values (Behzadian M. et al., 2010; Olson D.L., 2001).

Need 3.2: Ease of use

Strengths and weaknesses of the MCDA methods to fulfill need 3.2

Comparative analysis of MCDA approaches has indicated AHP to be the most popular compared to other methods due to its simplicity, ease to use and great flexibility (Kilincci O., Onal S.A., 2011; W. Ho et al., 2010; Srdjevic B., Medeiros Y.D.P., 2008; Duran O., Aguilo J., 2008; Babic Z., Plazibat N., 1998). It is an easier technique - with the exception of the eigenvalue calculations used to derive the local priorities of the elements in a cluster of the hierarchy and which remain actually hidden from the end-user - compared to MAUT and SMART and with less required cognitive skills compared to MAUT/MAVT and SMART (Ananda J., Herath G., 2009; Petkov D. et al., 2007). The users may directly input judgment data without getting into the mathematical background (Duran O., Aguilo J., 2008).

Multi Attribute Utility Theory (MAUT) was cognitively more difficult to understand but the Simple Multi Attribute Rating Technique (SMART), which belongs to the same group of methods, was found to be easy (Petkov D. et al., 2007). For MAUT a drawback is the requirements of interactive decision environment in formulating utility functions, complexity of computing scaling constants using the algorithm (Pohekar S.D., Ramachandran M., 2004).

For AMS Blechinger P. and Shah K. in 2011 mention that the method is user-friendly and transparent in the calculation process; usable without knowing in detail its methodological background.

"*Some versions of the ELECTRE methods (e.g. ELECTRE III) are considered complicated and therefore are not easily understood by DMs"* (Bojkovic N. et al., 2010). More specifically, the elicitation of preferential parameters used in these methods may be a complex task particularly when a group of DMs are involved or there is a need of using a greater number of categories (Brito A. J. et al. 2010).

PROMETHEE seems easier to be understood by DMs and simpler to be managed by the analyst compared to ELECTRE III (Behzadian M. et al., 2010). It is characterized by decreased complexity (Wang J.J. et al., 2009).

Both ELECTRE and PROMETHEE as outranking methods allow the introduction of new criteria or alternatives at any time during the analysis or the adjustment of the values of their thresholds (Linkov I. et al., 2004). This is a flexibility of these methods compared to MAUT and AHP.

Need 3.3: Low requirements on time and efforts

Strengths and weaknesses of the MCDA methods to fulfill need 3.2

Using pairwise comparison for the determination of the weight coefficients of the criteria and for the assessment of the alternatives is time-consuming and exhausting for the DM, particularly when their number is large (summing up the number of criteria and alternatives) (Konidari P., Mavrakis D., 2006; Loken E., 2007)..

Many different approaches of fuzzy AHP have been developed with the Chang's approach being the most popular one since its steps are relatively easier than those of the other approaches; it is similar to the conventional AHP and its is supported by real case applications (Heo et al., 2010; Celik M. et al., 2009; Bozbura F.T. et al., 2007). Fuzzy AHP "*requires considerable computations; careful handling of fuzzy operations and consistent interpretation of any results obtained*" (Heo E. et al., 2010; Srdjevic B., Medeiros Y.D.P., 2008; Pan N.-F., 2008).

SMART is usually quicker for a DM to implement since less ratings are required compared to the same number of pairwise comparisons (Honert Van Den R.C., 2001).

In the AMS method the AHP procedure is limited only to the determination of the weigh coefficients for criteria and for the sub-criteria level of each criterion. This restriction reduces the number of pair wise comparisons.

The advantage of the ELECTRE method is that the tradeoffs among multiple attributes are compensatory, and the information contained in the decision matrix is fully utilized (Qin X.S. et al., 2008). ELECTRE techniques demand the estimation of thresholds (three kinds in the general case) and weights. These factors however sometimes help the DM to understand fully the problem and form his/her preferences consistently. Nevertheless, these features represent some abstract meaning (Polatidis H. et al., 2004).

Need 3.4: Available software

The existence of software tools facilitates the users for the application of MCDA methods.

Strengths and weaknesses of the MCDA methods to fulfill need 3.4

Commercial or free software for solving AHP problems is available from: AHPProject[10], Decision Lens[11], EBM[12], Expert Choice[13], InfoHarvest[14], , MakeItRational[15], MindDecider[16], Krzysztof Kniaz[17] and Qualica Planning Suite[18] (Ishizaka A., Labib A., 2011; Lee A.H.I. et al., 2008). The Canadian Conservation Institute[19] offers a free web application for this method, guiding the user at each step. MultCSync of EBM is a software package accomplishing prioritization using AHP and having also a modification of AHP in accordance with multi-attribute value theory (MAVT).

On the contrary, there are a limited number of available software tools for fuzzy-AHP compared to the conventional one (Cakir O., Canbolat M.S., 2008). For Fuzzy-AHP a software using MAT LAB 7.0 was developed by Duran O., Aguilo J. in 2008. Cakir O., Canbolat M.S. in 2008 presented their developed decision support system based on Java Servlets Technology, MySql database, Apache Tomcat Tomcat web server and other open source support software. Lee A.H.I. et al. constructed in 2008 their own FAHP IS using Power Builder and MySQL. Killincci O., Onal S.A. in 2011 wrote their calculations in fuzzy AHP using macros in MS Excel.

Logical Decisions® (LDW)[20] is decision support software that incorporates MAUT and other MCDA methods. D-Sight[21] is also using utility functions. APIS for .NET[22] (Aggregated Preference Indices System) is a standalone application based on Multiple Criteria Decision Analysis (MCDA) and MAUT (Multi Attribute Utility Theory). V.I.S.A.[23] is based on MAUT and performs also sensitivity analysis. Knijnenburg P. Bart and Willemsen C. in 2009 developed an online MAUT-based recommender system.

HIPRE +3[24] and Criterium Decision Plus of InfoHarvest support AHP and SMART. Web-HIPRE supports all common weighting methods based on relative comparisons such as MAUT, SMART and AHP and their combinations also (Geldermann J. et al., 2009).

Clim-AMS is an integrated software tool for the AMS method so as to be used for evaluations within the area of climate change policy. The user receives assistance with help buttons available in all window forms and error messages appearing in case of inappropriate inputs. Clim-AMS has incorporated the set of weight coefficients produced under the AMS methodology. The user may accept the values of these weight coefficients or re-calculate them. In the second case the consistency of the new weight coefficients is tested against two indexes of Saaty and of Peláez J.I. and Lamata M.T. (Konidari P, Mavrakis D., 2007).

The Université Paris-Dauphine[25] developed software for ELECTRE IS, III-IV and TRI. DEFINITE[26] includes different multi-criteria methods, among which ELECTRE also.

Three software packages have been developed for PROMETHEE: D-Sight, DECISION LAB and PROMCALC (Behzadian M. et al., 2010; Macharis C. et al., 2004). The first one is currently used for implementing the method.

Some of the aforementioned companies and software packages are on the web-site of the International Society on Multiple Criteria Decision Making (http://www.mcdmsociety.org/soft.html). It is quite common for the researchers to use a template in Excel for their calculations (Killincci O., Onal S.A., 2011; Ishizaka A., Labib A., 2011). In other cases they developed software to correspond to the specific needs of the particular decision making problem such as MOIRA-PLUS which incorporates MAUT (Monte L. et al., 2009).

Outcome of qualitative comparison

The outcomes of the partial comparisons through objectives, assumptions, methodology, advantages-disadvantages for the user and applications are presented in Table 2.

Conclusions

Seven MCDA methods were compared for understanding which one fulfils better the needs of DMs for evaluation of climate change policy mixtures. The comparison demonstrated also the existing limitations of the methods and pinpointed directions for further research.

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[10] http://www.ahpproject.com/
[11] http://www.decisionlens.com/products/process
[12] http://ebmtoolsdatabase.org/tool/multcsync
[13] http://www.expertchoice.com/markets-we-serve/academic/
[14] http://www.infoharvest.com/ihroot/infoharv/products.asp
[15] http://makeitrational.com/
[16] http://www.minddecider.com/Products.MD.htm
[17] http://kniaz.net/software/AHP.aspx
[18] http://www.qualica.de/qps_ahp.html
[19] http://www.cci-icc.gc.ca/tools/ahp/index_e.asp
[20] http://www.logicaldecisions.com/prod01.htm
[21] http://www.d-sight.com/
[22] http://www.polyidea.com/blog/
[23] http://www.visadecisions.com/
[24] http://www.hipre.hut.fi/ and http://www.sal.tkk.fi/en/resources/downloadables/hipre3
[25] http://www.lamsade.dauphine.fr/spip.php?article236
[26] http://www.ivm.vu.nl/en/projects/Projects/spatial-analysis/DEFINITE/index.asp

Table 1: Application of multi-criteria evaluation methods for climate M/A policy issues.

No.	Evaluated policy options	Used method(s)	Authors
1.	Policy options for improving the EU-ETS/climate change policy	AMS	Clo S., Battles S., Zoppoli P., 2013
2.	Policy mechanisms for dissemination of EE and RES in Brazilian building sector	PROMETHEE	de Melo Augustus Conrado, de Martino Jannuzzi G., Tripodi Aline F., 2013
3.	Climate change adaptation approaches	Fuzzy AHP	Sanneh E. S., et al., 2013
4.	Strategies for coastal management/climate change policy	Stochastic Multi-criteria Acceptability Analysis	Felix A., et al., 2012
5.	Three policy goals linked with RES in Taiwan	AHP	Chen Y.C. et al., 2011
6.	Twelve GHG Emission Mitigating Policy Instruments for Trinidad and Tobago	AMS	Blechinger P., Shah K., 2011a; 2011b
7.	Three policy scenarios for the penetration of RES-E in Greece	AMS	Kampezidis H. et al., 2011
8.	Policy scenarios (mixture of climate change policy instruments)	AHP-PROMETHEE	Turcksin L. et al., 2011
9.	Six renewable energy sources as policy options for Taiwan	Fuzzy AHP	Shen Y.C. et al., 2010
10.	Three subsidy schemes for promoting Photovoltaic technology in Cyprus	AHP, ELECTRE, PROMETHEE	Theodorou S. et al., 2010
11.	Policy scenarios (options without support by defined policy instruments)	NAIADE	Browne D., O'Regan B., Moles R., 2010
12.	Feed-in-tariffs, carbon tax and combined scheme/	MCA (pairwise comparisons – AHP, sum preferences according to scale)	Grafakos S., Flamos A., Oikonomou V., Zevgolis D., 2010
13.	adaptation options under one of the scenarios of the Royal Netherlands Meteorological Institute	Multi-criteria analysis, weighted summation	de Bruin K., et al., 2009
14.	Twelve policy scenarios for low-carbon development in Bangkok (Thailand)	AHP and MAVT	Phdungsilp A., 2010; 2006
15.	Six adaptation actions for mitigating increased water consumption for Georgia basin in Canada	ELECTRE III	X.S. Qin et al., 2008
16.	Six transport policy options	AHP	Berrittella M. et al., 2008
17.	Twenty four energy efficiency initiatives	ELECTRE TRI	Neves L.P. et al., 2008
18.	Five scenarios for the increased use of RES in Austria	PROMETHEE	Madlener R. et al., 2007
19.	Four scenarios for the power generation sector in Greece	PROMETHEE	Diakoulaki D, Karangelis F., 2007
20.	EU-ETS performance in eight EU member States	AMS	Konidari P., Mavrakis D., 2007
21.	Flood management option/	Approach of DETR/MCA analysis –Rank sum and Rank order centroid	(Kenyon W., 2007)
22.	Two pairs of instruments for climate policy interactions under the Hellenic policy framework	AMS	Konidari P., Mavrakis D., 2006
23.	Thirty five options in three sectors (energy, transportations, forestry) of Peru	AHP and PROMETHEE	Borges P.C., Villavicencio A., 2004
24.	Twenty seven CO_2 reduction measures for the period 2000–2010 in the Greek energy sector	ELECTRE TRI	Georgopoulou H. et al., 2003

Table 2: Comparison of methods. Three scales are used with three levels each (High (High+, High 0, High -), Moderate (Moderate +, Moderate 0, Moderate -) and Low (Low+, Low 0, Low -)).

	AHP	Fuzzy AHP	MAUT	SMART	AMS	PROMETHEE	ELECTRE
Need 1							
Set of criteria/sub-criteria	High 0	High 0	Moderate +	Moderate +	High +	Moderate -	Moderate +
Form and provide information	High -	High -	High -	High -	High +	Moderate -	Moderate 0
Need 2							
Mathematical and procedural background	High 0	High 0	High 0	High 0	High 0	High 0	High 0
Main elements	High 0	Moderate +	Moderate -	Moderate -	High 0	Moderate 0	Moderate +
Need 3							
Flexibility in inputs	High 0	High 0	High 0	High 0	High 0	High -	High -
Ease to use	High 0	Moderate 0	High -	High -	High +	Moderate 0	Moderate +
Low requirements in time and efforts	Moderate 0	Moderate 0	Moderate +	Moderate +	Moderate +	Moderate 0	Moderate 0
Available software	High+	Moderate -	Moderate 0	Low +	Low +	Moderate +	Moderate 0
Total	High 0	High -	High -	Moderate +	High 0	Moderate +	Moderate -

AHP and AMS rank first followed by PROMETHEE. The main disadvantage of AHP is the excessive number of pairwise comparisons needed in determining weight coefficients and performance particularly for assessing one proposed Directive in the respective European Union level of 25 countries, (Konidari P., Mavrakis D., 2007). The calculations are tremendous for an international level policy instrument such as the three Kyoto Protocol mechanisms. The combination of AHP with any other MCDA method reduces this number of pairwise comparisons and makes its application more flexible and feasible. This is the case of AMS.

Although MAUT and SMART are not preferred as much as AHP, their combination with AHP produced a more preferred method compared to them, the AMS.

Since the application of PROMETHEE is equivalent with that of MAUT and SMART, a combination of AHP and PROMETHEE might be also successful in fulfilling the needs of such an evaluation, as long as the preference function of each criterion and the value of its thresholds (indifference, strict preference) are determined correctly (Behzadian M. et al., 2010). Further research on such combinations need to be conducted.

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Sustainable Energy Action Plans for cities: the potential of the building sector

Dr. Theodora SLINI [1]

Senior Researcher, Laboratory of Heat Transfer and Environmental Engineering, Department of Mechanical Engineering, Aristotle University of Thessaloniki, Greece

Dr. Efrosini GIAMA

Senior Researcher, Laboratory of Process Equipment Design, Department of Mechanical Engineering Aristotle University of Thessaloniki, Greece

Prof. Agis M. PAPADOPOULOS

Director, Laboratory of Process Equipment Design, Department of Mechanical Engineering, Aristotle University of Thessaloniki, Greece

Mr. Grigoris KALAMPOUKAS

Region of Central Macedonia, Thessaloniki, Greece

Mrs Chrysanthi KISKINI

Region of Central Macedonia, Thessaloniki, Greece

[1]Contact details of corresponding author
Tel: +30 2310 996139
Fax: +30 2310 996012
e-mail: lora@aix.meng.auth.gr

Address: Laboratory of Heat Transfer & Environmental Engineering, Department of Mechanical Engineering, Box 483, Aristotle University Thessaloniki, GR-54124 Thessaloniki, Greece

Abstract

The Energy for Mayors was launched, in order to support the EU climate and energy strategies towards a smart sustainable energy future by "involving European cities and towns in sustainable energy planning, reducing energy consumption and increasing the share of Renewable Energy Sources (RES)". The Sustainable Energy Action Plan (SEAP) is a formal commitment describing how authorities need to move towards a sustainable energy future. The current paper is focused on the development and the assessment of SEAPs for seven municipalities of the broader Thessaloniki Area. Under municipal planning the main sectors affected by local policies are municipal buildings, public transport and municipal services. The potential for energy conservation in municipal buildings and the manner by which the SEAPs aim at utilizing this potential will be presented and assessed in this study. In order to achieve this, a methodology was developed and applied taking under consideration specific objectives and targets were selected for each municipality, taking under consideration the characteristics of the area, such as topographic and microclimatic parameters, along with the size of population, the housing density and the municipal infrastructure in terms of buildings (Karakanias et al., 2010; Theodoridou et al., 2012). The action plans were considered with respect to the type and use of buildings, the sort of interventions possible and the expected outcomes. Emphasis was placed on improving or maintaining, depending on the current situation, the levels of thermal comfort and indoor air quality. Last but not least, recommendations and guidelines were elaborated, regarding the process of developing an effective and efficient local energy strategy in terms of administrative and financial planning (UNEP, 2007; ürge-Vorsatz et al., 2007).

Introduction

Since 2006, the European Commission is trying to establish a common European policy on energy via a plethora of directives, papers, resolutions, such as the "Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy" [COM(2006) 105 final], the "Energy 2020: A strategy for competitive, sustainable and secure energy" [COM(2010) 639 final], the "Energy Roadmap 2050" [COM(2011) 885 final], the Energy Efficiency Plan [COM(2011) 109 final] and the

"Green Paper: A 2030 framework for climate and energy policies" was issued recently [COM(2013) final 169]. All initiatives are focused on priorities that include the following:

- The promotion of energy efficiency and the reduction of greenhouse gas (GHG) emissions;
- The establishment of an integrated energy market;
- The empowerment of consumers ensuring the highest possible level of protection and security;
- The promotion of energy technology and innovation;
- The support of the external dimension of the European energy market.

Towards a smart sustainable energy future, the *Energy for Mayors* (URL 1), a project run under the Intelligence Energy Europe, was launched aiming at supporting the EU climate and energy strategies by "involving European cities and towns in sustainable energy planning, reducing energy consumption and increasing the share of renewable energy sources (RES)". By this means the Covenant of Mayors, a European initiative for climate protection, is also enhanced (URL 2). The Covenant of Mayors intents to join the European cities and towns in combating climate change and its effects. Local authorities are thus committed to go beyond the European climate and energy objective set for 2020 by decreasing carbon dioxide (CO_2) emissions in their regions by at least 20%. The successful implementation of the Covenant of Mayors is supported by the *Energy for Mayors* project involving the development of Sustainable Energy Action Plans (SEAPs) in selected municipalities and further the assessment of the SEAP results in the energy management in the studied urban areas. SEAP is a formal commitment towards a sustainable energy future describing the direction in which authorities need to move. The specific objectives and targets are selected following the comparison with the current situation set as baseline, while the financial framework is determined taking under consideration conditions and limitations of local budgets. The objectives and goals to be adopted should follow the concept of SMART objectives, that is specific, measurable, achievable, realistic and time-bound (Covenant of Mayors, 2010).

Moreover, the development of SEAPs in the *Energy for Mayors* will support the application of an Energy Management System (EMS) according to the ISO 50001 standard in selected pilot municipalities. This means that a set of additional requirements for organizations will be established, as also discussed in the C40 Cities Climate Leadership Group (C40, URL 3), a network of the world's megacities committed to addressing climate change, that is:

- the development of an energy efficiency policy
- the set of specific targets and objectives so as to meet the adopted policy
- the effective use of available data towards decisions about energy use
- the assessment and the review of the results on how policy works, and
- the continually improvement of the energy management system.

At a municipal scale authorities can act with many different roles in the energy sector such as an energy consumer, an energy producer and supplier, a regulator and/or investor, a leading motivator for energy efficiency strategies (Covenant of Mayors). According to these roles the local authorities have the potential to take actions and influence the energy usage and consumption in both ways: directly at their own operation and indirectly via the residents' habits and energy behaviour. Among the initiatives local authorities can launch fostering energy efficiency are the following:

- retrofit of municipal building stock (restoration, standards and audits)
- effective management of energy transportation
- monitoring of fuel consumption by the public transport
- preventive maintenance of transport vehicles
- renewal of the transport vehicles fleet
- optimization of the transport communication schemes with a view to reduce traffic intensity
- preventive maintenance of street lighting systems and equipment
- use of renewable energy sources (RES)
- optimization of the energy distribution systems
- sustainable urban and local planning
- implementation of pilot bioclimatic architectural projects and civil engineering solutions for high energy performance.

The Laboratory of Heat Transfer and Environmental Engineering (LHTEE) closely collaborated with the Central Macedonia Region, Greece in order to support the development and assessment of SEAPs of seven local municipalities of the Greater Thessaloniki Area:

- Municipality of Thessaloniki
- Municipality of Ampelokipoi- Menemeni
- Municipality of Koredlio- Evosmos
- Municipality of Delta
- Municipality of Lagadas
- Municipality of Thermaikos
- Municipality of Chalkidona.

LHTEE's main task was to consider possible interventions and rate their final impact in order to gain a 20% reduction of GHG emissions compared to the reference year 2001 by 2020. Towards this direction LHTEE had to determine the energy consumption in the private sector, assess of the energy consumption in the municipal buildings and provide viable solution that can be adopted in the final Sustainable Energy Action Plans (SEAPs). The suggested solutions were analysed and evaluated taking under consideration the characteristics of the area, such as topographic and microclimatic parameters, along with the size of population, the housing density and the municipal infrastructure in terms of buildings (Karkanias et al. 2010; Theodoridou et al., 2012). The calculation of the suggested savings was based on the recent regulation of building energy efficiency (KENAK) and, where appropriate, the related EN standards (YPEKA, 2013).

Current situation

The problem of energy consumption in the building sector remains a complex technical and cost-effective problem, the dimension of which was initially identified in 1970 during the two oil crises. However, reducing energy costs by 30% in real terms in the period from 1991 to 2000, led to numerous negative, though faint, experiences. As a result, throughout the period of strong economic growth from 1994 to 2005, the increase in energy consumption in residential buildings, office buildings and public buildings in general touched growth of around 4% per year, essentially cancelling the results of any saving measures implemented in the 1980s. Thus, in 1980 the buildings in Greece absorbed 22% of total energy consumption, a number that had increased to 29.8 % up to 2005. As the price of oil to be doubled and at the same time to halve the income in the period 2009-2012, the energy performance in buildings needs to be re-thought and re-designed (Agoris et al., 2004). As an example, Figure 1 presents the energy consumed in 42 school blocks in the Municipality of Thessaloniki for the period 2008-2012. Buildings are capital intensive investments with high initial costs and long life (Power, 2008). In this sense, any omission, neglect or failure of design and construction leads to drawbacks and long-term additional costs.

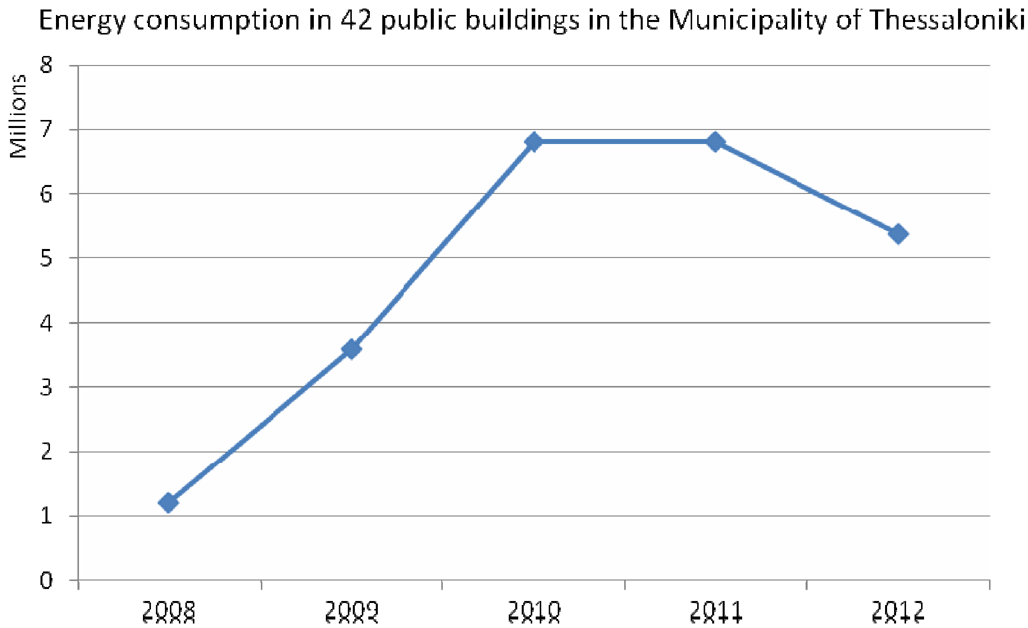

Figure 1. The annual energy consumption in 42 school blocks in the Municipality of Thessaloniki for the period 2008-2012 (in kW).

Causes of the problem

The increase in energy consumption in buildings is both quantitative and qualitative: more energy is consumed in absolute size, while the need for electricity keeps rising. The foreseen estimates regarding the next decades are unfortunately pessimistic, even if effective measures are taken immediately, with several years required in order to reverse this trend (Davies and Osmani, 2011). In an effort to identify and analyse the current situation, it is essential the causes of the problem to be highlighted:

a) The vast majority of built environment, accounting for 68% of the total building stock, is constructed before the introduction of Thermal Insulation Regulation in Buildings in 1979, meaning that is not thermally insulated and requires huge amounts of energy so as to ensure acceptable comfort conditions levels in winter.

b) The insufficient insulation of buildings in the early years of the implementation of the Thermal Insulation Regulation in Buildings conventionally considered over the period to 1985.
c) The existence of old and of moderate preserved heating installations, leading to reduced energy efficiency and therefore to increased consumption and high environmental impact.
d) The continuous increase in both number and installed capacity of systems and appliances that consume mainly electricity. This concerns residential constructions, however mainly office and commercial buildings.
e) The increasingly intensive demand for improved living and working conditions, particularly as regards the thermal comfort in the summer, combined with the lower cost of equipment, led to the installation and operation of over 3,000,000 conditioning units.
f) The fact that in the design of buildings the fundamentals of energy planning are still underestimated, such as the sun shading, natural ventilation and the use of the heat capacity of the building envelope.
g) The delayed introduction of an updated, integrated energy regulation to the Greek legislation. Only in 2010 the Energy Performance of Buildings Regulations (KENAK, TEE, 2010) came into force at a time when, unfortunately, the construction activity was practically diminished.

Potential interventions in public buildings

Based on the foregoing findings the need for immediate intervention seems inevitable, both in the design of new buildings and the upgrading of old ones. The necessary interventions into categories corresponding to those of the causes of pure energy efficiency of public buildings are the following:

Improving the thermal protection of the building shell

The main actions focus on the retrospective insulation of facades, the roof and the replacement of openings. The problem of retrospective insulation of facades of a building can be solved with a variety of construction options. The suggested solutions depend significantly on the insulation position, internally or externally of the construction, and the way the coating material is applied.

The thermal insulation of the roof is a simple and inexpensive process which further contributes to reducing cooling loads during the summer. The solution proposed is that of an inverted roof. Along with its excellent properties in terms of structural physics, this solution presents the important advantage that the existing structure needs not to be demolished.

The thermal insulation of pilotis, where it exists, is technically the simplest intervention performed externally by applying the insulation at the roof.

Finally, the replacement of the frames is an intervention type that is technically simple and simultaneously contributes to the sound insulation. The selection of the frames, as to the operation (opening, sliding) and the material (aluminium, plastic materials, wood), is associated with criteria of architecture functionality as well as potential cost.

Improving the efficiency of heating systems

Satisfactory maintenance, proper settings and, where necessary, the application of thermostatic control sets, as provided by KENAK, but further the replacement of boilers as well as the cleaning and maintenance of boilers consist apparent measures that unfortunately are not engaged to the extent it should. However, great care must be taken to the appropriate training of technical personnel as progress in heating systems is important and require constant updating.

The fact that in Central Macedonia, and northern Greece in general, the heating loads are the most essential factor for consumption, unfortunately often ignored in decision-making at the central level, making it difficult to cover the necessary heating needs because of the high cost over the last years.

Electric devices and installations

It goes without saying that the number of electric systems and equipment will continue to grow. However, special attention should be placed on the promotion and use of devices with low energy consumption based on international “green” standards. This concerns both the "white" appliances (washing machines, cookers, refrigerators) and office equipment. The difference in power consumption is estimated about 25-40 %.

Air conditioning

Air conditioning turns out to be a difficult and complicated problem, since one cannot demand from people who live and work in a building that overheats not to use air conditioning. What can be achieved is the reduction of cooling loads, using mainly shading systems, natural and nocturnal ventilation (where feasible), better maintenance of air conditioning systems and their rational use (Atkinson et al., 2009). These measures could mitigate the problem, However they are not sufficient to prevent it. An integrated strategy is required to address the problem successfully.

Methodological Approach

The classification of buildings was based on criteria such as the use and the age following the basic principles of the Hellenic Statistical Authority (2007; 2010).

The buildings were divided according to their use the following categories:

a) Residential buildings: the category includes houses and block of flats.
b) Public buildings: this class includes public buildings that are municipal buildings, municipal services offices, medical and cultural centres, warehouses.
c) Schools: the category refers to all school infrastructures that operate under the surveillance of the municipality.
d) Sport centres: the class consists of open air grounds and indoor facilities.

According to their year of construction the buildings were classifies as follows:

a) Before 1960: non insulated with old methods of construction
b) 1961 - 1985: non insulated
c) 1986 - 1995: poorly insulated
d) 1996 - 2010: fully insulated (according to the Thermal Insulation Regulation)
e) 2011 – today: structured employing the KENAK.

The majority of the interventions aiming at the potential energy saving are exposed in Table 1 and all possible combinations of the actions presented. Moreover, there are additional measures that focus on the potential of employing integrated air conditioning systems (Cooling/ Heating/ Ventilation), where applicable (Avgelis and Papadopoulos, 2010).

Table 1. Potential interventions in public buildings.

1	Thermal insulation of roof
2	Thermal insulation of facades
3	Replacement of openings
4	Thermal insulation of pilotis
5	Insulation of pipes
6	Installation of solar units for hot water use
7	Replacement of boiler
8	Installation of automation systems

In accordance with the literature, different types of buildings, such as typical office and mixed-use constructions, schools etc., were selected. Depending on the age of the building and construction characteristics, the primary energy consumption (Santamouris et al., 2007 and 2010) was calculated by the Hellenic Energy Performance tool TEE-KENAK. Subsequently specific energy-saving interventions were adopted and their efficiency was estimated and evaluated using the same software (Anastaselos et al., 2011).

The geographical location, the topography, the density of the built environment can affect considerably the microclimate of urban sites. The extensive use of cement, the lack of parks and vegetation along with heavy traffic can cause an extremely low thermal comfort index and thus poor air quality indoor and outdoor. The aforementioned characteristics describe the majority of the municipalities under study, meaning that there is an additional intensive need for energy.

It is proved that specific interventions can significantly reduce energy costs. It is noteworthy that the recovery of energy from the wasted amount a reduction of 20 % can be achieved. If the former action is accompanied by replacement of installations with high efficiency devices and HVAC systems combined with the appropriate automation, the savings can be increased at a rate exceeding 50 %.

Evaluation and discussion

The analysis of consumption in different categories of buildings regarding the energy resources used as well as the use is a difficult process that can only be accomplished by an extended field research, thus leading to a “bottom-up” analysis (Böhringer and Rutherford, 2008).

Aiming to determine the energy consumption of public buildings situated in the studied municipalities data originated from the relevant published literature regarding the Region of Central Macedonia were required. Available information related to the energy performance of public and municipal office buildings, schools and sports facilities was used (Papadopoulos et al., 2002; Theodoridou et al., 2011a and 2011b; Theodosiou and Ordoumpozanis).

Additionally, data and conclusions were exploited deriving from previous research activities of LHTEE (REASURE, 2004), on behalf of the Prefecture of Thessaloniki, the Energy Regulatory Authority and the Centre for Renewable Energy. On the basis of this analysis, the consumption for each building category was estimated describing firstly the current situation and secondly the respective foreseen figures following the implementation of the suggested saving measures. Indicatively Figure 2 exhibits the energy consumption of public buildings in the Municipality of Lagadas as the current situation and the estimated figures after a set of interventions. In some cases, e.g. the Municipality of Kordelio- Evosmos the percentages of heating and electric loads were presented for the different building categories.

As regards the correlation of consumption (and saving) of energy and the carbon emissions, CO_2 emission factors were engaged as stated in the Technical annex to the SEAP template instructions document (Energy for Mayors, 2010). Concerning the thermal loads, in many municipalities in the Greater Thessaloniki Area, the majority of public buildings uses natural gas, and at same time there is a positive rising trend of natural gas installation in residences exceeding 67% (Slini et al., 2013). However, there are municipalities and districts where there is no network yet and hence there is lack of natural gas provision, such as the Municipality of Lagadas, in favour of oil use for heating purposes. It is also highlighted that the current analysis did not include data about the last two years during which, due to the deep economic recession and the uneven increase in the price of heating oil, there is a significant difference in the amount of energy consumed, especially in the residential sector, as no detailed data exist so far.

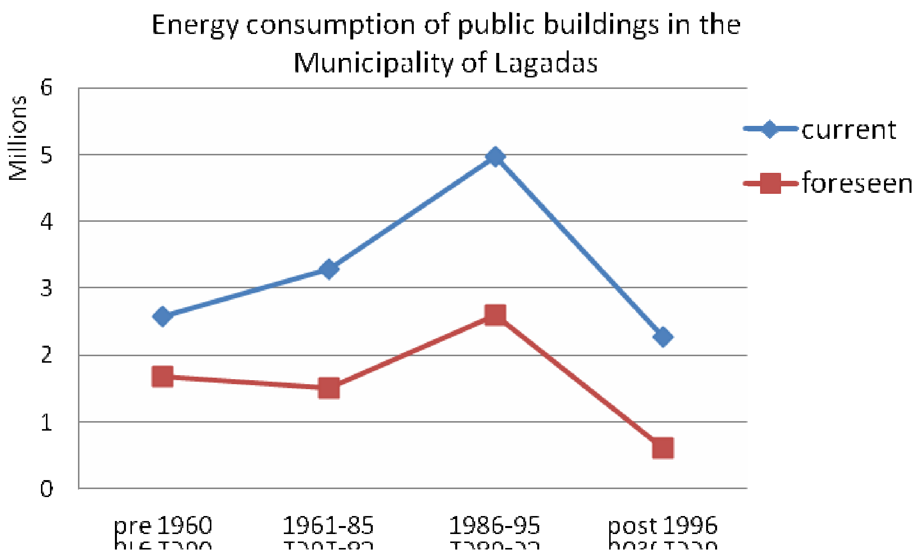

Figure 2. The annual energy consumption of public buildings in the Municipality of Lagadas (in kW) by built year.

In terms of electricity, however, it must be highlighted that the emission factor for electricity (that is 1,167 tCO_2/MWheq) refers to 2006 and is at present outdated. Based on the Operator of Electricity Market (LAGIE, URL 4) and because of (a) the significant penetration of renewable energy (wind and solar), (b) the increase of thermal units of natural gas and (c) due to the reduction of electricity consumption, as a result of the recession, more than 14% compared to 2009, the lignite power plants reduced their proportion to the electricity mix of Greece. Therefore this rate is estimated at 0,867 for 2012 (Hatzigeorgiou et al., 2011). However, in order to be consistent with all the studies submitted to the SEAP, the figure specified in the Technical Annex was selected.

Based on the calculation of energy consumption in current situation and calculate the potential savings for typical buildings where, according to scenarios and interventions using the computational TEE – KENAK tool revealed the final results for each Municipality.

Conclusions

The issue of energy renovation measures in existing buildings is important and complex, as it has been acknowledged by the initial Energy Performance of Buildings Directive and emphasized by its recast. The energy saving potential is significant, but there are barriers that have to overcome, technical, financial and regulatory problems, the technical being probably the most easy to deal with. Considering the harsh reality of Greece, a dramatic increase of energy poverty is already prevailing and this has been proven, as a result of the most dramatic drop in living standards experienced anywhere since World War II. The latest increase in energy prices is a very good reminder of how short-sighted the policy of neglecting to implement saving measures was. Furthermore, as those results do not take into consideration the tax increase on oil and the price increase in electricity in the winter period 2012-2013, they are an alarming warning for the coming years. A change in energy policy considering both the support for the energy renovation of buildings and the taxation of energy has to take place, before the energy problem will become an existential problem for big parts of the Greek society.

The role of municipalities and regional authorities is crucial for a series of reasons: they are responsible for the operation of public buildings affecting sensitive population groups, like schools and centres for elderly people. They can provide the good example needed to promote new energy conservation technologies. And, what is perhaps most important, as the budgets of municipalities are getting ever tighter, it is essential to reduce operational costs, energy being a major component of those.

Finally, international cooperation is valuable, in order to develop sustainable and viable energy action plans. Multilateral initiatives and implementing agreements seem to be the most successful way to address climate change with *Energy for Mayors* to be recognized as a successful example.

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Transition to green economy-a new vector of Kazakhstan's innovative development

As. Prof. Sergey INYUTIN

Head of IT Department of the "Turan-Astana" University

Prof. Gulghamal ZHAPAROVA

Rector of the Turan-Astana University

Dr. Lyubov INYUTINA

Head of the Department of Innovative Technologies, SRC KAHIMINVEST

Contact details of corresponding author

Tel:+7 7172- 437703
Fax:+7 7172- 437703
e-mail: s.inyutin@mail.ru

Address: 29, Street Y. Dukenuly, Astana, 010000, Republic of Kazakhstan

Abstract

Transition to Green Economy is a new political course for Kazakhstan since 2013, due to the current initiatives (2017 Expo and Green Bridge). Emission Trading Scheme (ETS) is one of the elements of Kazakhstan Green Growth Framework recommended at national level and presented to the international Community. It is characterized as a cap and trade system with threshold of more than 20 000 tons of carbon dioxide per year and covering six sectors (energy, oil and gas, mining, chemical industry, agriculture and transport). The National allocation Plan has been developed for 2013 as a pilot phase of ETS, it covers the178 installations(enterprises) with total of carbon dioxide emission (allowances) in amount of 147.1 million tons. Grandfathering principle is used for the three years (2013-2015) ,while since 2016 the benchmarking principle for allocations will be adopted. Allowances from the national ETS include Kyoto project based mechanisms units and the units from the domestic reduction projects within Kazakhstan. Studying the existing carbon markets regarding the possibility of linking in the future along with strong focus on monitoring verification system are among future steps for ETS promoting. In conclusion, the four key steps to Green Growth are determined for Kazakhstan, including: strong political leadership; active government intervention; active public participation and mobilization of global and local partnership.

Keywords: Emission trading, green economy

1. Introduction

"Turan-Astana University"[1] in cooperation with SRC "KAZHIMINVEST" is participating in "PROMITHEAS-4" Project implementation in Kazakhstan, hosted the national seminar " Development of Mitigation/Adaptation in Climate Change Policy Portfolios for Kazakhstan" in June 2013[2]. Transition to Green Economy is a new political course for Kazakhstan since 2013, due to the current initiatives (2017 Expo and Green Bridge) actively developed by the Ministry of. Environment Protection of the Republic of Kazakhstan (MEP) [3].The main tasks in the key economy sectors (water resources, agriculture, energy efficiency, power sector, air pollution and wastes utilization) were defined by the Working Group under MEP. Green house gas emissions reduction in power sector is one of priorities with the following targets: 15% decrease by 2030 and 40% decrease by 2050 [3]. Emission Trading Scheme (ETS) is one of the elements of Kazakhstan's innovative development and Green Growth Framework recommended at national level and presented to the international Community.

2. Green Growth Concept of Kazakhstan and main development challenges

Kazakhstan's macroeconomic performance is the strongest in Central Asia but the oil-rich country faces imbalances in longer-term economic development. In particular, the national oil reserve was estimated at 39.8 billion barrels (2010), the country's major revenue generator, it is expected to last for only 63 years Kazakhstan has significant gaps in energy and infrastructure sector, especially on appropriate policies, markets and institutional frameworks to allow efficient development of these sectors. Kazakhstan has been identified as one of the countries with high vulnerability and low adaptation potential for climate change effects. In this regards the main development challenges defined are the following:

- Reducing excessive dependency on primary industries and commodity exports, mainly oil & gas;
- Addressing lack of capacity and institutional structure, especially in the water and energy sectors;
- Protecting its fragile ecology (semi-desert geography) from the adverse impacts of climate change.

Kazakhstan's long-term national vision on innovative development is based on the "Strategic Plan 2020" (President Order No.922 dated 2010) [5]. In 2010, a national report on the" Integration of Green Growth Tools in the Republic of Kazakhstan" was presented at the 3rd Astana Economic Forum and at the Sixth Ministerial Conference on Environment and Development in Asia and the Pacific (MCED-6), Astana.

The Green Growth Concept in Kazakhstan is concerned with integrating environmental security and resource efficiency considerations at the heart of country’s economic development planning and implementation; accepts a country’s growth targets as a given rather than trying to adapt or subordinate them to a particular environmental agenda; analyzes the policy options that could yield significant co-benefits for growth and environmental protection and resource security within the economy or within its significant sectors; is a practical attempt through economic policy to operate the normative frameworks represented by the sustainable development and seeks to fuse sustainable development’s three pillars into a single intellectual and policy planning process, thereby recasting the very essence of the development model so that it is capable of realizing sustained economic growth while safeguarding or improving the environment.

In order to be Green Kazakhstan beyond the expected Top Green Nation in Central Asia it is recommended to develop three strategic directions, such as: Green existing asset; promoting new growth engine through industry restructuring and building the foundation for the sustainable green growth. These goals could be achieved by enhancing energy efficiency, good management of water national system, providing strategic reforms in industry, creating green education and jobs, mitigation of green house gasses (GHG) emissions, providing fiscal support of activities, further developing of legislative and institutional reform.

3. Kazakhstan climate change policy and institutional framework

Kazakhstan ratified Kyoto Protocol in 2009 and intended to be included in Annex B of it. In 2010, the "Plan of the Republic of Kazakhstan on the Transition to Low-carbon Development till 2050" was published. According to it the voluntary obligation to decrease the greenhouse gases (GHG) emissions by 15 percent by 2020 and by 25 percent by 2050 compared to the 1992 level. The implementation of this plan would mean that the country would meet its commitments entered into before the world community on quantified targets on the reduction of GHG emissions, improving energy safety and living standards.

The following priority areas of low-carbon development were specified in the Plan name above:

- Improvement of energy efficiency to reduce the expected level of energy consumption;
- Acceleration of renewable energy development (hydro, wind, biomass, waste, solar and geothermal);
- Regulation of national GHG emissions through the organization and functioning of the national market of quotas for GHG emissions;
- Population awareness raising on climate change

According to the outcome of the negotiations during the 17th Conference of Parties in Durban it seems likely that Kazakhstan will be an Annex B party to the second commitment period of the Kyoto Protocol (2013-2017 or 2013-2020), with full access to the trading mechanisms of the Kyoto Protocol. According to the Durban decisions [6] the specific rules for the second commitment period (CP2) of the Kyoto Protocol are the following:

- Limitation of authorized emission for CP2 above average 2008-2010 levels;
- Carrying-over of allowances and credits from the first commitment period of the Kyoto Protocol under conditions:
    - Full carrying-over of Assigned Amount units (AAUs);
    - Limited carrying-over for Certified Emission Reduction (CERs) and Emission Reduction Units (ERUs);
    - Use for compliance in CP2 authorized.

The calculations of GHG emissions on the second commitment period of the Kyoto Protocol (KP-CP2) for several countries including Kazakhstan compared to 2008-2010 emissions after implementation of new rules according to Durban decisions are presented in the Table 2.

One of elements of mitigation policy and elements of "Green Growth economy" of Kazakhstan is Emission Trading System (ETS). The ETS is part of the Government’s green agenda and will help Kazakhstan achieve its Kyoto Protocol emission reduction target of minus five per cent by 2020 compared to 1990 levels.

Table 1: Commitments in Kyoto Protocol - second commitment period (KP-CP2) (Source: CDC Climate Research, available at:http://www.cdcclimat.com/CDC-Climat-Research-s-publications.html)

Country	Base year emissions (1990 for most countries) (MtCO2eq.)	Commitment KP-CP2 pledged by countries (2013-2020) compared to base year	Commitment KP-CP2 compared to base year after limitation at 2008-2010 levels	Commitment KP-CP2 compared to 2008-2010[1] emissions after implementation of new rules (carry-over and limitation at current levels)
Australia	548	-0.5%	-0.5%	-3%
Belarus[2]	139	-12%	-36%	0%
Croatia[3]	31	-20%	-20%	-10%
EU-27[4]	5,772	-20%	-20%	-2%
Iceland[3]	3	-20%	-20%	-33%
Kazakhstan[2]	360	-5%	-29%	0%
Liechtenstein	0.2	-16%	-16%	-22%
Monaco	0.1	-22%	-30%	-11%
Norway	50	-16%	-16%	-19%
Switzerland	53	-15.8%	-15.8%	-16%
Ukraine	921	-24%	-58%	+ 87%
TOTAL	7,878	-18%	-24%	+ 4%
TOTAL excl. EIT[5]	6,457	-18%	-18%	-2%

Carrying-over calculation is based on 2008-2010 emissions. Notes:

[1]A positive percentage indicates that the average annual emissions for the 2008-2010 period (including credits and debits under "Land use, land use change and forestry"(LULUCF) are above the permitted emissions under the KP-CP2. The year 2010 is the latest year for which data have been validated in the framework of the United Nations Framework Convention on Climate Change (UNFCCC).

[2] Amendments including Belarus and Kazakhstan for the first period of the Kyoto Protocol (KP-CP1) have not been ratified so far.

[3] Croatia and Iceland will fulfill their commitments jointly with the European Union (EU) in accordance with Article 4 of the Kyoto Protocol.

[4] The EU-27 countries have differentiated commitments under the KP-CP1. The provided data therefore aggregates those of the concerned countries. According to the European Climate and Energy Package, countries are not allowed to use their surplus of AAUs for 2013-2020.

[5] EIT: Economies in transition. Here, only non-European countries are included: Belarus, Kazakhstan and Ukraine.

The Ministry of Environmental Protection (MEP) is the central executive body coordinating and leading the development and implementation of government policies on environment protection and management, including climate change issues. The Ministry of Environmental Protection (the Low Carbon Development Department) is primarily responsible for the implementation of the Kazakh ETS. The “Kazakh Research Scientific Institute on Ecology and Climate” (KazNIEK) is developing regulation to support emissions trading. Several other ministries are involved through coverage of their respective sectors in the mitigation policies. The oil and gas and energy companies play an important role in implementing innovation development, energy efficiency programs and utilization plans that affect the level of emissions.

4. Emission Trading Scheme in Kazakhstan

In 1990, Kazakhstan’s direct carbon emissions were 360 million tons [7]; this dropped to 189 million tons in 2000 and since then both the country’s economy and its emissions have recovered: in 2009 Kazakhstan emitted 261 million tons of greenhouse gases (without LULUCF), a 28 % increase over 2000 levels, while in 2010 Kazakhstan emitted 262.72 million tons of CO_2 equivalent[27], a 6.5% decrease to 2009 level. Energy activities, which is heavily based on coal, is an important source of emissions in the country, including 245.9 million tons of GHG emissions or 84% of total in 2009 (see Figure 1) while the renewable energy potential is largely untapped.

Motivating the industries to follow up on their pledges is one of the reasons for the introduction of the emission trading scheme (ETS) in Kazakhstan.

[27] :http://www.climate.kz/rus/?m=html&cid=42

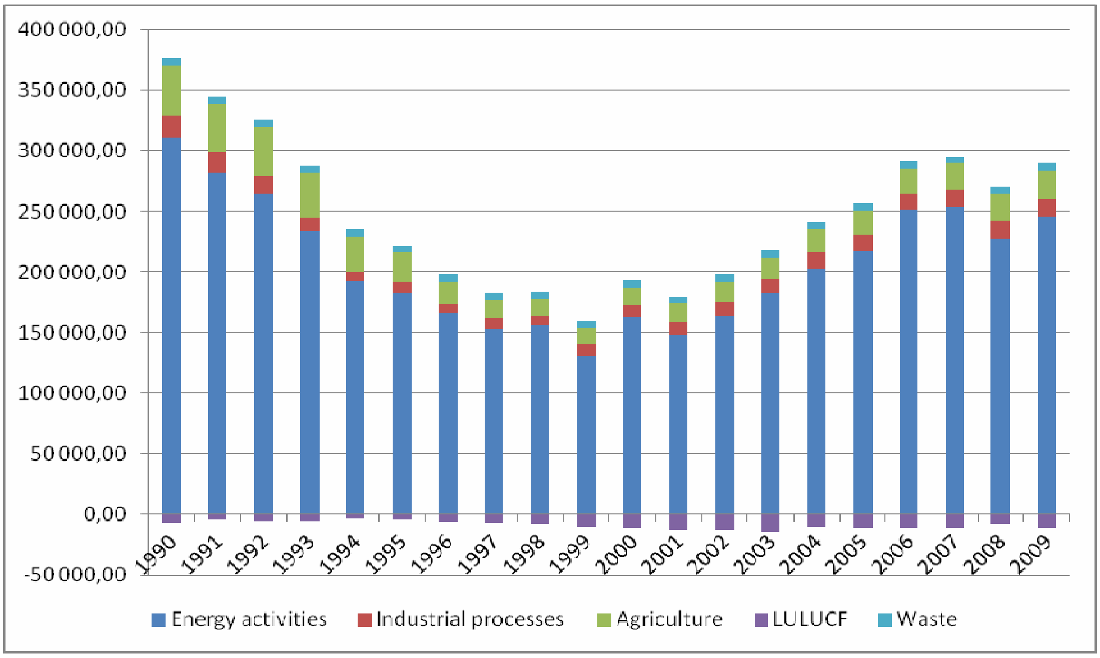

Figure 1 – GHG emissions time series in Kazakhstan for the years 1990-2009 (in Gg of CO_2 equivalent). Source: National inventory Report,2009, KAZNIEK available at:www.ecoclimate.kz

Table 2. National Allocation Plan 2013 per sector in Kazakhstan Source: Annex 1 of the National Allocation Plan 2013, Governmental Decree No.1588 dated 14.12.2012 - available at: online.zakon.kz/Document/?doc_id=31313146

Sector of economy	Number of installations (enterprises)	Number of allowances (tons of CO_2)	The volume of the quota (including commitments to reduce to 0% of 2010bbaseline emissions), tons of CO_2
Energy	55	84 002 771.97	84 002 773
Oil and Gas	69	19 773 943.61	19 773 944
Industry	54	43 413 375.40	43 413 375
Total	178	147 190 090.98	147 190 092

The National Emissions Trading Scheme (Kazakh ETS) is established and entered into force since 1 January 2013 with its pilot phase (2013-2014) according to the amendment by the law No. 505-IV entitled "On Amendments and Additions to Certain Legislative Acts of the Republic of Kazakhstan concerning Environmental Issues" (further the Law "On Amendments") adopted on 3 December 2011.

According to this law the amendments are done to Kazakhstan's "Ecological Code"28 dated 7 January 2007 with attention to State regulation of emissions and removals of greenhouse gases. It covers entities with overall annual emissions exceeding 20,000 tons of carbon dioxide (CO_2) within the specific economic sectors (agriculture, transport, oil and gas, mining and metallurgy, the chemical industry, and energy) [4] will be prohibited by law to operate unless they have obtained allowances for GHG emissions from the Ministry of Environmental Protection of Kazakhstan (MEP). More than half of Kazakhstan's emissions reported in 2010, a total of 145 million tons of GHG emissions from approximately 178 installations, is covered by the emission trading scheme in 2013. Emission Trading scheme (ETS) in Kazakhstan is characterized as a cap and trade system:

- capping of emissions via distribution of tradable emission quotas (1 quota = 1 ton of greenhouse gas, expressed in its CO_2 equivalent);
- a quota price depends on the level of restriction imposed by the authority (ratio of supply and demand);

ETS pilot phase (2013 -2014) covers 147 million tons of carbon dioxide equivalent (see Table 1) plus 20.6 tons of carbon dioxide equivalent reserve, it is presented in the "National allocation Plan"[8] approved by Governmental Decree No.1588 dated 14.12.2012. Reserve is created for new installations, expansions at existing installations, and for price management. For this period it covers only carbon dioxide emissions, but methane and nitrous oxide must be reported.

[28] Statement of the Parliament of the Republic of Kazakhstan, 2007, available at: http://adilet.zan.kz/rus/docs/Z1100000505

According to the approach applied the free allocations are determined on the basis of historical emissions, in particular, in the pilot phase (2013) 100% free allocations are given based on the 2010 emissions.

The penalties in Kazakhstan may apply from 2014 onwards for companies that exceed their emissions cap. A carbon price is thus expected to develop, which provides incentives to invest in energy efficiency, dependent on a company's marginal abatement cost curve. The scheme also allows for the use of credits from emission reduction projects in sectors not covered by the ETS ('domestic offset projects'). Emission reduction projects in the following sectors are prioritized, meaning that fast-track procedures apply: mining and metallurgy (non-CO_2 gases), agriculture, housing, forestry, prevention of land degradation, renewables, municipal and industrial waste, transport and energy efficient construction. In the second phase (2014-2020) the free allocations are based on the emissions over the last two years preceding the new period, aligned with the program for GHG emissions reduction that the operator submitted when entering the ETS. For the competitiveness purposes the priority sectors that should receive free allocation of allowances are defined. These are the same sectors that are currently covered by the ETS plus the petrochemical sector. Currently only domestic offsets are allowed under ETS, mobilized by conversion into allowances from the reserve. The ETS supporting regulation adopted by the government includes 17 Government decrees and 14 Ministerial orders [4]. The National allocation Plan has been developed for 2013 as a pilot phase of ETS, it covers the178 installations(enterprises). Grandfathering principle is used for the three years (2013-2015) ,while since 2016 the benchmarking principle for allocations will be adopted. Allowances from the national ETS include Kyoto project based mechanisms units and the units from the domestic reduction projects within Kazakhstan [9]. The ETS is considering linking to the European ETS and potentially other schemes, it is planned to be implemented based on the mutual agreements. The conditions of the use of the mutual recognized allowances will be specified in the national allocation plan of the next period (2014-2020).

5. Registry, monitoring reporting, verification

The operators participants of the ETS follow detailed monitoring and annual reporting procedures. The annual GHG inventory reports must be verified by independent accredited organizations. The state registry is under development recently. All allowances and domestic offsets are to be registered in the State registry. After Kazakhstan has reached an international agreement on climate change and ratify Kyoto Protocol- 2 all carbon units can also be held in the State registry. Three government decrees and six ministerial orders regulate the monitoring, reporting and verification system in Kazakhstan[10], nevertheless the regulation needs further development.

6. Key findings and conclusion

Transition to green economy is attractive for Kazakhstan and will help to realize its ambition of becoming one of the top-30 most developed countries. It is expected that the innovative development by 2050 will increase employment of more than 450.000 jobs, establish the new industrial and service sectors. Studying the existing carbon markets regarding the possibility of linking in the future along with strong focus on monitoring verification system are among future steps for ETS promoting.

Allowances and domestic offsets are registered in the state registry. After Kazakhstan has reached an international agreement on Climate change, AAUs, ERUs, CERs and removal units (RMUs)[29] can also be held in the state registry according to MEP Orders No.147-e dated and No.148-e dated 10.05.2012[10]. The mutual recognized allowances can be used in the Kazakhstan ETS for compliance only upon the establishment a bilateral or multilateral agreements between Kazakhstan and other countries.

In conclusion, the four key steps to Green Growth are determined for Kazakhstan, including: strong political leadership; active government intervention; active public participation and mobilization of global and local partnership.

The key steps to Green Growth include: strong political leadership, active Governmental intervention (top-down approach), active participation from the public(bottom-up approach) and Mobilizing of Global and Local Partners. Further steps for promoting ETS in Kazakhstan include:

- Improving the national legislation
- Designing National allocation Plan for the second period
- Selecting an exchange for distribution of the reserve to new installations
- Improving the data management systems
- Establishing the ETS Registry
- Studying the existing carbon markets regarding the possibility of linking in the future
- Strong focus on monitoring, reporting and verification system

29 http://unfccc.int/kyoto_protocol/mechanisms/emissions_trading/items/2731.php

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Azerbaijan: Transition to clean energy in the condition of climate changes

Dr. Rovshan KARIMOV,
Institute of Geography, Azerbaijan National Academy of Sciences

Abstract

Energy industry considerably affects climate changes, and this necessitate carrying out of studies on production of clean and efficient energy. Transition to wide use of environmentally safe sources of energy in practice is also needed. The economy of the Republic of Azerbaijan significantly bases on petroleum- and gas industry due to the rich fuel reserves. In the country, the process of transition to use of alternative resources of energy is at beginning stage of its development. The aim of the research is to:
- Study the influence of energy industry on air pollution in Azerbaijan and 'power capacity' of the country;
- Study the change of amount of harmful substances, emitted in energy industry and responsible for greenhouse effect.
- Analyze and study the potential of use of clean energy in Azerbaijan.
The expected outcomes are:
- Identify the changing role of energy industry in change of air quality in Azerbaijan;
- Assessment of the actions on transition to clean energy, implemented by the government of Azerbaijan in recent years;
- Scientific substantiation of potentials of using wind- and solar energy in the territory of Azerbaijan with putting forward proposals.

Key words: sustainable development, green industry, alternative resources, fuel, wind energy, solar, clean energy

Introduction

After recognition of necessity of sustainable development at Rio-92 Conference, all countries in the world started to follow this aim for reaching benefits of sustainability. It is obvious that development does not mean only preventing socioeconomic challenges, reducing poverty and improvement of living. Strong economic development requires sustainable content at present, because humanity and the next generations need sturdy future of the Earth. Being exposed to pressure, the world changes, and this is seen by climatic hesitations and abnormalities, increasing natural disasters, developing land erosion, challenges in effective and qualitative water supply, contamination-related deceases, etc. It should be regretfully mentioned that many economies in the world still develops dirty technology as well as unsafe production.

Heavy impact on nature is made considerably by industries, and it is no by chance that the concept of sustainable development later was followed by another conception – 'Greening of industry' which targets progressive technology and effective management, wise functioning, less environmental damage and high productivity. Significant part of sustainable development programs includes aim of production of cleaner energy and greening of industry in most countries. Considerable role is played by use of alternative resources, including solar- and wind energy as growing and more effective and environmentally efficient way of energy production.

Changes of air temperature in Azerbaijan

Energy production in the world closely relates to climate events. Carbon emissions and other emitted substances, their amount and composition affect the air quality. Change of the air quality in its turn affects climate events. In this study, analysis of climate changes is given on hesitations in air temperature in the territory of Azerbaijan.

Global climate changes are reflected in interrelations of regional climatic changes. As an integral part of the world, Azerbaijan experiences climate changes. In 2007, the intergovernmental group of experts from the Caucasus countries concluded that climate changes are underway, and this process is influenced in particular due to anthropogenic reasons, especially within the last 50 years. The studies carried out show that hesitations were observed on atmospheric circulations in the territory of Azerbaijan within the last 100 years. In 1906-2005, the average global temperature has been increased by 0,74°C. According to comparative statistical comparisons of data, fixed at points of Gadabay, Alibay, Griz and Altiaghaj (mountainous areas of the Great- and Less Caucasus) during the period from 1991 to 2008, the temperature of air has been increased by July, August, September and October (Safarov, Huseynov, 2010). The climate hesitations affect regime of flow of rivers, vegetative cover and landscapes. These processes lead to changes in decrease of areas of mountainous- and forest landscapes, including areas of forests and bushes, and also decrease and intensive degradation of high mountain- and the subalpine meadows in Azerbaijan.

The obvious climate anomalies were observed also by points of Agstafa, Samukh and Shamkir, the north-western part of Azerbaijan. Comparative analysis based on data of 1961-1990 and 1991-2005 periods shows that anomaly of air temperature in average is basically 0,4-1,6°C. Anomalies take place basically during summer season at Aghstafa point located in Ganka-Gazakh plain near the border with Georgia on the west, making up to 1,7°C. At Samukh point, the Jeyranchol area anomaly of air temperature makes 0,4-1,6°C. Here the anomalies take place mainly in August (1,7°C). At Shamkir point, anomaly of air temperature makes 0,4-1,3°C. Here the anomalies take place mainly in August, and makes up 1,3°C. It is expected that the air temperature will be increased by 0,2-0,4°C within the next 20-25 years in the territory of Azerbaijan (Israel Y. 2008).

'Development Program on hydrometeorology in Azerbaijan Republic' has been endorsed in 2004, and includes functions of carrying researches on hydrometeorology, assessment of climate changes and their impact on the environment as well as the study and prognostication of the related dangerous events.

Energy production and air pollution

In Azerbaijan, quality of the air is significantly influenced by stationary sources, including industrial areas, namely oil- and gas production, petrochemical industry, chemical plants, construction enterprises, textile industries, and others. Particular role here is played by the power industry, responsible for the emission of harmful substances (table 1).

Energy industry, oil- and gas extracting enterprises contribute about half of harmful substances, emitted in the territory of Azerbaijan. Among objects of energy industry, heat power stations using fuels bear major responsibility . Power stations, operating on the basis of fuels are located in Baku, Sumgait, Ganja, Mingachevir, and Shirvan.

The largest power stations include 'Shimal', located in Baku city, 'Azerbaijan' State Regional Power Station near Mingachevir city, another SRPS located 10-15 km off Shirvan city, and also the five heat- and energy centers located in Baku, Sumgait and Ganja. Operation of all these stations is managed by 'Azerenergy' Stock Company. The mentioned enterprises shares 80% of the overall capacity of power stations. The projected generation power of stations makes up 4,5 thousand mWt, but in reality they operate at 70-75% of capacity. The considerable advancement is that the power stations of Azerbaijan started to use only natural gas instead of hard black oil. This allowed sharply reduce harmful wastes, namely the amount of nitrogen oxide by 29% as well as the amount of sulfur-oxide by several times (Sh. Mammadova, 2007). The concentration of sulfur dioxide has been reduced in the air of Baku city from 0,025 to 0,015 mg/m3 within 2004-2010. Emission of fluoral compounds and hard substances in the air is also considerably reduced due to the mentioned progressive transition in use of fuel. Power stations operating with natural gas are responsible for 34 tons of carbohydrogenic compounds, 20 thousand tons of nitrogen oxide, 20,4 thousand tons of sulfur oxide, and 500 tons of harmful substances emitted into the air. In 1996-2003, the amount of harmful wastes emitted by fuel-using power stations reduced by 61%, making 13% of the overall emission fixed by stationary sources located in Baku, Sumgait, Ganja, Mingachevir and Shirvan.

In 2000-2007, the amount of heat energy was 41,2 million Gcal. The amount of electroenergy produced by heat power stations made up 150,8 million kWt/hour or 89,4% of the total indicator (Environment in Azerbaijan, 2008).

Energy intensity

One of indicators, reflecting level of sustainable development, is non-carbonization. In recent years, use of different indexes is widely carried out when analyzing sustainable development of countries. These indexes include energy intensity (I), carbon intensity (II), and differences between carbon and energy intensities (III) in countries. Energy intensity is measured by proportion between the amount of used energy and GDP of the country. Energy intensity of the country remains constant if proportion and energy efficiency of energy resources is constant. Energy capacity is different by countries. As for carbon intensity, it is measured on the basis of proportion of carbon emission and GDP, and indicates the amount of carbon emissions per unit of GDP. Here carbon intensity of fuel as well as share of fuel energy within overall energy production is taken into consideration. According to Mehtiyev M. and Suleymanov G., energy intensity index (I) is much more in Azerbaijan compared to Georgia, Iran (by about 2,3 times), India (by 3,5 times) and Moldova (by 3 times), and is less than that of Ukraine. As for carbon intensity index (II), for this indicator Azerbaijan surpasses Iran and India by 2,5-2,7 times, Egypt by 4,8 times, and Georgia by 2,4 times. Energy intensity (I) and carbon intensity (II) are nearly the same for Azerbaijan and Ukraine.

Table 1: Amount of gases emitted from stationary sources and responsible for arising of greenhouse effect in Azerbaijan (thousand ton).

Gas	2006	2007	2008	2009	2010	2011	2012
Carbonic dioxide (CO_2)	17 664,4	14 828,8	16 013,3	15 293,1	14 399,6	13 809,4	12 471,4
Nitric oxide (N_2O)	0,8	1,7	6,4	10,4	11,8	25,9	15,8
Methane (CH_4)	16,6	24,3	49,5	24,2	18,3	298,3	385,2
Hydrogen fluorocarbons	0,6	0,5	0,2	7,0	6,8	0,0	6,4
Sulfur hexafluoride	0,1	0,1	0,2	0,6	0,3	0,7	0,6
Perfluorocarbons	0,9	0,6	0,3	6,4	5,6	0,1	5,6

However, the main indicator that clearly shows sustainability, is a difference between carbon and energy intensities (III), which is lower in Azerbaijan whereas is much more in ‘high-carbonized countries’ like Moldova and India, whereas this indicator is lowest in France and Ukraine, showing that these two countries are the ‘non-carbonized’ (Mehtiyev, M., Suleymanov, G. 2013. pp.273-274). As seen, achieving progress on sustainable development requires more effective energy production in the future in Azerbaijan as well as in other CIS countries.

Energy production and sustainable development way of Azerbaijan

In Azerbaijan, juridical base of realization of the concept of sustainable development has begun to be formed since the second half of 90s. National laws on different aspects of sustainable development were officially adopted in different periods, including Laws ‘On Protection of Plants’ (03.12.1996), ‘On Keeping Human Health’ (25.07.1997), ‘On Fishing’ (27.03.1998), ‘On Protection of Environment’ (08.06.1999), ‘On Protecting Animal World’ (08.06.1999), ‘On Environmental Security’ (08.06.1999), ‘On Protection of Atmospheric Air’ (03.03.2001), ‘On Obligatory Ecological Insurance’ (12.03.2002), ‘On Ecological Education and Enlightenment’ (10.12.2002), ‘On Environmentally Safe Agriculture’ (16.06.2008) as well as others. ‘Plan of Complex Arrangements on Improvement of Ecological Situation in Azerbaijan within 2006-2010’ has been implemented. National Programs on ‘Environmentally Sustainable Socioeconomic Development of Azerbaijan Republic’ and ‘Restoration and Enlargement of Forests in Azerbaijan Republic’ (18.02.2003) as well as programs of ‘Rational Use of Summer and Winter Pastures and Hayfields, and Prevention of Desertification’ (22.05.2004) are also should be noted.

The State Program of ‘Development of fuel- and energy complex in Azerbaijan Republic‘ (2005-2015) includes duties such as: ‘Up-to-date development of energy industry’; ‘Providing ecological security in fuel- and energy complex’; ‘Realization of advanced technological measures on production, transition and consumption of energy resources’, and etc. Many commitments on developing energy efficiency have already been carried out.

On the background of adoption and implementation of these official documents, Azerbaijan is on the way of taking advantage of climatic resources. In the condition of plenty of fuel resources, process of transition to use of alternative energy resources, including wind- and solar energy has been developing relatively slowly in Azerbaijan in 90s and the first half of 2000s. The country is at preliminary stage of clean energy production. The main related notable works implemented in the country in recent years is given below

In 2011, the production of electric power in Azerbaijan Republic made up 20,3 billion kWt per hour (Industry of Azerbaijan. 2012). According to official statistics, it reached the peak in 2006, making up 24,5 billion kWt/h. For showing differences, the corresponding indicators can be given for other countries: Turkey - 186,0 bill. kWt/h, Denmark - 34,9 bill. kWt/h, Hungary - 32,7 bill. kWt/h, Slovakia - 23,7 bill. kWt/h, and etc. As for comparison with CIS republics, Azerbaijan prevails over many countries for this indicator, namely Armenia by over 2,7 times, Kyrgyzstan by 34 percent, Tajikistan by 25 percent as much and etc., lagging behind Belarus by 57,6 percent and Uzbekistan by 2,6 times as less.

At present, most of EU-members are planning to increase the role of ‘safe and green’ energy. The share of wind power within domestic electricity supply is 35% in Denmark as well as 16% in Portugal and Spain. In 2009, consumption of wind-generated electricity in Denmark topped as the highest indicator in the world per person (1,218 kWh). Regretfully, the share of alternative resources within the total amount is very small in many CIS countries, and particularly in Azerbaijan. Analyzing the official data by 2011, it may be concluded that 86,8% of the overall electricity was produced at thermoelectric power stations, operating due to fuel (natural gas). 13,2% of electricity was produced at hydroelectric power stations. As the statistics shows, the production of energy at the expense of wind power almost was not been implemented. In 2009 and 2010, the volume of energy gained at wind power stations made 2,1 and 0,5 million kWt/h respectively, which are extremely low indicators compared to overall energy production.

Azerbaijan cooperates with EU on achieving resource efficiency. In the future, the sides have to put into reality a number of programs and projects on increasing energy efficiency based on alternative resources. In summer of 2009, following a Presidential Decree, the State Agency on Alternative and Renewable Energy Sources (SAARES) was established as a part of the Ministry of Industry and Energy. Three years later it was converted to the state company, dealing with solution of the same problems. This entity has the mandate of the principal regulatory institution in the sphere of alternative and renewable energy and is tasked with assessment of sustainable energy potential, shaping relevant policies, including tariff policy, elaboration and enforcement of relevant procedures such as issue of special permissions to the public and private entities to construct power generation facilities (6). This was very significant event on the long way to establishing environmentally safe industry in the country. Taking into account the existing potential, the special emphasis in the process of use of alternative sources of energy should be laid on solar energy and wind power.

Solar energy: potential and perspectives

As is known, use of solar energy means absence of any harmful emission to the air. Perspective of use of solar energy is large in Azerbaijan due to advantageous agroclimatic potential of this country. The quantitative indicators of sunny hours are sufficient in the country. The yearly amount of sunny hours is 1800-2900 in Azerbaijan. The highest indicator is typical for the territory of the Autonomous Republic of Nakhchivan, reaching up to 2900 hours a year. The Kura-Araz lowland, Jeyranchol area, and the peninsula of Absheron are the territories with 2200-2400 sunny hours. The qualitative indicators are also favorable in term of use of solar power in many places of Azerbaijan, hesitating from 125 to 150 kcal per sq. centimeter. It is 125-134 kcal per sq. cm in the Kura-Araz and Lankaran lowlands. The highest figure is in Nakhchivan (145-160 kcal per sq. cm).

Sumgait-located AzgunTech plant, constructed by State Company of Alternative and Renewable Energy Sources, operates since 2012. The enterprise is the first commissioned plant of High-Tech Park. It produces sun panels and LED lamps. The plant works on a full capacity. Each module of solar panels in the plant has 60 solar cells with capacity of 42-250 watts. Production is also relevant to the project named "Thousand houses - thousand plants" designed for the housing sector, and is to provide installation of solar panels on homes. It is expected that the capacity of the plant will make up 120 thousand solar panels per year (with a capacity of 30 MWt) at the first phase of production. The indicator will made 240 thousand a year in the future. In the meantime, production of solar batteries in Sumgait is expected to be realized. Besides with these, the plant will produce 36 million LED chips and 12 million diode lamps.

Wind energy: great opportunities

Having its economic effects, use of wind power is also a significant process from view of sustainable development. Operation of a wind generator of 1 mWt prevents emission of 1800 tons of carbon dioxide, 9 tons of sulfur-dioxide and 4 tons of nitrogen-dioxide within a year. According to estimates of the World Wind Energy Association, wind energy industry will allow to reduce 1,5 billion tons of carbon-dioxide emissions by 2050. With transition to developing wind power industry, many developed countries reached to considerable reduction of amount of carbon-dioxide emissions. In Denmark, use of wind energy allowed to reduce these emissions at least by 2 times. The use of wind power at stations with 1 mWt power is equivalent to savings in 29 thousand of coal or 92 thousand barrels of oil within 20 years. Looking on economic sides of functioning of wind turbines, it is notable that increase of power by 2 times due to installation of modern equipment allows reducing of costs of electric power for 15%. The cost of installation of equipment of wind power station with 1 kWt is about $ 1000.

It is estimated that in Azerbaijan, natural and geographical condition, and also economic infrastructure may allow to produce 800 mWt of energy a year at the expense of wind power. This is equivalent to an electric energy of 2,4 billion kWt/hour. The best condition for developing wind power industry is on northwestern part of the Caspian Sea. Historically, a lot of windmills have been constructed in the territory of Azerbaijan, particularly in Absheron area with the purpose of using drinking waters of wells. This method is currently used in some places of Absheron.

Taking into consideration the power, directions, and continuation of winds as well as possibilities of taking advantage of wind energy, the two zones may be differed in the territory of country.

The first zone covers territories of Siyazan, Khizi, Absheron, Gobustan, Neftchala, Salyan, including the mouth of Kura River. This large area is dominated by Northern, and partially northwestern winds. The speed of Nord (northern winds) is up to 8-10 m/s. In this strip zone from Siyazan to the point of Alat, the amount of windy hours reaches 2000-2200. The average speed of wind reaches 6-9 m/s in the peninsula of Absheron.

The number of wind-blowing days is 245-280 in the mentioned territory. At least 8-10% of the territory of the peninsula is reliable for installation of wind turbines. There are great possibilities for development of wind farms also in the islands of the Caspian Sea, the number of which is up to 50 as well as the territories of Khachmaz, Masalli, and less-populated Gobustan. According to some experts, production of electric power at 1 kWt/hour is equivalent to $ 0,15-0,2.

The second winds-dominated zone encompasses Jeyranchol Plateau, the regions of Ganjabasar, Goranboy, Terter and surrounding areas where northwestern winds are dominant. Creation of wind power plants in these territories would be effective particularly due to plenty sunny hours of spring and winter.

Ganja-Dashkasan region, and also the administrative areas of Sharur and Julfa located in Autonomous Republic of Nakhchivan are favorable territories areas for construction of wind farm due to the dominant winds average yearly speed of which make up 3-5 m/s. The last indicator is advantageous for operation of wind stations of medium power. The average yearly speed of winds in the Great Caucasus is 0,8-2,3 m/s as well as 1,8-2,4 m/s in Lankaran-Astara, and 1,9-2,7 m/s in the Lesser Caucasus. These indicators and the carried out analysis give a basis to suggest about efficiency of using wind power chiefly in Absheron, Gobustan, Siyazan, and the adjacent Pre-Caspian territories (1), and also northwestern part of Azerbaijan – Ganja-Goranboy-Jeyranchol zone (2). In addition, it is favorable also in term of efficient land use, because the both mentioned zones have not fertile soils, and therefore, are less-populated areas. This is suitable for location of wind generators which must encompass relatively large area.

In order to use alternative energy, the construction of hybrid polygon is underway in Maraza settlement of Gobustan. The polygon operates at the expense of not only wind and sunbeam but also biomass. By 2012, 2,7 mWt of energy is produced due to wind power, 2,0 mWt of energy is gained by using sunbeam as well as 1,0 mWt from biomass. The polygon will provide Gobustan region with electricity in the future.

The wind farm in Pirakushkul is expected to be commissioned in 2013. The project sponsored by KWF Bank and the government of Azerbaijan is estimated at € 165 million. Another project – the creation of Sea Wind Farm in the Caspian Sea, estimated at € 250 million is to be invested by non-state entities and the government in the near future as well.

Conclusion

– The process of transition from hard fuel to liquid fuel as source of energy is completed in Azerbaijan. The power stations of Azerbaijan are using only liquid fuel, namely liquid gas, and this caused to decrease of the amount of nitrogen oxide, sulfur oxide and other harmful substance in the air. The share of power stations within the pollution process has been reduced whereas the share of vehicles has been increased in recent years.

– Improving technology, and also increasing requirement of society needs more energy in contemporary world. Transition to sustainable development and sustainability of energy industry necessitate looking for and developing new sources of energy in the 21th century. Even if fuel reserves will be the main origin for energy production for a few further decades, steady basis for developing alternative sources should be formed at the present. From this view, passing to alternative resources should be regarded as very important and needed process in Azerbaijan. The state company, being engaged in use of alternative and renewable energy, is functioning since 2009. More than 20 state programs and laws on sustainable development, including fuel energy and alternative resources have been adopted in the Republic of Azerbaijan. This is an essential step for the further practical activity on the way of transition to clean energy.

– In Azerbaijan, the percentage of clean alternative sources within the balance of energy must be gradually increased in the future. There are wide opportunities for development of environmentally safe energy industry based on alternative resources in the country. The creation of medium-sized wind farms in Absheron-Gobustan zone is only the beginning and such projects should be put into reality also in the Caspian Sea. As we think, the north-western and south and south-western coasts of the Caspian Sea (non-recreational zones, i.e., north to the Sumgait and south to Baku) are the more suitable areas for use of wind power. Within frame of beginning stage, use of wind energy must be implemented also in less-populated north-western part of Azerbaijan, to the west of Mingachevir water storage (Jeyranchol area, the territories of Samukh and Shamkir regoins). In the meantime, production output of solar panel-producing AzgunTech plant should be increased for wider use of its products in the territory of Azerbaijan.

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The assessment of Romania's progress towards 2020 greenhouse gas targets taking into account climate change mitigation and energy policy obejectives

Prof. Anca POPESCU,
Institute for Studies and Power Engineering – Romania

Abstract

Romania signed the United Nations Framework Convention on Climate Change in 1992, and ratified it in 1994. Also Romania signed the Kyoto Protocol in 1999 and ratified it in January 2001, being the first Annex 1 Party that ratified it. Romania committed itself to reduce the greenhouse gas emissions by 8% comparing to 1989 levels in the first commitment period 2008-2012. According to the National Inventory Report submitted in April 2013 there is a great probability to meet this commitment. Taking into consideration the European Union objectives presented in the Energy – Climate Change Package the Romanian Government prepared the "National Strategy on Climate Change" that provides policies and measures aiming at reaching the climate targets set as a member of the European Union. The paper presents the policies and measures adopted for the mitigation of GHG emissions and their effects on the economy. In order to assess Romania's progress towards 2020 targets the GHG emissions are forecasted for years 2015 and 2020 by taking into account the various economic-social, demographic and technological evolution scenarios, allowing to highlight the measures taken by Romania in order to transpose the EU requirements of the Energy-Climate Change Package. The energy sector projections are obtained by using the ENPEP energy planning package, developed by Argonne National Laboratory from Chicago. This package gives the energy demand forecast based on macroeconomic indicators evolution and power plants development program by considering the Romanian Government's adopted policies on renewable energy resources use and also estimates the impact on the environment.

1. *Introduction*

Romania signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, and ratified it in 1994 by Law 24. Romania signed the Kyoto Protocol in 1999 and ratified it in January 2001, being the first Annex 1 Party that ratified it. Romania committed itself to reduce the greenhouse gas (GHG) emissions by 8% comparing to 1989 (base year) levels in the first commitment period 2008-2012.

The Romanian Government adopted in July 2013 through Government Decision 529/2013 the second **National Strategy on Climate Change (NSCC) 2013 – 2020.**

The general objective of the strategy focused on measures taken by Romania in order to transpose the EU requirements of the "Energy – Climate Change" Package.

2. *Evolution of GHG emissions*

The evolution of the total GHG emissions is presented in figure 1. According to the figure above, there is a great probability for Romania to meet the Kyoto Protocol commitments on the limitation of the GHG emissions in the 2008-2012 commitment period. In 2011, the GHG emissions without LULUCF have decreased with 54.86% comparing with the base year level.

The evolution of the total GHG emissions reflects the main trends in the economic development of the country.

The period was characterized by a process of transition to a market economy, restructuring of the economy, bringing into operation of the first reactor at the Cernavoda nuclear power plant (1996). The emissions have started to increase after 1999 as a consequence of the economy revitalization; in 2009, the emissions decreased significantly comparing to the level in 2008 while in 2010 they continued to decrease, due to the economic crisis. In 2011, the emissions started to increase again, following the increase of economic activities level.

The largest contributor to the total national GHG emissions is CO_2, followed by CH_4 and N_2O. The share of each direct GHG in total emissions in 1989 and, respectively 2011 is presented in figure 2.

It can be noticed that the **Energy** sector represents the most important sector in Romania. The Energy sector accounted for 69.98% of the total national GHG emissions in 2011. The GHG emissions resulted from the Energy sector decreased with 55.00% compared with the base year.

Industrial Processes contributes to total GHG emissions with 10.21%. A significant decrease of GHG emissions was registered in this sector (64.40% decreases in 2011 compared to the level in 1989) due to the decline or the termination of certain production activities.

The trend of emissions resulted from s**olvent and other product use** follows the general trend: emissions have decreased seriously after 1989, then the emissions were relatively stable from 1992 to 2002; after 2002, emissions started to increase, and due to the revitalization of the relevant economic activities (automobile manufacture, construction and buildings).
The GHG emissions level decreased in 2011 by 80.55% in comparison with the level recorded in 1989.

Agriculture GHG emissions have also decreased. The GHG emissions in 2011 are 53.50% lower in comparison with the 1989 emissions due to:

- the decline of livestock;
- the decrease of rice cultivated area;
- the decrease of crop productions level;
- the decline of N synthetic fertilizer applied amounts.

In 2011, 15.36 % of the total GHG emissions resulted from the agriculture sector. The Romanian land use sector acts as a net sink, at an average uptake of 25,304.94 Gg/year, being relatively stable over the last 22 years.

Waste sector emissions have increased in 2011 with 14.91% in comparison with the level in 1989. The contribution of the waste sector to the total GHG emissions in 2011 is 4.35%.

3. *Energy sector strategies*

The Romanian Government established the strategic scope for the energy sector to meet both the current and the medium and long term energy demand, for the lowest possible price, adequate to a modern market economy and to a civilized living standard, under quality and safety in supply conditions, in observance of the sustainable development principles.

Romanian Energy Strategy for the period 2007-2020 has the following objectives:

Energy security, by:

- lower dependence of imported energy through the use of national resources of lignite and hard coal, hydropower and wind power;
- import diversification of resources through the use of both nuclear fuel and natural gas;

Sustainable development through:

- energy efficiency through the use of modern technologies in the years 2015;
- promotion of electricity in hydroelectric and wind power;
- promoting the production of electricity and heat in cogeneration plants using high-efficiency technologies for natural gas;
- rehabilitation of transmission and distribution system correlated to rehabilitation of buildings to reduce energy losses and the development of new intelligent buildings;

Competitiveness:

- development of markets for electricity, natural gas, uranium, green certificates, certification of greenhouse gas emissions;
- continuing restructuring of the electricity sector and natural gas;
- coal sector restructuring continue to increase profitability and access to capital markets.

Romania transposed the following EU Directives in its legislation, with implications on the national primary energy consumption, respectively:

- Directive 2006/32/EC on energy end-use efficiency and energy services - transposed by OG 22/2008 and the Methodological norms for the enforcement of GO 22/2008 approved by GD 409/2009;
- Directive 2005/32/EC establishing a framework for the setting of eco-design requirements for energy-using products - transposed by GD 1043/2007;
- Directive 2009/28/EC on the promotion of the use of energy from renewable sources - transposed by Law no. 220/2008 republished;
- Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market - transposed by GD 219/2007;
- Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles – transposed by GEO 40/2011;
- Regulation 2009/443/EC establishing the emission performance standards for new passenger cars – transposed by GD 90/2011;
- Directive 2010/40/EU on the framework for the deployment of ITS in the field of road transport and for interfaces with other modes of transport - transposed by GO 7/1021.

The second National Plan on Energy Efficiency for the 2011 - 2020 represents an update of the Energy Strategy for the period 2007 – 2020.
The primary energy saving measures on the generation of electricity and heating are as follows:

— Withdrawing from service the generating units whose lifespan has been exceeded and which have become obsolete and the replacement thereof with modern units with superior efficiencies;

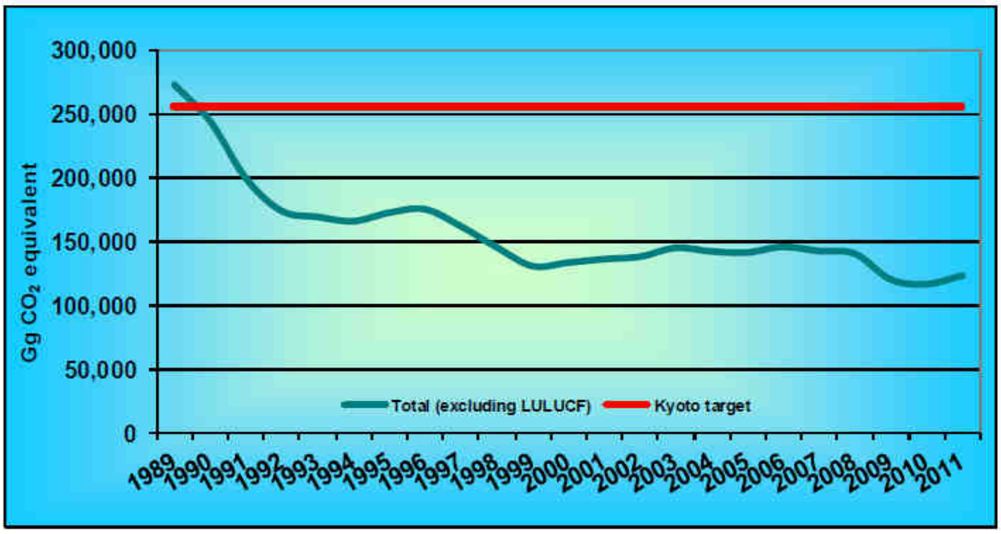

Figure 1. The total GHG emissions in CO_2 equivalent during 1989-2011 period (Source: Ministry of Environment and Climate Change – National Inventory Report, May 2013)

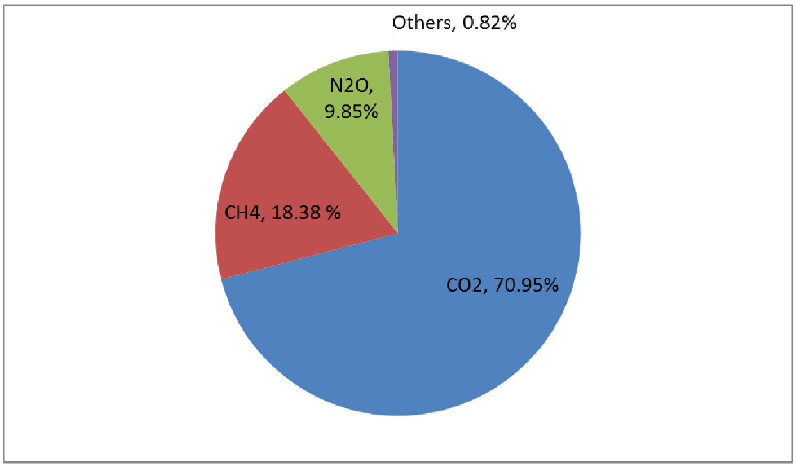

Figure 2. GHG by main categories – average share for the period 1989 – 2011.

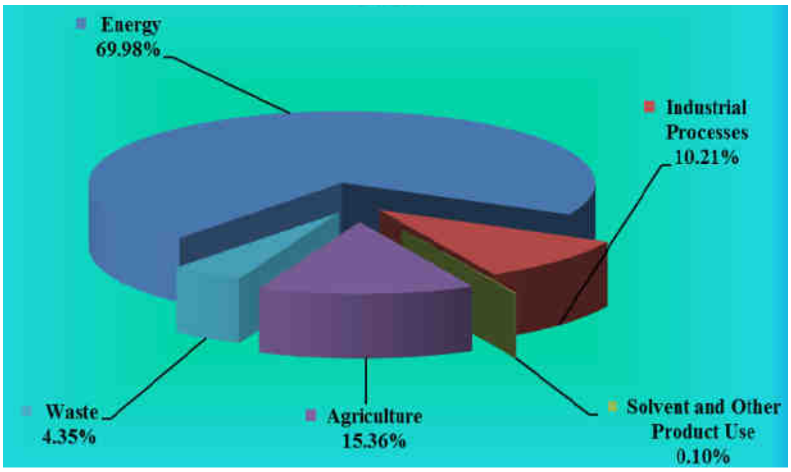

Figure 3. Sectorial GHG emissions in 2011 [%] (Source: Ministry of Environment and Climate Change – National Inventory Report, May 2013)

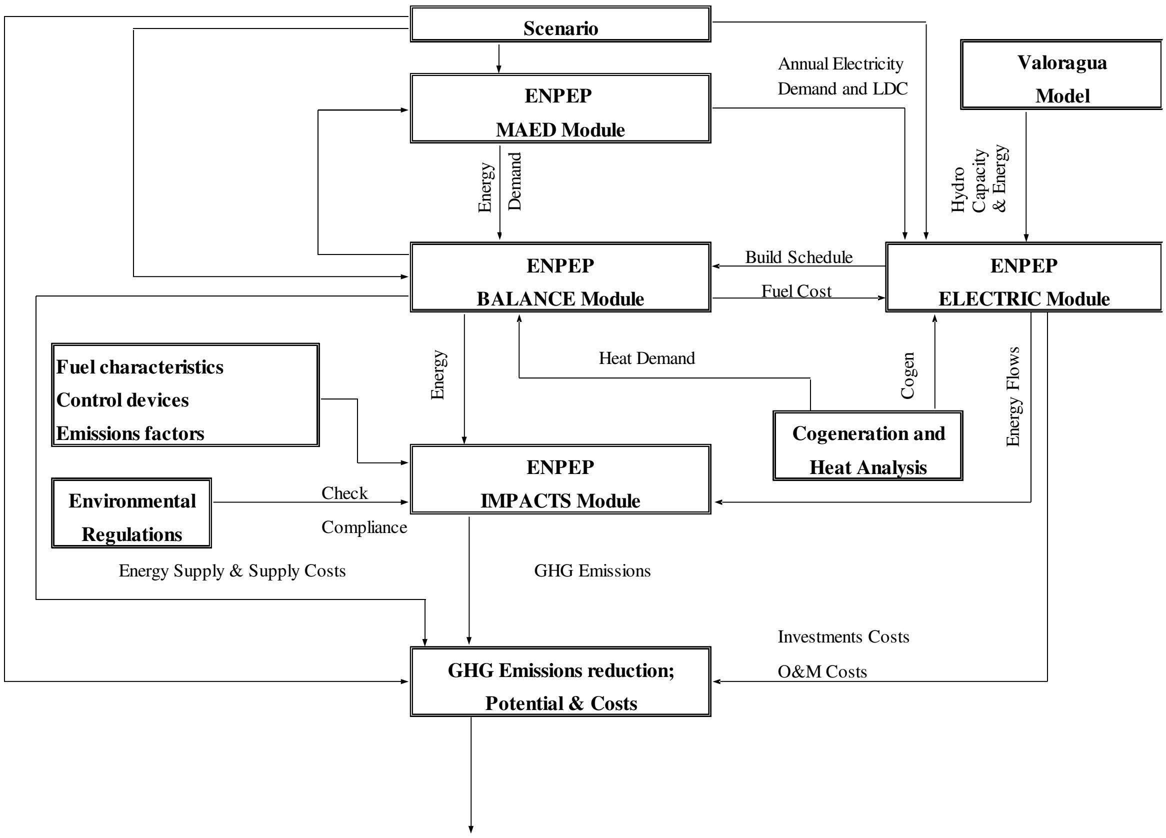

Figure 4. Integrated Modelling Framework for Assessment of GHG emissions and GHG Mitigation Options

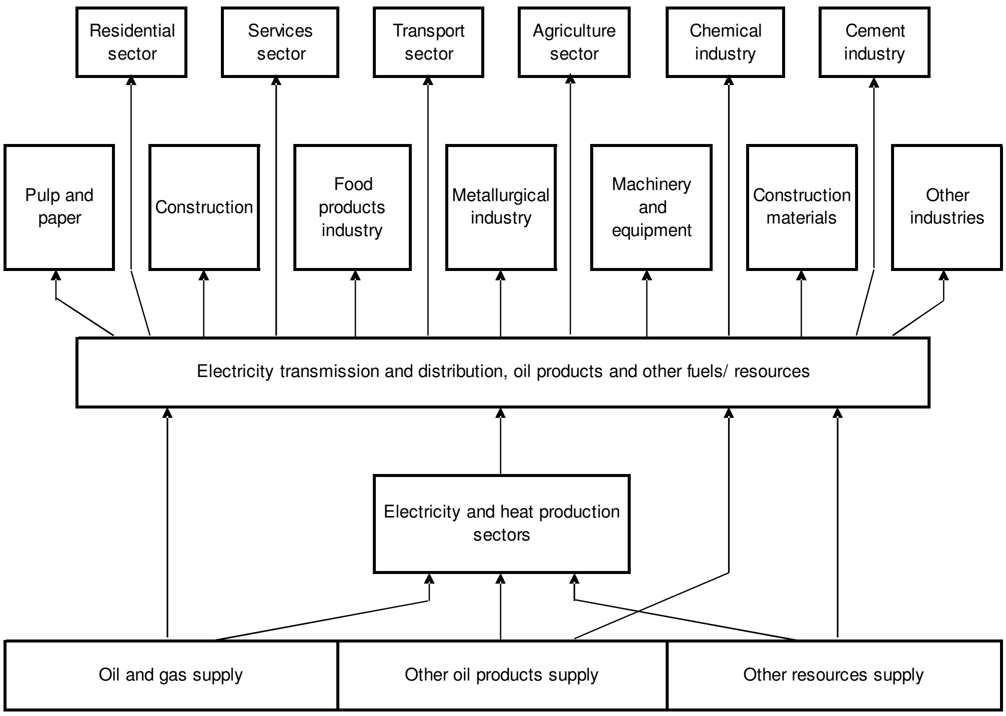

Figure 5. Romania's Energy Balance.

- Re-engineering 330 MW units operating in lignite-fired power plants;
- Promoting high efficiency cogeneration; gas turbines with a heat recovery boiler (GT+HRB) and a combined cycle with gas turbines (CC+GT) of approximately 1000 MW and 600 MW biomass-fired units shall be installed;
- Continuing the upgrade works of district heating supply systems, respectively the units generating heat fluid, the primary heat fluid (hot water) transmission grid, the heating stations and heating modules, the hot water and heat fluid distribution network;
- Generating electricity from renewable energy sources.

National Renewable Energy Action Plan indicates the installed powers per types of technologies from renewable energy sources, resulting the energies generated, indicated in table 1. It can be noticed that in 2020 the electricity production from renewable energy sources will represent 38% of total electricity production in Romania.

The participation of sectors to GHG emissions (excluding LULUCF) is presented in the figure 3.

4. *GHG forecasting methodology for energy sector*

The GHG forecasts for the energy sector were established considering the energy demand subsector (industry, transport, agriculture, household and commercial consumption) and the supplying sub-sector (primary energy resources extraction, their conversion in refineries, thermo-electric power plants, thermal power plants, transport and distribution of energetic products to consumers).

The projections are based on calculations carried out using the ENPEP (Energy and Power Evaluation Program) programs package, developed by Argonne National laboratory of US Department of Energy (DOE) and distributed to Romania by the International Atomic Energy Agency (IAEA) to perform an integrated energy analysis, economic and environmental.

Figure 4 presents the 9 modules of the software package. The main modules used in the study are:

- MAED is a simulation model designed for evaluate medium and long-term demand for energy (motor fuel, fossil fuel, district heating, electricity, coke, feedstock) based on the macroeconomic indicators evolution;
- ELECTRIC - determines the electricity power plants development programme considering the Romanian Government's adopted policies on renewable energy resources use, on ensuring the energy security, on technological evolution and on international market fuel prices;
- BALANCE module – determines the balance between energy demand – supply the entire system, including all the demand sectors and the supply sectors (oil, gas, coal, electricity, renewable, etc.) for every year of the study;
- IMPACTS – estimates, for the energetic system determined using the BALANCE module and for the electro-energetic system determined using the ELECTRIC module, the impact on atmosphere, water, soil, the impact of the specific waste, the impact on materials and labour needed for the installations construction and exploitation, the impact on related employees risk and health.

In order to allow the use of the modules package, a national energy balance has been prepared considering the available or imported primary energy resources. **Figure 5** shows a simplified energy balance with four major elements:

- primary energy resources;
- primary energy resources conversion technologies;
- transmission and distribution of energy products;
- energy consumers

Each sector is modelled in detail considering the technological processes and emission factors according to IPCC. Given this breakdown with the IMPACTS module the resulted GHG emissions are determined. The projected level of the total CO_2 emissions from the energy sector in the three analyzed scenarios in the period 2012 – 2020 is presented in **Figure 6**.

The European Parliament and Council adopted in April 2009 Decision 406/2009/EC on the effort of Member States to reduce GHG emissions in order to meet the Community's commitments to reduce GHG emissions by 2020.

This decision aimed to establish the minimum contribution of Member States to respect the Community's commitments to reduce GHG emissions in the period 2013 - 2020.

Taking into consideration that amount of verified emissions under the EU ETS from 2007 were 69,604.599 Gg CO_2eq. in Romania resulted that GHG emissions related to non – ETS sectors will be 77,200 Gg CO_2 eq. in the scenario with adopted measures. It may be noted that Romania complies with the requirements of Decision 406/2009/EC as GHG emissions projected for 2020 for the non – ETS sectors are smaller than would be required target of 85,627.510 Gg CO_2 eq.

5. *Conclusions*

All development strategies, policies and measures have been developed and implemented in accordance with EU documents ensuring harmonization of policies, plans and programs in accordance with the requirements of EU integration. As a result of transposing EU legislation into national legislation, Romania has introduced and implemented policies and measures in all economic sectors which will contribute indirectly to reducing GHG emissions.

Some example of the policies and measures effect is presented in the table 2.

Figure 6. The projected level of the total CO_2 emissions from the energy sector in the analyzed scenarios in the period 2012 – 2020.

Table 2. The effect of policy and measures on GHG emissions.

No	Policy/Measure	Estimated effect of the policy and measures on GHG emissions (kt CO_2 equivalent) in 2020
1	GD 1069/2007 Romania's Energy Strategy for 2007 – 2020	8,336.868
2	National Renewable Energy Action Plan	4,766.726
3	GD 22/2008 transposition of Directive 2006/32/EC on energy end-use efficiency and energy services	691.760
4	GD 780/2006 establishing the greenhouse gas emission allowance trading scheme, amended by GD 133/2010, GD 399/2010, GD 1300/2010 and the subsequent legislation	2,000.000
5	The second National Plan on Energy Efficiency for 2011-2020	955.660

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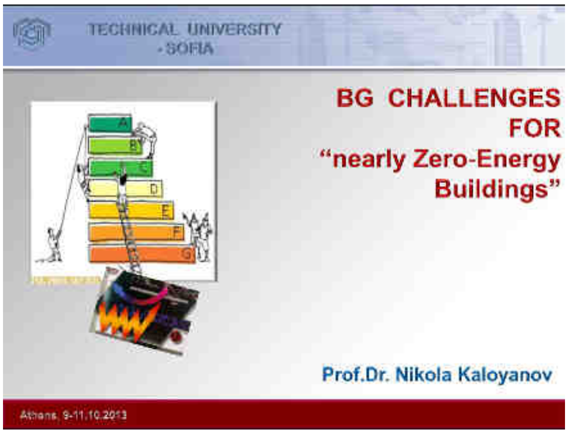
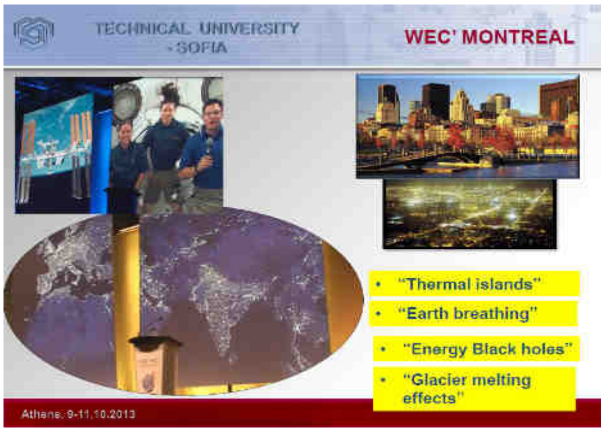
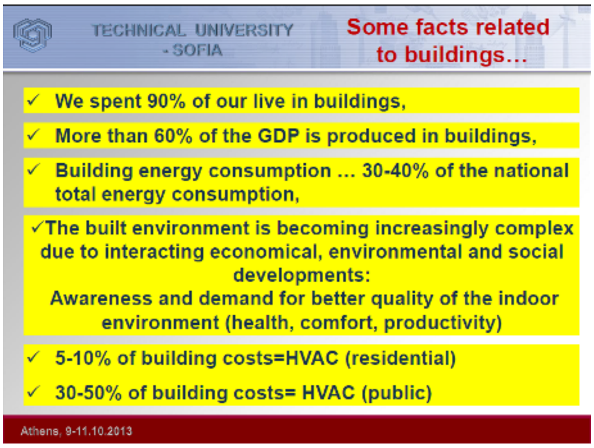
Energy Policy

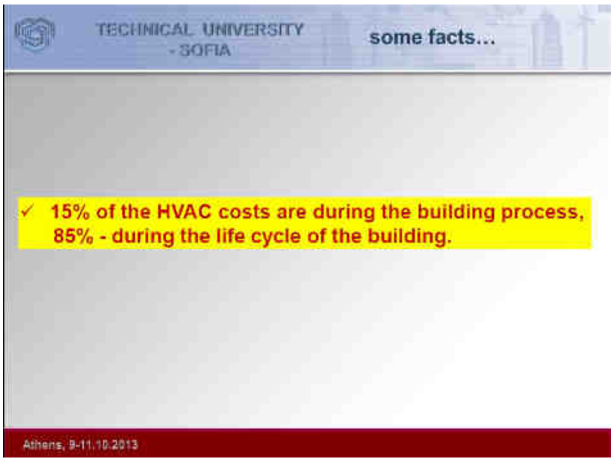
Keynote speaker: Nearly zero energy buildings

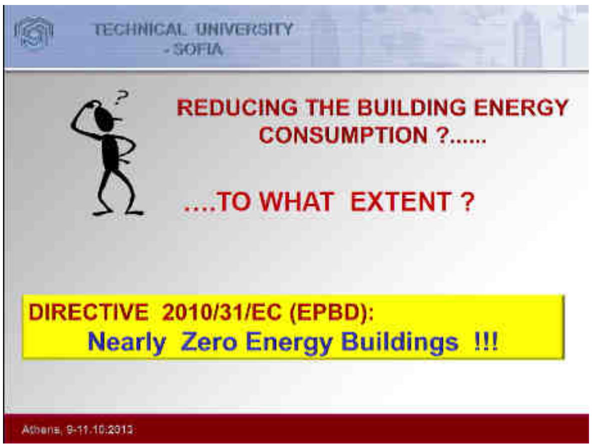
by Prof. Nikola KALOYANOV

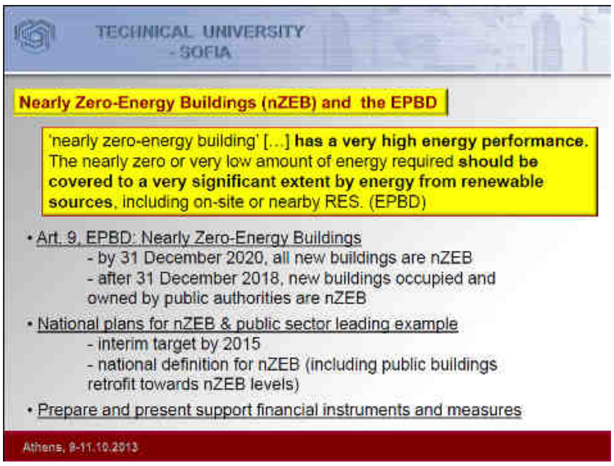


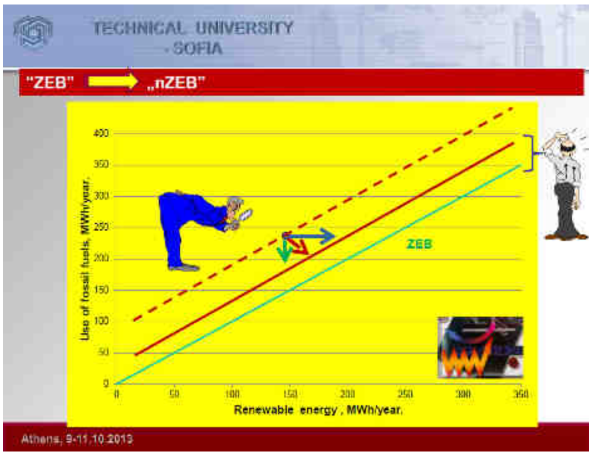


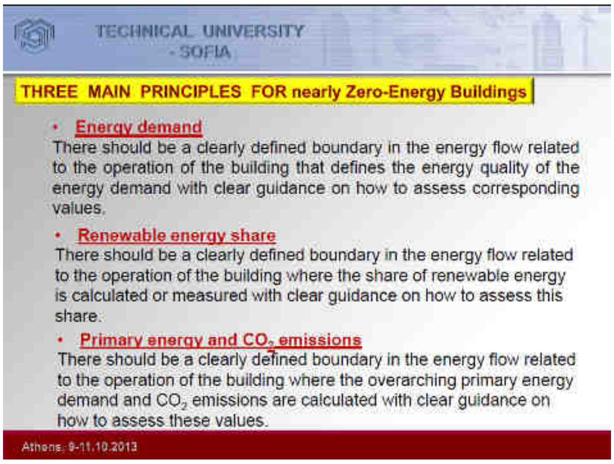


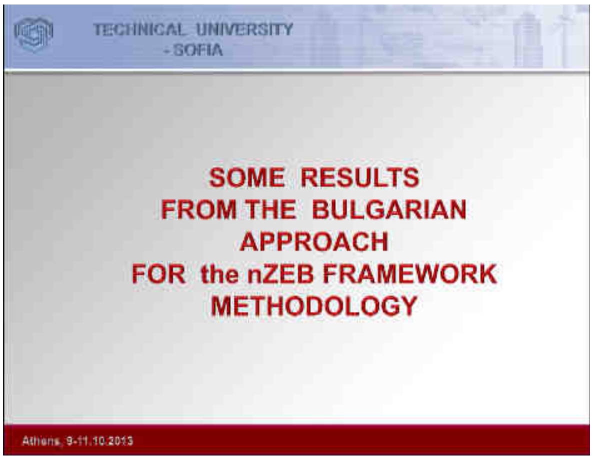


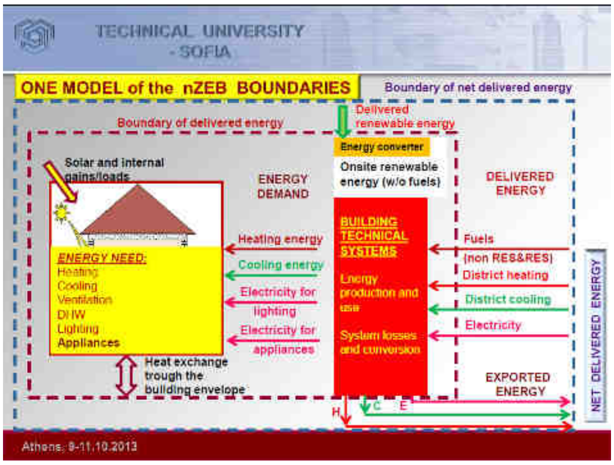


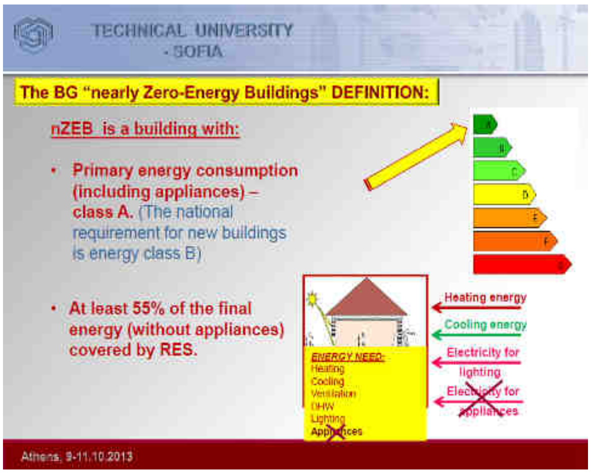


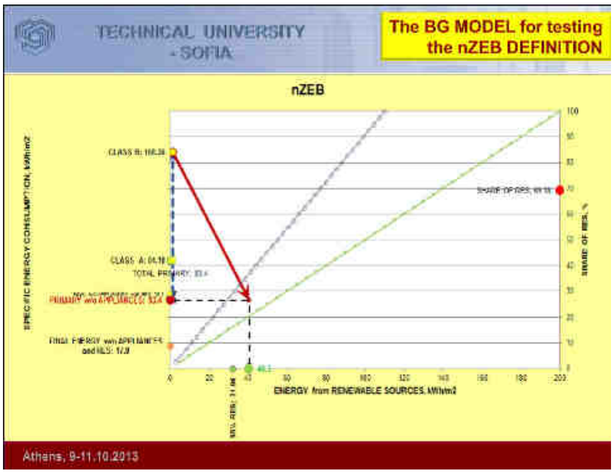

TECHNICAL UNIVERSITY - SOFIA
"ZEB" „nZEB"
Use of fossil fuels, MWh/year
ZEB
Renewable energy , MWh/year.
Athens, 9-11.10.2013

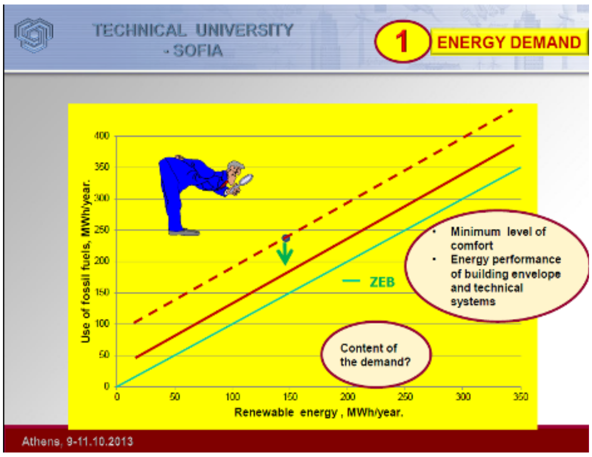

TECHNICAL UNIVERSITY - SOFIA
THREE MAIN PRINCIPLES FOR nearly Zero-Energy Buildings
• Energy demand
There should be a clearly defined boundary in the energy flow related to the operation of the building that defines the energy quality of the energy demand with clear guidance on how to assess corresponding values.
• Renewable energy share
There should be a clearly defined boundary in the energy flow related to the operation of the building where the share of renewable energy is calculated or measured with clear guidance on how to assess this share.
• Primary energy and CO2 emissions
There should be a clearly defined boundary in the energy flow related to the operation of the building where the overarching primary energy demand and CO2 emissions are calculated with clear guidance on how to assess these values.
Athens, 9-11.10.2013

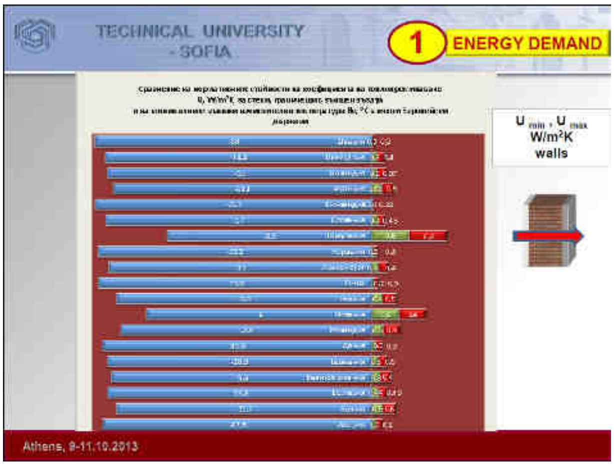

TECHNICAL UNIVERSITY - SOFIA
SOME RESULTS
FROM THE BULGARIAN
APPROACH
FOR the nZEB FRAMEWORK
METHODOLOGY
Athens, 9-11.10.2013

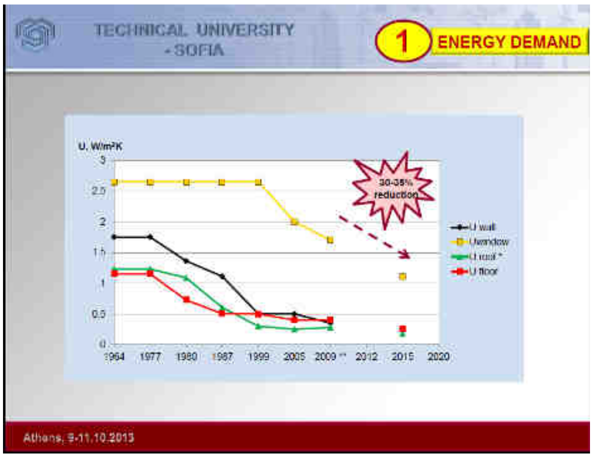

TECHNICAL UNIVERSITY - SOFIA
ONE MODEL of the nZEB BOUNDARIES
Boundary of net delivered energy
Boundary of delivered energy
Delivered renewable energy
Energy converter
Onsite renewable energy (w/o fuels)
Solar and internal gains/loads
ENERGY DEMAND
DELIVERED ENERGY
BUILDING TECHNICAL SYSTEMS
Heating energy
Cooling energy
Electricity for lighting
Electricity for appliances
ENERGY NEED:
Heating
Cooling
Ventilation
DHW
Lighting
Appliances
Energy production and use
System losses and conversion
Fuels (non RES&RES)
District heating
District cooling
Electricity
Heat exchange trough the building envelope
EXPORTED ENERGY
NET DELIVERED ENERGY
Athens, 9-11.10.2013

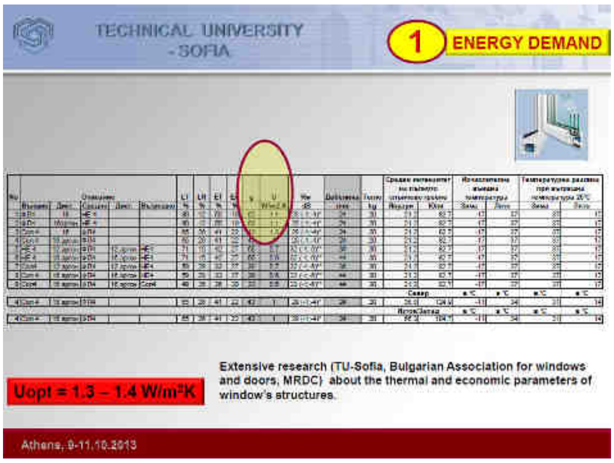

TECHNICAL UNIVERSITY - SOFIA
The BG "nearly Zero-Energy Buildings" DEFINITION:
nZEB is a building with:
• Primary energy consumption (including appliances) – class A. (The national requirement for new buildings is energy class B)
• At least 55% of the final energy (without appliances) covered by RES.
Heating energy
Cooling energy
Electricity for lighting
Electricity for appliances
ENERGY NEED:
Heating
Cooling
Ventilation
DHW
Lighting
Appliances
Athens, 9-11.10.2013

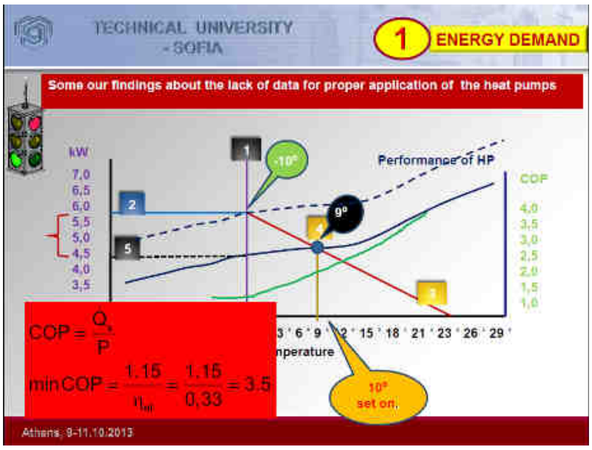

TECHNICAL UNIVERSITY - SOFIA
The BG MODEL for testing the nZEB DEFINITION
nZEB
SPECIFIC ENERGY CONSUMPTION, kWh/m2
SHARE OF RES, %
ENERGY from RENEWABLE SOURCES, kWh/m2
Athens, 9-11.10.2013

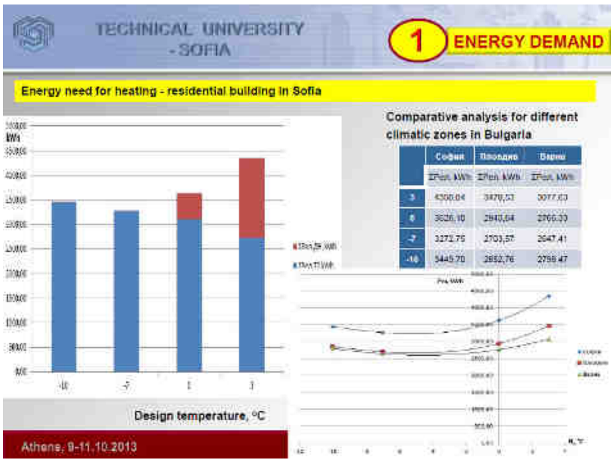

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
Use of fossil fuels, MWh/year.
Renewable energy , MWh/year.
ZEB
Minimum level of comfort
Energy performance of building envelope and technical systems
Content of the demand?
Athens, 9-11.10.2013

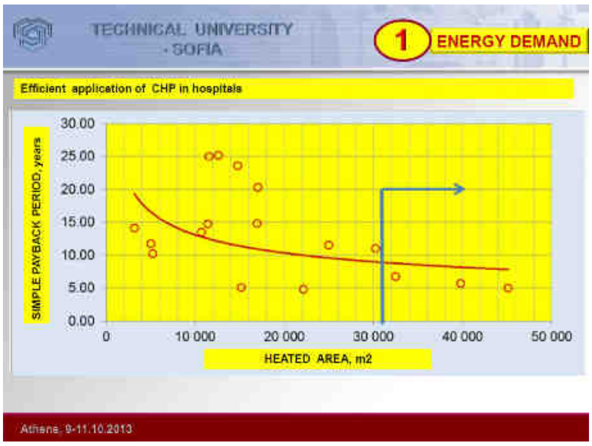

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
U min , U max W/m²K walls
Athens, 9-11.10.2013

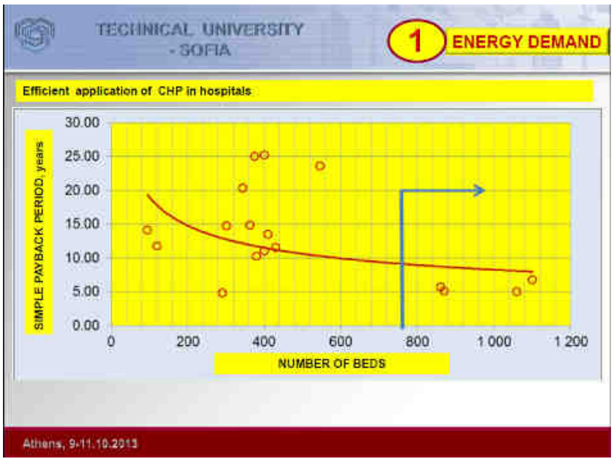

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
U, W/m²K
30-35% reduction
U wall
U window
U roof
U floor
Athens, 9-11.10.2013

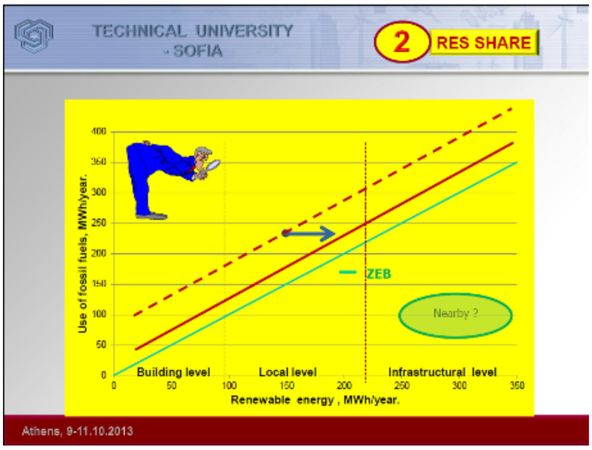

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
Uopt = 1.3 – 1.4 W/m²K
Extensive research (TU-Sofia, Bulgarian Association for windows and doors, MRDC) about the thermal and economic parameters of window's structures.
Athens, 9-11.10.2013

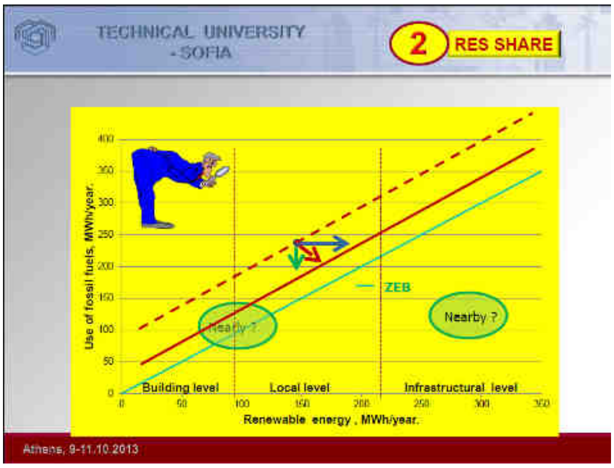

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
Some our findings about the lack of data for proper application of the heat pumps
kW
Performance of HP
COP
-10°
9°
$COP = \frac{Q_i}{P}$
$\min COP = \frac{1.15}{\eta_{el}} = \frac{1.15}{0,33} = 3.5$
10° set on.
Athens, 9-11.10.2013

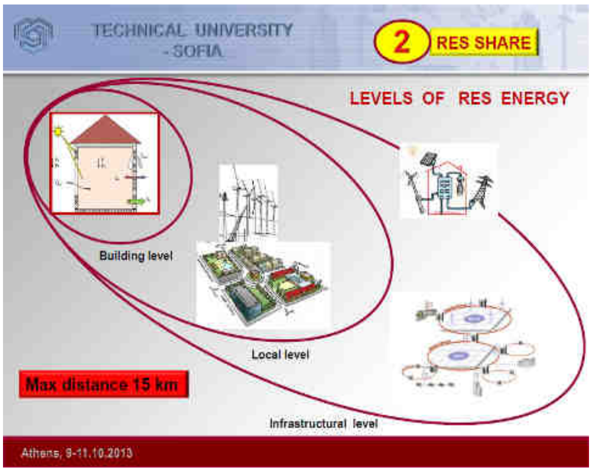

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
Energy need for heating - residential building in Sofia
Comparative analysis for different climatic zones in Bulgaria
Design temperature, °C
Athens, 9-11.10.2013

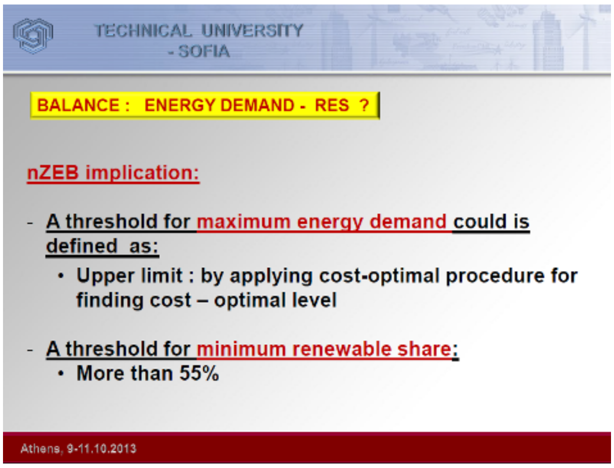

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
Efficient application of CHP in hospitals
SIMPLE PAYBACK PERIOD, years
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
10 000
20 000
30 000
40 000
50 000
HEATED AREA, m2
Athens, 9-11.10.2013

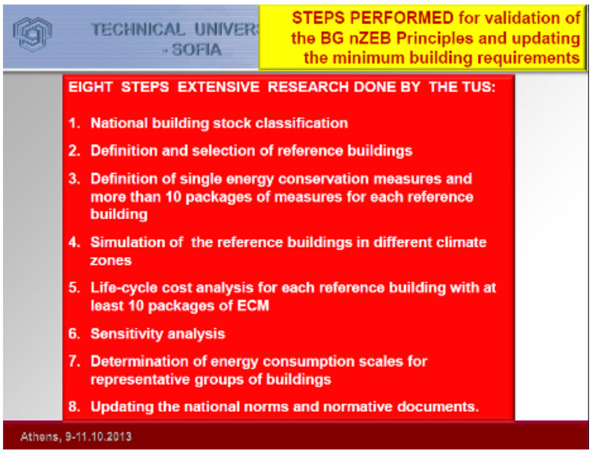

TECHNICAL UNIVERSITY - SOFIA
1 ENERGY DEMAND
Efficient application of CHP in hospitals
SIMPLE PAYBACK PERIOD, years
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
200
400
600
800
1 000
1 200
NUMBER OF BEDS
Athens, 9-11.10.2013

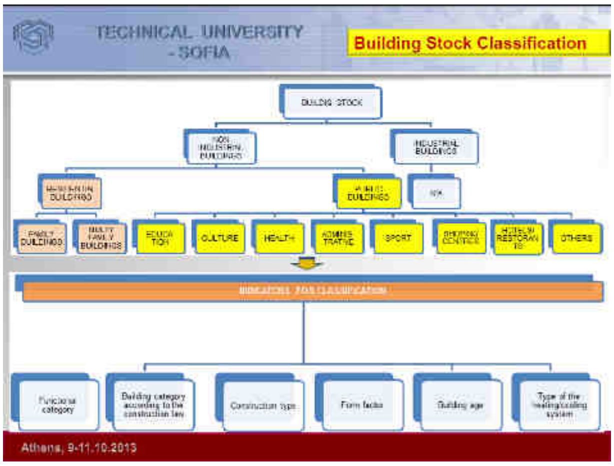

TECHNICAL UNIVERSITY - SOFIA
2 RES SHARE
Use of fossil fuels, MWh/year.
ZEB
Nearby ?
Building level
Local level
Infrastructural level
Renewable energy , MWh/year.
Athens, 9-11.10.2013

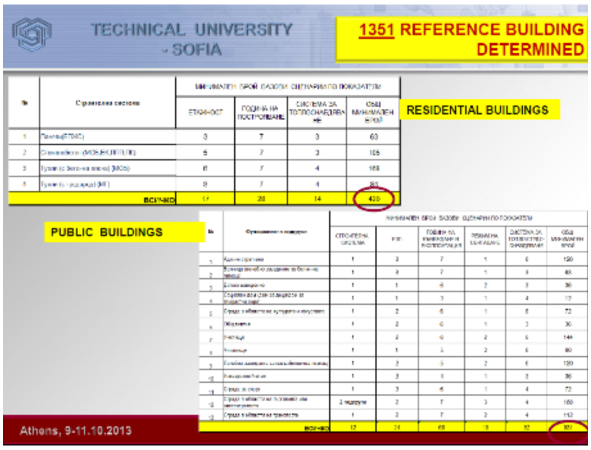

TECHNICAL UNIVERSITY - SOFIA
2 RES SHARE
Use of fossil fuels, MWh/year.
ZEB
Nearby ?
Building level
Local level
Infrastructural level
Renewable energy , MWh/year.
Athens, 9-11.10.2013

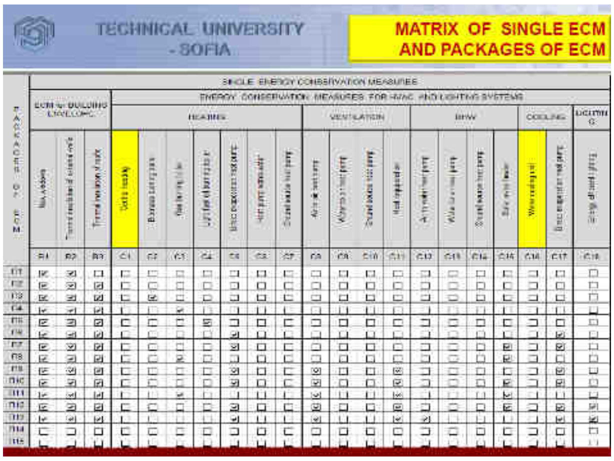

TECHNICAL UNIVERSITY - SOFIA
2 RES SHARE
LEVELS OF RES ENERGY
Building level
Local level
Max distance 15 km
Infrastructural level
Athens, 9-11.10.2013


TECHNICAL UNIVERSITY - SOFIA
BALANCE : ENERGY DEMAND - RES ?
nZEB implication:
- A threshold for maximum energy demand could is defined as:
• Upper limit : by applying cost-optimal procedure for finding cost – optimal level
- A threshold for minimum renewable share:
• More than 55%
Athens, 9-11.10.2013

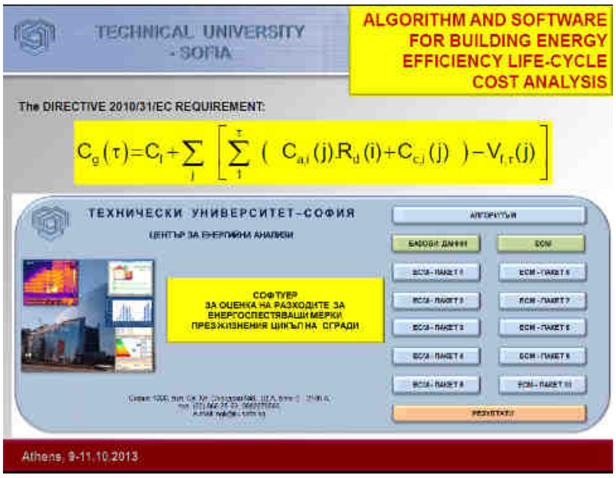

TECHNICAL UNIVERSITY - SOFIA
STEPS PERFORMED for validation of the BG nZEB Principles and updating the minimum building requirements
EIGHT STEPS EXTENSIVE RESEARCH DONE BY THE TUS:
1. National building stock classification
2. Definition and selection of reference buildings
3. Definition of single energy conservation measures and more than 10 packages of measures for each reference building
4. Simulation of the reference buildings in different climate zones
5. Life-cycle cost analysis for each reference building with at least 10 packages of ECM
6. Sensitivity analysis
7. Determination of energy consumption scales for representative groups of buildings
8. Updating the national norms and normative documents.
Athens, 9-11.10.2013

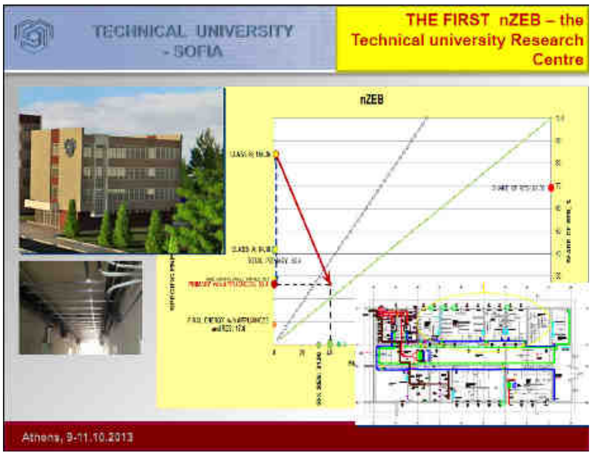

TECHNICAL UNIVERSITY - SOFIA
Building Stock Classification
Athens, 9-11.10.2013

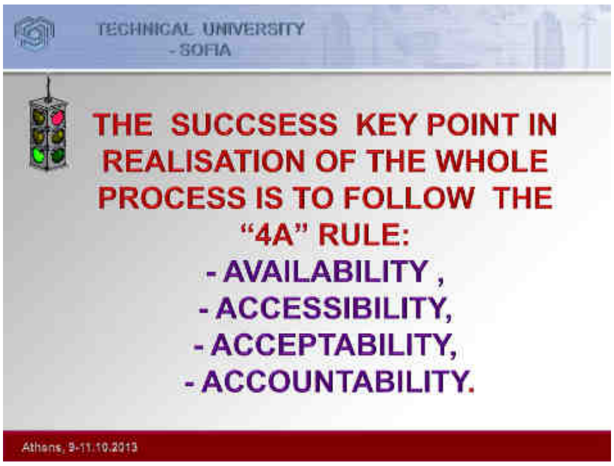

TECHNICAL UNIVERSITY - SOFIA
1351 REFERENCE BUILDING DETERMINED
RESIDENTIAL BUILDINGS
PUBLIC BUILDINGS
Athens, 9-11.10.2013

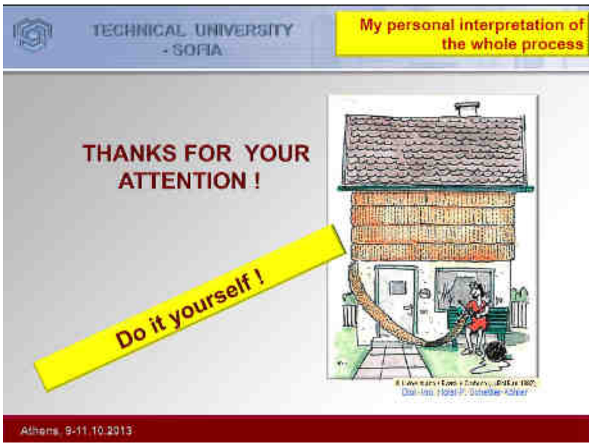

TECHNICAL UNIVERSITY - SOFIA
MATRIX OF SINGLE ECM AND PACKAGES OF ECM
SINGLE ENERGY CONSERVATION MEASURES


TECHNICAL UNIVERSITY - SOFIA
NATIONAL SOFTWARE FOR BUILDING ENERGY PERFORMANCE SIMULATION
EAB Software
EN ISO 13790
Technical University – Sofia
ENSI Energy Saving International AS
File Project Help
Athens, 9-11.10.2013


TECHNICAL UNIVERSITY - SOFIA
ALGORITHM AND SOFTWARE FOR BUILDING ENERGY EFFICIENCY LIFE-CYCLE COST ANALYSIS
The DIRECTIVE 2010/31/EC REQUIREMENT:
$C_g(\tau)=C_I+\sum_j\left[\sum_{i=1}^{\tau}\left(C_{a,i}(j)R_d(i)+C_{c,i}(j)\right)-V_{f,\tau}(j)\right]$
ТЕХНИЧЕСКИ УНИВЕРСИТЕТ-СОФИЯ
Athens, 9-11.10.2013


TECHNICAL UNIVERSITY
- SOFIA
THE FIRST nZEB – the Technical university Research Centre
nZEB
Athens, 9-11.10.2013


TECHNICAL UNIVERSITY
- SOFIA
THE SUCCSESS KEY POINT IN REALISATION OF THE WHOLE PROCESS IS TO FOLLOW THE "4A" RULE:
- AVAILABILITY ,
- ACCESSIBILITY,
- ACCEPTABILITY,
- ACCOUNTABILITY.
Athens, 9-11.10.2013


TECHNICAL UNIVERSITY
- SOFIA
My personal interpretation of the whole process
THANKS FOR YOUR ATTENTION !
Do it yourself !
Athens, 9-11.10.2013

Sensitivity of Emissions and their Drivers to economic Growth and Fossil Fuel Availability: a regional Analysis

Ioanna MOURATIADOU*, Gunnar LUDERER, Elmar KRIEGLER

*Contact mouratiadou@pik-potsdam.de

Potsdam Institute for Climate Impact Research (PIK), PO Box 60 12 03, 14412 Potsdam, Germany

Abstract

Climate change remains one of the most prominent challenges to global societies and natural ecosystems. In the context of a 2°C target, mitigation efforts and costs are contingent on baseline developments, while the regional dimension of the climate problem remains critical. This paper aims to enhance the understanding of regional emission patterns and their drivers, and investigate the effects of baseline uncertainty on regional responses to climate action. That is achieved through an exploration of baseline and policy scenarios on economic growth and fossil fuel availability, as simulated by the REMIND model. The analysis focuses on key regions for climate policy of developing, emerging and developed economies: Africa, India, China, Europe and the USA. The results indicate that faster growth induces higher emissions, but accelerates energy intensity improvements, and also exhaustion of fossil fuels leading to an earlier transition towards renewables. Emissions are more sensitive to fossil fuel availability assumptions which impact directly on the structure of energy systems. More fossils and faster growth are generally associated to larger mitigation efforts, but the technological implications of climate stabilization are robust against economic growth and fossil fuel price uncertainty. Regional reactions are more diverse in response to structural changes rather than demand induced developments, but a different degree of regional flexibility to adapt to non-fossil based systems is evident in both baseline and policy scenarios.

Keywords: climate change mitigation; baseline uncertainty; regional analysis; economic growth; fossil fuels; REMIND

Introduction

Climate change remains one of the most prominent challenges to global societies and natural ecosystems. Although the debate around the preferred mitigation strategies, the distribution of costs, and the quantification of climate damages, is a vibrant one, the scientific community has clearly pointed out the need for deep emission reductions in order to avoid the most dangerous outcomes of climate change. In the policy arena, the global community has adopted the long-term target of limiting the average global temperature increase to a maximum of 2°C compared to pre-industrial levels in the Copenhagen Accord (UNFCCC, 2009), and this objective has been re-endorsed in the subsequent climate conferences in Cancun and Durban.

Given the broad agreement of the scientific and policy communities on the need for significant emission reduction requirements in order to meet the 2°C target, numerous studies have assessed the technical and economic implications of policy action (e.g. Edenhofer et al., 2010; van Vuuren et al., 2007). Naturally, these implications are contingent on the evolution of baseline developments, since the baseline scenario serves as the reference for emissions and energy systems choices against which the feasibility of mitigation strategies is assessed. As confirmed by various studies, baseline scenario assumptions on uncertain parameters like economic trends, population growth, technological progress, and portfolio of considered technologies can significantly affect baseline results and as a consequence the absolute level of required emissions reductions (Kepo and Rao, 2007; Fisher et al., 2008; Den Elzen and Hφhne, 2008). Despite the above, a comprehensive exploration of alternative baseline scenarios has attracted, in-so-far, little attention in the literature.

This paper aims to provide a broad and systematic exploration of baseline and decarbonization scenarios for the energy system with a focus on the regional implications of these scenarios. We analyze emissions and their drivers in five major regions at different stages of their economic development: Africa, India, China, Europe and the USA. The analysis is based on the results of the integrated assessment model *Regional Model of Investments and Development* (REMIND) (Bauer et al., 2012; Leimbach et al., 2010) on a set of scenarios conducted as part of the *Roadmaps* *towards Sustainable Energy futures*[30] (RoSE) study (Kriegler et al., in preparation).

A key novelty of the paper is the assessment of a set of alternative scenarios with a focus on their regional implications both with and without climate policy. The scenario approach allowed for a structured exploration of the uncertainty space on two factors with indispensable importance for understanding better the prospects of achieving long-tern climate protection targets: (i) economic growth trajectories determining energy demand and (ii) fossil fuel availability determining fossil prices and the supply structure of energy systems. This allowed assessing the type of regional results that are sensitive to baseline uncertainty versus results that remain robust irrespective of the levels of economic growth and fossil fuel availability.

The objective of the paper is to enhance the understanding of the possible effects of alternative economic growth or fossil fuel availability assumptions on regional emission patterns, the drivers of these emissions, and the associated technology portfolios. The following policy questions guided our analysis: What is the level of cumulated regional emissions, who are the greatest emitters, and do regions converge regarding their per capita emissions? What are the main drivers behind emission developments and should policies emphasize on energy or carbon intensity improvements? How do developments in energy mixes associate to these drivers? Particular emphasis is given on how regional characteristics and alternative assumptions on possible futures regarding economic growth and fossil fuel availability influence answers to the above questions.

Methodology

The RoSE study aims at assessing 21st century energy transformation scenarios across different policy regimes and different reference assumptions for future socio-economic and fossil resources development. The set of RoSE scenarios analyzed in this paper is based on three key dimensions: (i) assumptions on future socio-economic development determined by economic growth, (ii) reference assumptions on long-term fossil fuel availability, and (iii) stringency of climate protection targets. The variation of the first two dimensions provided baseline projections that were adopted by the REMIND model to explore the sensitivity of systems transformations to the underlying socio-economic and fossil resource assumptions. These baseline assumptions were then combined with climate target scenarios in order to provide insights of the involved mitigation options under alternative futures. The set of RoSE scenarios investigated in this paper can be seen in Table 2. Each column corresponds to a combination of socio-economic and fossil resource drivers, and each raw is linked to a climate policy regime.

The socio-economic scenarios build on the 2008 Revision of the UN World Population Prospects and encompass assumptions regarding the speed of economic growth (*slow – medium – high*) between 26 aggregate world regions. The development of these scenarios is described in Kriegler et al. (in preparation). Fossil fuel availability was characterized in terms of supply curves describing extraction costs as a function of cumulative extraction. First, data on the estimated total size of the fossil resource base have been assembled. Oil, gas and coal have been treated separately, with an additional division into conventional and non-conventional resources. In a second stage, historical data for recovery rates have been examined and then extrapolated, under varying assumptions about technological progress, toward future resources. Finally, the costs of extraction for different grades of each of the resources have been estimated. The output of this process consists of three extraction cost curves, assuming *low*, *medium*, and *high* resource availability, for each of the three fossil resources. These assumptions on the availability of oil, gas, and coal, have then been combined into concrete scenarios. Finally, the policy dimension includes two different policy cases representing different levels of ambition of climate policy action. The first one is the *baseline* which represents a no climate-policy case. The second one is the *450 ppm CO_2-equiv*, which corresponds to a 450 ppm CO_2 equivalent concentration stabilization target allowing for overshoot and with full when-where-what flexibility of emissions reductions after 2010. It accounts for the radiative forcing of all radiative substances including Non-Kyoto gases and aerosols[31].

The above scenarios have been simulated with the integrated assessment model REMIND (version 1.4). REMIND is a multi-regional hybrid model which couples an economic growth model with a detailed energy system model and a simple climate model. The macro-economic core of REMIND is a Ramsey-type optimal growth model in which intertemporal global welfare is optimized subject to equilibrium constraints. REMIND considers 11 world regions (Figure 1) and explicitly represents trade in final goods and primary energy carriers. Macro-economic production uses capital, labor and energy as input factors. The macro-economic core is hard-linked to the energy system module. Economic activity results in demand for final energy such as transport energy, electricity, and non-electric energy for the stationary end-uses.

[30] http://www.rose-project.org

31 Further details on the scenario description can be seen at http://www.rose-project.org/scenarios and Kriegler et al. (in preparation).

The demand for final energy is determined via a nested constant elasticity of substitution production function. There are three basic mechanisms for energy intensity improvements outlined in Luderer et al. (2013). These are a) exogenously determined autonomous reductions in energy intensity, b) substitution between energy and capital through the CES production function, and c) investment in more efficient energy efficiency technologies for the conversion of final energies. The exogenously determined energy efficiency parameters are assumed to change at the same rate as labor efficiency parameters, but include also an additional adjustment factor separately determined for each region and energy type. This factor is determined in a way that per capita energy use for transport, stationary non-electric and stationary electricity follow a converging trend between regions, when expressed as final energy per capita over GDP per capita (expressed in Purchasing Power Parity (PPP) terms).

Labor efficiency parameters are exogenous and, as a matter of fact, for the RoSE project their adjustment constitutes the mechanism for enforcing the different economic growth scenarios. That is, the RoSE GDP scenarios have been implemented by adjusting the regional labor efficiency parameters of the CES production function through an iterative process, until the GDP trajectories assumed in the different scenarios were reproduced (Kriegler et al. in preparation).

The energy system module considers endowments of exhaustible primary energy resources as well as renewable energy potentials. A substantial number (~50) of technologies are available for the conversion of primary energies to secondary energy carriers[32].

As part of our analysis, we use the Kaya identity (Kaya, 1990) to identify the contribution of population, GDP per capita, energy intensity, and carbon intensity[33] to total regional emissions.

$$Emissions = Population \cdot \left(\frac{GDP}{Population}\right) \cdot \left(\frac{Final\ Energy\ Use}{GDP}\right) \cdot \left(\frac{CO_2\ Emissions}{Final\ Energy\ Use}\right)$$

Results

Emissions and their drivers without climate policy

Regional emission patterns

The five regions under analysis account for 63% of global emissions in the course of the century. China is the greatest emitter, followed by the USA and India, and then Europe and Africa (~23%, 13%, 12%, 9% and 7% of total emissions, respectively). Emissions peak around 2040 in China, 2060 in the USA, and 2080 in India, while they are at their maximum at the end of the century for Europe and Africa (Supplementary Material (SM) Figure 1). The picture on major emitters changes when looking at per capita emissions. More affluent regions tend to be associated to higher per capita emissions and only modest convergence is observed across developed and developing countries. Specifically, emissions in the USA, but also Europe and China, start and remain above the world average for the whole century. On the other hand, they remain below the world average for Africa and India, despite considerable increases in the first half of the century. The temporal evolution of emissions also differs across regions. Emerging and developing economies are characterized by an initial sharp growth in total emissions, accompanied by either stabilizing (Africa) or declining emissions (China and India). Inversely, in the USA and Europe noteworthy increasing emission trends are only observed in the second half of the century. An exploration of emission drivers using the Kaya identity, allows identifying the main components that shape these differences but also some similarities across regional emission patterns (Figure 2).

Firstly, per capita final energy demand, shaped by economic growth and final energy intensity improvements, is the main driver of emissions for the majority of regions and time periods. Indeed, the tendency for these two factors to explain most of the variation of emissions in baseline scenarios is confirmed in many other studies (e.g. Blanford et al. 2012). Final energy demand per capita is explained by the interplay of numerous factors including GDP levels, substitution of energy with capital, autonomous energy efficiency improvements, and energy prices. Differences in the growth of GDP per capita across regions, as determined by RoSE scenario assumptions, explain a significant part of the variation in emission trends. High economic growth rates in China and India mainly for the first half of the century, and also Africa, are leading to the observed sharp increase in their emissions.

However, these regions also exhibit more accentuated energy intensity improvements compared to the developed regions, which reduces their energy demand growth rates. This, on the one hand, is due to the higher substitution of energy with capital caused by sharper increases in average final energy prices observed in these regions. Another reason is differences between regional energy efficiency parameters of the CES production function, which assume the same rate of improvement as labor effiency (see section 0 for details on how these parameters are determined). An implicit consequence of that is that developing regions are associated to sharper improvements of the energy efficiency parameters as opposed to

[32] A detailed description of the REMIND version used in this study can be found in Kriegler et al. (in preparation).
[33] We focus on CO_2 emissions from fossils fuels and industry.

developed regions, and that is also portrayed in the resulting energy intensity levels.

Secondly, the effect of population is greater in the case of Africa, and also India and China. In Africa, population triples throughout the course of the century. The associated increasing trend until 2080 is partly responsible for the steep increase in total emissions. In India and China rising population till about 2050 and 2030 respectively, drives emissions upwards, but after these points shrinking population reduces emissions.

Thirdly, the effect of carbon intensities is also important and notably diverse across regions. In less developed regions, namely India but mostly Africa, carbon intensities increase sharply at the first few decades of the century but decline thereafter. Inversely, for the other three regions carbon intensities initially decline but later in the century they rise again. This occurs around mid-century in the USA, around 2080 in Europe, and 2100 in China. These rising carbon intensities are the main reason for the increasing emissions in the second half of the century noted earlier for the USA and Europe.

Table 2: Scenario matrix defining the scenarios and their names and short descriptors.

Drivers / Policy	Medium Growth: Medium Growth Fast Convergence Medium Pop	Slow Growth: Slow Growth Fast Convergence Medium Pop	Fast Growth: Fast Growth Fast Convergence Medium Pop	Medium Growth: Medium Growth Fast Convergence Medium Pop	Medium Growth: Medium Growth Fast Convergence Medium Pop
	Medium Fossils: Medium Oil Medium Gas Medium Coal	Medium Fossils: Medium Oil Medium Gas Medium Coal	Medium Fossils: Medium Oil Medium Gas Medium Coal	High Fossils: High Oil High Gas High Coal	Low Fossils: Low Oil Low Gas Low Coal
Baseline	BAU DEF	BAU SL Gr	BAU FS Gr	BAU HI Fos	BAU LO Fos
450 ppm CO2-equiv	450 DEF	450 SL Gr	450 FS Gr	450 HI Fos	450 LO Fos

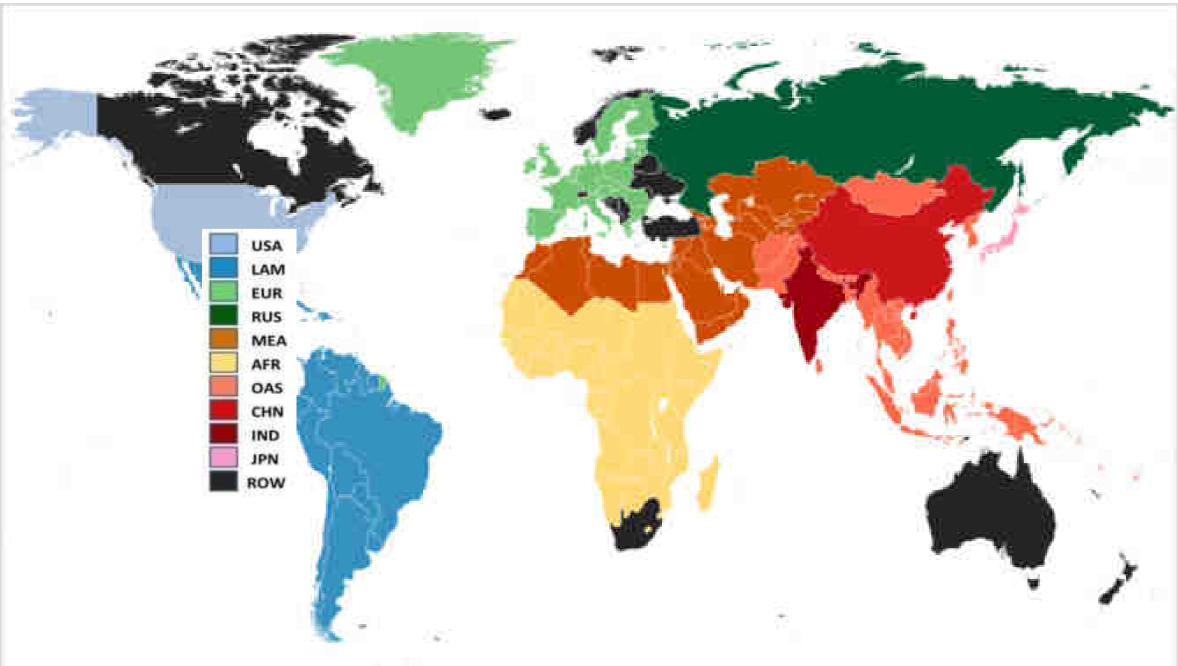


Figure 1: REMIND model regional definitions[34].

[34] The regional acronyms are as follows: USA – USA; LAM – Latin America; EUR – Europe; RUS – Russia; MEA – Middle-East; AFR – Africa; OAS – other Asia; CHN – China; IND – India; JPN – Japan; ROW – rest of the World.

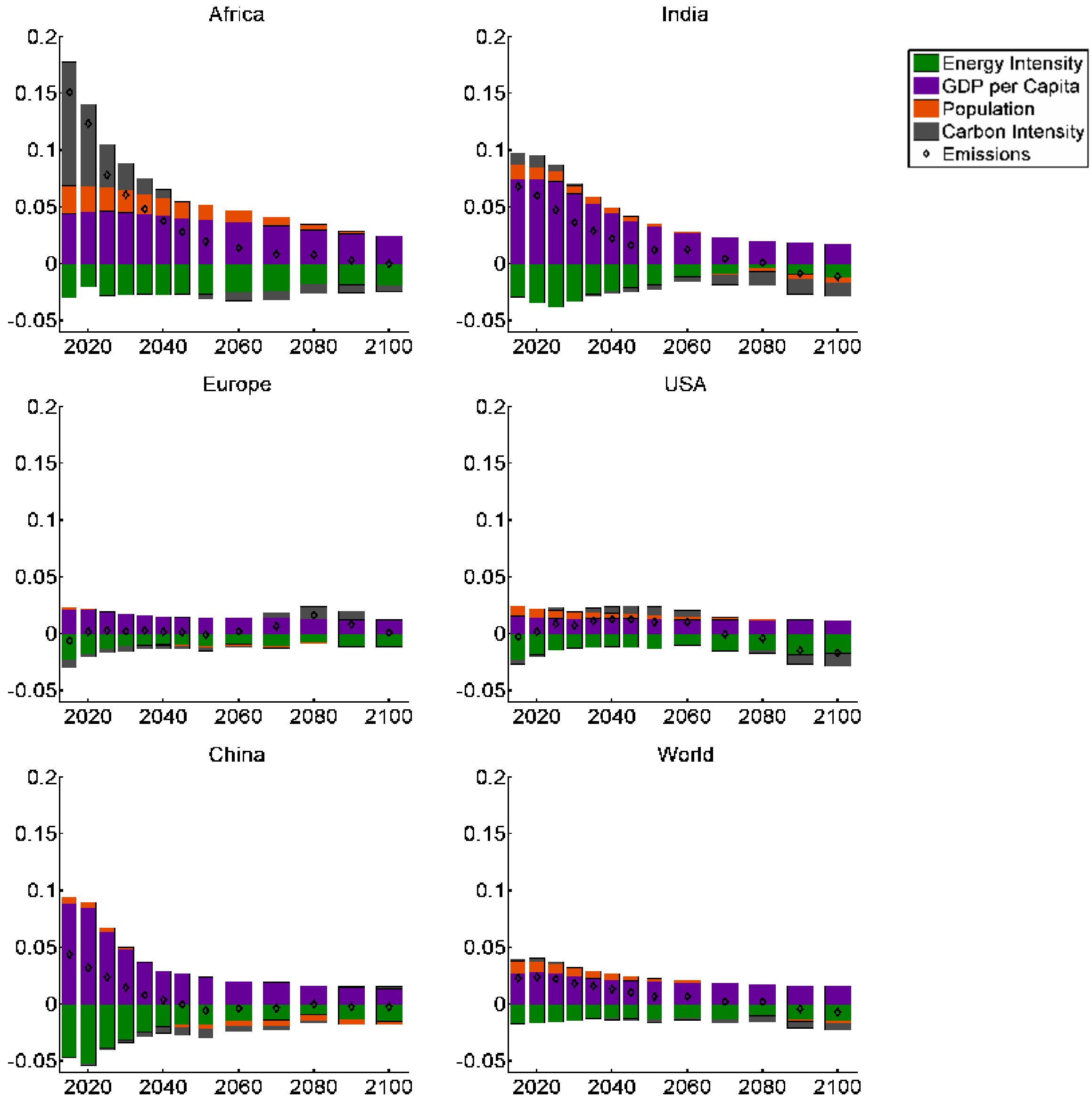


Figure 2: Annual growth rates of Kaya factors between consecutive periods in BAU DEF.

Changes in carbon intensities are explained by changes in regional energy mixes (**SM Figure 3**-SM Figure 2). Firstly, absolute carbon intensities levels are generally higher than the world average for the USA, China and India (SM Figure 1), since their energy systems are more heavily reliant on coal and oil. Regarding temporal trends, in both Africa and India their strong carbonization in the first half of the century is due to increasing fossil fuel use caused by a) a switch from traditional biomass to coal for solid fuels, b) increasing use of gas for grids, c) higher oil shares for liquids. In the second half of the century, reliance on dirtier fossils is reduced with solids being gradually replaced by grids, and increasing use of renewables for electricity and biofuels for liquids. On the other hand, developed regions commence from a significant reliance on oil, gas, and to a less extent coal. However, considerable increases in coal shares primarily for liquids later in the century give rise to the carbon intensities and emissions rises mentioned above. China bears similarities to both developing and developed regions regarding its coal use, with coal initially being used for solid fuels and towards the end of the century for liquids.

Sensitivity of regional trends under baseline uncertainty

For the three different economic growth scenarios, China followed by the USA and then India remain the greatest emitting regions out of the five investigated ones. Also, per capita emissions remain higher in the more affluent regions (USA, Europe, China), since faster growth leads only slightly to higher regional convergence in per capita emissions. Nonetheless, growth assumptions have some significant implications for regional emission patterns. Generally faster growth is associated to higher cumulated emissions across the century. Total global cumulated emissions range by 14%

between BAU SL Gr and BAU FS Gr scenarios[35]. The sensitivity of different regions ranges only slightly compared to the global figure (18% for India, 16% for China, 13% for the USA and EUR, and 10% for Africa).

Differences in emissions, mainly in the first half of the century, are explained almost entirely by differences in the growth rates of GDP per capita and energy intensity for all regions (Figure 3). That is, slower growth leads to lower emissions due to the residual effect between lower GDP per capita and higher energy intensities (vice versa for faster growth). Differences in GDP per capita are exogenous due to scenario assumptions. Slower growth leads to higher energy intensities for two main reasons: a) it is associated to lower average energy prices and thus lower substitution of energy with capital, and b) energy efficiencies are lower under slow growth, since they change at the same rate as labor efficiencies, thus resulting in higher energy intensities.

These patterns are valid also for the second half of the century, but during that period also carbon intensities are sensitive to growth assumptions, contributing to considerable changes in emission patterns. Carbon intensities are lower in all regions for BAU FS Gr, due to higher deployment of biomass and non-biomass renewables. Despite these carbon intensity reductions, overall cumulative extraction of fossil fuels, and associated emissions, over the century are higher in all five regions for BAU FS Gr. That implies that faster growth leads to faster exhaustion of cheaper fossil reserves that ultimately enhances the competitiveness of renewable energy sources earlier in time, without however resulting in any net emissions gains over the course of the century. On the other hand, in BAU SL Gr cumulated fossils extraction is lower for all fossils and regions, but carbon intensities tend to be higher in the second half of the century for some regions (Europe, Africa, and slightly India), mainly due to lower renewables deployment. In the liquids sector, developed regions substitute coal with oil under BAU FS Gr, while China and India do the inverse (and vice versa for BAU SL Gr), due to changes in the resource prices that individual regions face.

The range of emissions variation differs more when varying fossil fuel availability assumptions, as opposed to economic growth assumptions. Firstly, the relative order of greatest emitters (China, USA, India, Europe and Africa in descending order) can slightly change between regions and scenarios. Specifically, India's emission shares are greater than those of the USA for both BAU LO Fos and BAU HI Fos, while Africa's share of emissions can get as high as those of Europe for BAU HI Fos, since the sensitivity of emissions differs significantly across regions (50% for Africa, 42% for India, 27% for China, 24% for the USA, 13% for Europe, and 34% for the World)[36].

Further, the relationship between fossil fuel availability and emissions is not straightforward. Even though emissions are lower for all times and regions in BAU LO Fos, they are not consistently higher for BAU HI Fos for the whole century in Europe and the USA. In the USA, even total cumulated emissions are lower for BAU HI compared to BAU DEF. Also, emission growth rates in the second half of the century appear more elevated in BAU LO Fos than in BAU DEF for some regions (India, Africa) and vice versa for BAU HI Fos (Europe, China) (Figure 3).

In the case of variation of fossil fuel availability, differences in emissions are mainly due to differences in carbon intensities. Energy intensities play a smaller role, with a general tendency to be higher in BAU HI Fos, due to more limited price induced incentives for energy intensity improvements through energy to capital substitution. Like emissions, carbon intensities tend to be lower under the BAU LO Fos scenario, and vice versa for BAU HI Fos, but they are the drivers of the exceptions mentioned above regarding growth rates compared to BAU DEF due to differences in the structural changes in the energy mixes. The similarities across regions are that in BAU HI Fos all regions are associated to higher oil shares for liquids, higher gas and coal shares for electricity, and lower renewables shares (non-biomass renewables for electricity and biomass for liquids), while the inverse trends are observed in BAU LO Fos (SM Figure 4). However in BAU HI Fos, the USA, Europe and China, substitute significantly coal by oil for liquids, which leads to lower carbon intensities and emission growth rates for this scenario. On the other hand in BAU LO Fos, emission growth rates in Africa and India in the second half of the century are higher compared to BAU DEF, due to a significant increase in the shares of coal mainly for liquids.

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[35] This has been estimated, separately for the World and each of the individual regions, as the difference in cumulated 2005-2100 emissions between BAU SL Gr and BAU FS Gr, divided by cumulated 2005-2100 emissions in BAU DEF.

[36] As for the economic growth scenarios, this has been estimated separately for the World and each of the individual regions, as the difference in cumulated 2005-2100 emissions between BAU LO Fos and BAU HI Fos, divided by cumulated 2005-2100 emissions in BAU DEF.

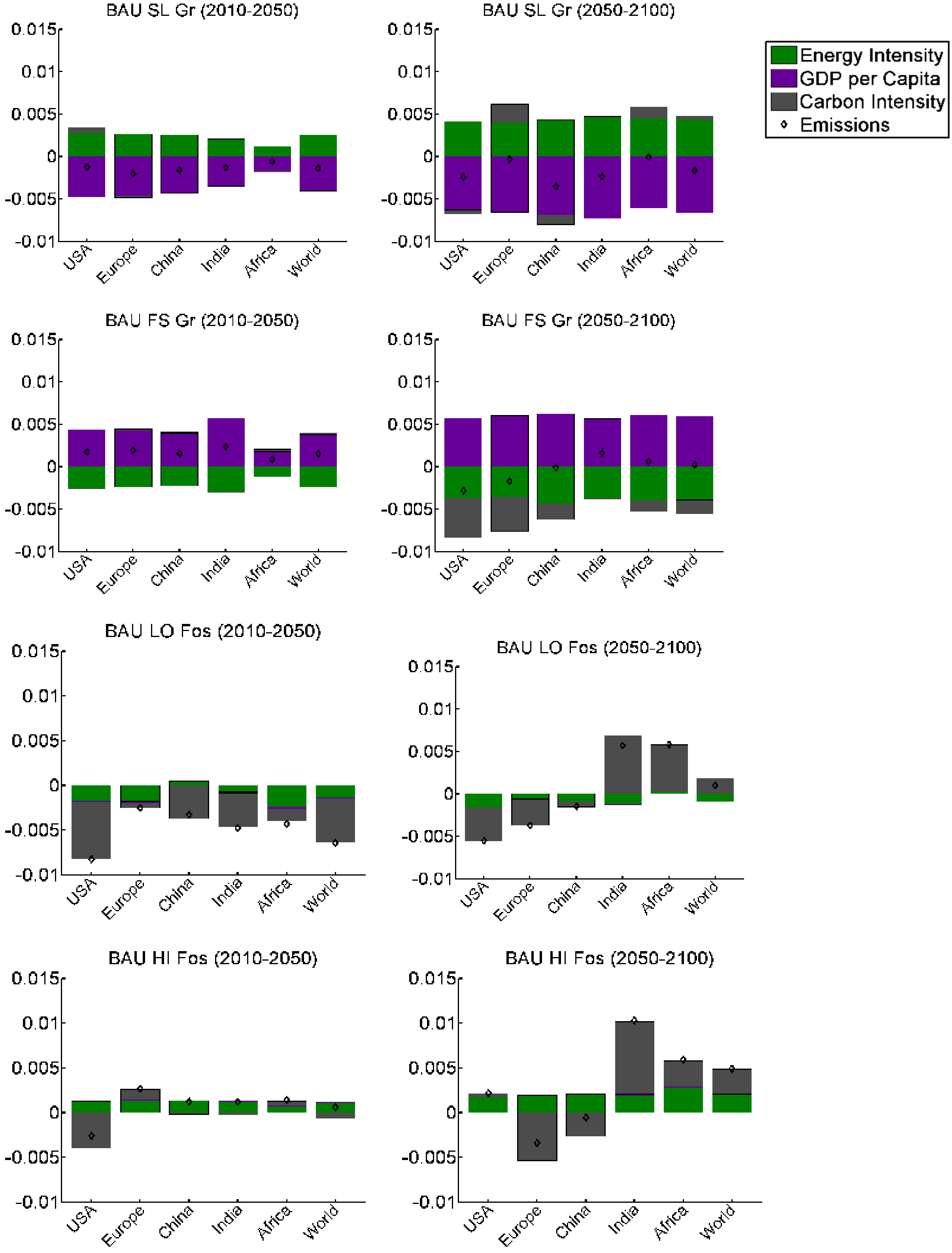

Figure 3: Difference in average annual growth rates of Kaya factors between baseline variation scenarios and BAU DEF in 2010-2050 (left) and 2050-2100 (right).

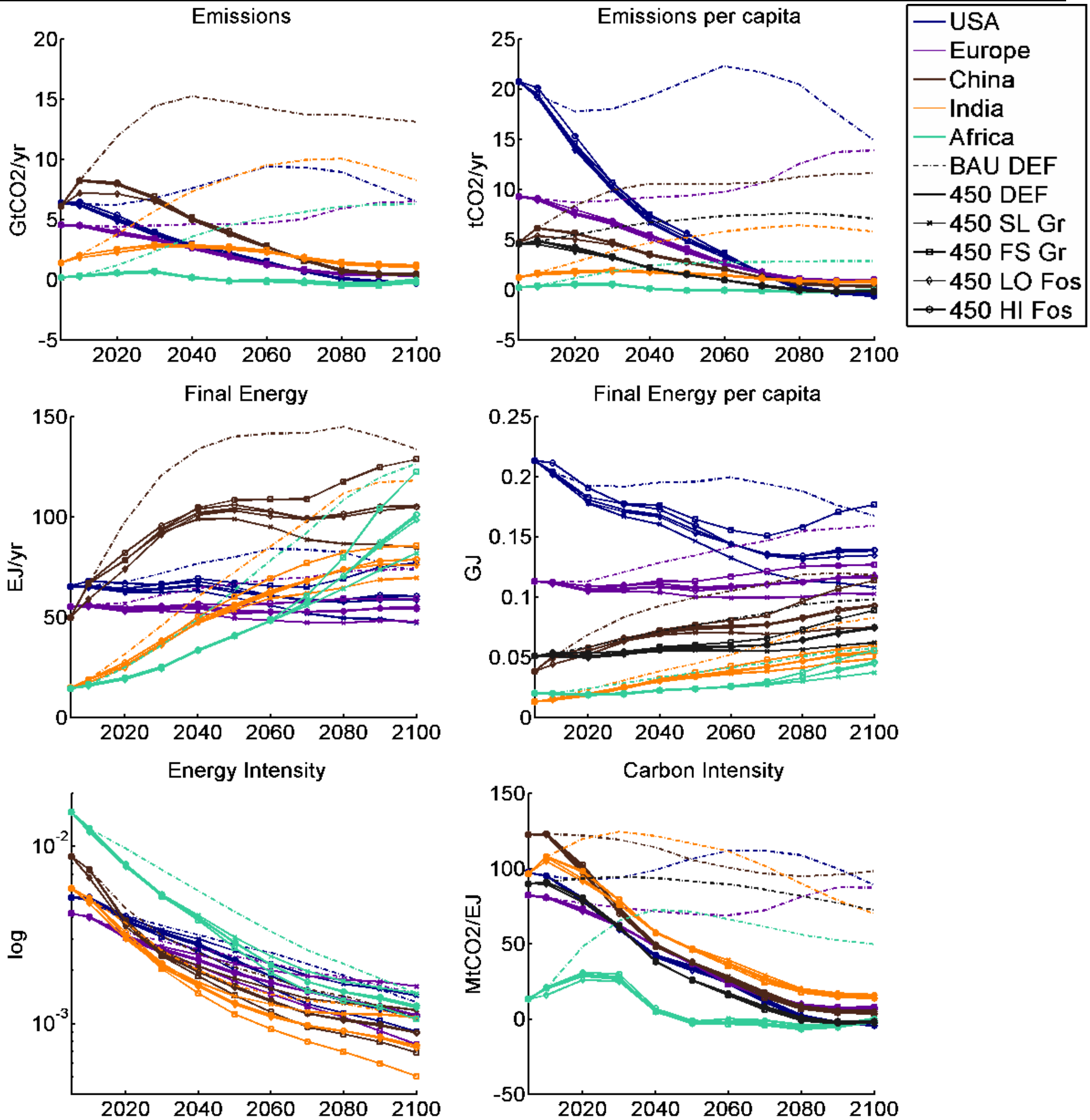

Figure 4: CO_2 fossil fuel and industry emissions, final energy and Kaya factors in time for the BAU DEF and the 450 scenarios.

Emissions and their drivers with climate policy

Climate policy induces drastic total and per capita emissions reductions in all explored regions (Figure 4). Achieving the stabilization target requires the abatement of about 75% of global emissions of BAU DEF. Africa achieves an almost 100% reduction of its baseline emissions, China, India, and the USA an about 70% reduction, and Europe a 59% reduction. The relative order of major emitters remains unaltered to a no climate policy regime, with China being the greatest emitter, followed by the USA, India, Europe and Africa (~28%, 16%, 15%, 14% and 0% of total emissions in 450 DEF).

Due to drastic emission requirements, the stabilization target induces a general convergence pattern in per capita emissions across regions. The maximum convergence across the five regions is achieved at about 2080, since regions with low emissions at the beginning of the century, like Africa and India, maintain these low levels throughout the century, while China, Europe, and particularly the USA, start from much higher per capita emissions, primarily due to their higher final energy per capita demand, that are radically and gradually reduced. After 2080 a slight divergence is observed due to different capacities across regions to reach very low per capita emissions. Specifically, India, followed by Europe and China, are on the high end, while the US and Africa reach lower emission levels, mainly due to their lower carbon intensity levels.

It is noteworthy that, under climate policy, emissions trajectories show very little variation across economic growth and fossil fuel availability scenarios. In the case of fossil fuel variations, both carbon and final energy intensities remain almost entirely unaffected. This indicates that, in a climate policy context, fossils are in any case being gradually abandoned for less-carbon intensive energy sources, thus rendering uncertainty about fossil fuel prices less relevant. Little variation in carbon intensities is also observed under economic growth assumptions. On the other hand, final energy per capita and energy intensity levels still show some sensitivity to GDP assumptions. However, even though total energy demand and the scale of energy systems differ across GDP assumptions, the underlying structure of energy systems is not significantly impacted, as demonstrated by the lack of variation in the associated carbon intensities.

Exploring more carefully the contribution of Kaya factors on emission reductions, it is observed that although these reductions are associated to both carbon and energy intensity improvements, the bulk of them is achieved through an intensive decarbonization of energy systems (SM Figure 4). The former is in average in the range of 0.35-0.45 of the equivalent baseline value in the period 2050-2100, while the latter in the range of -0.05-0.15. Also, energy intensity improvements take place mainly in the first half of the century, while in the second half their contribution is minor. On the other hand, carbon intensity improvements occur throughout the century and are the key determinant of continuous emission reductions in the second half of the century.

However, significant differences across regions are observed. Firstly, developed regions and particularly Europe reduce their energy intensities less drastically than China and India, while Africa achieves the most important reductions. This is in line with other findings in the literature (e.g. van Sluisveld et al., accepted), that report greater energy efficiency reductions under climate policy for developing regions, but is also an assertion that has been criticized (Steckel et al. 2013). Secondly, as already noted, Africa and the USA achieve greater carbon intensity reductions compared, to China, Europe and lastly India, due to their greater deployment of biomass with CCS (BECCS). In particular Africa abates almost 100% of its emissions throughout the century (SM Figure 5). The capacity of different regions to abate emissions via BECCS depends on their biomass potentials in combination to their total emissions dictated by the composition of their energy mixes. Africa’s primary energy consumption is based on biomass and non-biomass renewables, with significantly lower fossil fuel consumption compared to other regions from early in the century. On the other hand, other regions consume considerably more fossils, particularly in the first half of the century, and only start developing substantial renewable and to smaller extent nuclear capacities in the second half of the century, when nevertheless still some reliance on oil and gas remains.

Although differences across scenarios are not as prominent as differences across regions, it is worth noting some important findings. In all regions, the faster is the growth the higher are the required emission reductions. The divergence between fossil variation scenarios is clearly greater than this between economic growth scenarios since baseline emissions for the equivalent scenarios differ more. Not surprisingly, lower fossils availability is related to lower mitigation effort in order to achieve the climate stabilization target. As already seen some variation in final energy demand remains across economic growth scenarios, and this translates in higher/lower employment of non-fossil primary energy sources. Except this, the findings on regional energy mixes remain robust across scenarios on economic growth or fossil fuel availability variations.

Summary and Conclusions

This paper analysed regional emission trends and their drivers across a range of regions in different stages of their economic development, with a focus on differences and similarities across world regions, and their sensitivity to economic growth and fossil fuel availability assumptions with and without climate policy.

It was found that regional total and per capita emissions are sensitive to baseline variation in a no-climate policy world, but this is not the case under climate policy. In baseline scenarios, in most regions faster growth and higher fossil fuel availability induce higher cumulated century emissions. On the other hand, regional emission patterns remain largely unaltered under climate policy scenarios. As a consequence, higher fossils availability and faster growth are associated to higher mitigation efforts. The order of major emitters and per capita emissions convergence in the baseline is not affected significantly by baseline variations. China, followed by the USA and India, are the greatest emitters, which highlights the importance of these countries decision-making for the future of global climate. Per capita emissions start and remain higher than the world average in developed and emerging economies, but lower for developing economies, till the end of the century. In fact, the maximum convergence in per capita emissions is observed under climate policy, since all regions need to implement intensive emission reductions.

Regarding the drivers of these emissions, a unifying finding across regions is that, in the baseline, the scale of emission levels is mainly driven by changes in economic growth and energy intensities, while carbon intensities play an important role in shaping temporal emissions trends. Naturally, in case of economic growth variations, the most dominant effect is that differences in the growth rates of GDP per capita and energy intensity are the main drivers of differences in emissions, but structural changes in energy mixes, and consequently carbon intensities, can also occur under increasing resource exhaustion. On the other hand, under fossil fuel variation, changes in emission developments are mainly induced by differences in carbon intensities, although higher energy prices under low fossil fuel availability can also incentivize energy intensity improvements. Nevertheless, regional reactions to these changes were more idiosyncratic and less predictable compared to those on economic growth variations, due to the exposure of all regions to international fossil markets and more intensive inter-fuel substitution. In policy scenarios, although both energy and carbon intensity reductions are contributing to emission reductions, energy systems appear more flexible in readjusting their structure than do economic systems in reducing their energy demand, as indicated by significantly more pronounced carbon intensity reductions.

Except of varying effects of emissions drivers across scenarios, their effect across regional patterns also differs. In the baseline, higher economic growth rates and population increase in developing and emerging economies, are leading to a boost of emissions in the first half of the century, but due to their higher energy intensity improvements, per capita emissions are maintained at lower levels at the end of the century. Also, carbon intensity developments differ across regions. They are increasing considerably in the beginning of the century for developing regions since fossils are used more intensively in order to fuel their development. On the other hand, in developed regions, oil scarcity is the main cause of carbon intensities increase due to an inter-fuel substitution of oil by coal. Under climate policy, regional potentials to decrease energy and carbon intensities differ, and lead to considerable differences in regional emission levels at the end of the century. Evidently, higher utilization of BECCS in Africa and the US, allows these regions to abate a more significant part of their emissions and reduce their carbon intensities more prominently. Also, the carbon price induces more drastic energy intensity improvements in developing regions, which are faced with higher energy intensities in the baseyear.

Energy mixes appear particularly sensitive across scenarios and regions, and are primarily motivated by energy prices associated to regional resource availability, global demand for these resources, and carbon pricing. Development of renewable sources seems inevitable even in baseline scenarios in the case of higher energy prices under faster growth or lower fossil fuel availability, or unanimously in all policy scenarios due to carbon pricing. This can result in significant carbon savings in the case of low fossils availability, and greater savings under climate policy, but not in the case of faster growth since this transition is mainly motivated by a faster exhaustion of fossil fuels. Also, inter-fuel substitution across regions, can differ across scenarios depending on regional reserves, pressure from total global demand and fossil trade flexibility. As a result, in the baseline regions are found to substitute fossil fuels differently, and particularly oil and coal, within the same growth or fossil fuel availability scenario. This reveals the substitutability between fossils and highlights the importance of relative fossil prices across scenarios, which can lead to counter-intuitive effects of resource availability since higher oil scarcity can lead to an increase in carbon intensities due to substitution with coal. Developing countries can be more vulnerable to such price fluctuations, especially in the case of oil whose price tends to be more influenced by global demand, since it is more easily transported and traded across regions compared to coal. Energy mixes responses are less diverse across climate policy scenarios but also regions, since they evolve towards a significant reduction of fossils, and particularly coal, and a distinct reliance on biomass and non-biomass renewables in all regions. Also, scenario assumptions do not influence significantly the structure of energy systems, which demonstrates that the technological implications of climate stabilization are robust despite uncertainty on economic growth and fossil fuel price trajectories.

Not surprisingly, it is important to note that numerous model and scenario assumptions are evident in the results. These include a) more accelerated energy intensity improvements for developing countries, partly driven by the analogy between labor efficiency and energy efficiency improvement parameters, b) the degree of substitution between oil and coal to liquids, as opposed to liquefied gas (currently not implemented) and electricity (based on an initial parameterization), c) exogenous assumptions on the phase out of traditional biomass, leading to a transition into coal in developing regions, d) economic growth assumptions across regions determined by exogenous assumptions, e) high substitutability within energy systems as opposed to a more stylized representation of the economic system, resulting in a more flexible readjustment of the former as opposed to the latter, and potentially emphasizing more supply side as opposed to demand side sensitivity and adjustment to enforcement of climate policy. An increasing number of work dedicated to a critical evaluation and validation of model assumptions and results through comparison to historic data and across-model comparisons is emerging in the literature (e.g. Steckel et al. 2013, Blanford et al., Leimbach et al., van Sluisveld et al.). Also, although technological portfolios of climate stabilization are robust across baseline uncertainty, the mitigation costs associated to these developments and also their distribution across world regions merits particular attention. Future research aims at these two directions.

Acknowledgements

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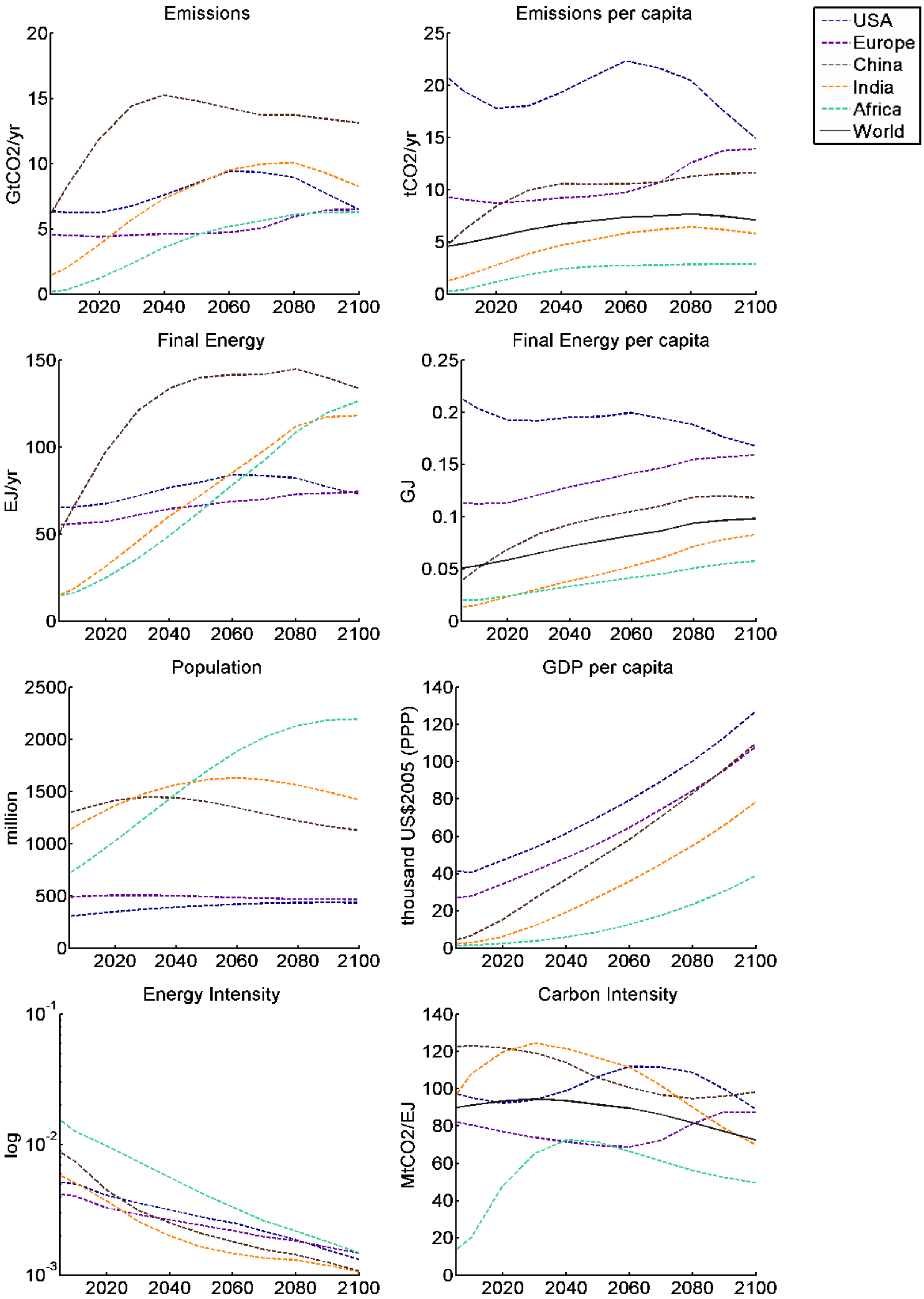
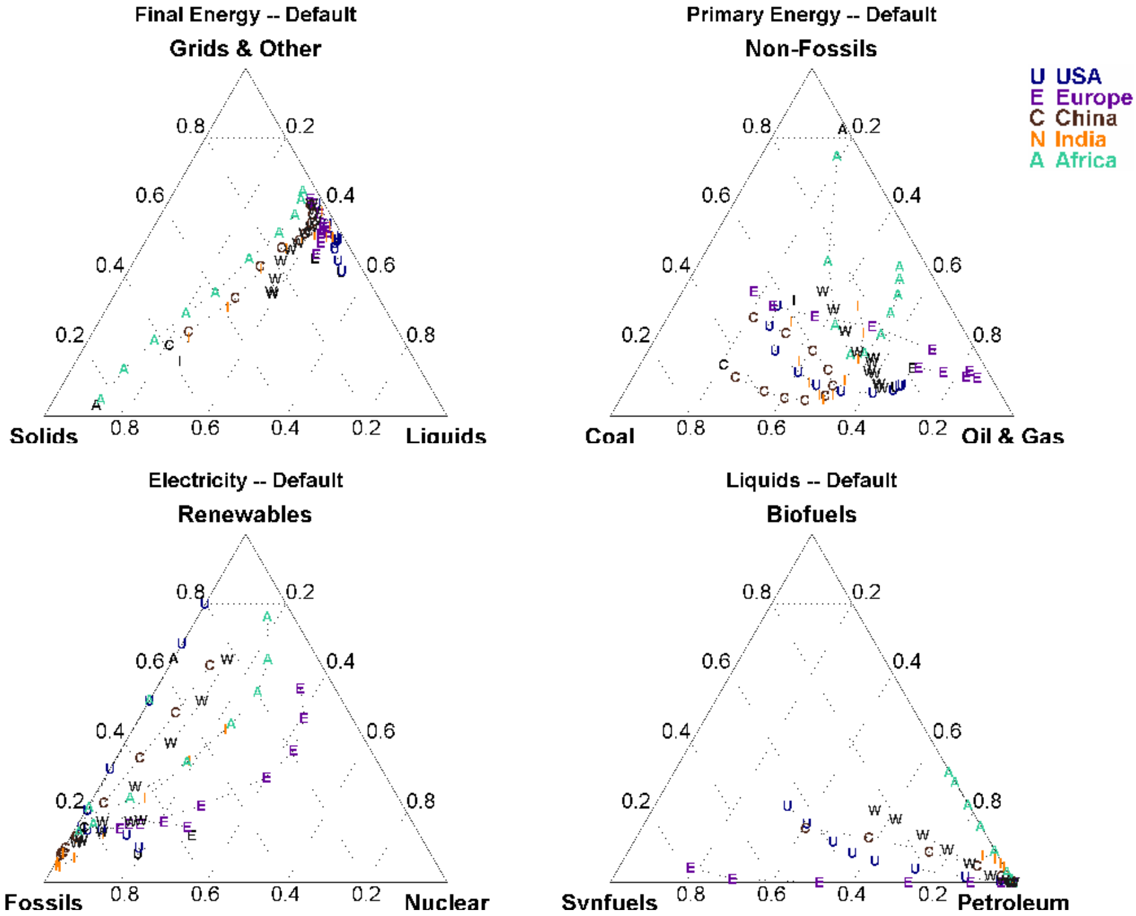
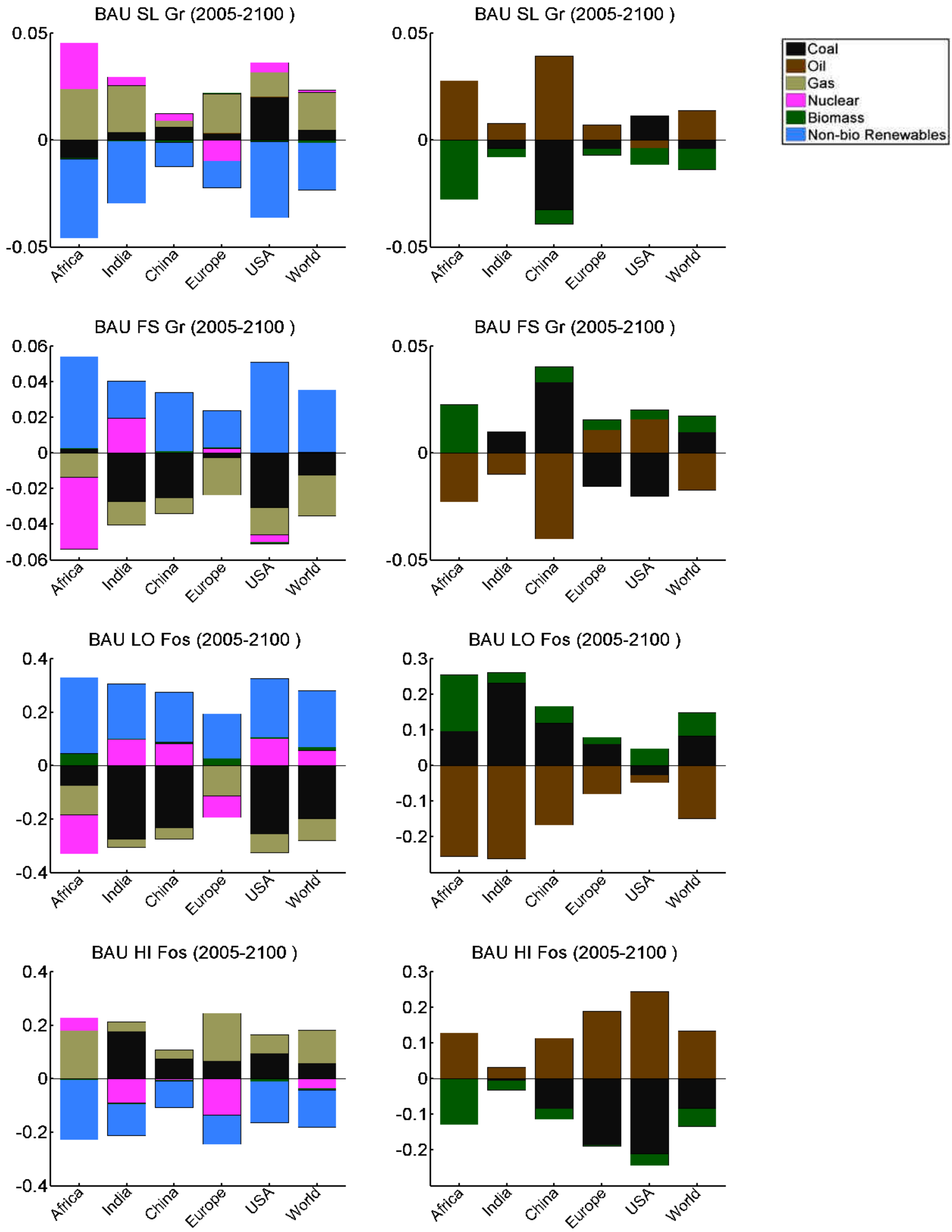
Supplementary Material



SM Figure 1: CO_2 fossil fuel and industry emissions, final energy and Kaya factors in time for the BAU DEF scenario.

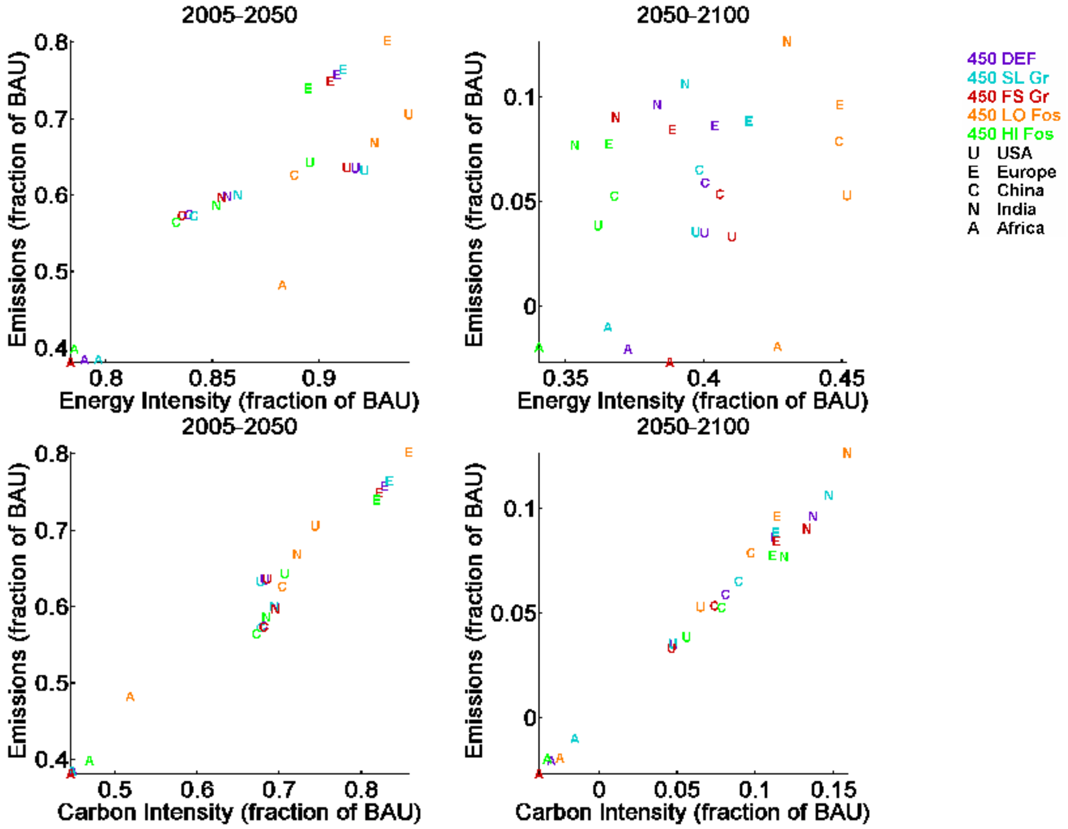


SM Figure 2: Structural changes of final energy (top left), primary energy (top right), electricity (bottom left), and liquids (bottom right). Letters in black indicate the starting point in 2005 and movement towards (further away from) a vertex indicates increase (decrease) of its share in the total.

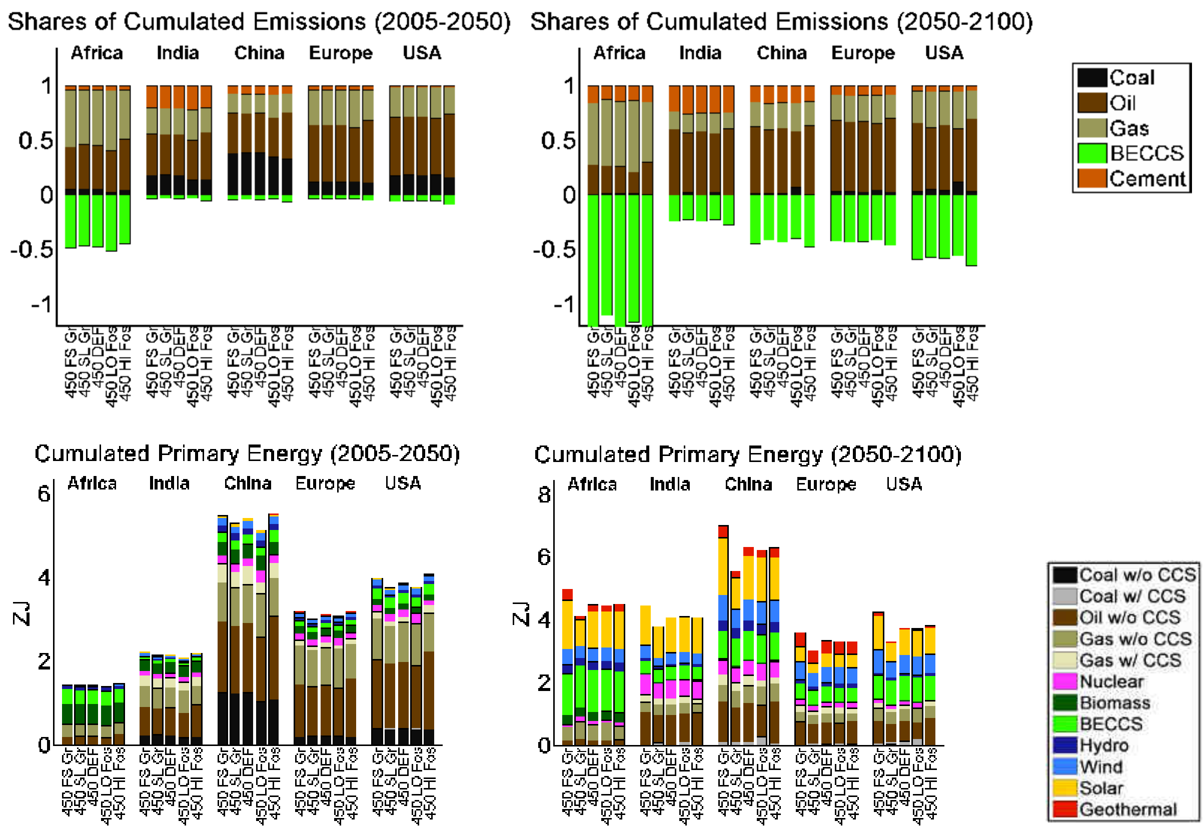


SM Figure 3: Average differences in electricity (left) and liquids (right) shares between baseline variation scenarios and BAU DEF. These have been estimated by subtracting the shares per source and scenario from the corresponding shares of BAU DEF, and then averaging over time.

SM Table 3: Change in LCOEs and Prices in the period 2050 to 2100.



SM Figure 4: Changes in CO_2 fossil fuel and industry emissions over changes in energy intensity and carbon intensity for the 450 scenarios. All values are expressed as average fractions of the equivalent BAU scenario, by dividing the value in each 450 scenario by the value of the equivalent BAU scenarios, and then averaging in time for the depicted periods.



SM Figure 5: Shares of cumulated emissions and cumulated primary energy for 2005-2050 (left) and 2050-2100 (right).

Significance of dependability concept for electricity security of supply

Dr. Miloš TANASIJEVIĆ[1], Associate Professor
Dr. Dejan IVEZIĆ, Associate Professor
Dr. Predrag JOVANČIĆ, Associate Professor
MSc. Aleksandar MADŽAREVIĆ, Research Assistant
University of Belgrade - Faculty of Mining and Geology
Djusina 7, 11000 Belgrade, Serbia
[1]Tel: +38113219155
Fax: +38113219101
e-mail: milos.tanasijevic@rgf.bg.ac.rs

Abstract

Serbian electricity sector is based to operation of lignite fired thermal power plants. These power plants produce over 60% of current indigenous production and their operation is closely related to reliable coal production, based to huge and expensive plants and machines. Unplanned down-time of these systems can cause significant financial losses, but they also can influence to country's security of energy supply. For that reason, systematic monitoring of operation and maintenance process for systems of coal exploration is very important. The aim is to predict and prevent their failures and to evaluate and estimate their remaining capabilities.

Concept of dependability, introduced by standard ISO-IEC 300, was accepted as the most comprehensive indicators of service quality for complex technical systems such as systems of coal exploitation. This standard gives the definition of dependability in descriptive linguistic style without firm determination. This paper presents the model for dependability assessment through fuzzy sets utilization; concrete to introduce fuzzy theory in dependability analysis regards to performances of reliability, maintainability and maintenance support, as well for synthesis of dependability from lowest to higher level of system structure. Maintenance support and dependability itself can only be described by linguistic variables on the base of experts' judgment. Reliability and maintainability have usually been presented on the base of probability theory. Fuzzy sets theory was introduced as a convenient mathematical model that gives mutual synergy to calculations with hybrid data. Besides overview of model, the results of few model implementations to lignite open pit mines in Serbia are presented.

Key words: Electricity security, Lignite, Bucket Wheel excavator, Dependability

1. Introduction

Lignite, as an energy resource, is a mainstay of electricity generation in the Republic of Serbia. Installed capacity of lignite power plants represents 68% of the total installed capacity of Electric Power Industry of Serbia, the only company in Serbia which manages electricity generation (Jovančić et al., 2011). Systems of lignite exploitation are based to huge and expensive plants, equipment and machines, and they are characterized by very complex technological process and difficult working conditions. Unplanned down-time of these systems can cause important financial losses (several thousand euros per hour), but they also can effect to country's security of energy supply. Systems of lignite exploitation and overburden moving consist of: bucket wheel excavators, rubber belt conveyors, stackers, auxiliary machinery…. All these elements of the system of exploitation are in series link in terms of reliability, so that failure of one element causes a breakdown of the whole system. Of the above, systematic monitoring of operation and maintenance process for systems of lignite exploration is very important in order to ensure constant production of lignite, generation of electric power and supply security of users of electricity. The target of Electric Power Industry of Serbia managers is to predict and prevent failures of operating system and to evaluate and estimate their remaining capabilities and dependability in general.

Concept of dependability, introduced by standard ISO-IEC 300, was accepted as the most comprehensive indicators of service quality for complex technical systems such as systems of lignite exploitation (Tanasijević et al., 2007). According to standard, dependability is defined as complete concept used to define availability and its determining indicators: reliability, maintainability, and maintenance support (Standberg, 1991). Reliability and maintainability indicators are usually expressed quantitatively, as the probability function for failure likelihood in the case of reliability or as the probability function for duration of selected maintenance operation in the case of maintainability; for real time dependent systems, as they are systems in open pit mines. Maintenance support is indicator of the level of logistical support for maintenance operations. Includes: spare parts, training of craftsmen, quality tools, organization, etc.. Maintenance support has no a conventional numerical method of assessing. This standard gives the definition of dependability in descriptive linguistic form without firm determination. This paper presents the model for assessment of dependability through fuzzy sets utilization. Model was formed to introduce fuzzy theory in dependability analysis regards to performances of reliability, maintainability and maintenance support, as well for synthesis of dependability from lowest to higher level of system structure. These performances, especially maintenance support and dependability itself, can only be described by linguistic variables, on the base of experts' judgment and estimations. Unlike them, reliability and maintainability have usually been presented by time-dependent function on the base of probability theory. In these analyses, especially for complex mechanical systems (as the example of such system, bucket-wheel excavator will be analysed latter), problems related to systems' structure definition in reliability sense, characterizations of incomplete failures and similar problems can be arisen as serious obstacles in definition of probability functions. Also, problems in collecting and quality of collected data in the sense of uncertainty and generalization can make difficulty. On the other hand, analyses of maintenance support are only based to experts' evaluations. Fuzzy sets theory i.e. fuzzy inference, fuzzy proposition and composition were introduced as a convenient mathematical model that gives mutual synergy to calculations with hybrid data, quantitative and qualitative, numerical and linguistic.

Fuzzy logic (Klir and Yuan, 1995; Zadeh , 1996) is a type of multi-valued logic derived from fuzzy set theory to deal with judgment that is flowing or approximate rather than rigid and exact. In difference with "crisp logic", where binary sets have two-valued logic, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy sets theory has arisen as appropriate tool that will work simultaneously with insufficiently accurate terms and expressions that hardly can be represented by models with numerical inputs, as well as with to some extent strongly determined facts. Fuzzy logic is extensively used for solving problems in the field of system science in terms of optimization, decision-making and similar. Complex technical systems are common industrial systems, which have a difficult relation between parameters of reliability, availability, dependability etc. Relation has two aspects: vertical and horizontal. The first one depends on the structural-hierarchical outlook of technical system and the second on the interdependence of the mentioned parameters on the level of one hierarchical level of tehnical system (component, sub-system, system). Theory of fuzzy logic gives possibility for representing parameters of the system's condition and their mutual synthesis into one parameter as well as for synthesis from lower hierarchical levels to higher ones. Representation of temporary condition of parameters is performed with membership function which can have values from 0 to 1. Hence, the problem is to make synergetic approach to all dependability indicators and their synthesis at dependability itself. Considering dependability indicators, fuzzy sets theory property to calculate with linguistic variables is especially applicable in integration of maintenance support performance in dependability evaluation. In analysis of logistic parameters as the maintenance support is, at the level of dependability determination, practically there is no other way for its estimation without utilization of experts' judgments given as linguistic descriptions. However, even reliability and maintainability performances very often can only be expressed at the level of experts' opinions. Therefore, fuzzy model for dependability evaluation should enable synthesis of differently defined dependability indicators, but also it should enable possibility for quality and systematically analysis of relations and connections between individual indicators, i.e. stated performances of technical systems' behaviours.

This article highlights the importance of the concept of dependability for the systems of lignite exploitations and electricity generation and presents mathematical and conceptual model of dependability computation on the base of fuzzy sets rules. Besides overview of conceptual and mathematical model, the results of few implementations of model to open pit lignite mines in Serbia are presented, concrete on the bucket wheel excavator as one of the most complicate and most responsible machine (Tanasijević et al, 2007). The timely revitalization (Tanasijević et al., Journal of Scientific ..., 2011) and estimate the remaining capabilities of these machines (Tanasijević et al., Underground Mining Engineering, 2011), is essential to the security of electricity supply.

2. Dependability evaluation and max-min logic

The concept of synthesis (Tanasijević et al., Quality and Reliability Engineering International, 2013) is mentioned in both mentioned aspects - vertical and horizontal, and its role is to identify all relations and to find their interaction within complexity of composite technical system. In fuzzy theory there is a concept of fuzzy composition, which gives possibility for synthesis of membership function. The so called max-min logic, also called pessimistic, is often used as fuzzy composition. The idea is to make overall assessment equal to the partial virtual representative assessment. This assessment is identified as the best possible one between the worst partial grades expected. Partial grades in the horizontal aspect are assessments of parameters, and in the vertical aspect are assessments of elements which are located on a certain lower hierarchical level.

For determination of dependability (D) performance it is necessary to complete synthesis of estimations for reliability (R), maintainability (M) and maintenance support (L). Synthesis has been done according to appropriate, max-min fuzzy composition (Wang et al., 1995), in the following way:

$$D = R \circ (M \times L) \qquad (1)$$

In this equation Cartesian product (×) was used to join in indicators with mutual dependence M and L. Conjunction "and" i.e. product with operator (○) is used in cases when fuzzy sets / relations simultaneously exist, but there is no functional conditionality between them, in this case, reliability indicator and maintenance indicators (maintainability and maintenance support, together).

Chosen max-min composition sets maintenance support performance as "critical" for dependability determination. Even in the case when same system has the excellent performances of reliability and maintainability, relatively poor characteristics of for maintenance support means that the overall performance of dependability will also be at a low level. Although this feature characterized max–min composition as ‘pessimistic’, it has been usually used in the analysis of technical systems.

The Cartesian product (Ivezic et al., 2008) of maintenance related indicators (M, L), i.e. membership function has been defined as follows:

$$\mu_{M \times L} = (\mu_{M \times L}{}^{ij})_{n \times n} \qquad (2)$$

- with

$$\mu_{M \times L}{}^{ij} = \min(\mu_M{}^i, \mu_L{}^j) \qquad (3)$$

- where the membership functions for maintainability and maintenance support has been given as:

$$\mu_M = (\mu_M{}^1, \mu_M{}^2, \ldots, \mu_M{}^n) \quad (4)$$

$$\mu_L = (\mu_L{}^1, \mu_L{}^2, \ldots, \mu_L{}^n) \qquad (5)$$

Composition of dependability membership function, for reliability membership functions:

$$\mu_R = (\mu_R{}^1, \mu_R{}^2, \ldots, \mu_R{}^n) \qquad (6)$$

- and the Cartesian product of maintainability and maintenance support membership function given in (1), can be determined as:

$$\mu_D = \mu_{R \circ M \times L} = (\mu_D{}^j)_{1 \times n} \quad (7)$$

-here is:

$$\mu_D{}^j = \max(\min(\mu_R{}^1, \mu_{M \times L}{}^{1j}), \ldots, \min(\mu_R{}^n, \mu_{M \times L}{}^{nj})),\ j = 1, 2, \ldots, n \qquad (8)$$

That is, dependability can be presented in final form:

$$\mu_D = (\mu_D{}^1, \mu_D{}^2, \ldots, \mu_D{}^n) \quad (9)$$

If the membership functions μ_D of the more elements are observed, the possible combinations of the membership function can be identified, and the outcome can be determined for each of them. It is customary to use the "IF-THEN" rules. E.g. IF all the elements of the partial evaluation are "excellent", THEN the outcome of a set of elements is "excellent". In the case that assessment of combination of different elements is known, average assessment should be calculated and determination of outcome should be done based on it. Max-min composition is then applied as follows: for each combination, search for the MINimum value of the intersection of dependability membership function and the value of brunt of membership function for each element; for each of the outcomes find the MAXimum between previously identified minimums; finally, the maximum value is normalized to 1. This procedure of max-min composition is applicable in vertical aspect. It is characteristic that all elements in the group have the same influence on smooth functioning of technical system, namely that there is a serial link in the sense of reliability. This is exactly the case with majority of technical system.

The technical system with x subsystems and y components in each subsystem has been considered (Figure 1). The next task is how individual assessment of dependability, obtained for all components at single hierarchical level, synthesized into dependability assessment for the next, upper level in hierarchical structure. Z elements[*] and their membership functions μ_D (9) are considered. These membership function can form $C = n^z$ different combinations. For the set of elements[**] with dependability assessment for the k-th element (k = 1 to z) given in form (9), it is possible to write the following combinations of membership functions (c = 1 to C):

$$D_c = \left[\mu_{D_{k=1}}^{j=1,\ldots,n}, \mu_{D_{k=2}}^{j=1,\ldots,n}, \ldots, \mu_{D_{k=z-1}}^{j=1,\ldots,n}, \mu_{D_{k=z}}^{j=1,\ldots,n}\right]$$

for all c = 1 to C (10)

If only values $\mu_{D_k}^{j=1,\ldots,n} \neq 0$ is taken into account, the combinations that are named outcomes (o = 1 to O, where $O \subseteq C$) are obtained.

[*] These elements according to Figure 1 can be components or subsystems.
[**] According to Figure 1 “set of elements” can be subsystem or system.

Further, for each outcome its value is calculated (Ω_c). The outcome which would suit the combination c, it would be calculated following the equations:

$$\Omega_c = \left[\sum_{k=1}^{z} j_k \right]_c / z \qquad (11)$$

Each of these outcomes represents one possible synthesis dependability assessment. Finally, all of these assessments are treated with max-min composition, as follows:

i For each outcome search for the MINimum value of μD_k^j in vector D_c (10). The minimum which would correspond to the combination o, could be calculated following the equations:

$$MIN_o = \min\left\{\mu D_{k=1}^{j=1,\ldots,n}, \mu D_{k=2}^{j=1,\ldots,n}, \ldots, \mu D_{k=z-1}^{j=1,\ldots,n}, \mu D_{k=z}^{j=1,\ldots,n}\right\}$$
$$\text{for all } o = 1 \text{ to } O \qquad (12)$$

ii Outcomes are grouped according to their values Ω_c (11), namely the size of j.

iii Find the MAXimum between previously identified minimums (i) for each group (ii) of outcomes. The maximum which would suit value of j, it would be calculated following the equations:

$$MAX_j = \max\{MIN_o\}, \text{ for every } j \qquad (13)$$

Dependability assessment of set of elements is again obtained in the form (9):

$$\mu D = (MAX_{j=1}, \mathrm{MAX}_{j=2}, \ldots, \mathrm{MAX}_{j=n}) = (\mu D^1, \mu D^2, \ldots, \mu D^n) \qquad (14)$$

In this way, synthesis of dependability assessment for the set of elements can be represented as assessment of virtual representative element which would be identified as the best possible one among the expected worst elements of the set of elements.

3. Case study

Based on presented theory, bucket wheel excavator SchRs630 (BWE), which operates at open pit Kolubara Tamnava west field, Serbia, is analyzed. Excavator analyzed in this study, with regard to mechanical systems (excluding technological and electrical shut downs), was in 2007 available 7792 hours per year out of possible 8760 (available 89 %). This is above average in comparison to other 4 excavators working on the coal from the mine Kolubara (available 87 %.The analysis is performed on the basis of statistically processed expertise judgments (Tanasijević et al., 2009) obtained from ten employees working on the machine maintenance (Ivezic et al,. 2008). Ratings were given by the j =1 best and worst j =7.

The figure 1 presents the analysis of situations of single parts in the hieratical structure of the excavator (Tanasijević et al., 2010; Tanasijević et al 2012).

One of five main functional systems of BWE (Figure 1) - System for transport of materials is considered first. This functional system is consisted of five subsystems – Drive unit, Rotating elements, Main structure, Rubber belt, Lubrications system (Figure 1).

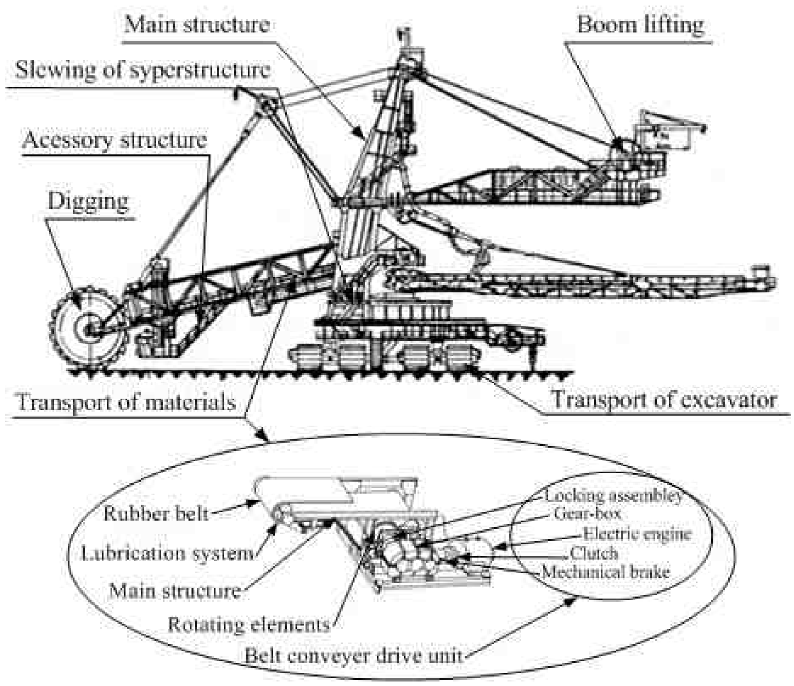


Figure 1: Hierarchical structure of observed excavator.

Table 1. Dependability scores through belt conveyer drive unit structure.

	$\mu_R =$	$\mu_M =$	$\mu_L =$	$\mu_D =$
Electric engine:	0, 0.2, 0.5, 1, 0.3, 0, 0	1, 0.3, 0, 0, 0, 0, 0	1,0.75,0,0,0,0,0	0.2, 0.2, 0, 0, 0, 0, 0
Clutch:	0.1,1,0.4,0,0,0,0	1,0.2,0.1,0,0,0,0	1,0.6,0.2,0,0,0,0	0.2,0.2,0.2,0,0,0,0
Mechanical brake:	0.2,1,0.3,0,0,0,0	0.1,1,0.4,0,0,0,0	1,0.75,0,0,0,0,0	1,0.75,0,0,0,0,0
Gear-box:	0.1,1,0.4,0,0,0,0	0.1,1,0.8,0,0,0,0	1,0.5,0.2,0,0,0,0	1,0.5,0.2,0,0,0,0
Locking assembly:	0.1,1,0.1,0,0,0,0	1,0.2,0.1,0,0,0,0	1,0.4,0.1,0,0,0,0	0.2,0.2,0.1,0,0,0,0

Drive unit is the subsystem consisting of the following components: electric engine, clutch, mechanical break, gear box and locking assembly (Figure 1). For each component of BWE, reliability, maintainability and maintenance support have been evaluated in the form of $j = 7$ (in accordance with recommendation (Wang et al., 1995)) to membership function (4) – (6).

For example, it will be further shown calculation account for gear-box.

The first step of max-min composition (1) is used, as follows:

$$\mu_{M \times L} = (\mu^{ij}_{M \times L})_{7 \times 7},$$

$$\mu^{ij}_{M \times L} = \min(\mu^j_M, \mu^j_L) = \begin{bmatrix} 0.1 & 0.1 & 0.1 & 0 & 0 & 0 & 0 \\ 1 & 0.5 & 0.2 & 0 & 0 & 0 & 0 \\ 0.8 & 0.5 & 0.2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\mu^j_D = \max(\min(\mu^1_R, \mu^{1j}_{M \times L}), \ldots, \min(\mu^7_R, \mu^{7j}_{M \times L})),\ j = 1, \ldots, 7.$$

$$\mu^1_D = \max(\min(0.1, 0.1), (1,1), (0.4, 0.8), (0,0), .., (0,0)) = 1$$

$$\mu^2_D = \max(\min(0.1, 0.1), (1, 0.5), (0.4, 0.5), (0,0), .., (0,0)) = 0.5$$

$$\mu^3_D = \max(\min(0.1, 0.1), (1, 0.2), (0.4, 0.2), (0,0), .., (0,0)) = 0.2$$

$$\mu^4_D = \max(\min(0,0), ..., (0,0)) = 0$$

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$$\mu^7_D = \max(\min(0,0), ..., (0,0)) = 0$$

Finally, dependability of gear-box is estimated as: $\mu_{D(GB)} = \mu_{R \circ M \times L} = (\mu^j_D)_{1 \times 7} = (1, 0.5, 0.2, 0, 0, 0, 0)$

With obtained dependability eveluations for these 5 components of drive unit subsystem; dependability of drive unit subsystem is calculeted by using of the second step of max-min composition.

For $j = 1$ to 7 and $k = 1$ to 5, it is possible to make $C = 7\ 5 = 7 \cdot 7 \cdot 7 \cdot 7 \cdot 7 = 16.807$ combinations of D_c (10). If in equations $\mu_{D(EE)}$ ... $\mu_{D(LA)}$ only sizes of membership function (μ_D) different form zero are taken into account, the number of combinations is reduced to the number of outcomes which is equal to $O = 2 \cdot 3 \cdot 2 \cdot 3 \cdot 3 = 108$.

For each outcome further are calculated Ω (11) and MIN (12). Due to limited space in this paper, only one calculation example will be presented.

Table 2. presents sizes μ_D for all 5 components on drive unit depending on j. As the example one of possible outcomes, $o_{2\text{-}2\text{-}1\text{-}3\text{-}2}$ is chosen.

Table 2. Memberships function μ_D for all $k = 5$ components, depending on $j = 1$ to 7

k \ j	1	2	3	4	5	6	7
1. (EE)	0.2	$\boxed{0.2}$	0	0	0	0	0
2. (Cl)	0.2	$\boxed{0.2}$	0.2	0	0	0	0
3. (MB)	$\boxed{1}$	0.75	0	0	0	0	0
4. (GB)	1	0.5	$\boxed{0.2}$	0	0	0	0
5. (LA)	0.2	$\boxed{0.2}$	0.1	0	0	0	0

For $j = 2, 2, 1, 3, 2$, we get:

$$\Omega_{2-2-1-3-2} = \frac{2+2+1+3+2}{5} = 2,$$ which can be rounded as integer 2.

Minimum between values of appropriate memberships function:

$$MIN_{2-2-1-3-2} = \min\{\mu_{D^{j=4}_{k=1}}, \mu_{D^{j=2}_{k=2}}, \mu_{D^{j=3}_{k=3}}, \mu_{D^{j=3}_{k=4}}, \mu_{D^{j=2}_{k=5}}\} = \min\{0.2, 0.2, 1, 0.2, 0.2\} = 0.2$$

This and all other outcomes can be grouped around sizes j = 1, 2 and 3. Further, for each set of grouped outcomes the maximum is sought (13). For example, for outcome 2 it can be written:

$$MAX_2 = \max\{MIN_{1-1-1-2-3}, MIN_{1-1-1-3-2}, ..., MIN_{2-2-1-3-2}, ..., MIN_{2-3-2-3-1}, MIN_{2-3-2-3-2}\} =$$
$$= \max\{0.1, 0.1, ..., 0.2, ..., 0.1, 0.1\} = 0.2$$

For other sizes of outcomes, it is obtained: $MAX_1 = 0.2, MAX_2 = 0.2, MAX_3 = 0.1$.

Finally, total dependability of drive unit is obtained in the form:

$$\mu_{D(DU)} = (0.2,0.2,0.1,0,0,0,0)$$

The same procedure is implemented to remaining 4 subsystems in the same functional system, 5 systems and whole excavator; and their dependability estimations are obtained in table 3.

Table 3. Dependability scores through BWE structure

Subsystem level		System level		Technical system level	
Drive unit:	0.2,0.2,0.1,0,0,0,0	System for transport of materials:	0,4,0.5,0.2,0,0,0,0	Bucket wheel excavator	0,0.4,0.4,0.4,0.1,0,0
Rotating elem.:	0.5,0.5,0.1,0,0,0,0				
Main structure:	0.5,0.5,0,1,0,0,0				
Rubber belt:	1,0.75,0.1,0,0,0,0				
Lubric.system:	0,0.4,1,0.4,0.2,0,0				
…………… ……………	…………… ……………	System for digging:	0,0,0.1,0.5,1,0.4,0		
…………… …………… ……………	…………… …………… ……………	System for transport of excavator:	0,0.3,0.4,0.4,0.2,0,0		
…………… ……………	…………… ……………	System for boom lifting:	0.1,0.6,1,0.2,0,0,0		
…………… …………… ……………	…………… …………… ……………	System for slewing of superstructure:	0,0.4,1,0.4,0.1,0,0		

In this way dependability of whole technical system has been obtained starting from particular estimations for all of its components.

To make the final score of dependability $\mu_{D(BWE)}$ was clear, the value of j = 1 …7 can be expressed through the value of J can be expressed through the following fuzzy sets (table 4):

Table 4. Dependability fuzzy sets defined by linguistic variable and membership function to the value j = 1…7

	1.	2.	3.	4.	5.	6.	7.
Poor	0	0	0	0	0	0.75	1.0
Average	0	0	0	0.5	1.0	0.25	0
Good	0	0.25	1.0	0.5	0	0	0
Excellent	1.0	0.75	0	0	0	0	0

Best-fit method (Wang et al., 1995) is used for transformation of dependability description (14) to form that which defines grade of membership to fuzzy sets: poor, average, good, excellent. This procedure is recognized as dependability identification. Best-fit method uses the distance d between dependability attained by "max-min" composition (14) and each of the dependability expressions to represent the degree to which D is confirmed to each of them (table. 43). Final expression for dependability performance after best-fit treatment, are in the clearer form:

D_i = {(β_{i4}, "excellent"), (β_{i3}, "good"), (β_{i2}, "average"), (β_{i1}, "poor")}, $\Sigma\beta_{ij}$ = 1

Where β is share in a belonging to appropriate linguistic variable / fuzzy set (table 3).

$$d_1(D,excellent) = \sqrt{\sum_{j=1}^{7}\left(\mu^j{}_D - \mu^j{}_{H_i}\right)^2} =$$
$$= \sqrt{(0-1)^2 + (0.4-0.75)^2 + (0.4-0)^2 + (0.4-0)^2 + (0.1-0)^2 + (0-0)^2 + (0-0)^2} = 1.20520$$

Likewise:

$d_2(D,good) = 0.63443$;

$d_3(D,average) = 1.09659$;

$d_4(D,poor) = 1.43265$

For $d_{i\,\min} = d_2$:

$$\alpha_1 = \frac{d_2}{d_1} = \frac{0.63443}{1.20520} = 0.52641,$$

$\alpha_2 = 1.00000$, $\alpha_3 = 0.57855$, $\alpha_4 = 0.44283$;

$$\beta_1 = \frac{\alpha_1}{\sum_{i=1}^{4}\alpha_i} = \frac{0.52641}{0.52641 + 1 + 0.57855 + 0.44283} = 0.20661,$$

$\beta_2 = 0.39250$, $\beta_3 = 0.22708$, $\beta_4 = 0.17381$;

D_{BWE} = {(0.21, "excellent"), (0.39, "good"), (0.23, "average"), (0.17, "poor")}

This procedure can be done for the scores at the lower hierarchical levels of the system. The following figures present the analysis of conditions of single parts in the structure of the excavator (figure 1). Belt conveyer drive unit components (figure 2-a) are observed first, which are a structural part of the system for transport of materials (figure 2-b), which is by itself one of the systems that compose bucket wheel excavator (figure 2-c). It can be concluded that weak points, namely the points on the excavator which are in the worst condition, are the following: Electric engine, Lubrication system and System for digging, respectively - depending on the hierarchical level from which the excavator is observed.

Article (Tanasijević et al, Eksploatacja i Niezawodnosc, 2013) describes this procedure for the case when it is necessery to defuzzificate time depending function of reliability and maintainability into memebersheep function form.

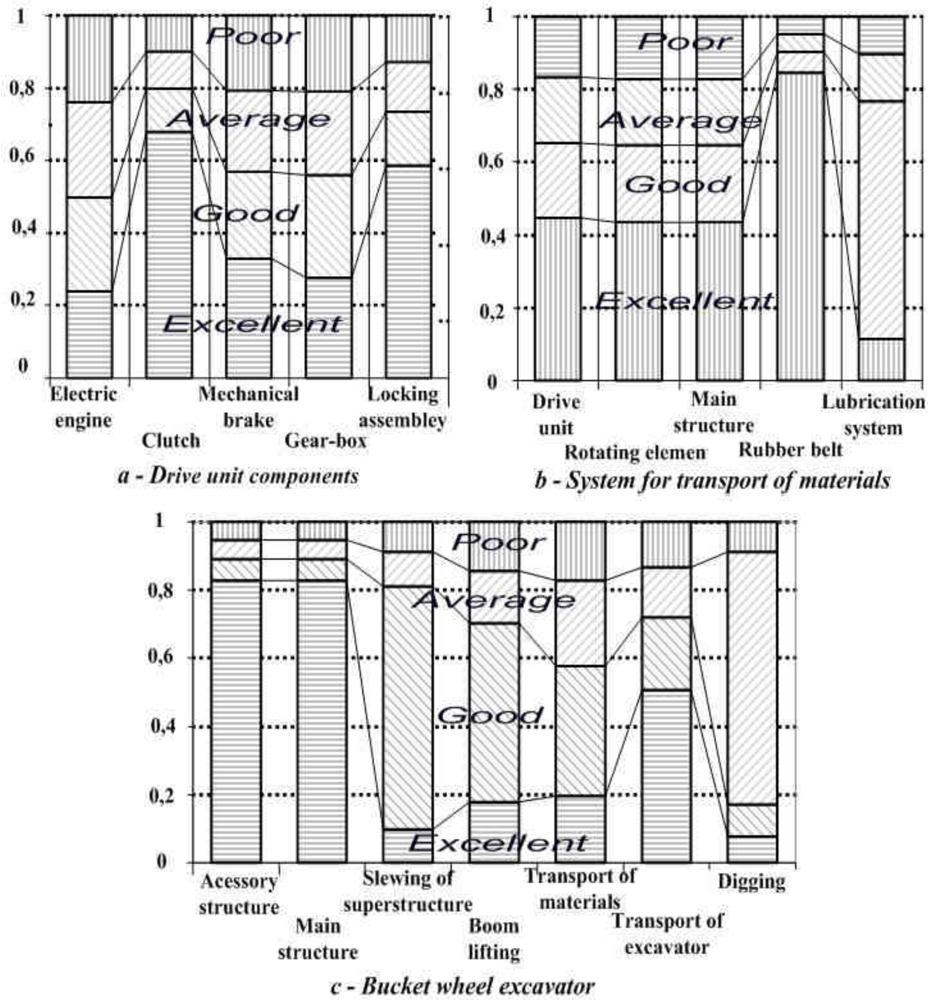

Figure 2. Condition estimation of several elements of excavator structure.

Conclusion

The importance of this research is reflected in the overall perception of complex mechanical systems in the sense of dependability. Fuzzy logic is used in that process, concretely max-min logic for simulation of the interaction of the elements of mechanical system and mutual interaction of dependability indicators. Quality assessment of dependability can contribute significantly to the management of coal production and electric generation in general. This is significant contribution for electricity security of supply. The papers presents the example of bucket wheel excavator, as one of the most complex systems in the industry.

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A Study on the Application of Energy Storage Devices for Electricity Expense Reduction

Dr. Ruay-Nan WU [1*]
Professor of Department of Electrical Engineering, NTUST, Taiwan
Dr. Chien-Kuo CHANG [1]
Ph. D. of Department of Electrical Engineering, NTUST, Taiwan
Dr. Chien-Te FAN [2]
Professor of law, Institute of Law for Science & Technology, NTHU, Taiwan
Sheng-Hung LEE [1]
Ph. D. student of Department of Electrical Engineering, NTUST, Taiwan

*Contact details of corresponding author
Tel: + 886+2+27376675
Fax: +886+2+27376699
e-mail: rnwu@mail.ntust.edu.tw
Address: #No.43, Sec. 4, Keelung Rd., Da'an Dist., Taipei 106, Taiwan (R.O.C.)

Abstract

The electric utility could provide two-direction way of energy services, such as time of use (TOU), demand response (DR) and Feed-in Tariff (FIT), by the technical plant consisting of advanced metering infrastructure (AMI), smart appliances and renewable energy generation. In this scenario users might not only buy electricity but also sell it. This paper proposes a home energy management system (HEMS) depending on the above scenario. HEMS schedules the operational states of smart appliances and the charge state of the energy storage device on the following day. The schedule is calculated by an optimal algorithm function according to time of use, predicted demand profile and predicted generation of renewable energy. The schedule of smart appliances and energy storage devices could reduce the peak load and the total electric fee compared to the non-controllable ones. However, the real condition of electric usage and renewable generation must be different from the prediction condition. Hence, the energy management will immediately control the optimal operation of energy storage devices. The energy management system on the demand side could enhance the effect of TOU and DR by the utility company. The energy management system could also improve the stability of the renewable energy system with a variety of generation. The system operation in the residential condition was simulated and analysed in this paper. However, the investment efficiency of the HEMS depends on the operation and maintenance cost of energy storage devices. The suitable specification of energy storage needs to be determined in the further studies.

Introduction

The general situation of reserve margin in the next ten years in various probable cases based on the power supply development plan (September 2011) of Taiwan Power Corp., such as commercialization of Nuclear Power Plant IV, non-commercialization of Nuclear Power Plant IV and non-extension of service life of Nuclear Power Plant I, II and III. It is preliminarily known that even if Plant IV is commercialized as scheduled, the reserve margin ratio will be lower than the legal value 16% after 2013. The situation will be worse if Plant IV is not commercialized, the minimum reserve margin will be 3.0% in 2015, thus, it can be seen that the prospect of Taiwan's power supply development is undetermined.

This paper proposes using energy storage system to optimize the application of electric energy by peak reduction and valley filling, so as to reduce the demand for peak power generation effectively without influencing the existing loading condition, as well as to reduce the reserve margin and increase the reserve margin ratio. This study uses a power storage plants as accumulation systems for simulation. After peak reduction and valley filling, the reserve margin can be improved from 3.0 % to 9.9% in 2015 in case of non-commercialization of Nuclear Power Plant IV. However, large-scale energy storage systems are difficult to be built. When the energy storage system is closer to the load, the efficiency is better. Therefore, distributed energy storage systems will be convenient at early stage. The load factor is the index evaluating the peak reduction and valley filling effect. The electricity consumers will be encouraged to invest in energy storage equipment by specifying the load factor, so as to improve the power utilization quality. This proposal is expected to solve the bottleneck in the power supply development of the domestic power system.

A peak shaving and valley filling method was proposed to change the user's load characteristics, and the SQP is used as solution algorithm. Through the way of software simulation and analysis, the optimized scheduling program of the energy storage system was build. Besides, it can also reduce the demand for peak power generation effectively without influencing the condition of existing load.

This paper develops an algorithm combine load schedule with operating schedule of battery energy storage device, to build a computer program of home energy management. Load schedule use the traditional load schedule method, operating schedule of battery energy storage device use reduced gradient method. The optimal schedule for load and optimal operating schedule for battery energy storage device was reached by using the proposed algorithm. A TOU(time-of-use) rate user was used as an example to test this program. Test results demonstrate combine traditional load schedule method with sequential quadratic programming (SQP) method can obtain optimal schedule for load and battery output at each time interval under satisfy all constrain functions, reach the minimum electricity charge of TOU rate user. The computer program developed in this study can be used as a useful tool for TOU rate user when they intend to install a battery energy storage device in their system.

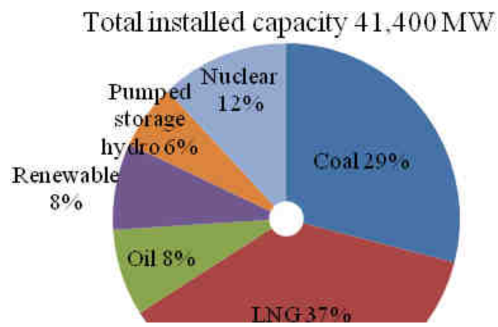
Power system situation in Taiwan

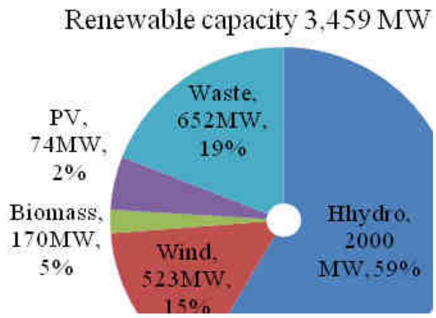
The total installed capacity of power utility was 41,400 MW in Taiwan in 2011. The ratios of different kind energy were as follows, natural gas (LNG) 37%, oil 8%, nuclear 12%, pumped storage hydro 6% and renewable energy 8%. The total installed capacity of renewable energy was 3,459 MW, including conventional hydro 2,000 MW, wind 523 MW, PV 74 MW, biomass power 170 MW and waste power 652 MW.

The government of Taiwan claimed the policy of energy to response the issues of low carbon and the Fukushima nuclear disaster in Japan. These policies are "Nuclear insurance, decreasing nuclear stably, make green energy and low carbon environment, tend to nuclear-free homeland".

(1) Promoting the renewable energy: The installed capacity will be 9,952 MW (14.8% in total capacity) in 2025; then it will be 9,952 MW (16.1% in total capacity) in 2030.

(2) Project 1 "Thousand Wind Turbines": The installed wind power capacity will be 4,200 MW. The process is inland wind farm first and off-shore later.





(a) Installed capacity (b) Renewable capacity

Fig. 1 Electricity supply and demand in Taiwan in 2011.

(3) Project 2 "Million rooftop PVs": The installed PV capacity will be 3,100 MW. The process is rooftop first and ground later.

The reserve margin is to avoid that actual peak load exceeds a predicted peak load which cause to power rationing.

According to Taipower company's power generation development plan (2011). If the 4th Nuclear Power Plant (Longmen) will not operate in 2014,the net peak capacity will be reduced by 1,350MW and 2,700MW in 2013 and 2015. The reserve margin rate will down to 3% in 2015.

Peak shaving can improve the insufficient reserve margin in summer without changing the mode of electric use. Utility do not need to invest more generation facilities to serve short-term peak loads.

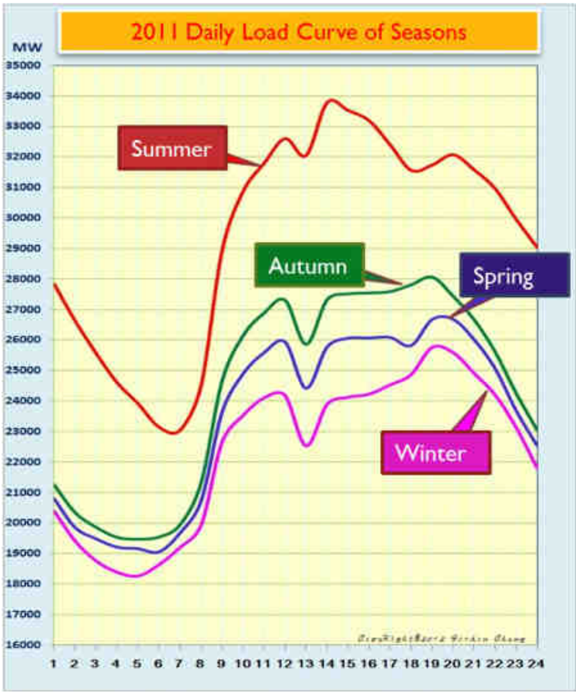


Fig. 2 Daily load curve in peak day of four seasons in 2011.

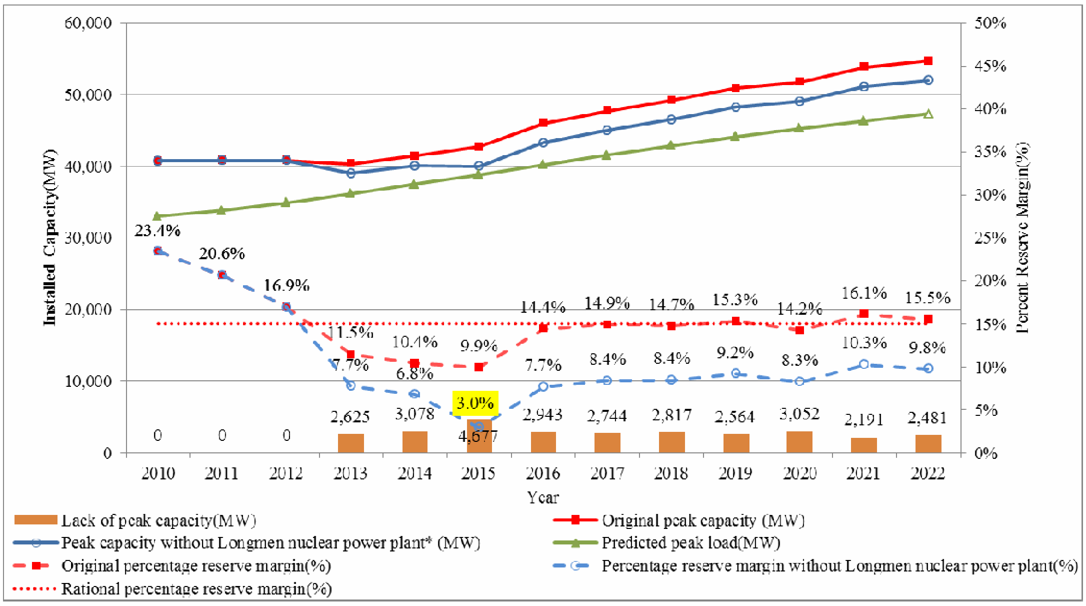


Fig. 3 The power generation development plan in with and without the 4th Nuclear Power Plant (Longmen).

The load factor (LF) is the ratio of average load and peak load in the specified time period. It is suitable for assessing the level of peak shaving.

$$\text{Yearly load factor} = \frac{\text{Yearly total energy}}{\text{Peak load} \times 8760 \text{ hours}}$$

$$\text{Daily load factor} = \frac{\text{Daily total energy}}{\text{Peak load} \times 24 \text{ hours}}$$

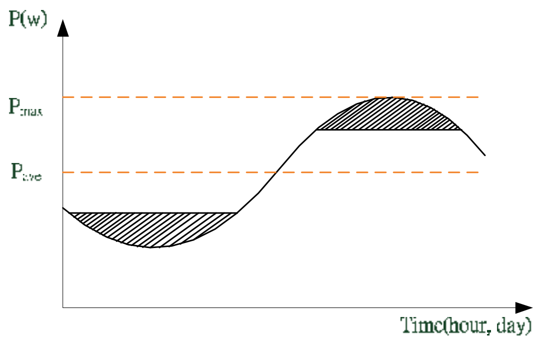


Fig. 4 Peak shaving.

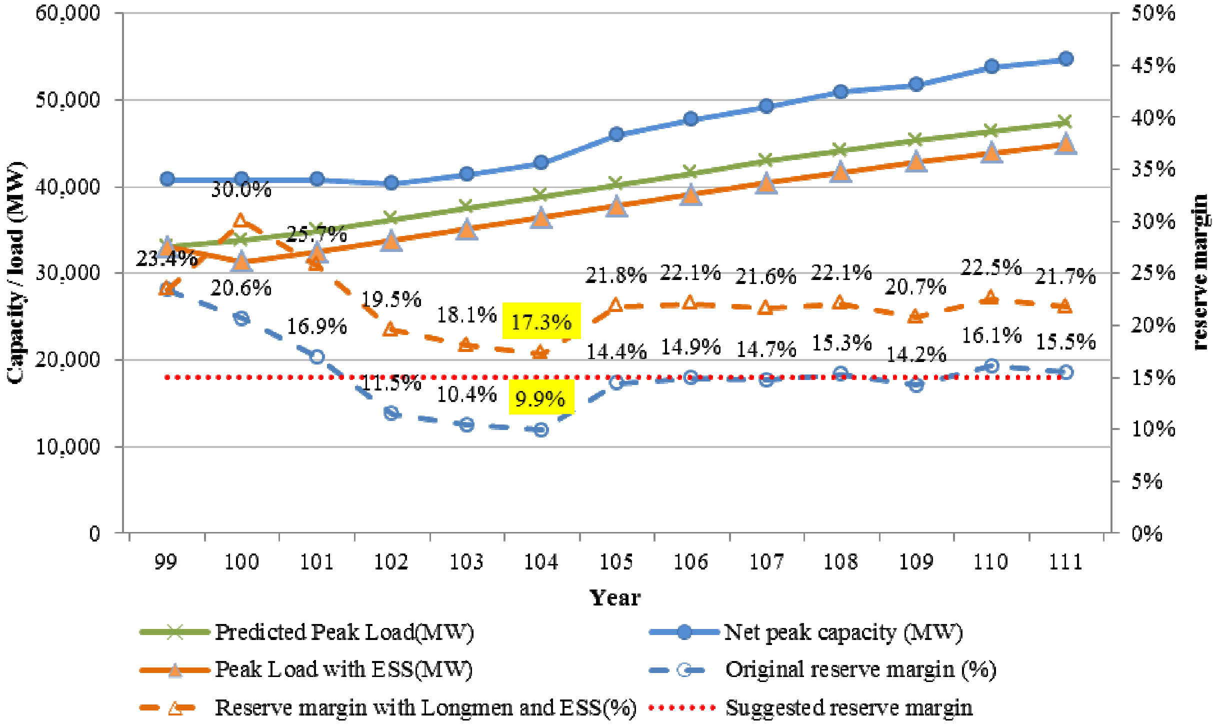


Fig. 5 The power generation development plan without the 4th Nuclear Power Plant (Longmen) by energy management process.

The energy storage technology is able to decrease peak load to maintain the adequate reserve margin rate and reduce the possibility of blackout risk. It also reduces investment of generation equipment and improves the power company operation.

A distributed energy storage devices in demand side is suggested. The strategy is to make a rational load factor with an incentive which makes users able to compensate the costs of devices in a specific period.

Home energy management system for Load Factor improvement

The concept of home energy management system(HEMS) consists of renewable energy generator such as PV, a energy storage system (ESS) as well as load information collected by smart meters/outlets. The energy management program in computer can make optimal discharge schedule for energy storage system to attain the purpose of peak shaving.

The object function of energy dispatch is total cost (TC). The flow chart of optimal energy management process was shown as fig.7.

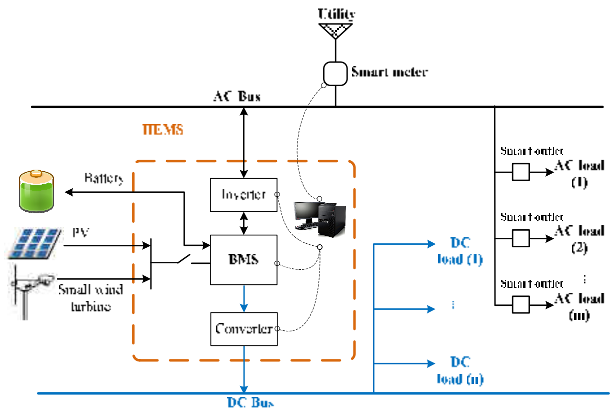


Fig.6 architecture of home energy management system (HEMS).

It calculate the movable load schedule (block 4) and discharge power schedule of Energy storage system(ESS) (block 5) on every time interval to minimize total cost under operating constraints.

$$\mathit{Minimize}\ \ TC = C_{demand} + C_{penalty} + \sum_{t=1}^{T} C(t) \times P_{grid}(t)$$

$$P_{grid}(t) = P_D(t) - P_{PV}(t) - P_{bat}(t)$$

$$C(t) = \begin{cases} C_s(t), & P_{grid}(t) < 0 \\ C_b(t), & P_{grid}(t) > 0 \end{cases}$$

where:

TC：total cost

C_{demand}：base electric fee

$C_{penalty}$：penalty with over capacity of contract

$P_{contract}$：capacity of contract

T：total number of time interval in a day

C(t)：electric price in t time interval

$P_{grid}(t)$：power from grid in t time interval (positive is buying, negative is selling)

$P_D(t)$：power of load in t time interval

$P_{PV}(t)$：power output from PV in t time interval

$P_{bat}(t)$：power from energy storage system in t time interval (positive is discharging, negative is charging)

$C_s(t)$：selling electric price in t time interval

$C_b(t)$：buying electric price in t time interval

Operation al constraints:

Power Balance：

$$P_{PV}(t) + P_{Wind}(t) + P_{grid}(t) + P_{bat}(t) = P_D(t)$$

Limit of generation in PV： $P_{PV}(t) \le P_{PV}^{\max}$

Discharging rate of battery

$$\left|P_{bat}(t)\right| \le P_{bat}^{\max}$$

Limit of SOC

$$SOC(t) = SOC(t-1) - P_{bat}(t) \times \Delta t$$

$$SOC_{\min} \le SOC(t) \le SOC_{\max}$$

Initial and final state of SOC in battery

$$SOC(0) = SOC_{initial}$$

$$SOC(T) = SOC_{final}$$

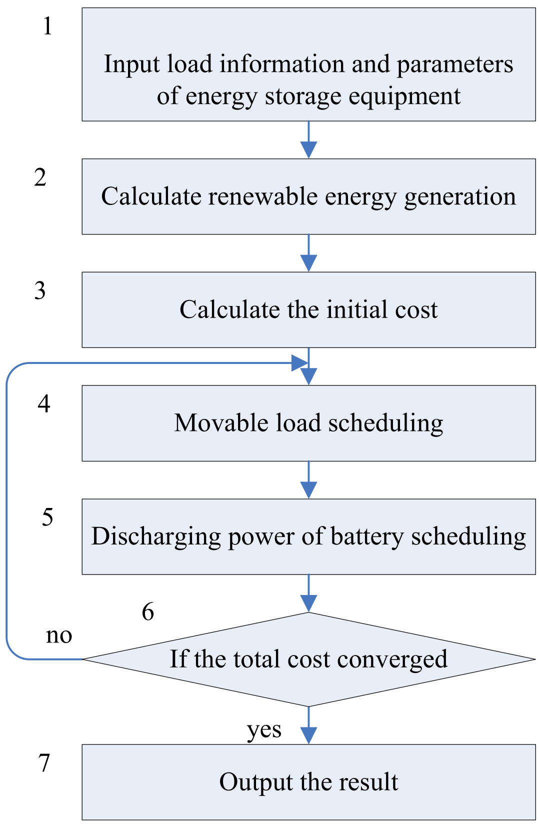


Fig. 7 The flow chart of optimal energy management process.

According to the price of buying and selling electricity, such as Fig. 8, the net expense will be lowest by optimal energy management analysis. A day is separated into 48 time intervals. Fig.9 (a) is the initial energy schedule. Fig.9 (b) shows the use time of movable load changed to off-peak time. The energy was charged in battery during off-peak time(lower price) and discharged during peak time(higher price). Fig. 10 is the state of charge of battery. Fig. 11 is the power from grid and discharge power of battery.

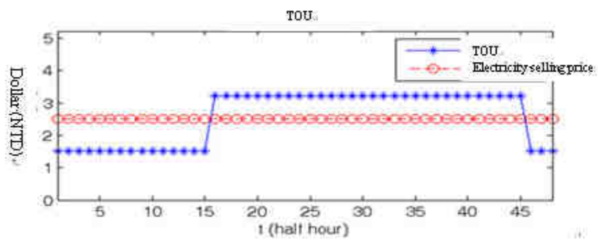
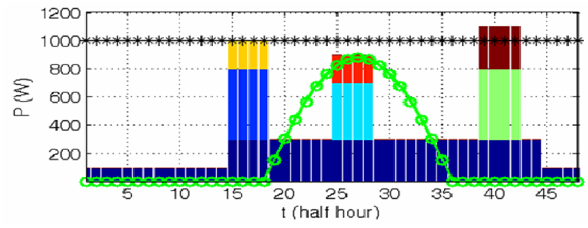
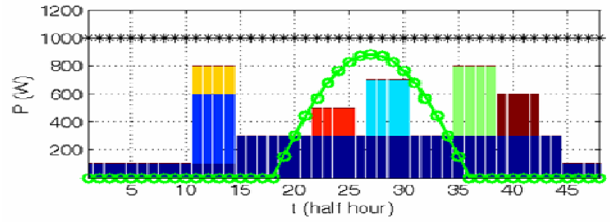


Fig. 8 electricity buying price (TOU) and electricity selling price.



(a) Initial load schedule



(b) Load schedule at minimum total cost

Fig. 9 the energy schedule before and after the management process.

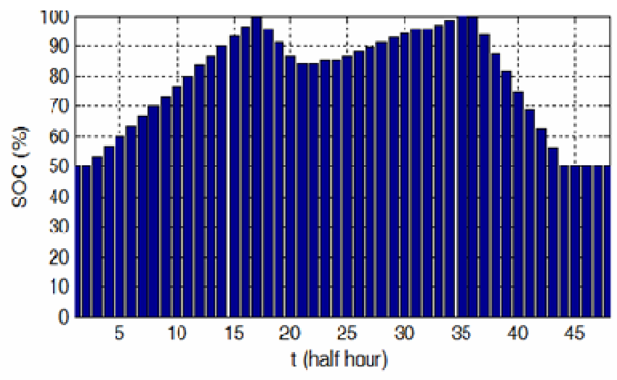


Fig. 10 SOC of energy storage system

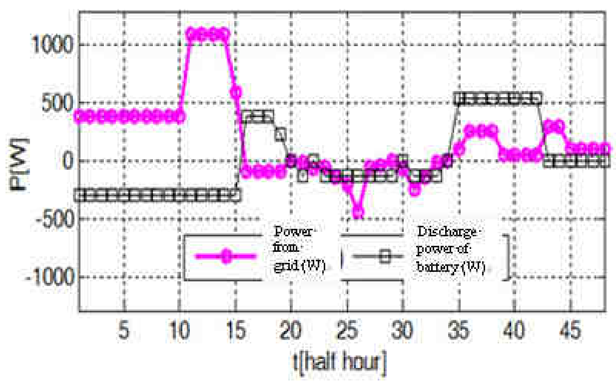


Fig. 11 power from grid and discharge power of battery.

Conclusion

The system operation in the residential condition was simulated and analyzed by using energy storage system to optimize the application of electric energy by peak reduction and valley filling. The load factor is the index evaluating the peak reduction and valley filling effect.

According to time of use rate, immovable load, and renewable energy generation, an energy management system (EMS) with energy storage devices, is able to solve optimal load schedule and discharge schedule of Energy storage system(ESS) on every time intervals via its optimal solution. It makes users' total electricity cost minimized, and reduce the peak load.

If there are plenty of distributed storage devices equipped, it will be able to reduce power company's investment cost of reserve margin. Energy storage system can also improve the intermittence of renewable energy and attain local balance between supply and demand.

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Formulating Energy Efficiency Revolving Fund Scheme in Indonesia: a Policy Analysis

Dhani SETYAWAN[a]*

[a] *Centre for Climate Change Financing and Multilateral Policy*
Fiscal Policy Office-Ministry of Finance of Indonesia

E-mail: dhanisetyawan83@gmail.com

Abstract

In the last 10 years, Indonesian government has allocated in average 80% of the total subsidy for the energy subsidy. These phenomena show that the current subsidy policy has put huge pressure on the development budget, thus significant change has to be made. The era of cheap energy has to be changed and government has to take significant efforts to adjust to this new condition. Energy subsidy becomes a heavy burden for the Indonesian state budget. Due to its role as the fiscal authority, Ministry of Finance of Republic of Indonesia (MoF) has to work hard to reduce the pressure on the state budget from the subsidy expenditures by encouraging the energy efficiency. In this context, MoF has provided various kind of incentives in order to influence the economic actors/investors to implement energy saving measures. Unfortunately, as of now, these incentives have not been able to influence the energy efficiency investments. The investors still require further support in form of low-interest financing. By conducting a suitable financing policy, this study will also analyze the drawbacks of the implementation. This research applies a cost and benefit analysis (CBA) to analyze the correlation among economical determinants, social and environmental implications in order to get general point of view.

Keywords: Revolving Fund, Energy Efficiency, Energy Conservation

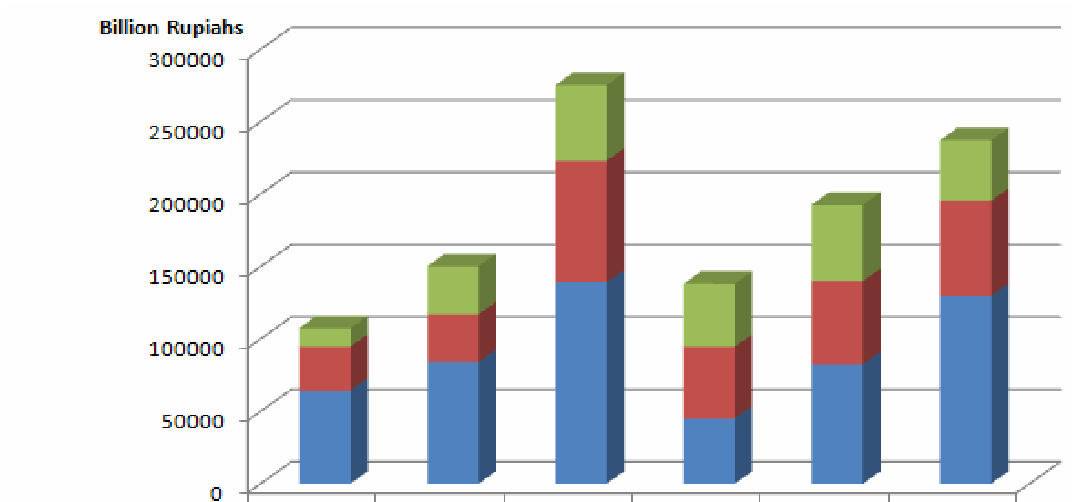
1. BACKGROUND

Energy has always been one of the crucial issues faced by each country (Asiif and Muneer, 2007)[1]. Appropriate policies in the energy sector will bring a positive impact to the economic stability, vice versa; improper policies will bring a country in to a trap of high economic cost as a result of inefficiencies in the economy. The Indonesian population is increasing every year, in line with the economic growth and the variety of economic activities which also followed by the need for significant energy resource. Based on data from the World Bank, Indonesia's economic growth is increased from 5.7% in 2005 to 5.9% in 2010, and projected to reach 6.6% by the end of 2012 (World Bank, 2012)[2]. Denoting to that growth, Indonesia is strongly interest to manage and utilize the energy as effectively and efficiently as possible (Hartono and Resosudarmo, 2008)[3].

In the last ten years, the average number of total subsidies for energy has absorbed about 80% of the total budget allocation for subsidy. At APBN-P 2012 (Figure 1), the total budget allocation for fuel subsidy is about IDR 137 trillion, while for the electricity subsidies is around IDR 65 trillion. There are only 20% (IDR 43 trillion) of the total budget allocation for subsidies allocated for the non-energy sectors (such as food subsidies, fertilizer subsidies, seed subsidies, PSO, credit subsidy programs and tax subsidies). These phenomenon showed that the current energy subsidy policy has been squeezing the other sector development budget allocation. The huge allocation of the energy subsidy shows that the era of cheap energy is already over, therefore the government needs to adjust the budget allocation to the current condition (Dartanto, 2013)[4].

Based on figure 2., it depicted that in the last two decades, the growth of energy demand has increased very rapidly almost 3-fold from the 90's (248 million BOE) up to 740 million BOE[37] (in 2010). There are four major sectors of energy user, namely: the household sector, commercial sector, industrial sector and transportation sector. In 2010, the largest user of energy is the industrial sector with the total energy demand reaching up to 327 million BOE (44.2% of the energy needs share). The next largest consumer is the transport sector reaching up to 301 million BOE (40.6% of the energy needs share), followed by the household sector amounted to 11.4% and the commercial sector by 3.7%.

[37] Barrels Oil Equivalent (BOE)



	2006	2007	2008	2009	2010	2011
Non Energy Subsidy	12826,4	33348,6	52278,2	43496,3	52754,1	41906
Electricity Subsidy	30393,3	33073,5	83906,5	49546,5	57601,6	65565,1
Fuel Subsidy	64212,1	83792,3	139106,7	45039,4	82351,3	129723,6

■ Fuel Subsidy ■ Electricity Subsidy ■ Non Energy Subsidy

Figure 1. Trend of Subsidy Allocation Budget (Sources: Financial Note and State Budget, 2013)[5].

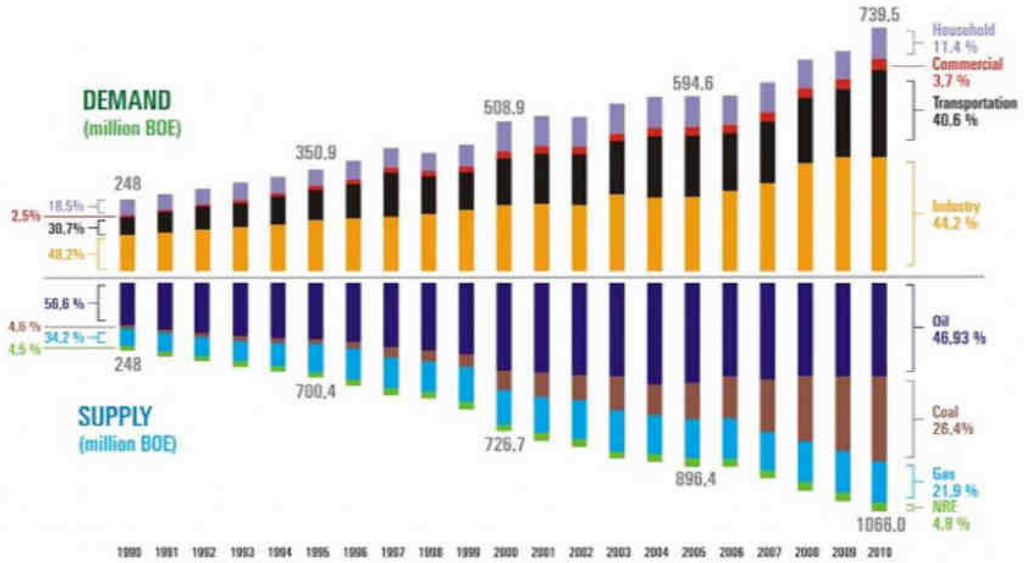


Figure 2. Consumption and Energy Supply (Source: Ministry of Energy and Mineral Resources, 2011)[6].

Until now, the main source of energy is coming from fossil fuels, namely kerosene by 46.93%, coal at 26.4% and natural gas by 21.9%; while hydropower and other renewable energy is only 4.8% of the total renewable energy resources.

The increasing energy subsidies yearly is a logical consequences of the rising incomes and purchasing power as well as the increased economic activity. The huge energy subsidy has hindered the efforts to encourage the development of different types of energy alternative as well as renewable energy (Keyuraphan et.al, 2012)[7], since the large energy subsidies have distorted the market and also give major obstacle for inducing clean energy investments.

The huge subsidies for energy have given onerous burden to the state budget (Dartanto, 2013). As the fiscal authorities, the Ministry of Finance must struggle to make the state budget healthier over the raising energy subsidies by encouraging energy efficiency initiatives. In this context, the Ministry of Finance has provided various forms of incentives to influence economic actors in order to implement sustainable energy savings programs, namely providing tax incentives and different facilities on components/spare parts and raw materials for energy-efficient appliances.

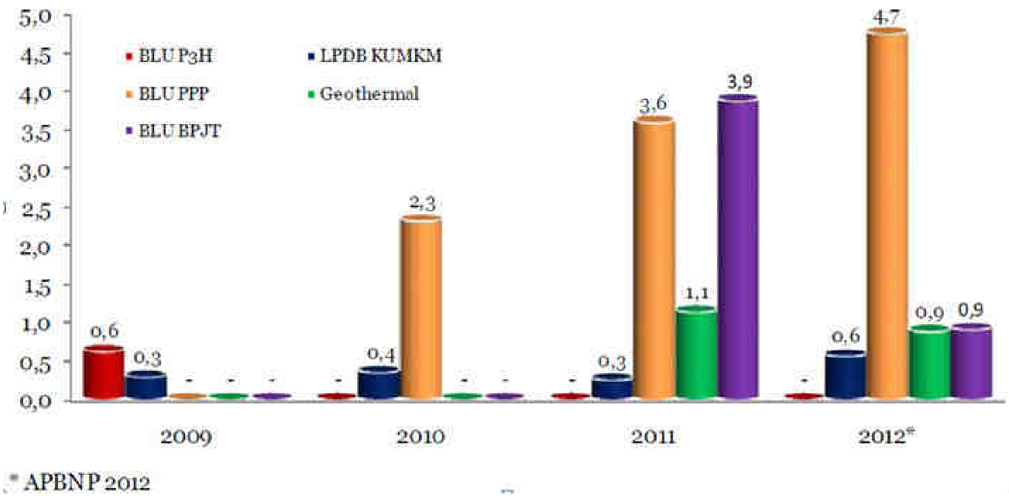


Figure 3. Trend of Total Amount for BLU Financing (Sources: Financial Note and State Budget, 2013).

However, until now, those incentives could not able influencing the development of energy efficient investments. From some FGDs that has been done, some of the market player convey their reluctance for utilizing those incentives such as: difficulties to fullfill the requirements for receiving incentives, lacked of informations, the incentives are not fit with the market needs, etc. The market still needs other forms of support such as low-interest financing (Sarkar and Singh, 2010)[8]. This support is in line with the mandate of Law Number 30 of 2007 on Energy, which is then further regulated by Government Regulation No. 70 of 2009 on Energy Conservation Article 20 that stated the Government can provide incentives in form of low interest rates for conservation in the energy investment. One of the advantaces by proposing this new kind of policy incentives, i.e. the government can stimulate the involvement of the financial sector (banking institutions) in order to support the government's energy efficiency programs. By inviting the banking sectors, the government could disseminate and socialize the policy incentives to the market easily and effectively. As a response to the mandate of the Government Regulation, this study attempts to formulate a new incentive mechanism to support energy efficiency programs. This financing scheme is so called energy efficiency revolving fund.

The commitment of Indonesian government for the provision of revolving funds is indicated by the raising of its allocation yearly. During the period 2009 to 2011, the budget allocation for the revolving fund is not the same in each fiscal year; it is highly depending on the government policy. In the 2013 state budget, the government allocated the revolving fund budget around IDR 2.1 trillion or 14.7% of the total government investment funds.

There are slightly different characteristics in terms of financing the energy efficiency projects compared to other investment financing projects, i.e.:

1. The main objective of energy efficiency investment projects is neither to increase the quantity of sales or to raise the market share, but the goal is to reduce the cost;
2. In general, the equipments for energy efficiency investment projects are usually installed a brand-new technology which has detailed specification. These new equipment usually do not have a reference price comparison with other ordinary equipment;
3. In addition, the reference price for resaling the outdated equipment is very difficult to be obtained.

Those conditions ensue the banks/financial institutions to have a strong reluctance in terms of lending their money, since they have difficulties in conducting financial feasibility analysis. For financial analysis, the bank generally requires a reference resale price as the basis for anticipating the default risk.

	Type	State Budget 2012	State Budget 2013
1.	Revolving Fund for Micro, Small, Medium Enterprise	557.7	1000.0
2.	Revolving Fund for Toll road	900.0	-
3.	Revolving Fund for housing	4709.3	-
4.	Geothermal revolving fund	876.5	1126.5
	Total	**7043.5**	**2126.5**

Figure 4. Revolving Fund, 2012 – 2013 (Billion Rupiahs) (Sources: Financial Note and State Budget, 2013).

The lack of human resource capacity expertise in the banking sector to conduct financial analysis is one of the major causes of the insufficiency for developing energy efficiency projects. However, the low interest rate incentives could not answer all of the challenges ahead, but for some extends it could raise the awareness of the market players in order to support the government initiatives in solving the energy issues.

To answer those challenges, the Government needs to make a breakthrough in order to catalyze the market as well as to enhance the energy efficiency projects awareness. Within this framework, this study sought to establish a form of revolving fund scheme mechanism by analyzing the drawbacks of its implementation.

The main purposes of this study are:

1. to examine the possibility of conducting a revolving fund scheme financing to support energy efficiency programs in Indonesia;
2. to examine the possible sources of funding;
3. to formulate criteria projects that is suit to the financing scheme;
4. to assess the institutional arrangements amongst related stakeholders.

2. METHODOLOGY

This study attempts to review different literatures as well as assessing recent regulations that is relevant to support the implementation of the revolving fund scheme in Indonesia. It also explores the current variety of revolving fund schemes in Indonesia. Furthermore this study tries to measure the cost and benefit of implementing this policy[38]. Most of the research involve field survey and in-depth interview and discussions with key government agencies and related private stakeholders such as Ministry of Finance, Ministry of Development and Planning (Bappenas), Ministry of Energy, Ministry of Environment, Bank Indonesia, Commercial Banks and private sector businesses.

3. REVIEW LITERATURE

3.1. Concepts, Characteristics and Mechanism of Revolving Fund

By definition, revolving fund means a funding that lend and rolled out to the public in the management of the Budget User (Pengguna Anggaran/PA) or Authorized Budget (Kuasa Pengguna Anggaran/KPA). The main goal of this funding is to assist and strengthen the venture capital for the development of koperasi, micro-, small- and medium-businesses in order to reduce poverty, unemployment and to enhance national economic development. There are some interesting financing scheme that has been developed and implemented in Indonesia i.e. Kredit Usaha Tani (KUT), Kredit Pengusaha Kecil dan Mikro, Kredit Modal Kerja Usaha Kecil-Menengah, Kredit Penerapan Teknologi Tepat Guna, Kredit Penerapan Teknologi Produk Unggulan Daerah, etc. However, those kind of financing scheme could not address the energy financing issues.

According to Minister of Finance (MoF) Regulation number 99/PMK.05/2008 which was amended further by the MoF Regulation No. 218/PMK.05/2009[9] regarding Revolving Fund Management Guidelines for the Ministry / Agency, there are some specific characteristics of revolving fund, as follows:

a. a Revolving Fund is a part of the State Finance / Local Government finance.
b. Under the Law No. 17/2003 regarding State Finance, a revolving fund that has been given by the external party to the central government / local government is recognized as part of the state wealth / local government wealth.
c. Sources of funding for the Revolving Fund are possibly coming from: state budget (APBN) / local government budget (APBD) as well as public funds or grants.
d. The revolving fund is reported in the APBN/APBD and / or in the financial statements.
e. The revolving fund is under controlled and owned by the PA or KPA.
f. PA/KPA has the authority to foster, to monitor and to supervise all of the activities in order to enhance the utilization of the revolving fund.
g. Revolving means the funding is channeled to the public/community group and charged back from the public with or without a further added value, hence to be distributed back to the community / society groups and so on.
h. The government may withdraw the revolving fund.

3.2. Lesson Learnt Thailand

Thailand's Energy Efficiency Revolving Fund (TEERF) is under the management of Department of Alternative Energy Development and Efficiency (DEDE) of Thailand's Ministry of Energy. This funding mechanism is founded in 2003 with the initial allocation around THB 2 billion (APEC,2005)[10]. This funding get revenue from the excess of levies on fuel at 0.04 THB (USD 0.001) per liter.

[38] The Cost and Benefit Analysis is attached in the Appendixes.

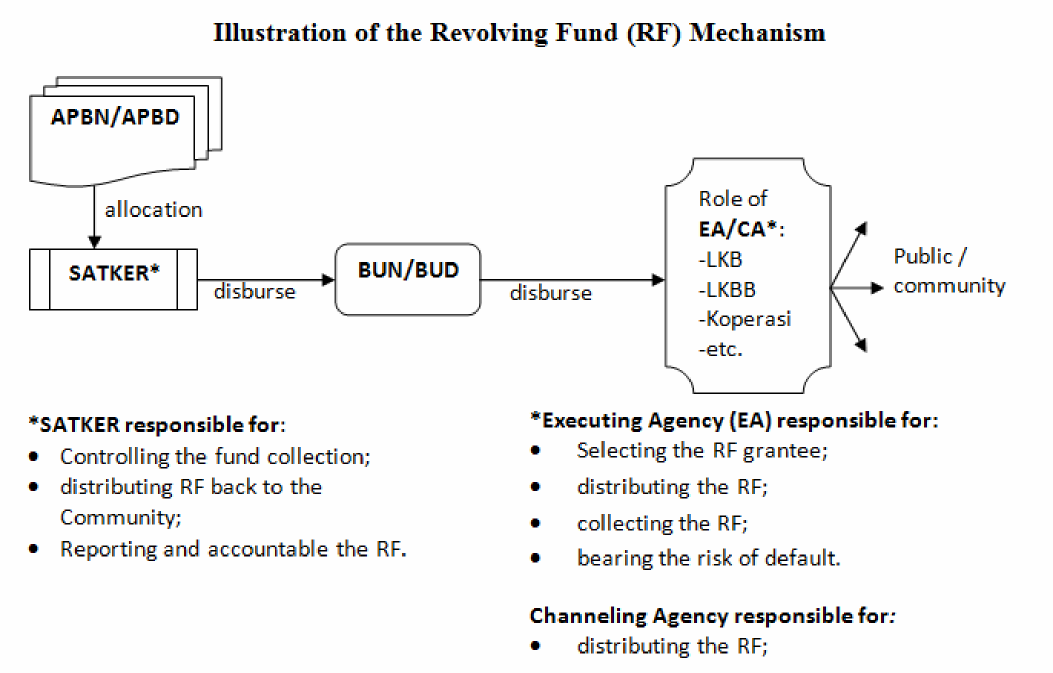


Figure 5. Revolving Fund Illustration in Indonesia.

From the total revenue over the levies, this funding revolve to be the source of funds for supporting the energy efficiency programs and renewable energy and became the forerunner of the establishment of a revolving fund energy efficiency programs. In this program, the maximum loan amount is restricted up to THB 50 million (USD 1.25 million) per project (Grunig et. al, 2012)[11].

In order to distribute the funds, the Government of Thailand is involving 11 commercial banks. This funding scheme is provided by the government (DEDE) to the commercial banks through 5 phases. For the phase 1 (period 2003-2006), as a part of the government energy efficiency programs, the government gave a free interest rate financing. Then, the next phases (period 2006-2013), the government charging interest rate to banks with 0.5%. The bank then lends it to the projects with interest not more than 4% per year in order to fund energy efficiency projects and renewable energy projects (at that time the Thailand market interest rates is ranging from 6-7%). These financing schemes can generate additional revenues in average up to USD 50 million per year. As of June 2011, the Energy Conservation Fund has raised more than USD 500 million (Twarath, 2012)[12]. Currently, the total amount of electric savings and fuel savings reached to 5,423 million Baht.

Generally, banks provide revolving fund credits below the maximum limit of 2.7% per year with cost of funds conditions around 2-3 % per year and the reference rate for bank loan 5.75%. By giving this low rate, the businesses is very interested to use it (Painully et. al. 2003)[13], though the collateral-based lending mechanism is still the first priority for the banks in terms of providing the credit lines. The loans can be utilized to financed projects such as (Vorasayan, 2012)[14]:

a. Purchasing and installing the energy efficient equipment projects;
b. engineering design and supervision costs as well as cost savings guarantee (guarantee fee savings) for the Energy Services Company (ESCo);
c. installation cost and operational cost of energy efficient appliances;
d. Transportation costs, demolition costs, customs duties and related value added tax (VAT).

However, the loans are prohibited for:

a. purchasing land field and land preparation, as well as costs associated with land acquisition;
b. providing construction costs that are not directly related to the energy efficiency equipment installation;
c. Other costs which are irrelevant according to DEDE regulation.

4. ANALYSIS

4.1. Sources of Funding

In the pre-phase of the program, the government needs to provide initial revolving fund budget in order to carry out the project activities. It is needed to funding the loan as well as to finance the operations of management activities. The sources funding could be provided from the state budget.

The basis of this allocation could be made under the reference of the mandate Law Number 30 of 2007 regarding Energy, which stated that the efforts for national energy conservation is under responsibility of the Government, Local Government, busineses, and public[15]. According to Government Regulation No. 70 of 2009, it states that the government and/or local government can provide facilities and incentives to energy users and producers of energy-efficient appliances that implement energy conservation program[16]. On Article 20 of that regulation, it noted that one of the forms of government incentives is the low interest rate funding facility for energy conservation investments.

4.2. Beneficiaries criteria

The energy efficiency financing facility is granted to energy conservation projects of small and medium-scale that meet the technical criteria. Incentives can be provided through different regulatory options. If referring to Government Regulation No. 70 of 2009, there are at least 2 groups that could be given incentives in terms of achievement for successful conservation, namely:

1. The users of energy greater than or equal to 6,000 tons of oil equivalent per year which successfully implementing energy conservation for a given period. The success of the project can be measured by: (1) measuring the amount of reduction of specific energy consumption and (2) the elasticity of energy consumption;
2. The manufacturers of energy-saving equipment that are managed to conserve energy in a certain period. The measurement included: (1) Projects should be able to produce energy-saving equipment higher from the predetermined benchmark and (2) projects should be able give labeled on the products appliances in accordance with applicable standards.

Meanwhile, according to the MoF regulation No. 99/PMK.05/2008, the criteria can be divided based on the scope of business scale, namely:

1. “Micro businesses” define as family-owned enterprises or individual Indonesian Citizen that have individual sales up to IDR 100,000,000 (one hundred million rupiahs) per year;
2. “Small businesses” define as economic activities that meet the criteria of having a net worth assets up to IDR 200.000.000 (two hundred million rupiahs), not including land and buildings, or having an annual sales turnover IDR 1.000.000.000 (one billion rupiahs), belongs to Indonesian citizens, not a stand-alone subsidiaries or branches of companies owned, controlled by, or affiliated directly or indirectly with medium or large businesses;
3. “Medium enterprises” define as economic activities that have annual sales turnover of IDR 10,000,000,000 (ten billion rupiahs), belongs to Indonesian citizens, not a stand-alone subsidiaries or branches of companies owned, controlled by, or affiliated directly or indirectly with big business ;
4. “Other businesses” define as businesses that are not included in the cooperatives, micro, small, and medium enterprises, categorized as a recipient of the Revolving Fund scheme as long as they are not enthused to be funded by the commercial banks.

In addition, besides those groups, the Energy Efficiency Revolving Fund can also be given to a company that engaged as an Energy Service Company-ESCo[39] (Navawongse, 2012)[17]. There are some examples of projects that could become the target for this funding, i.e. table 1.

4.3. Loan Characteristics

Characteristics of the loan are:

1. Loans are given from the range between IDR 1 billion to 10 billion for financing small and medium-scale investments;
2. Loans are granted after the projects comply with all of the technical support of the committee standardization, i.e.:
   a. Cope with technical standards (technology-based approach: a list of energy-saving technologies and equipment)
   b. Cope with eligibility standards (feasibility study approach, based on assessment based approach), namely: successful in reducing specific energy consumption or showed an increase in the elasticity of energy consumption.
3. The loan period can be provided with a range of 5 to 7 years including grace period.
4. Interest rate of bank loan is up to 7-9% per year.
5. The funding can be used to replace production equipment out-dated as the following example:
   - Rehabilitation or replacement boilers (condensing boilers)
   - Cooling energy efficient (EE Chiller)
   - The use of various types of "speed drives"
   - Rehabilitation of compressed air systems
   - Rehabilitation of power distribution systems
   - Installation of monitoring and control devices
   - Installation of the utilization of renewable energy (hydropower, solar panels and wind power)

[39] ESCO is company that provides consulting services to design the project and implement energy efficiency, energy conservation, and energy infrastructure outsourcing and risk management. Some forms of ESCo business are: retrofitting, replacement of major equipment, the provision of co-generation, etc.

Table 1. List of projects for funding.

No.	Manufacture	Building
1.	Fuel efficiency in the production process	Efforts to reduce the heat radiation of sunlight into the building
2.	Efforts to prevent wasted energy	Efficient use of air conditioning and maintaining the room temperature
3.	Recycling wasted energy	Use of construction materials that enable energy conservation
4.	Efforts to use renewable energy	Improved lighting into the building
5.	Efficient use of electricity during peak hours (peak hours), the replacement of energy-saving equipment, or other efforts	Utilization of energy-saving equipment, machines and systems that better control over the use of equipment
6.	**And various other measures that belong to the conservation of energy**	

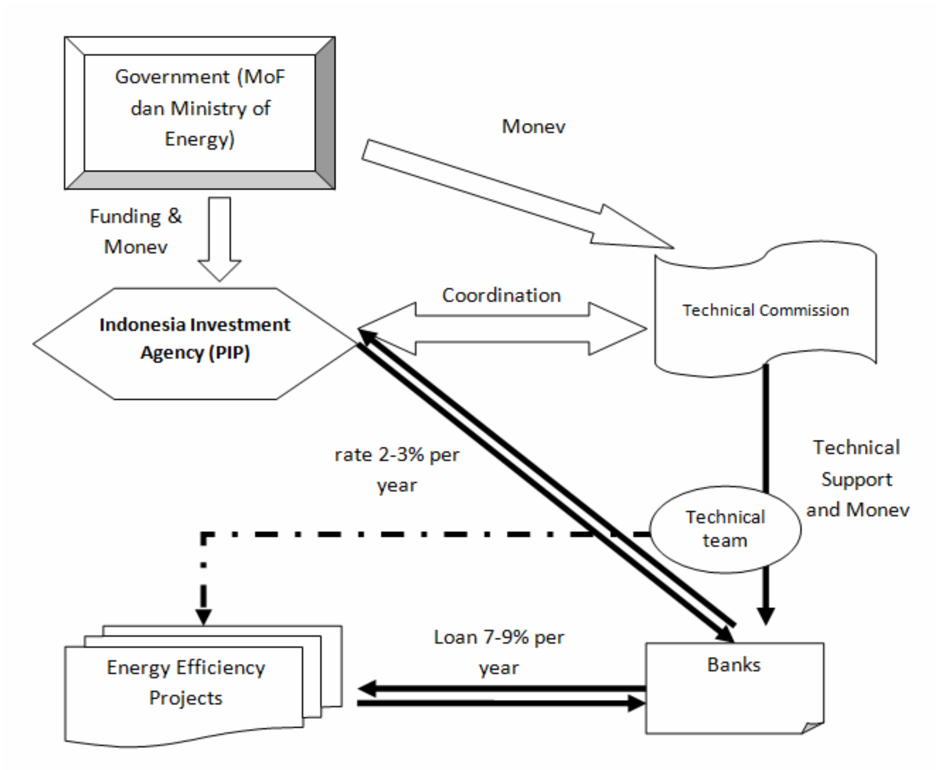


Figure 6. Energy Efficiency Revolving Fund Scheme Concepts.

4.4. Interest Rate

a. The interest rate is determined around 2-3% per year from Indonesia Investment Agency (PIP) to the commercial Banks. PIP will receive a management fee for managing the fund up to 0.5-1% per year. The Government is expected to receive a total margin lending spreads of 1-2% per year of the total funds which could be paid by PIP to the State Treasury Account. The interest rate spread will be utilized by the government as additional funds for revolving the next funding for the following year.

b. It is mandated that the interest rate from the bank to the specified energy efficiency project will not exceed the range of 7-8% per year, depending on the risk of the project. The difference sperad of interest rate around 5-6% per year is expected to cover all of the management fees and credit risk of loans disbursed from the banks.

c. In terms of devault[40] project, the Bank may terminate funding to the project or to provide a penalty to the project by imposing interest rate equal to the prevailing market interest rate.

4.5. Delivery Mechanisms of Energy Efficiency Revolving Fund

On this scheme, the government put some funds through the mechanism of the state budget to the Government Investment Center (PIP), which is intended as a source of funds for the loan to be disbursed through the bank / financial institution. Furthermore, the bank / financial institution mandated to manage the fund, will be distributed in the form of loans to energy efficiency projects. PIP placement to fund the government through disbursement of Account Treasury (RKUN) to the Parent Account Investment Funds (RIDI). Of RIDI, PIP will put a number of funds to the Commercial Bank Account.

In order to monitor and to control the interest rates much lower than the market rate, the government utilize the PIP as the channelling agent for the revolving fund. The funds will be placed through the PIP before it distribute to the designated Bank with interest rate around 2-3% per year. Further, Banks will lend the fund to the energy efficiency projects at a maximum interest rate of 7-9% per year, far below the corporations Prime Lending Rate (SBDK)[41].

4.6. The process of Revolving Fund Application Procedure

In order to prepare the loan project application, the applicants shall prepare a funding proposal projects with the assistance of technical expertise (namely, ESCO). After the assessment process and after having an approval from the Bank, the Bank will submit the project proposals to the PIP (included: funding proposal, administrative matters and technical requirements documents as well as feasibility study report).

The executing bank responsible for doing financial assessment/ risk management evaluation as well as Technical Assessment upon the proposed application. The financial assessment is carried out through the standardized criteria that applied in the common banking regulations. The financial assessment seeks for the standardize asset-based lending, meaning the Bank provides loans by reviewing cash flows, assets and companies savings, not only project-based lending (in this case the Energy Efficiency Project). Therefore, the loan application is assessed with reference to the capacity / ability to pay the loan and the amount of project collateral owned by the owner of the project. Thus, the Bank also has the freedom and the power to stop the project funding or loan restructuring or foreclosure on the assets owned by the project if the project defaults on the agreement. The bank, as an executing agency, will fully bear the credit risk, which means the Bank is required to pay the credit line to the government's (with an interest rate 2 to 3% as agreed with the government).

If the Bank does not have any adequate human resources to carry out technical assessment, then the Bank may work with an ESCO. In the initial stage, the Technical Commission will provide consultancy assistance (technical and related aspects with the project monitoring and evaluation).

In addition, the Technical Commission responsible to conduct and evaluate periodiccally the projects and further consider the report results from the PIP and banks. The Technical Commission is composed of Ministry of Energy and Mineral Resouces (MEMR), BPPT, Fiscal Policy Agency, PIP and designated University. In order to streamline between the Bank and the Project progress, the Committee form a Technical Support Team. This team, as the Energy Manager, is responsible for making reports of the energy performance projects, energy audits reports, and formulate plans for the achievement of energy efficiency targets.

The application process of revolving fund disbursement will include:

1. Before proposing application, the energy efficiency projects must have a feasibility study (F/S) which carried out either by the owner of the project or by an energy management services company (ESCO). The main focus of having the feasibility study are:
   a. To assess whether the energy efficiency project is technically feasible to be implemented or not;
   b. To measure the amount of energy savings that can be achieved from the project;
   c. To determine whether the loan repayment commitment can be achieved within the agreed period time.
2. If the assessment result indicates that the project is feasible, then the project owner will proceed the application and submitted to the Bank. If the loan application is made by a third party, the project owner and the third party (i.e. ESCO) must make an agreement that determine the specific procedures and accountability of energy efficiency projects.

[40] The default risk could be defined as: The project does not use the funds as intended, the project late in the repayment of loans as well as the projects not able to repay the loan, and so on

[41] Prime Lending Rate (SBDK) is not count the risk premium component which the magnitude depends on the bank's assessment of the risk of each borrower (generally SBDK is ranging from 12-14% per year)

3. Bank will conduct a financial feasibility analysis and technical feasibility analysis of the project.
4. On the basis of the recommendation of energy consultants, Bank will decide whether the project is feasible to be given funding. If the project is feasible, then the Bank will proceed to apply for a loan to the PIP.
5. On the basis of the Bank's loan application, the PIP will disburse funds to the Bank, then the Bank will disburse the loan to the project. Thus, the projects could utilize the fund in order to implement the energy efficiency projects that have been agreed upon.
6. Periodically, the project shall pay the loan principal included interest to the Bank and give performance report to the Technical Commission.

In addition, there is also monitoring and evaluation process to measure the performance of the projects and the executing banks, i.e.:

1. Executing Bank shall make pipeline credit list of feasible projects. The list will be utilized as a part of assessment for project performance and Bank;
2. Every 3 to 6 months, PIP and Technical Commission will hold a technical meeting to assess the performance of the project and the Bank;
3. PIP will focus on assessing the performance of the Bank's, while Technical Commission will assess the project performance reports in terms of targets energy savings achievement;
4. Technical Commission evaluate and determine the appropriateness of the projects list which meets to the technical criteria.

There are some main reasons why the government should employ banks in the revolving funds scheme, i.e.:

1. Banks have a wide operational network, so that the loan may able to reach the target market more efficiently;
2. Banks have the knowledge, expertise and experience in terms of lending, thus minimizing the default risk;
3. Bank has the list of customer which has potential to receive the fund, as well as Bank may facilitate effectively the information of energy efficiency programs;
4. By involving the banking sector, the risk of default which supposed to be borne by the government (PIP) can be shifted to the banks.

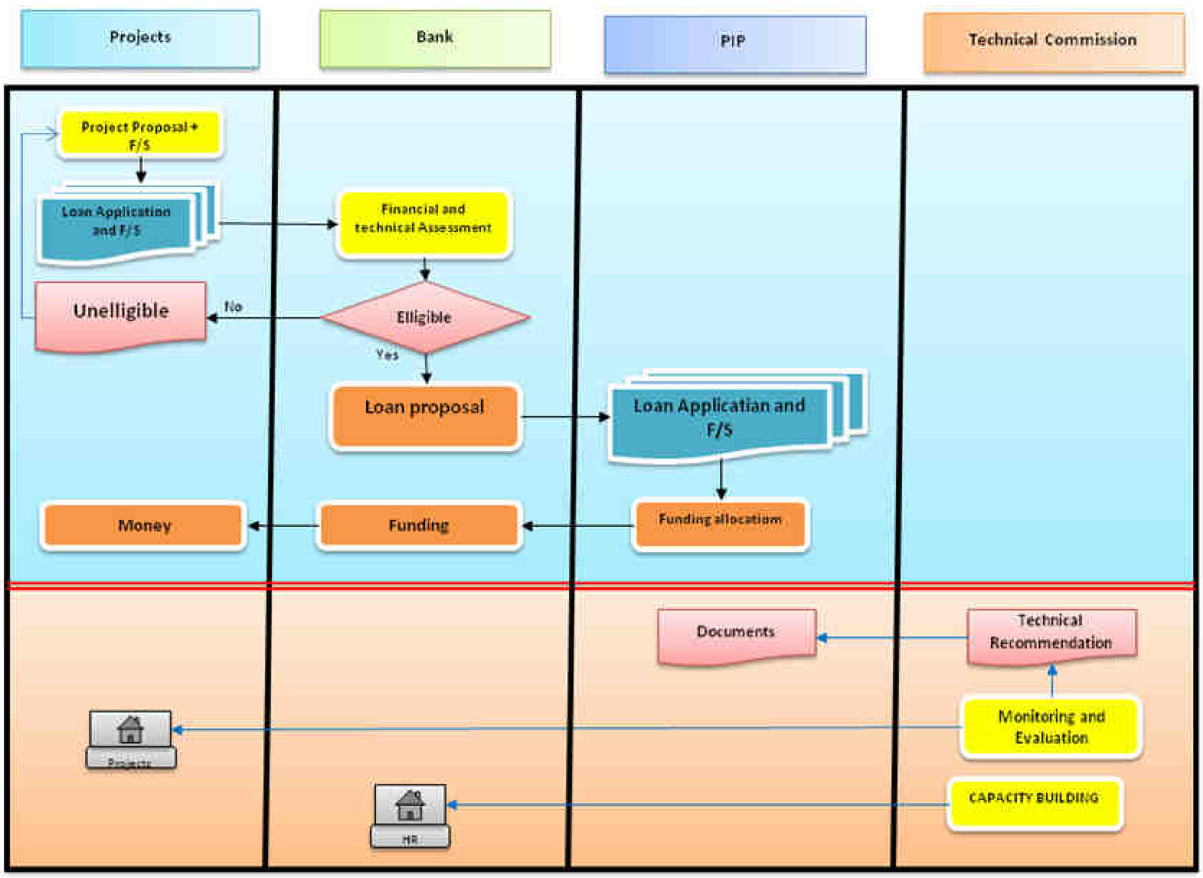


Figure 7. The Application Process of Revolving Fund Disbursement.

The limited capacity of the banking sector in terms of technical aspects of energy efficiency programs can be solved by providing technical assistance to the banks under the government aid, for example, the government in collaboration with consultants can provide technical support for conducting the feasibility study.

4.7. Monitoring and Evaluation

Bank, as the executing agency, is responsible for monitoring the utilization of loan. The monitoring is carried out routine every 2 to 3 months. If the project does not give report upon the project activities, the Technical Commission will send a technical team to the project in order to inspect and to collect related information.

Periodically, PIP will collect accountability report of the banks activities every 3 month, 6 month and annually in order to analyze the performance of the banks and the projects as well as to make sure the utilization of the funds as intended. In addition, the report also used to see how far the bank can reach the target of funds distribution in regards of energy efficiency projects. The report included the total loans disbursed, the total repayment, and the period of loan repayment as well as providing an indication snapshot of the energy saved compare to the baseline scenario.

In terms of fund administration, Technical Commision play huge role, namely (1) to ensure that the project is an energy efficiency projects, (2) to provide technical support to the bank and to the project, (3) together with PIP, Technical Commission will ensure the funds fit with targeted loans, (4) evaluate the project's performance and targets achievement as well as to measure energy savings. All of these activities are carried out by the Technical Commision.

4.8. Legal Basis PIP as Channeling Agent

According to MoF Regulation No. 99 of 2008, it states that the Revolving Fund management under the Ministry/Agency shall be managed by a specific financial management unit. PIP is the implementing unit that is best-suit to administer and to manage the fund. PIP has been established since 2007 as the government investment provider-based under the Ministry of Finance. According to Government Regulation No. 1 of 2008 regarding Government Investment, it stated that the Government investment could be done in the form of investment securities and direct investments[18]. The potential source of fund for PIP are: (1) State Budget allocation; (2) investment gains; (3) Grants; (4) Other possible legitimate funding sources.

According to Minister of Finance Regulation No. 177/KMK.01/2010, it mentioned that PIP may invest directly to environmentally friendly investments included: renewable energy, sustainable transport, waste management, biomass, bio-ethanol, REDD +[19]. The aim of this funding are:

a. To support sustainable development programs particularly in the context of climate change;
b. To expand and to accelerate public investment as well as to enhance cooperation between government and private investment.

Some characteristics of PIP financing schemes for Sustainable Projects, i.e.:

1. Type of funding of PIP is a flexible funding through soft loan and convertible debt;
2. There is no restriction on the maximum amount of funding per project;
3. Grace period refers to the length of the project development and the feasibility assessment (ranging from 1 to 3 years);
4. The interest rate depends on the risk of the project, on average BI rate plus 2%;
5. Repayment period from 5 to 10 years.

5. CONCLUSION AND RECOMMENDATIONS

The implementation of energy efficiency revolving fund scheme is expected to provide the optimal socio-economic and environmental benefits:

1. To encourage the utilization of energy-efficient technologies;
2. To stimulate the involvement of the financial sector (banking institutions) in order to support the government's energy efficiency programs;
3. To increase potential energy savings, i.e. reduction of electricity consumption in the industrial sector;
4. To Reduce the amount of energy subsidies;
5. To decrease greenhouse gas emissions (GHG). This inline with the government policy direction in the RAN-GRK with stated to implement efficiencies in energy utilization in all sectors of energy users, namely transportation, industrial, residential, and commercial.

The implementation of revolving fund scheme for energy efficiency in Indonesia is very potential to be done, due to various forms of legislation and fund management mechanism has been established. However, there are several steps that need to be considered before it can be implemented, namely:

1. Fund Preparations.

The source of funds shall be determined in the initial stage. If the government set the source of fund from the state budget, it is necessary to set the legal basis under Constitution in order to accommodate the allocation budget.

2. Institutional Arrangements for Energy Efficiency Revolving Fund scheme.

As defined in the chapter analysis, the revolving fund program can be implemented and managed by PIP. Therefore, it is necessary to establish a legal basis under constitution in order to give PIP the legitimacy to manage the energy efficiency revolving fund.

3. In-depth discussion with banks / financial institutions.

Discussions with the banks / financial institutions are strongly needed, in order to get feedback on the revolving fund initiative policy. It is very urgent, since at the end, the banking sector is the one who run the policy. Inputs from the banks are strongly needed to capture ideas of the best-suit revolving fund scheme.

APPENDIXES

COST AND BENEFIT ANALYSIS CALCULATION

Table 1. Number of Enterprises/Institutions According to Group of Audit and Size/Scale of Enterprises/Institutions in 2010-2012 (Unit)

No.	Classification of The Size/Scale	Buildings	Industry	Total
1	Small (1-19 Labor)	0	0	**0**
2	Medium (20-99 Labor)	33	32	**65**
3	Large (≥ 100 Labor)	150	266	**416**
	Total	**183**	**298**	**481**

Table 2. Number of Enterprises/Institutions According to Group of Audit, PLN Tariff/Client Group, and Size/Scale of Enterprises/Institutions in 2010-2012 (Unit)

No.	Classification of The Size/Scale	Buildings			Industry		Total
		Goverment Buildings	Business	Social	Manufacturing	Energy Provider	
1	Small (1-19 Labor)	0	0	0	0	0	**0**
2	Medium (20-99 Labor)	10	18	5	32	0	**65**
3	Large (≥ 100 Labor)	70	41	39	246	20	**416**
	Total	**80**	**59**	**44**	**278**	**20**	**481**

Table 3. Number of Enterprises/Institutions According to Group of Audit and Energy Consumptions in 2010-2012 (Unit)

No.	Classification of Energy Consumptions	Buildings	Industry	Total
1	Group I (< 100 MWh/Year)	20	8	**28**
2	Group II (100-<500MWh/ Year)	46	38	**84**
3	Group III (500 - <1000 MWh/ Year))	27	29	**56**
4	Group IV (1GWh -< 10 GWh/ Year)	80	124	**204**
5	Group V (10 - < 100 Gwh/ Year)	10	55	**65**
6	Group VI (≥ 100 GWh/ Year)	0	44	**44**
	Total	**183**	**298**	**481**

Table 4. Number of Enterprises/Institutions According to Group of Audit, PLN Tariff/Client Group, and Energy Consumptions in 2010-2012 (Unit)

No.	Classification of Energy Consumptions	Buildings			Industry		Total
		Goverment Buildings	Business	Social	Manufacturing	Energy Provider	
1	Group I (< 100 MWh/Year)	15	3	2	8	0	**28**
2	Group II (100-<500MWh/ Year)	27	5	14	38	0	**84**
3	Group III (500 - <1000 MWh/ Year))	12	9	6	29	0	**56**
4	Group IV (1GWh -< 10 GWh/ Year)	26	32	22	123	1	**204**
5	Group V (10 - < 100 GWh/ Year)	0	10	0	55	0	**65**
6	Group VI (≥ 100 GWh/ Year)	0	0	0	25	19	**44**
	Total	**80**	**59**	**44**	**278**	**20**	**481**

Table 5. Number of Enterprises/Institutions According to Group of Audit and Implementation Cost for Energy Efficiency in 2010-2012 (Unit)

No.	Classification of Implementation Cost	Buildings	Industry	Total
1	< 1 Billion IDR	169	221	**390**
2	1 - < 10 Billion IDR	13	59	**72**
3	10 - < 20 Billion IDR	1	10	**11**
4	20 - ≤ 50 Billion IDR	0	5	**5**
5	> 50 Billion IDR	0	3	**3**
Total		**183**	**298**	**481**

Table 6. Number of Enterprises/Institutions According to PLN Client Group and Tariff Classification in 2010-2012 (Unit)

No.	Client Group	Tariff Classification	Voltage Category	Enterprises/Institutions
1	Social	S-2 / >2200 VA s/d 200kV	Low	19
2	Social	S-3 / > 200 kVA	Medium	25
3	Business	B-1 / 900 vA	Low	1
4	Business	B-2 / 2200 VA s/d 200 kVA	Low	12
5	Business	B-3 / > 200 kVA	Medium	46
6	Industry	I-2 / >14 kVA s/d 200 kVA	Low	57
7	Industry	I-3 / >200 kVA	Medium	193
8	Industry	I-4 / >30.000 kVA	High	21
9	Government Buildings	P-1 / >2200 VA s/d 200 kVA	Low	46
10	Government Buildings	P-2 / > 200 Kva	Medium	34
11	Energy Provider (Neither PLN customer)			20
12	Manufacturing (Neither PLN customer)			7
Total				**481**

Table 7. Number of Enterprises/Institutions According to PLN Client Group and Tariff Classification in 2010-2012 (Unit)

No.	Client Group	Tariff Classification	Voltage Category	Enterprises/Institutions
1	Social	S-2 / >2200 VA s/d 200kV	Low	19
2	Social	S-3 / > 200 kVA	Medium	25
3	Business	B-1 / 900 vA	Low	1
4	Business	B-2 / 2200 VA s/d 200 kVA	Low	12
5	Business	B-3 / > 200 kVA	Medium	46
6	Industry	I-2 / >14 kVA s/d 200 kVA	Low	57
7	Industry	I-3 / >200 kVA	Medium	193
8	Industry	I-4 / >30.000 kVA	High	21
9	Government Buildings	P-1 / >2200 VA s/d 200 kVA	Low	46
10	Government Buildings	P-2 / > 200 Kva	Medium	34
11	Energy Provider (Neither PLN customer)			20
12	Manufacturing (Neither PLN customer)			7
Total				**481**

Table 8. Number of Enterprises/Institutions According to PLN Client Group and Tariff Classification as Target Sample of Revolving Fund (Implementation Cost: Between 1 up to 50 Billion IDR in Buildings and Industry) In 2010-2012 (Unit)

No.	Client Group	Tariff Group	Voltage Category	Enterprises/Institutions
1	Social	S-2 / >2200 VA s/d 200kV	Low	-
2	Social	S-3 / > 200 kVA	Medium	-
3	Business	B-1 / 900 vA	Low	-
4	Business	B-2 / 2200 VA s/d 200 kVA	Low	-
5	Business	B-3 / > 200 kVA	Medium	6
6	Industry	I-2 / >14 kVA s/d 200 kVA	Low	-
7	Industry	I-3 / >200 kVA	Medium	42
8	Industry	I-4 / >30.000 kVA	High	17
9	Government Building	P-1 / >2200 VA s/d 200 kVA	Low	-
10	Government Building	P-2 / > 200 Kva	Medium	8
11	Energy Provider (Neither PLN customer)			13
12	Manufacturing (Neither PLN customer)			2
Total				88

Table 9. CBA for Buildings and Industry with Implementation Cost: Between 1 up to 50 Billion IDR in 2010-2012

No.	Group	Total Sample (Enterprises/Institutions)	Volume of Energy Consumption (MWh/Year)		
			Early Consumptions	Savings	Percent
1	Buildings	14	58,189.86	15,941.95	27.40%
2	Industry	74	306,273,075,78	3,111,288,59	1.02%
Total		88	306,331,265,64	3,127,230.55	1.02%
No.	Group	Cost of Implementation During 5 Years (Million IDR)	Electricity Payment (Million IDR/Year)		
			Early Payment	Savings	Percent
1	Buildings	37,869.60	49,633.44	13,553.40	27.31%
2	Industry	412,285.04	185,195,841.42	884,676.18	0.48%
Total		450,154.64	185,245,474.86	898,229.59	0.48%
No.	Group	Payback Period (Year)	Subsidy of Electricity (Million IDR/Year))		
			Early Subsidy	Savings	Percent
1	Buildings	2.79	15,131.88	4,189,99	27.69%
2	Industry	0.47	2,295,300.94	205,059.49	8.93%
Total		0.50	2,310,432.81	209,249.48	9.06%
No.	Group	Internal Rate of Return (IRR for 5 Years, Percent)	CO2 Emissions (Ton/Year)		
			Early Emission	Reductions	Percent
1	Buildings	23.16%	39,000.71	10,528.26	27.00%
2	Industry	213.87%	294,829,361.45	2,179,449.95	0.74%
Total		198.70%	294, 868,362.15	2,189,978.21	0.74%

Table 10. Number of Enterprises/Institutions According to Group of Audit, Implementation Cost for Energy Efficiency and Financial Feasibility (IRR > 10%)
(Implementation Cost: Between 1 up to 50 Billion IDR in Buildings and Industry) in 2010-2012 (Unit)

No.	Classification of Implementation Cost	Buildings			Industry			Total		
		Feasible	Not Feasible	Total	Feasible	Not Feasible	Total	Feasible	Not Feasible	Total
1	1 - < 10 Billion IDR	11	2	13	55	4	59	66	6	72
2	10 - < 20 Billion IDR	0	1	1	7	3	10	7	4	11
3	20 - ≤ 50 Billion IDR	0	0	0	2	3	5	2	3	5
Total		11	3	14	64	10	74	75	13	88

Note : for IRR > 15% also same

Table 11. Cost and Benefit of Implementation for Target Sample Revolving Fund of Energy Efficiency (Whole Sample: 481 Enterprises/Institutions) in 2010-2012

No.	Group	Total Sample (Enterprise/Institutions)	Volume of Energy Consumption (MWh/Year)		
			Early Consumption	Savings	Percent
1	Buildings	183	455,566.81	55,323.99	12.14%
2	Industry	298	315,997,225.40	4,420,993.82	1.40%
Total		**481**	**316,452,792.22**	**4,476,317.80**	**1.41%**
No.	Group	Cost of Implementation During 5 Years (Million IDR)	Electricity Payment (Million IDR/Year)		
			Early Payment	Savings	Percent
1	Buildings	76,600.37	394,105.98	47,786.14	12.13%
2	Industry	706,927.97	187,606,793.29	1,659,571.93	0.88%
Total		**783,528.34**	**188,000,899.27**	**1,707,358.07**	**0.91%**
No.	Group	Payback Period (Year)	Subsidy of Electricity (Million IDR/Year))		
			Early Subsidy	Savings	Percent
1	Buildings	1.60	120,903.38	15,189.36	12.56%
2	Industry	0.43	2,789,071.43	273,324.66	9.80%
Total		**0.46**	**2,909,974.81**	**288,514.03**	**9.91%**
No.	Group	Internal Rate of Return (IRR for 5 Years, Percent)	CO2 Emissions (Ton/Year)		
			Early Emissions of CO2	Reductions	Percent
1	Buildings	55.53%	332,212.00	39,660.65	11.94%
2	Industry	234.20%	299,343,207.58	3,106,820.79	1.04%
Total		**217.23%**	**299,675,419.58**	**3,146,481.44**	**1.05%**

Table 12. Number of Enterprises/Institutions According to Group of Audit, Implementation Cost for Energy Efficiency and Financial Feasibility (IRR > 15%)

No.	Classification of Implementation Cost	Buildings			Industry			Total		
		Feasible	Not Feasible	Total	Feasible	Not Feasible	Total	Feasible	Not Feasible	Total
1	< 1 Billion IDR	156	13	169	205	16	221	361	29	**390**
2	1 - < 10 Billion IDR	11	2	13	55	4	59	66	6	**72**
3	10 - < 20 Billion IDR	0	1	1	7	3	10	7	4	**11**
4	20 - ≤ 50 Billion IDR	0	0	0	2	3	5	2	3	**5**
5	> 50 Billion IDR	0	0	0	1	2	3	1	2	**3**
Total		**167**	**16**	**183**	**270**	**28**	**298**	**437**	**44**	**481**

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Renewable Energy Sources

A Successful Framework to Promote Offshore Wind Energy in Europe: Lessons for Taiwan

Dr Anton Ming-Zhi GAO [1]

Assistant Professor,

The Institute of Law for Science and Technology (ILST), National Tsing Hua University, Taiwan [1]

Tel: +886 (03) 571-5131 ext. 42430
Fax: + 886 (03) 562-9380
E-mail: antongao@mx.nthu.edu.tw

Address: 101, Sec. 2, Kuang-Fu Road, Hsin Chu 30013, Taiwan

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Abstract

Given the recent proliferation of onshore renewable energy (RE) infrastructure, environmental and public concerns have emerged. In order to facilitate further growth in RE, many countries are looking to set up their RE infrastructure offshore or in less controversial spaces. As such, offshore wind farms (OWFs) have emerged as lucrative avenues in the energy policy of many countries, especially after the Fukushima accident of 2011. Europe has recently emerged as a pioneer in facilitating large-scale deployments of OWFs. Taiwan has expended much effort in facilitating the development of offshore wind technology since the 2000s. In 2006, a formal policy to develop OWFs—as the first phase of offshore wind energy production—was announced, but developments are yet to take place. After the Fukushima accident, Taiwan's government launched additional measures to realize the country's "first" OWF by both creating an Office and a Programe of Thousand Onshore and Offshore Wind Farms and promulgating a Demonstration Subsidy Ordinance. Several demonstration projects are scheduled to be funded under this scheme. Yet, whether these efforts would give birth to Taiwan's first OWF remains to be seen. The purpose of this article is to draw lessons from the European experience to evaluate Taiwan's approach in promoting OWFs, and identify the possible challenges and potential solutions.

Introduction

Recent environmental and public concerns have emerged in response to the proliferation of onshore renewable energy (RE) infrastructure. In order to facilitate further growth, many countries are looking to offshore infrastructure as a potential solution. As such, offshore wind farms (OWFs) have become an attractive and lucrative energy policy option in many countries, especially following the Fukushima nuclear accident of 2011. Europe has recently pioneered large-scale facilitation of OWF deployments. After preliminary study, I conclude that Europe's successful record of OWF implementation could be attributed to continual efforts to establish and promote a good framework for translating technology into practice.[42] The example set by these early adopters could inspire and provide important lessons for late-comers. This article attempts to use this example to devise energy policy recommendations for Taiwan.

[42] The lessons is gained from the reletate follwing references, See e.g., H. T. Anker et al. (eds), Legal Systems and Wind Energy: A Comparative Perspective (UK: Kluwer, 2009); Commission Green Paper of 29 November 2000 "Towards a European strategy for the security of energy supply" [COM(2000) 769final]; Commission Communication of 26 November 1997 on energy for the future: renewable sources of energy - White Paper for a Community strategy and action plan [COM(97) 599 final]; Commission Green Paper of 20 November 1996 on renewable sources of energy [COM(96) 576final]; Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 13 November 2008 – 'Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond' [COM(2008) 768 final]; Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market; Commission Green Paper of 8 March 2006: "A European strategy for sustainable, competitive and secure energy" [COM(2006) 105 final]; Knud Pedersen, Arno Behrens, and Christian Egenhofe, Energy Policy for Europe: Identifying the European Added-value: CEPS Task Force Report (Belgium: Centre for European Policy Studies, 2008).

Since the early 2000s, Taiwan has expended great effort to facilitate the development of offshore wind technology. In 2006, a formal policy to develop OWFs, the Programme of the First Phase of Offshore Wind Energy Production, was announced, but further development has yet to occur. (Hwa Meei Liou, 2011) After the Fukushima incident, Taiwan's government took additional steps to implement the country's first OWF by creating the Thousand Wind Turbines Promotion Programme and promulgating a Demonstration Subsidy Ordinance. (Gao, 2012: p. 271-272) Several demonstration projects will receive funding under this scheme, but whether these efforts will help realize Taiwan's first OWF remains to be seen.

The purpose of this article is to identify lessons from the European example, to evaluate Taiwan's approach to promoting OWFs, and to identify possible challenges and potential solutions. This article will firstly briefly outline the European OWF framework and its realization. According to the preliminary opinion of this author, this framework should be comprehensive, integrating technology, policy, law (including incentives and regulations) and also, most importantly, a central authority tying all elements together. This framework should prove helpful for OWF realization in Taiwan.

II. Offshore Wind Energy Promotional Framework in Europe

Technology plays a key role in the foundation of wind energy promotion. Technological advancement in countries such as Germany encourages the government to create a local market for OWF, but can also contribute to deployment in countries with less advanced wind technology, such as the UK and Greece. In order to bring OWFs into practice, each government usually incorporates OWFs into relevant policies, such as energy, climate, environmental or electricity policy, and then designs the necessary legal structure to promote and enforce the plan. These legal methods usually consist of wealthy incentives and appropriate but not excessive regulations (carrots and sticks), and tend to function as a last mile in realizing OWF technology. Finally, the role of politics in promoting offshore wind cannot be ignored. The driving force behind drafting the related policy and laws, i.e. the government and competent authorities, deserves particular attention. The framework to promote OWFs in Europe is illustrated in Figure 1.

1. Technological Development and Support

Europe and its member states have gone to great effort to advance offshore wind technology. Most of this research and development (R&D) has been funded by scientific and technology research programmes or by individual governmental R&D budgetss. At the European level, there are general framework programmes (FPs) and energy-specific programmes, such as alterner and Alterner II, while considerable R&D funding for OWF is also available at the member states level. With a view to develop commercially viable OWF products, R&D tends to focus on not only the wind installations themselves, e.g., wind blades and towers, but also related areas of concern, such as construction techniques, wind and marine resource evaluations, legislations, etc. This technologically comprehensive R&D approach facilitates further development of the necessary policy and legislation.

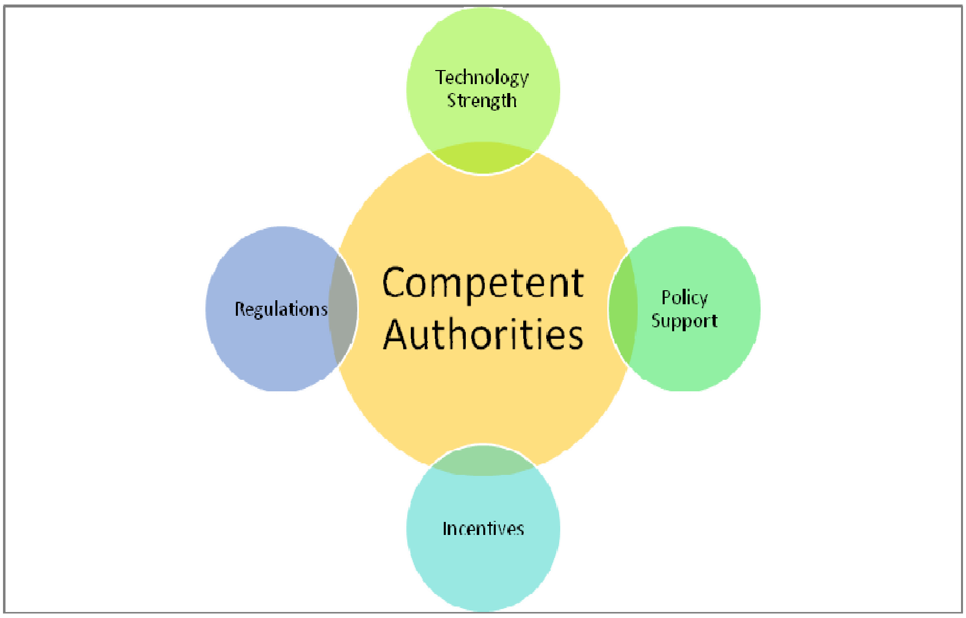


Figure 1: Europe's Comprehensive Promotional Framework for Offshore Energy (Source: compiled by the author).

2. Policy Support

The aforementioned FP and other related policies, including the EU's Strategic Energy Technology Plan (SET-Plan), emphasize the importance of technological development in OWF realization. (EC, 2007) Aside from technology issues, other offshore wind concerns are emphasized in energy- or climate-related policies, such as the EU's Offshore Wind Energy: Action, which identifies climate and energy challenges that must be addressed to meet energy policy objectives for 2020 and beyond. (EC, 2008) Indeed, many European member states and other countries around the world have forged policy connections between R&D and *sector-specific* policy.

Since most European countries now mention OWF in their technology, energy and climate policies, the question now is how to distinguish good policy from bad. Of the 28 European member states, 23 have implemented OWF policy, a relatively high proportion. (4C, 2013) The successful implementation of OWF in the EU and its member states lies in their combined *qualitative and quantitative* approach. For instance, one policy statement indicated that "the potential exploitable by 2020 is likely to be some 30-40 times the current installed capacity, and in the 2030 time horizon it could be up to 150 GW, or some 575 TWh". (EC, 2007) Yet certain countries may devise policies that take a qualitative approach without a quantitative target, which could slow down OWF realization.

3. Legal Support and Enforcement

Democratic societies require legislative support to achieve policy objectives and quantitative targets. Legislative incentives provide a secure investment environment, while regulations provide added certainty as well as legal frameworks to resolve environment, health and security (EHS) disputes.

(1) Incentives

In order to bear the extremely high cost of new OWF installations, development plans require effective incentives at both the EU and its member state levels. In the EU, three main renewable electricity subsidy schemes play a central role: feed-in tariffs (FIT), tendering schemes, and renewable obligations (RO). For instance, Germany has adopted a FIT for OWFs, (Offshore-windenergie.net, 2012) while the UK and France have opted for a tendering scheme and an RO, respectively. (DECC, 2013; CRE 2011)

Apart from these main subsidy schemes, supplementary subsidy schemes are also indispensable in bringing OWFs to fruition. These measures include proper grid connection cost sharing schemes (e.g., super-shallow connections), (Miguel Mendonça et al., 2009: p.33) low interest loans and guarantees, (Kfw, 2013) tax incentives, and investment subsidies. (DTI, 2008) Though some of these schemes may appear less relevant to successful OWF development, they do play a substantial role. For instance, in the case of grid connection schemes, the Alpha Ventus project in Germany requires a 60 km line to connect to the onshore electricity network. If a wealthy FIT scheme were used without a cost-sharing scheme integrating a super-shallow connection, it would be impossible for the developers to bear the extraordinarily high cost of the project.

Thus, a robust combination of main and supplementary incentives is recommended in order to replicate the successful development of OWF in many EU member states.

(2) Regulations

OWF is relatively clean compared with other traditional energy sources; however, some EHS concerns will inevitably arise. The EU and its member states have implemented regulatory regimes to deal with these concerns at all levels. According to one important study, the most effective regulatory regime involves a complex interrelation of international law, EU law, planning & zoning law, environmental protection law (such as noise, marine pollution, etc.), nature protection law, environmental impact assessment (EIA) and strategic environmental assessment (SEA) legislations, energy law, etc. (Helle Tegner Anker et al. eds., 2009) As we can see from the following examples in Germany and the UK, establishing a regulatory regime that incorporates SEA, EIA, large-scale infrastructure, and permissions acquisition is vital to achieving a successful OWF implementation.

EIA, for example, can be a useful tool to address the potential environmental impacts of OWF projects prior to development. However, exceptionally strict environmental requirements can overburden small projects. In order to address this potential issue, Germany's EIA strikes a careful balance, noting, "Offshore wind farm projects comprising more than 20 turbines require an environmental impact assessment". (BSH, 2013a) This means that small offshore wind projects comprising only one or two turbines are exempted from a potentially heavy regulatory burden, which in turn promotes a very friendly environment for R&D and demonstration activities. Furthermore, in order to improve regulatory certainty, German authorities also made sure to provide very detailed rules regarding EIA standards. (BSH, 2007a)

It is also important to provide a clear rule of game in order to avoid further regulatory uncertainty during the permission stage of OWF deployment. BSH, the competent authority in Germany, stipulates very comprehensive guidelines on OWF-related permission requirements and licensing procedures. (BSH, 2013b) Moreover, the government has devised detailed design and usage standards in its documents, “Design of Offshore Wind Turbines”, (BSH, 2008 and 2007b) and "Guidance for use of the BSH standard, Design of Offshore Wind Turbines”, including verification of the geotechnical safety of foundation elements, hierarchy of standards, cyclic loads, and dynamic pile load testing (BSH, 2007c).

Aside from the usual environmental and permissions concerns, the EU has adopted the SEA model under the SEA Directive with a view toward broadly integrating environmental and other concerns beyond the individual project level. (EC, 2001) As observed in the UK and Germany, (Offshore wind.de, 2013; DECC, 2013b) a well-executed SEA of OWF programmes could facilitate the permissions and EIA process, and could enhance investor security and regulatory certainty. In the early stages, SEA is very helpful in preliminarily filtering out unsuitable sites with low wind resources, high ecological or environmental concerns, military or fishery conflicts, etc. This kind of advance investigation by the government could also benefit OWF developers and investors and in the later regulatory EIA and permissions stages. Indeed, it is perhaps no coincidence that, under these regulatory regimes, the UK and Germany have set OWF milestones for farm size and distance from the coast. The SEAs of OWF programmes in the UK and Germany are illustrated in Figure 2.

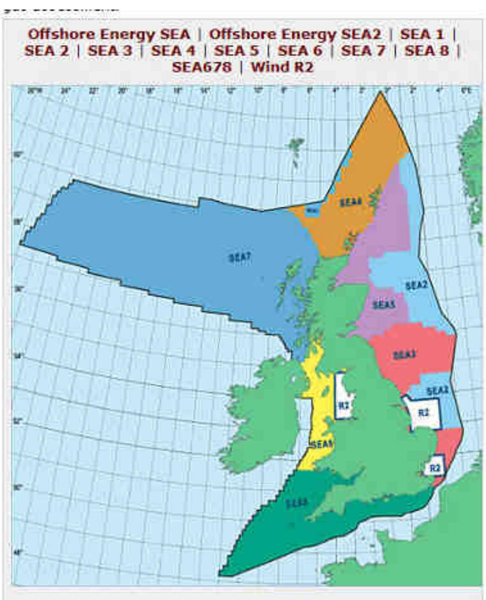
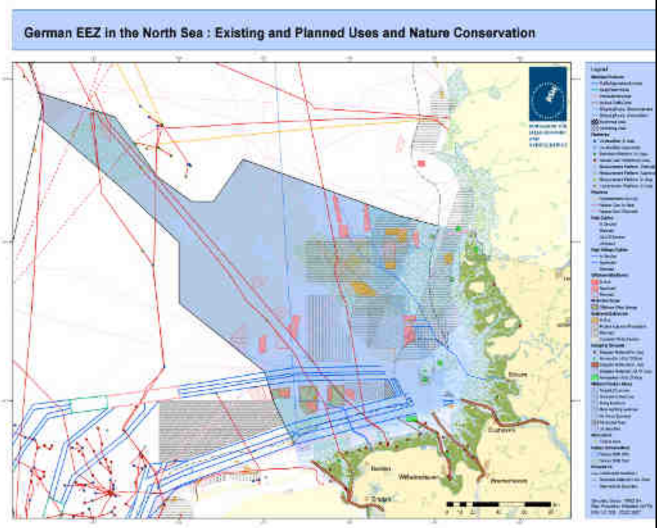
UK	Germany
	

Figure 2: SEAs of OWF Programmes in the UK and Germany (Source: offshorewind.de, 2013; DECC, 2013b)

Finally, grid connection and expansion represents another untraditional legal challenge to OWF development. Large-scale construction, expansion and power line replacements or upgrades are required in order to connect OWFs to mainland electricity grids. However, under the old regulatory regime, fragmented legislations could lead to delays and inappropriate administrative barriers. (BMU, 2011, p. 18) In order to remedy this, OWF-friendly countries like Germany and UK have introduced legal reforms relating to infrastructure and grid development, including the Energy Line Extension Act of Germany (EnLAG) of 2009, the Grid Expansion Acceleration Act for Transmission Networks of Germany (NABEG) of 2011, the Third Act Revising the Legislation Governing the Energy Sector of 2012 (BMWI, 2012), and the UK’s Planning Act of 2008. (legislation.gov.uk, 2008) In these countries, these four elements appear to contribute to the success of OWF development.

II. Behind the Scenes: the Driving Force of Competent Authorities

The development and realization of OWF projects requires the heavy participation of different ministers and agencies in both central and local government. The participation of so-called “multi-players” can be particularly beneficial; for instance, the simultaneous provision of R&D support from different agencies in their relevant policy areas, such as technology, environment and energy, would promote a healthy R&D environment. Emphasis on the role of OWF in different government policies could also be helpful.

However, involving authorities from many different sources in regulatory efforts can lead to bureaucracy, red tape, and a lack of central accountability. The typical bureaucratic "not-in-my-authority" (NIMA) attitude can bring development to a standstill, even going so far as to potentially cause the failure of OWF policies and incentives. For instance, the relevant climate and energy authorities may both appear to actively promote OWF in their policies, but if they are not accountable to a central authority in charge of the project, there may be no way to evaluate the effectiveness of their efforts. Incentive schemes could also suffer insufficient funding in such a scenario.

Incorporating technology, policy and incentives into OWF development inevitably covers a wide range of governmental authorities. However, as in the UK and Germany, it is important to identify the main authority in charge of the project. For instance, in Germany, the *ocean* authority (BSH) is in charge of OWF development, while in the UK, the *climate and energy* authority is responsible. Clearly, there is no absolute answer as to who should bear the responsibility of promoting OWF in all countries, but the European example suggests that a high-functioning, competent authority is the key to facilitating the development of technology, policy, incentives, and regulations. While good policy and legislation may appear, from an outsider's perspective, to be the most important factors in implementing OWFs, the central authority is the true driver. Without this single accountable authority driving the project, development would crumble under the weight of the perception that "everybody's business is nobody's business".

The aforementioned SEA scheme could be a useful way to resolve this issue. SEAs can incorporate full consideration of licensing issues, which may prove beneficial in countries where legislation remains piecemeal and fragmented across numerous public departments. SEAs could thus save time and bureaucratic effort, and in turn strengthen investor trust in the project. (Cristina Huertas-Olivares & Jennifer Norris, 2008) Again, judging from SEA implementation in the UK and Germany, this "one-stop shop" approach to accountability seems to contribute to quick and effective OWF development.

III. Conclusion: Lessons for Taiwan

By observing OWF implementation in the EU and its member states, we can devise an effective framework comprised of technology, policy, incentives, regulations and competent authorities. This framework seems quite simple *per se*, but it is difficult to implement in practice. Using this framework, this section will evaluate why OWF deployment failed in Taiwan, and to how best to move forward.

With regards to technology, Taiwan is a late-comer, having only recently adopted wind farm technology at all (not to mention the more advanced OWF technology). The government, and particularly the Energy Agency, has conducted considerable research on these technologies in the past decade: for example, a five-year project on the "demonstration and promotion of wind power [from] 2000-2004"[43] was conducted by the Industrial Technology Research Institute in Taiwan (ITRI), while a special research project on offshore wind farms, "The Development of Offshore Wind Power Technology" was conducted from 2009-2010.[44] Additionally, the Master Programme on Offshore Wind Power, under the National Science and Technology Programme-Energy (NSTPE) will promote offshore wind technology research from 2013-2015. However, as local funding schemes are unable to provide the latest technology, the first two planned demonstration plants (MOEABOE, 2013) will use technology provided by Siemens (a German company). Thus, while a promising amount of research is planned, more funding is needed to drive OWF technology development in Taiwan.

In terms of policy, previous efforts have mainly focused on R&D policy, rather than on demonstration and large-scale development under energy, climate or industrial policies. Even though the Executive Yuan approved The Program for the First Stage of Offshore Wind Development in August 2007, (MOEABOE, 2007a; Gao, 2012b: p.143) most other policy efforts continue to focus on R&D, as detailed in the 2007 Energy Technology R&D White Paper (MOEABOE, 2007b) and the 2012 Energy Industry Technology White Paper. (MOEABOE, 2012) A common failing among such policies is that they privilege qualitative direction over quantitative targets. On the other hand, following the 2011 Fukushima accident, the New Energy Policy of 2011 provides a concrete programme consisting of 1000 onshore and offshore wind farms, with quantified development targets of 600 offshore wind turbines to be installed before 2030, and an energy goal of 4.25GW of electricity. The following year, a Special Office in Realizing One Thousand Onshore and Offshore Wind Farms (Thousand Wind Turbines Promotion Programme) and One Million PV Roofs was established on 28 March 2012. (MRPV, 2012) In addition to these important, long-awaited measures, "The Ordinance on Demonstration Subsidies for Offshore Wind Farms", was completed in July 2012, (MOEABOE, 2012b) which awarded investment money to 4-6

[43] Wind Power Demonstration Poject (2000-2004), ITRI, research projects issues by Energy Commission and (latter on) Bureu of Energy, Ministry of Economic Affairs.

[44] Techonology Developiment of Offshore Wind Power Geenration (離岸風力發電技術開發, 2009-2010, ITRI, ITRI, research projects issues by Bureu of Energy, Ministry of Economic Affairs.

demonstration turbines scheduled to be completed in 2015, as well as an additional 300MW offshore wind farm to be completed before 2020. However, whether these ambitious plans can be completed on such a tight schedule remains to be seen.

In order to promote overall RE development, Taiwan passed the Renewable Energy Act of 2009, which is similar to the German Renewable Energy Act of 2000. The act mainly promotes OWF development via FIT, with a rate of 4.1982 NTD/kWh (for 20 years) in 2010, (MOEABOE, 2010) later increased to 5.5626 NTD/kWh. (MOEABOE, 2011; MOEABOE 2012c; MOEABOE, 2013b) Unfortunately, this FIT failed to facilitate the deployment of infant technology, leading to the implementation of “The Ordinance on Demonstration Subsidies for Offshore Wind Farms” as a corrective and additional measure. In addition to these main subsidy schemes, Article 16 of the act is also likely to promote tax incentives, such as the exemption of the OWF excise duty. However, a lack of low-interest loan and guarantee programmes, unfavourable grid rules (currently a mixture of shallow and deep connections for all RE as per Article 8 of the act), and a dearth of other incentives (such as more ambitious tax incentives or an emissions trading market) could impair further OWF development.

The slow progress of OWF development in the past few years appears to have correspondingly delayed OWF regulations. So far, the leading OWF regulations mainly concern EIAs, the German Exclusive Economic Zone and the continental shelf: for example, Article 29 of the Ordinance of Compulsory EIA Projects (EPA, 2012) and Articles 5, 7, and 21 of the Law on the Exclusive Economic Zone and the Continental Shelf of the Republic of China of 1998. (MOJ, 1998) As EEZ/continental shelf regulations only deal with general OWF permissions schemes, most of the regulatory burden could fall to EIA. However, the current EIA regime is not engineered for ideal OWF development. For instance, according to Article 29 of the EIA Ordinance, geothermal and marine energy projects are eligible for EIA pilot-test or demonstration exemptions, but OWFs are not, suggesting that EIA could potentially hinder OWF development. Additionally, as several non-governmental organizations (NGOs) have used EIA to stall the development of many onshore wind and other RE projects, they might do the same to prevent OWF realization. In light of these potential regulatory challenges, Germany’s demonstration and small-scale exemption model should be strongly considered in the implementation of Taiwan’s demonstration projects.

Europe’s example highlights the importance of a single motivating engine or central authority, such as the BSH in Germany and the DECC in the UK, operating as the driving force behind an OWF project. Taiwan’s reliance on a multi-authority model, rather than this single central authority, may account for the failure of OWF development in the past few decades. This issue was raised during the first phase of offshore wind energy production in 2006, but went unaddressed. The government has provided a summary of the many authorities relevant to OWF development (Table 1), suggesting it recognizes this multi-authority pitfall, (MOEABOE, 2007a) but there have been no efforts to integrate or coordinate these authorities. Governmental reorganization of the Executive Yuan, which began in February 2010, has only worsened this problem. (MOJ, 2010) Fortunately, since the Special Office noted earlier began to tackle the issue in 2012, the development of the proposed 4-6 wind projects has shown promising progress. However, the NIMA problem is still highly likely to re-emerge, particularly during the construction and permission stages. This article still urges the establishment of a “one-stop shop” or central authority in order to avoid the multi-authority pitfall. The prospective new Ministry of Economy and Energy Affairs (currently the Ministry of Economic Affairs) may help solve this problem, as it appears to be similar to the UK’s DECC.

Ultimately, Europe’s example teaches us that coordinating technology, policy, law and multiple authorities is inevitably difficult. However, the success stories of Germany and the UK (particularly with respect to their SEA utilization) could provide precious lessons for Taiwan. Keeping this in mind, this article strongly advises that offshore wind programmes be incorporated into Taiwan’s SEA Ordinance (EPA, 2006).

Table 1: Authorities Relevant to OWF Development (Source: MOEABOE, 2007a).

Matter	Authority
Establishment of electricity business	Ministry of Economic Affairs (Bureau of Energy)
Laying of undersea electricity cable	Ministry of the Interior (Department of Land Administration)
Artificial islands and structure	Ministry of Interior (Construction and Planning Agency)
State-owned and non-public land	Ministry of Finance (National Property Administration)
National security-related regulations and construction-prohibited matters	Coast Guard Administration, Executive Yuan (Ministry of Defence)
Flight safety	Ministry of Transportation
Shipment safety	Ministry of Transportation
Environmental impact assessment	Environmental Protection Administration
Marine pollution	Environmental Protection Administration
Mining rights	Ministry of Economic Affairs (Bureau of Mining)
Fishing rights	Agricultural Commission, Executive Yuan (Fishery Agency)

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BMWI, (2012), No 112/12 Berlin, 29.08.2012 Federal cabinet adopts offshore liability regime and introduction of offshore grid development plan, http://www.erneuerbare-energien.de/en/unser-service/press/detailview/artikel/federal-cabinet-adopts-offshore-liability-regime-and-introduction-of-offshore-grid-development-plan/?tx_ttnews%5BbackPid%5D=94

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BSH, (2007b), Standard Design of Offshore Wind Turbines, http://www.bsh.de/en/Products/Books/Standard/7005eng.pdf

BSH, (2007c), Guidance for use of the BSH standard „Design of Offshore Wind Turbines" Verification of the geotechnical safety of foundation elements Hierarchy of standards, cyclic loads, dynamic pile load testing Guidance for use of the BSH standard, http://www.bsh.de/en/Products/Books/Standard/Guidance.pdf.

BSH, (2008), Standard Ground Investigations for Offshore Wind Farms Format, http://www.bsh.de/en/Products/Books/Standard/7004eng.pdf

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LCOE as a policy tool to design RES-E support schemes

Dr. Christos TOURKOLIAS, Dr. Yannis VOUGIOUKLAKIS, Mr. Vasilis PAPANDREOU, Mr. Kostas TIGAS, Mr. Christos NAKOS, Mrs. Myrto THEOFILIDI
Division for Energy Policy and planning – Center of Renewable Energy Sources and Savings
Tel: +30210 6603300
Fax: +30210 6603301
e-mail: ctourkolias@cres.gr
Address: 19th km Marathonos Ave, 19009, Pikermi Attiki Greece

Abstract

The Levelized Cost of Electricity (LCOE) is considered a significant tool for the effective design of policies and support mechanisms in the power sector, since it provides an insight of the viability of investments in different electricity generation technologies and helps assessing the most coherent financial support integrating all relevant parameters The aim of this paper is to implement a methodology utilizing the LCOE to assess the current and future financial schemes supporting investments in wind power and photovoltaics in Greece and to demonstrate how this methodology can be implemented to design various financial support schemes. Specifically, the analysis takes into consideration the development of various parameters for the two examined RES technologies within the period 2009-2013, such as capital costs, operational and maintenance costs, capacity factors, potential incentives and taxes. The identification of the most crucial factors affecting the economic viability of wind and photovoltaic energy is realized by assessing their impact on LCOE as well as on the levels of the support schemes. Moreover, Monte Carlo sensitivity analysis is performed for those parameters with the highest degree of uncertainty, in order to obtain more robust estimates. The implementation of Monte Carlo analysis is performed through the selection of triangular distributions for the examined parameters targeting to the representative depiction of the current RES market in Greece. Finally, the effectiveness of LCOE as a decision-making tool and the requirement of the continuous monitoring of the support schemes through the corresponding LCOE estimates are analyzed and highlighted.

Keywords: Levelized Cost of Electricity, Monte Carlo analysis, Wind energy, Photovoltaic energy.

1. Introduction

The estimation of Levelized Cost of Electricity (LCOE) provides an overall insight of the parameters that mostly affect the cost for generating electricity. It can be, therefore, effectively utilized either for the evaluation of existing support schemes for the penetration of Renewable Energy Sources (RES) technologies, or for the design of new, cost-efficient financial mechanisms. The aim of this paper is to develop a methodological framework for the effective evaluation of the support mechanisms in the RES electricity sector, which will be based on the combination of LCOE estimation and Monte Carlo analysis. This combination allows the simultaneous manipulation of the various fluctuations, occurring by the uncertainties of the assumed input parameters. The implementation of this methodological approach will be performed for two typical cases of wind and photovoltaic energy and focus will be laid on the monitoring procedure of the obtained results until 2020. Recent experience regarding the rapid drop of the photovoltaics capital cost and the resulting deviation of the actual electricity generation cost from the provided feed-in-tariff scheme has indicated that the continuous monitoring of the calculated LCOE should be a priority for the effective implementation of each financial support mechanism.

Various studies estimating the LCOE for the case of RES technologies have been published in recent years. The U.S. National Renewable Energy Laboratory (2011) presented a comparative analysis of the LCOE of wind energy for various countries describing the separate cost components of a typical wind energy unit in each of the examined countries. The same approach was implemented separately from Fraunhofer ISE and International Renewable Energy Agency (2012), as they calculated the LCOE for various types of RES technologies. Branker et al (2011) developed a methodology for the calculation of the LCOE of photovoltaic units attempting to clarify all the existing misconceptions regarding the assumptions, which were identified in the relevant literature. A sensitivity analysis was performed detecting the most important variables, while it was concluded that PV will become an advantageous technology for electricity production in economic terms in specific geographical regions. Adaramola et al (2011) examined the economic valuation of small to medium size commercial wind turbine in selected sites in Nigeria exploiting the LCOE. Levitt et al (2011) in their study analyzed the factors, which affect the cost of offshore wind energy projects.

Specifically, the LCOE was estimated determining input parameters as defined by the analysis capital markets and 35 operating and planned projects in Europe, China, and the United States. Hernandez-Moro and Martinez-Duart (2013) calculated the LCOE for photovoltaics and concentrated solar power plants developing a mathematical model for the estimation of both the present value of the LCOE and its future evolution until 2050. The obtained results can be utilized in energy planning policies (tariff-in schemes, tax exemptions, etc), since the LCOE of each examined technology can be comparatively assessed for the period 2010-2050. Finally, Gass et al (2013) assessed the economic viability of wind turbine sites through the comparison of LCOE with the current feed-in tariffs scheme in Austria taking into consideration various constraints (such as infrastructure, natural environment and ecological preservation zones).

The uncertainties of the LCOE's input parameters require the implementation of a more dexterous manipulation of the obtained fluctuations. Nevertheless, only few attempts have been performed focusing on the uncertainty analysis. Darling et al (2011) calculated the LCOE for PV based on input parameter distributions implementing a Monte Carlo simulation. The examination of the assumptions focused on the impact of sunlight variation, panel performance, operating costs, and inflation to the calculated LCOE. Battke et al (2013) combined the estimation of the LCOE with the implementation of Monte Carlo analysis in order to investigate the impact of uncertainty for various parameters on the lifecycle costs of four battery technologies in the case of six different electricity system applications.

2. Methodology

The proposed methodological approach aims at the estimation of the LCOE for the cases of a typical wind park and a typical photovoltaic station, along with the identification of the most uncertain parameters required for the calculation of the LCOE. Moreover, a Monte Carlo analysis will be performed in view of obtaining more reliable results by considering the fluctuation of the selected input parameters until 2020. All the derived outcomes will provide a more precise basis that should be taken into consideration for the efficient design of RES support schemes in Greece, integrating a set of potential fluctuations of the vaguest parameters, which affect the economic viability of each RES technology. For this purpose, the variation of the calculated LCOE due to the impact of the selected parameters was examined for three different time slides, namely 2013, 2015 and 2020.

The LCOE refers to the necessary costs for the generation of electricity on the basis of net power supplied to the grid. All the cash flows regarding the expenditures for the generation of electricity are discounted to their present values in a specified base year by determining a discount rate. The LCOE is equal to the ratio of the total lifetime expenses of the examined station for the generation of electricity to the total expected electricity production, expressed in terms of present value equivalent. It represents the average price of electricity required for the investor to be fully repaid for the whole expenses (initial capital cost, operational and maintenance cost, fuel cost etc.), by setting the rate of return equal to the discount rate.

In the present study, the LCOE was calculated as follows:

$$LCOE = \frac{CC - \Sigma_1^N \frac{DP + IN}{(1+DR)^n} + \Sigma_1^N \frac{LN}{(1+DR)^n} + \Sigma_1^N \frac{OM}{(1+DR)^n} \times (1 - TR) - \frac{RV}{(1+DR)^n}}{\Sigma_1^N \frac{Electricity\ production \times (1 - DEG)^n}{(1+DR)^n}}$$

where CC is the capital cost minus any investment tax credit or grant, OM is the annual operational and maintenance cost, DR is the discount rate, RV is the residual value, DEG is the unit's degradation rate, N is the lifetime of the unit in years, DP is the depreciation, IT is the interest payment, LN is the loan payment, and TR is the taxation rate (Darling et al, 2011).

Many of the parameters considered for the calculation of LCOE are characterized by a high degree of uncertainty, which may lead to misleading conclusions regarding the formulation of a support mechanism for RES. For this reason, the implementation of a probabilistic sensitivity analysis was selected in order to handle effectively the existing fluctuations of LCOE due to uncertain parameters. These methods assign ranges and distribution to the uncertain parameters and evaluate the fluctuation of the obtained results. One of the most common utilized techniques is Monte Carlo simulation (Briggs et al, 1994, Baltussen et al, 2004).

Monte Carlo simulation involves the random sampling of values based on an appropriate probability distribution for each uncertain input parameter used in the calculation procedure producing many scenarios (iterations). The most crucial steps for the implementation of the Monte Carlo analysis consist of the specification of an exact number of input parameters, which are important to be analyzed, and the estimation procedure, which will lead to the set of outputs. In this sense, Monte Carlo simulation evaluates iteratively the specified output using sets of random numbers as inputs. The main difficulties of this method for the specific case study are the determination of the proper probability distribution in order to realistically depict the uncertainty effects for each input parameter and the large number of uncertain parameters, as few studies have attempted to examine these issues.

The necessary steps for the effective implementation of Monte Carlo simulation consist of:

Step I: Identification of input and output parameters
Step II: Generation of a set of random values for all input parameters from a probability distribution for a specified number of iterations (for example 1000)
Step III: Assessment of the obtained results of output parameters
Step IV: Reiteration of the procedure utilizing different assumptions regarding the input parameters
Step V: Analysis of the results with the demonstration of appropriate histograms and summary statistics like mean or median value, variance etc

In the present study, 7 different scenarios were evaluated with Monte Carlo simulation for three different time slides, namely 2013, 2015 and 2020. The input parameters of the examined scenarios are presented below, while the calculated LCOE was the output parameter of the implemented uncertainty analysis.

The examined scenarios focused on the analysis of the following parameters' variation:

- ❒ Capital cost
- ❒ Operational & Maintenance cost
- ❒ Capacity factor
- ❒ Discount rate
- ❒ Loan share
- ❒ Interest rate

Moreover, an additional scenario was developed examining the simultaneous impact of all previously mentioned parameters to the calculated LCOE.

Triangular distributions were selected in order to depict the contribution of each parameter to the triggered fluctuations in the calculated LCOE estimates. The specific distribution type is selected on the basis of factors such as implementation simplicity, previously successful applications of these distributions in similar case studies and the capability of providing all the necessary data more realistically.

The description of the examined parameters and the selected triangular distribution is described in the following section.

3. Assumptions

For the scope of this work, certain assumptions are made in order to formulate the two typical cases for the estimation of LCOE, namely those of a wind park and a photovoltaic station. The list of assumptions is presented below. It should be mentioned that the definition of the specific parameters is performed taking into consideration that the implemented analysis examines a 20 MWp typical wind park and a 500 kWp photovoltaic station. Moreover, the suggested assumptions aim to act as representative ones and do not represent current nor expected extreme figures of cost and technology –related parameters of the market. In this sense, scope of the study is to assess and analyze the impact of the various parameters to the LCOE and not to evaluate and compare the findings with existing support schemes.

➢ ***Technological parameters***

- *Capacity factor (%)*

The capacity factor is considered as one of the most crucial parameters for the economic evaluation of RES investments, as it represents the annual electricity production of a power plant. The capacity factor mainly depends on the available RES potential (e.g. wind potential and solar irradiation for the case of wind and photovoltaic plants respectively) and various technological parameters that affect a plant's efficiency. Determining the capacity factor for a RES plant in a certain region is a complicated procedure depending on a large number of uncertainties and as such its variations can severely affect the calculation of LCOE. For this reason, the capacity factor is selected as one of Monte Carlo analysis' input parameters. The appropriate triangular distributions assumed for the capacity factors of both typical plants are presented in Tables 1 and 2. The capacity factor of a typical wind park is assumed to have quite intense variations due to the significant entry of new wind parks, which are expected to be developed in the islands of the non-interconnected system of Greece by 2020, exploiting significantly higher wind potential in comparison to the wind potential exploited by units operating in the mainland of Greece. However, sites with lower wind potential will be also exploited following the expected growth and penetration of wind in the energy mix. The capacity factor is also highly influenced by the technological progress, resulting to higher values per installed MW at the same regions in the future mainly for the case of photovoltaic plants.

- *Electricity curtailment (%)*

The level of absorption of the produced electricity by the electrical system is subject to restrictions implied by the energy curtailment, which can occur when the customer load is low and RES generation is high. The electricity curtailment can be also differentiated from the potential development of RES storage projects and from the imposed uncertainty during the prediction of electricity demand. For the purposes of the current paper the electricity curtailment is considered relatively low and is fixed at 2% for the Greek electricity system for both of the two examined cases.

- *Annual reduction of produced electricity (%)*

  Only for the case of the typical photovoltaic station a reduction on its technological efficiency is assumed, which leads to 1% annual reduction of the produced electricity due to the technological degradation of the photovoltaic systems.

- *Lifetime (years)*

  The plant's lifetime is considered to be the planning horizon of the economic analysis performed and is set equal to 20 years for both examined cases.

➢ ***Cost parameters***

- *Capital cost (€/kW)*

  The capital cost of the technologies considered in this paper and its future development are assumed on the basis of international studies and reports on the costs of RES technologies (International Renewable Energy Agency, 2012a, 2012b and 2012c; Black & Veatch, 2012; Ministry of Environment, Energy and Climate Change, 2012) taking into account national circumstances. The capital cost refers to all cost expenses occurring before the actual operation of a plant and concerns development (engineering, licensing, land, etc.), construction (equipment, transport, installation), connection works and financial cost during construction (interest, etc.). The fluctuation of LCOE due to the variations of the capital cost is analyzed with the implementation of Monte Carlo analysis defining the appropriate triangular distributions (see Tables 1 and 2). The potential inclusion of taxes in the future for specific types of components constitutes an additional source of uncertainty, which affects the estimated LCOE.

  Specifically for the case of wind parks, the capital cost can be differentiated significantly according to the topology of the installation location of a wind park, considering the equipment transportation costs, grid enhancement works and various other parameters affecting installation cost. Moreover, the installation of a wind park in the non-interconnected islands implies an additional cost due the required civil works and grid connection costs, which can result to an increase up to 15% of the total capital cost.

- *Operational and maintenance cost (%)*

  The operational and maintenance costs are considered on an annual basis from the first year of the plants' operation and refer to the annual expenses required for operating and maintaining the plant. In particular, these constitute the cost of repairs and maintenance works, the insurance cost both for the project and for the annual revenues, wages, labour, management cost and other miscellaneous operating expenses, such as benefits to third parties, rentals, material consumption and other general or unexpected expenses. For both technologies, photovoltaic and wind parks, these costs are considered fixed. The determination of the specific cost component is performed taking into consideration the mean cost for the operation of the existing units and it is expressed as a share of capital cost. The variation of LCOE due to the impact of the operational and maintenance cost is analyzed with the implementation of Monte Carlo analysis defining the appropriate triangular distributions (see Tables 1 and 2).

- *Special levy in favor of local authorities (%)*

  In the presented analysis, cost parameters related with the existing support scheme in Greece have been also considered in order to obtain more representative results. In specific, every RES-electricity producer is subject to a special levy (annual fee), specified by a Joint Decree of the Ministers of Finance and Development. This special levy is set at three-percent (3%) of the producer's electricity sales to the grid. This charge is collected by LAGIE S.A. (the Operator of the Greek electricity market) and is given to the local authority, within the area of which the RES power facility operates, for the finance of local development projects. PV plants are exempted from this obligation.

➢ ***Macro-economic and financial parameters***

- *Inflation (%)*

  The inflation as expressed by the consumer price index affects directly the operating expenses of each examined investment. Within the scope of the present study, the current inflation rate is set equal to 0.5% for 2013, while the weighted average inflation rate for 2015 and 2020 is considered equal to 2% taking into account both the current figures and the forecasts regarding the evolution of Greek economy.

- *Discount rate (%)*

  The discount rate is a crucial parameter, which represents the minimum acceptable profit of an investment. Specifically, the discount rate consists of the desired investment rate of a safe investment (opportunity cost) and the acceptable rate in order to secure the investment (cost risk). The discount rate is another uncertain parameter as it is difficult to predict the future conditions in relation to the degree of technological maturity for each examined technology and to evaluate other parameters, which are related directly to the risk of each investment. The triggered fluctuation due to the impact of discount rate is analyzed with the identification of triangular distributions within the framework of Monte Carlo analysis (see Tables 1 and 2).

- *Taxation (%)*

  The effective tax scheme is considered as an important parameter that affects the cost of electricity production. The tax rate depends on the type of enterprise and the general fiscal framework regarding the taxation policy of dividends and investments. In the present study, a taxation rate equal to 20% is assumed for 2013, while according to newly adopted taxation policy the rate is expected to reach 26% for both 2015 and 2020.

- *Residual value (%)*

  The residual value of the examined investment is assumed to be zero after the completion of the 20 year period of the operational lifetime.

- *Depreciation*

  The depreciation rate refers to the gradual reduction of the value of the fixed assets of an investment (i.e. construction costs) and is utilized for recovering the initial investment and any potential replacement of the equipment until the end of life. In the present study, the depreciation of the investment is performed allocating equivalently on an annual basis the capital cost during the examined period of 20 years for both wind parks and photovoltaic stations.

➢ ***Financing scheme parameters***

The financing scheme of each investment is formed according to the prevailing financial market conditions, the RES technology and the investor's characteristics. It may include a combination of input from the following sources:

- Own capital (%), which usually varies from 25% to 70%
- Loan (%), the level and parameters (loan duration, interest rate, etc.) of which relies highly on the national financial and credit environment. The loan usually varies from 30% to 75%.
- Subsidy (%) according to the corresponding framework with financial incentives.

Other significant parameters regarding the financing scheme of the examined investments are the interest rate and the loan duration. The interest rate varies depending on the characteristics of the investor, the loan amount and the general economic environment. For the purposes of the current analysis, no subsidy is considered for the development of the RES plants as well as no extra electricity curtailment that could lead to additional compensation. However, in this analysis, no parameter related to the cost of money for the time duration through the licensing procedure is considered, which especially for the case of wind parks can be rather significant. On the other hand, the loan scheme and the interest rate are defined with appropriate triangular distributions for their simulation with the implementation of Monte Carlo analysis.

Finally, the duration of the loan is assumed equal to 10 years for both of the examined technologies.

The establishment of the triangular distributions is performed assuming a gradual improvement of the economic environment, as depicted for both the higher share of loan and the lower interest rate (see Tables 1 and 2). The selected triangular distributions for the implementation of Monte Carlo analysis are presented in Tables 1 and 2.

4. Results and Discussion

The proposed methodological approach was applied to the aforementioned selected typical cases and the obtained results regarding the LCOE are presented for each examined scenario separately. Beginning with the analysis of the examined wind park, a significant decrease of the calculated LCOE is achieved in 2020 in comparison to the corresponding estimates for 2015 and 2013 (Figure 1). Specifically, the LCOE ranges between 48 and 92.6 €/MWh in 2020, between 54.8 and 102.6 €/MWh in 2015 and between 64 and 122.3 €/MWh in 2013. This wide range of LCOE variation, while considering all the available parameters, leads to a first finding that the "concept" of a typical wind park cannot be justified and that on the contrary different "types" or "categories" of wind parks should be addressed and monitored separately.

Table 1:Defined assumptions for the estimation of LCOE for the examined wind park.

Wind	2013			2015			2020		
	min	mode	max	min	mode	max	min	mode	max
Capital cost (€/kW)	1,100	1,200	1,400	1,070	1,100	1,250	990	1,040	1,200
Discount rate (%)	8.0%	9.0%	11.0%	8.0%	9.0%	11.0%	7.0%	8.0%	10.0%
Loan (%)	30.0%	60.0%	70.0%	30.0%	60.0%	70.0%	30.0%	60.0%	80.0%
Interest rate (%)	8.0%	9.0%	9.5%	6.0%	7.0%	8.0%	5.0%	6.0%	7.0%
Capacity factor (%)	21.0%	26.0%	35.0%	21%	26.0%	35.0%	21%	26.0%	35.0%
O&M (%)	3.0%	3.4%	4.0%	2.0%	3.2%	4.0%	2.0%	3.0%	4.0%

Table 2: Defined assumptions for the estimation of LCOE for the examined photovoltaic station.

PV	2013			2015			2020		
	min	mode	max	min	mode	max	min	mode	max
Capital cost (€/kW)	1,000	1,250	1,400	950	1,100	1,184	865	1,000	1,075
Discount rate (%)	8.0%	9.0%	11.0%	8.0%	9.0%	11.0%	7.0%	8.0%	10.0%
Loan (%)	0.0%	40.0%	70.0%	0.0%	50.0%	70.0%	30.0%	60.0%	80.0%
Interest rate (%)	8.0%	9.0%	10.0%	6.0%	7.0%	9.0%	5.0%	6.0%	8.0%
Capacity factor (%)	16.0%	17.0%	18.7%	16.2%	18.0%	19.8%	17.1%	19.0%	20.9%
O&M (%)	1.5%	2.5%	3.0%	1.5%	2.0%	3.0%	1.5%	2.0%	3.0%

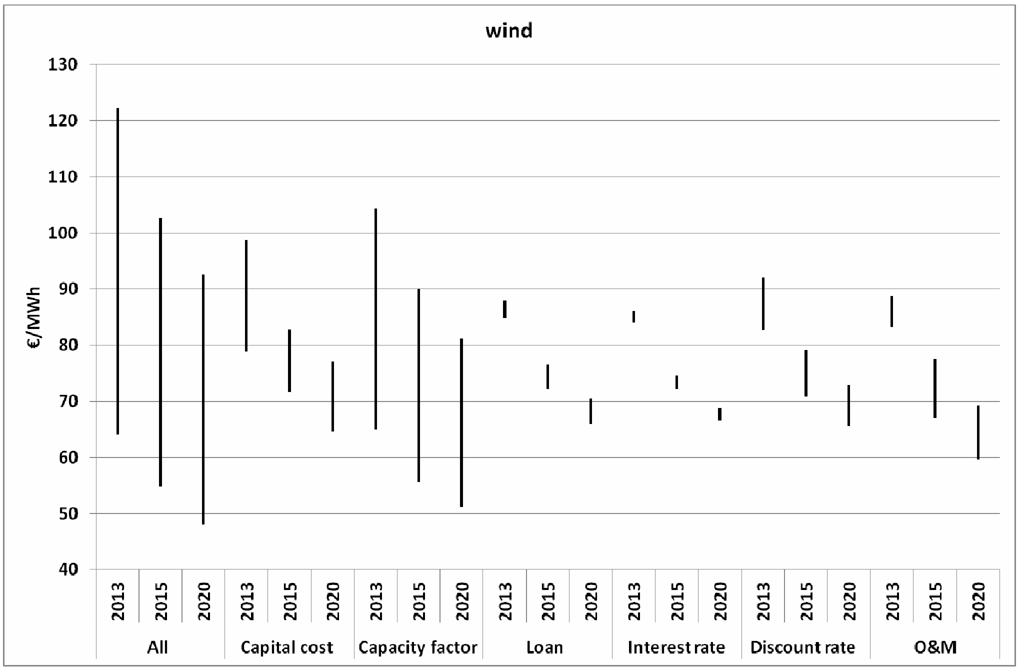

Figure 1: Range of LCOE of the examined wind park due to the impact of the examined uncertain parameters.

However, valuable observations result from the time analysis of this methodological approach.

The scenario, which assumes that all parameters are simultaneously uncertain, has the highest fluctuation for all the examined time slides in comparison with the other scenarios. Therefore, it is important to identify which parameter contributes mostly to the creation of this variation of LCOE estimates.

As depicted in Figure 1, the capacity factor is considered as the parameter with the highest contribution to the triggered fluctuation. The LCOE for this specific scenario ranges between 51.2 and 81.1 €/MWh in 2020, between 55.7 and 90 €/MWh in 2015 and between 65 and 104.4 €/MWh in 2013.

The impact of capital cost becomes less important in 2015 and 2020 as the technological advancements have moved forward. Finally, the impact of the discount rate and the operation and maintenance cost appear to be more decisive factors for the estimation of LCOE in comparison to the contribution of interest rate and loan portion. Nevertheless, the impact of operation and maintenance cost seems to be similar with the capital cost in 2015 and 2020.

Figures 2-4 present the percentiles of LCOE for the three examined time slides in order to identify the possibility of LCOE to be lower than or equal to a specific value. As presented in Figure 2, 70% of the iterations lead to a range of LCOE between 85.5 and 92.4 €/MWh in 2013 among the examined scenarios for the associated parameters. The corresponding range in 2015 is between 73.6 and 78.8 €/MWh (Figure 3), while in 2020 it is lower, i.e. between 65.9 and 71.6 €/MWh (Figure 4).

The fluctuation of LCOE is smoother in the scenarios examining the impact of loan, interest rate, discount rate and operation and maintenance cost, while the contribution of capital cost and capacity factor is more intense. Therefore, the continuous monitoring of these uncertain parameters is vital for the effective design of the RES support scheme for the case of wind energy.

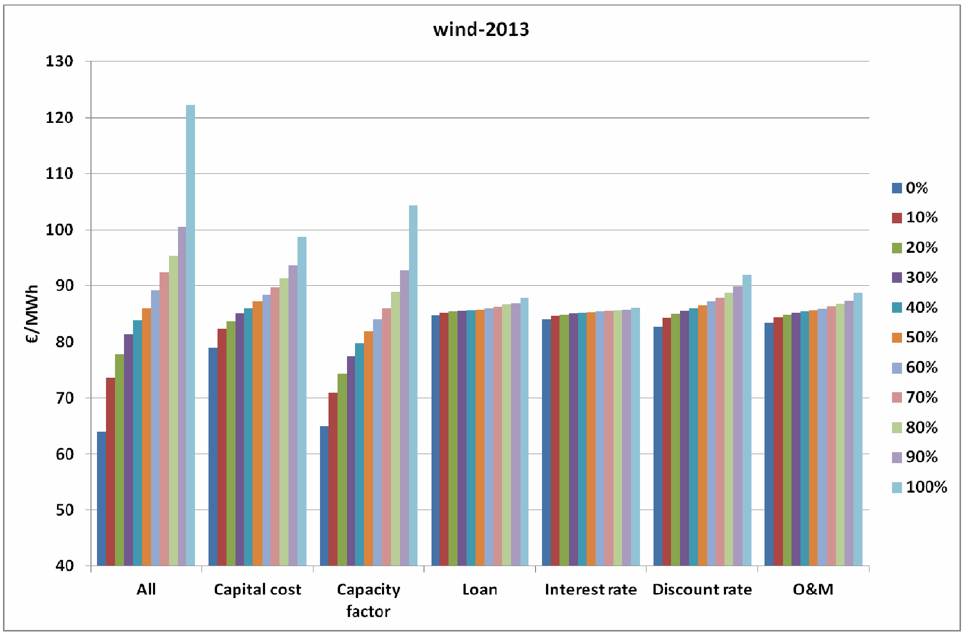

Figure 2: Percentiles of LCOE for the examined wind park in 2013.

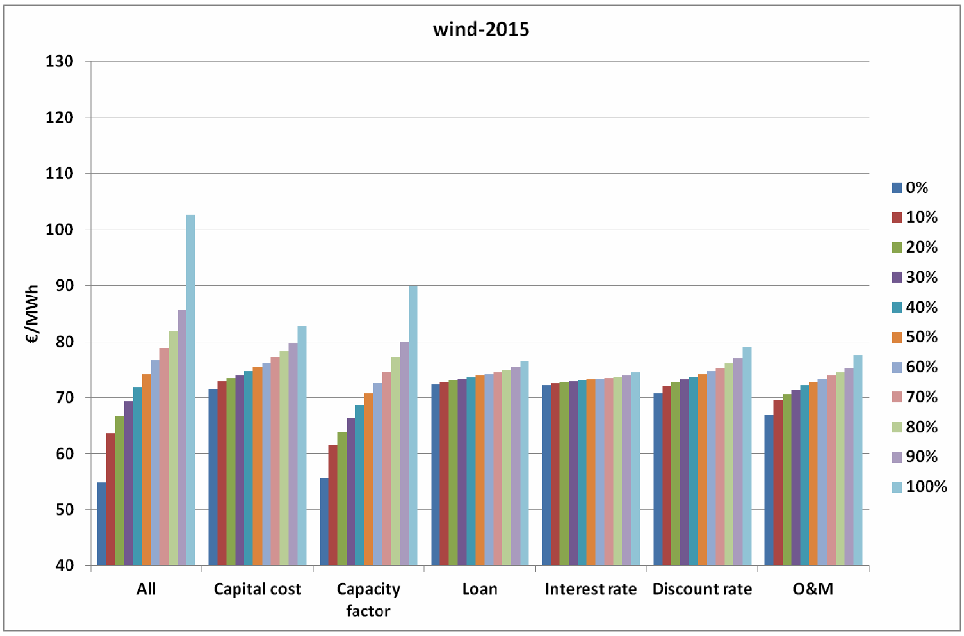

Figure 3: Percentiles of LCOE for the examined wind park in 2015.

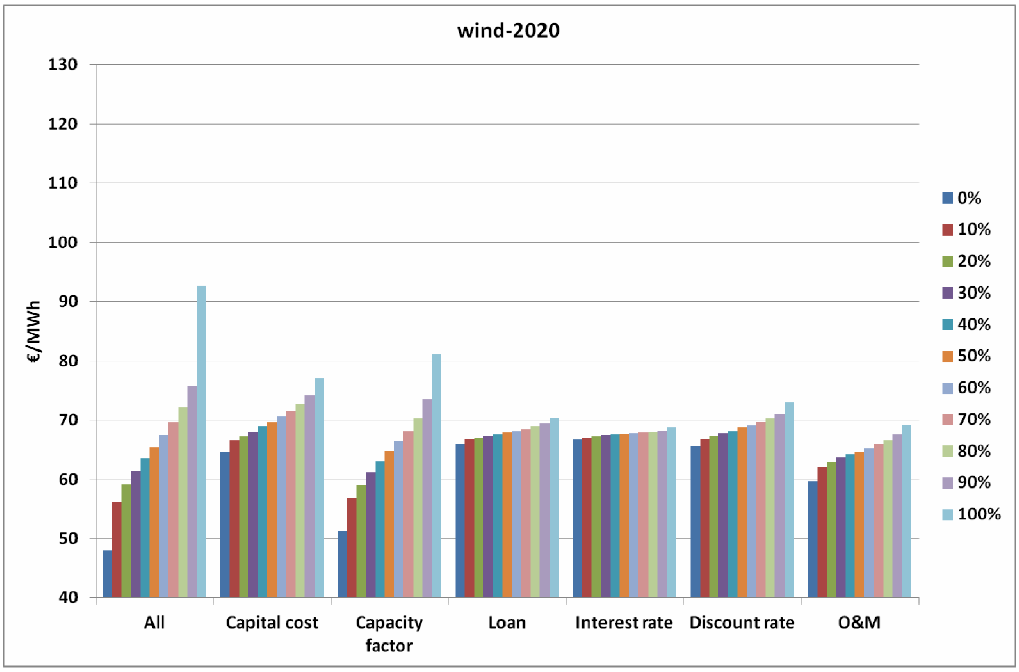

Figure 4: Percentiles of LCOE for the examined wind park in 2020.

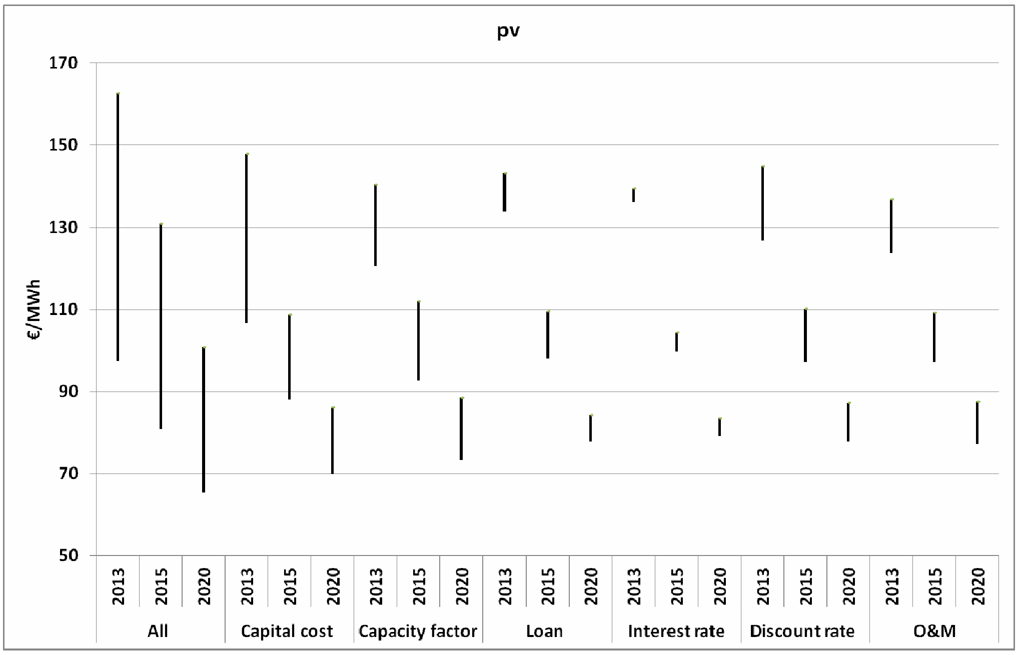

Figure 5: Range of LCOE of the examined photovoltaic station due to the impact of the examined uncertain parameters.

The same analysis was performed for the examined photovoltaic station.

According to the obtained results, a significant decrease of the calculated LCOE will be achieved in 2020 in comparison with 2015 and 2013 (Figure 5). More specifically, the LCOE will range between 65.4 and 100.7 €/MWh in 2020, between 80.8 and 130.9 €/MWh in 2015 and between 97.3and 162.8 €/MWh in 2013. The exhibited wide range of LCOE, also for the case of photovoltaics, reveals the need of examining separate categories of projects with more uniform characteristics and values for the associated parameters in order to isolate smaller ranges of capital cost and capacity factor.

In specific, the capital cost is considered as the parameter with the most important contribution to the triggered fluctuation of LCOE (Figure 5). Specifically, the estimated LCOE in the case of the capital cost ranges between 69.9 and 86.1 €/MWh in 2020, between 88 and 108.8 €/MWh in 2015 and between 106.8 and 147.9 €/MWh in 2013. Finally, the impacts of capacity factor and discount rate appear to be more decisive factors in comparison with the contribution of the other parameters.

Figures 6-8 depict the percentiles of LCOE for the three examined time slides for the identification of the possibility of LCOE to be lower than or equal to a specific value. As presented in Figure 6, 70% of the iterations lead to a range of LCOE between 132.6 and 139.3 €/MWh in 2013 among the examined scenarios for the associated parameters. The corresponding range in 2015 is between 102.1 and 109.3 €/MWh (Figure 7), while in 2020 is lower, namely between 80.7 and 85.6 €/MWh (Figure 8).

The fluctuation of LCOE is almost identical for all the examined scenarios, a fact that proves the significance of continuously monitoring these uncertain parameters for the effective design of the RES support scheme for the case of photovoltaic energy.

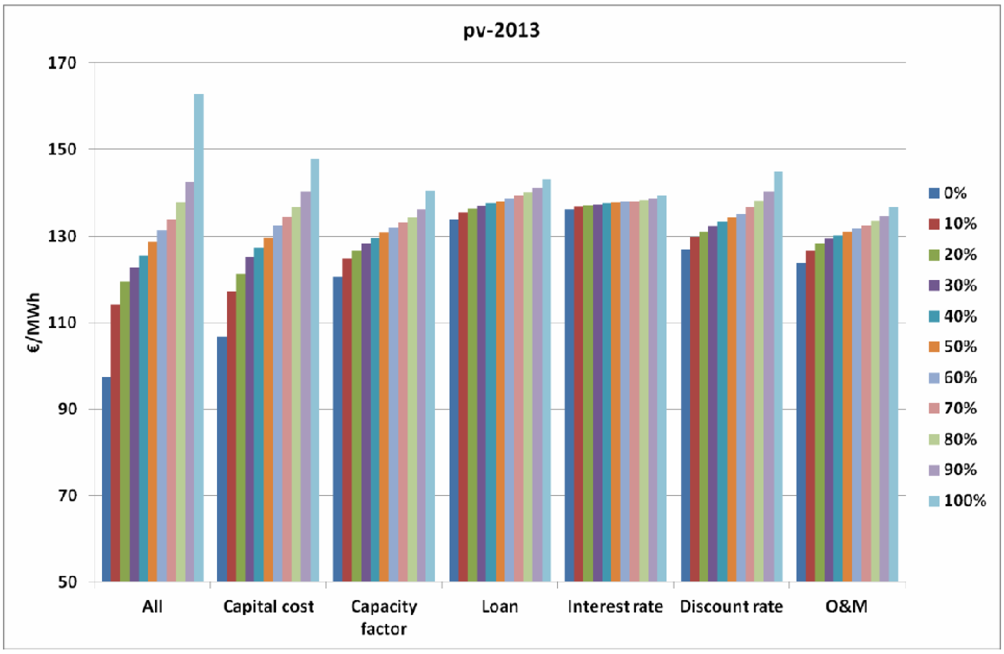

Figure 6: Percentiles of LCOE for the examined photovoltaic station in 2013.

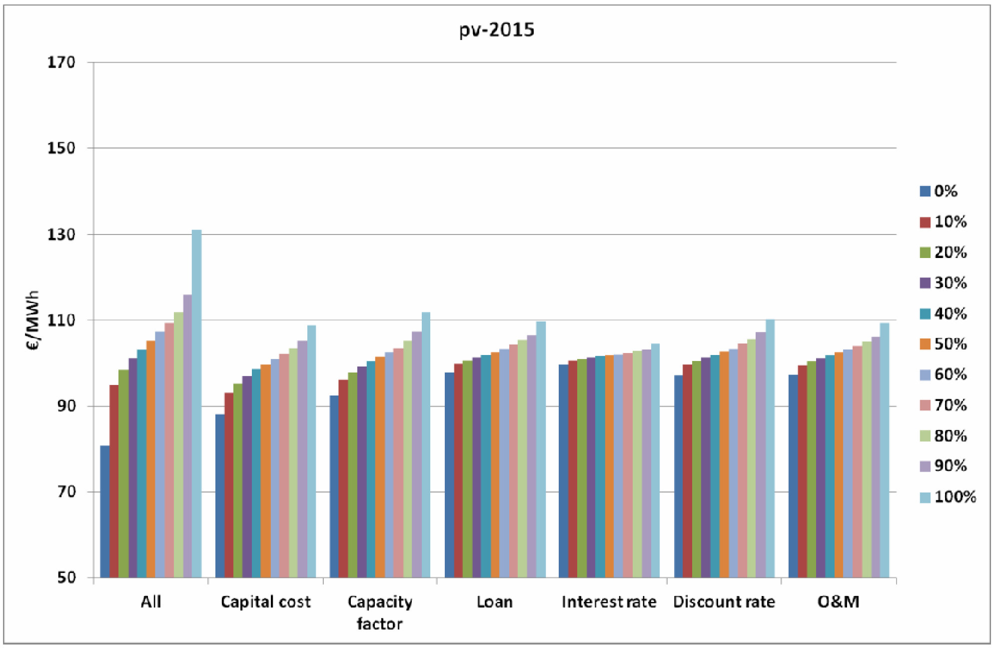

Figure 7: Percentiles of LCOE for the examined photovoltaic station in 2015.

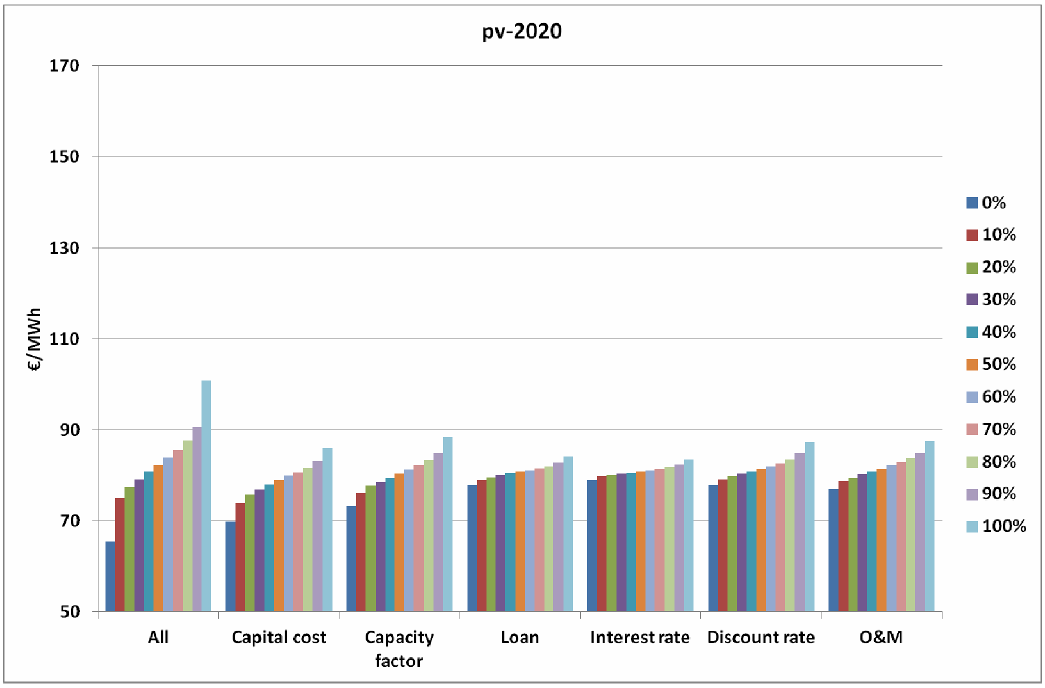

Figure 8: Percentiles of LCOE for the examined photovoltaic station in 2020.

5. Conclusions

A methodological approach is proposed within the scope of the current paper in order to identify and analyze the impact of the various parameters to the investment's viability for typical RES plants in terms of LCOE. This methodology could also act to the effective evaluation of existing support schemes and the strategic design of new policies and financial mechanisms for the further development of RES technologies in the future. Specifically, the combination of LCOE estimation and the implementation of Monte Carlo analysis provides a methodological framework for both the examination of the economic viability of RES technologies as well as the manipulation of those uncertain parameters that affect their economic efficiency and lead to significant fluctuations. The approach was implemented for a typical wind and photovoltaic unit and showed that a significant decrease of LCOE is expected until 2020 for both of the examined technologies. Moreover, the capacity factor for wind energy and the capital cost for photovoltaic energy are identified as the most influential parameters to the creation of the triggered fluctuation. In this context, the integration of market based figures for all the referenced parameters as well as the insertion of others if applicable, could either narrow or shift the resulted ranges of LCOE and lead to different categories of projects for the same technology, which must be examined separately. Therefore, it is suggested that the proposed methodology is implemented on a continuous basis enabling the monitoring, assessment and updating of the available RES support schemes. Finally, the integration of additional uncertainty techniques into the proposed methodology, such as Fuzzy sets, Real Option Valuation method, Bayesian techniques etc., will be further examined in future research.

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The impact of Renewable Energy Project in Nepal

by

Dr. Alexander SPACHIS

Ambassador / Head of Delegation - Delegation of the European Union to Nepal

Mr. Lluis NAVARRO

Head of Cooperation - Delegation of the European Union to Nepal

Mr. Ranjan Prakash SHRESTHA[1]

Senior Programme Manager - Delegation of the European Union to Nepal

[1] *Contact details of corresponding author*

Tel: +977-1-4429445
Fax: + 977-1-4423541
e-mail: Ranjan.SHRESTHA@eeas.europa.eu
Address: Uttardhoka Sadak, Lainchaur, Kathmandu, NEPAL

Abstract

A mountainous country Nepal situated between two economic giants - India and China has one of the world's lowest rates of per capita electricity consumption averaging 80 kWh annually, despite its huge hydro potential. Nepal has formulated various policies and strategies to expand energy services, however energy access to poorer segment of the country remain very poor. Nepal lacks investments to harness its hydropower potential to transform its social, economic and environmental development. European Union has been supporting developing countries to manage pressure on water, energy and land for inclusive and sustainable development through its development cooperation programmes. Further, EU's new development policy "Agenda for Change" also identifies energy as a key driver for inclusive growth. Renewable Energy Project is one of the EU's initiatives to create renewable energy infrastructure in remote areas to alleviate poverty in Nepal. This papers aims to analyse and demonstrate the impacts of renewable energy services on improving living conditions through economic empowerment, sustainable growth and delivery of social services. It also examines and analyses the impacts of the projects in line with a correlation between energy and poverty, including specific impacts on MDGs. Further, the paper analyses dependency on conventional and fossil fuels and thereby promotion of sustainable and renewable energy technologies that contributes to the reduction of emission of the Greenhouse Gases, improving the environment at local and global level. The authors explore initiatives of various actors, including SE4ALL to increase access to energy services that has a multiplier effect on livelihood of rural population.

Key words: Energy, environment, project, livelihood

Introduction

A 15 Million EUR Renewable Energy Project - NPL/AIDCO/2000/2244 (2589) was one of the initiatives of the European Union (EU) to create renewable energy infrastructure in remote areas of Nepal to alleviate poverty through income generation, sustainable growth and delivery of social services. The main aim of the project was to increase access to energy service facilities to rural communities without grid extension or micro or mini-grid hydro-power potential, contributing towards the rural development of Nepal.

Description of the Project

Country	: Nepal
Title	: Renewable Energy Project
Total budget	: EUR 15.675 million
EU contribution	: EUR 15 million
Government of Nepal	: EUR 0.675 million
Project period	: 2004 - 2012
Installed capacity	: 1.02 MWp
No. of PV systems	: 933 (EUR 10 million)
No. of solar thermal	: 38 (0.15 million)
No. of districts	: 21 districts
No. of beneficiaries	: Approx. 1 million
Executing agency	: Alternative Energy Promotion Centre (AEPC), Ministry of Environment, Science and Technology, Government of Nepal

Figure 1: Project Implemented Districts.

PV Package	Number of PV packages in						Total PV packages
	Lot 1	**Lot 2**	**Lot 3**	**Lot 4**	**Lot 5**	**Lot 6**	
Health post	-	68	39	42	57	-	206
School-1	-	74	45	47	72	-	238
School-2	-	31	29	34	46	-	140
Computer literacy	-	12	6	11	0	-	29
Community communication centre	-	33	20	38	33	-	124
Community entertainment	-	16	17	21	5	-	59
Agro-grind milling	107	-	-	-	-	-	107
Water pumping	-	-	-	-	-	30	30
Total	**107**	**234**	**156**	**193**	**213**	**30**	**933**

Nepal has 75 districts and the project was implemented in only 21 districts. These districts were selected on the basis of following criteria:

- low electrification
- large number of rural communities with remote possibility of electric-grid extension in next 5 years
- large number of rural communities residing in the areas with no potential sites for mini/micro-hydro power generation
- low human development index
- high solar radiation
- existence of mature Community Organizations (COs) groomed by other interventions

The main objective of the REP is to contribute to reduce poverty in rural areas of Nepal by improving the quality of social service delivery and by creating income generating opportunities for local communities. The project has been implemented in 21 hilly and mountainous districts of Nepal, with a target of benefitting more than 1 million people from improved social services and increased income due to the availability of electricity in their communities.

The project supported installation of solar PV and solar thermal equipment in 206 health posts, 378 schools, 107 milling, 30 water pumping, and 212 other community services that includes computer literacy, community entertainment, community telecommunication centres, 38 solar thermal systems that include 24 solar dryers and 14 solar hot water systems.

The solar systems worth EUR 10 million have been installed in schools, mainly primary/secondary/higher schools for light, audio visual education, training and entertaining, computing, internet service, printing, and photocopying facilities, and rural health posts for lighting, vaccine refrigerators, and other vaccines. The electricity provided for communities to use for lighting, computer education, adult literacy classes, audio-video entertainment, telecom, computing internet service and training as well. There were solar thermal systems for the total amount on EUR 150,000 to promote agro-business (agro-grinding, tea withering and drying, drying of hand-made paper, drying of crops and spices) and hot water supply for tourism industry in rural areas. The installation of water pumping is for drinking and other domestic use.

Key Impacts of the Project

The project stimulated the rural development by improving energy service provision to end users in rural communities with no grid extension or mini-grid hydro-power potential. It has been instrumental to provide energy service for social services of the rural communities. The key impacts of the project are as follows;

- Drudgery reduction and time saving of the beneficiaries of all the water pumping systems. Women are benefited as they used to fetch water from a distant water-source before the installation of solar water pumping system. The saved time is being used in other activities such as kitchen gardening, cattle farming, studying etc..
- Availability of nearby agro-grinding facility with the aid of solar PV powered agro-grind milling systems has started reducing the drudgery and saving the time of the beneficiaries to a considerable extent. Prior to installation of the milling systems, the users had to walk a long distance with the load agricultural grains for milling.
- Computers, printers and photocopy machine are being operated with solar power in all the schools supported by the project. The computer education is being provided to the students of remote rural areas who had never got such opportunity before.
- The villagers are able to use mobile phones and CDMA phones due to availability of charging facilities in their village. They can also talk to their family abroad due to these facilities.
- They internet facilities are available at the village and they can use the internet for information and knowledge outside the village.
- The lighting facility in the rural health posts, the health workers are now providing services to the emergency case patients in night times also. Particularly, pregnant women have been benefitted during the delivery.
- The project has been beneficial to build and strengthen the capacity of the Nepalese institutions. The project contributes to the capacity building of AEPC officials, providing an opportunity to take trainings and studies abroad. It also assisted to extend AEPC's Management Information System (MIS) to institutional solar PV and solar thermal applications; electronic monitoring of all projects; public access to the MIS via Internet.
- The project supported Renewable Energy Test Station to equip and staffed for to perform the quality control of solar energy equipment, including the solar thermal applications. The quality assurance schemes, codes of practices, and
- minimum standards for institutional solar PV systems etc. have been developed in central and rural areas;

Obstacles for the promotion of small hydro in Kazakhstan: analysis of the barriers to technology transfer

As. Prof. Sergey INYUTIN

Head of IT Department of the "Turan-Astana" University

Dr. Yevgeny KALASHNIKOV

President of SRC KAHIMINVEST

Dr. Lyubov INYUTINA

Head of the Department of Innovative Technologies, SRC KAHIMINVEST

Contact details of corresponding author

Tel:+7 7172- 437703
Fax:+7 7172- 437703
e-mail: lyubov.inyutina@mail.ru

Address:33/20, Seifulin Street, Branch of SRC KAZHIMINVEST, Astana, Republic of Kazakhstan

Abstract

Modern hydropower is the most energy-efficient and environmentally friendly method of power generation as compared to other traditional power industry sectors. Small hydropower along with wind is more advanced in Kazakhstan among climate technologies to be transferred. Kazakhstan's total hydro potential amounts to 170 terawatt-hours (TWh), and the already exploited amounts around 30 percent of the technical-economic exploitable. The main reason for this gap is the lack of effective implementation of projects and funding mechanisms. The authorities in Kazakhstan showed great interest in the development of small hydro projects as a way to compensate the deficit in electricity demand for South rural areas in the amount of 7 TWh. The paper presents an analysis of barriers and identification measures to facilitate the promotion of climate technologies in Kazakhstan. The tools such as Logical Problem Analysis (LPA) and Market Mapping are applied for this analysis. and a guide to the development of a Renewable energy Action Plan is presented. The results will contribute to the improving of RES planning, climate projects development, security of power supply. Adequate access to financing will facilitate small hydro construction and 10% increase employment in the remote areas by 2020.

Keywords: RES, energy plan

1. Introduction

The leading nations of the world are already working to develop and implement mid to long-term goals to develop Renewable Energy Sources (RES). Though fossil fuels remain cost competitive, governments in the developed world have already realized the potential of RES and are actively investing in and developing related industries.

Kazakhstan has very large coal, oil, gas and uranium resources that are all being actively exploited. From the point of the abundance of energy resources and availability of cheap coal for power sector(power generation is more than 85% based on coal) there is lack of a driver in developing renewable energy sources (RES), but from the point of the necessity to reduce greenhouse gas (GHG) emissions and to strengthen local power supply and energy independence brought the attention of the Government of Kazakhstan (GOK) to improve energy efficiency and promote RES.

In line with this global trend, the government of Kazakhstan has also set a target to meet 3% of its energy needs with Renewable Energy Sources by 2020[1], which is equivalent to 2.5 TWh [2] of total energy consumption with RES by 2020. Taking international trends and experiences into account, Kazakhstan must develop a strategic direction for RES development that is tailored to its current needs and conditions.

2. Current status, potential of RES development

Modern hydropower is the most energy-efficient and environmentally friendly method of power generation as compared to other traditional power industry sectors. Mini hydropower is even more advanced in this field. Small hydro is actual for rural areas where there is deficit of electricity or for providing an extra contribution to national grid for peak demand.

Of great importance are the small hydropower plants (SHP), the power of less than 35 MW. The greatest prospects in the development of small hydro power plants exist in the southern sub regions of the country, with considerable potential, but at the same time importing electricity from the northern regions.

The majority of SHPs don't have large water reservoirs that is to say water is not accumulated behind a dam. They generate power, if a natural water level in the river is sufficient, but in the periods of drying out or decrease of the flow speed below a certain value, power is not generated.

High capital costs are the largest barrier to development of small hydropower. However, in spite of this fact and a long pay-back period (7-10 years in some countries), small hydro power plants are cost-effective because of their long-lasting lifetime (over 70 years) and low costs for technical maintenance.

The energy sources for small hydropower are:

- small rivers and streams,
- natural fluctuations of heights in lake water catchment areas and in irrigation channels of irrigation systems,
- technological watercourses (industrial and sewage) discharges,
- fluctuations of heights of drinking pipelines, water preparation systems and other pipelines constructed to pump various types of liquid products.

Application of small hydro-power technology lines with the country's social, economic and environmental development priorities. With regard to the country's social development priorities, application of the above-mentioned technology will create new employment opportunities and will also have a positive influence on public opinion, which would realize the necessity to protect the environment and reduce consumption of the traditional energy resources. Regarding the country's economic development priorities, the technology will reduce energy production costs. With regard to the country's environmental development priorities, the application of an environmentally sound technology that has zero emission will help create a better environment.

Hydropower accounts for approximately 12% of Kazakhstan's total generating capacity (19, 488 MW in 2010) [1]. Average annual hydropower generation in Kazakhstan amounts to 7.78 billion kWh [3]. By absolute indices of potential hydro resources Kazakhstan is third amongst countries with emerging economies [4]. Hydro resources are spread throughout the country, but there are three major districts: the Irtysh River basin with main tributaries (Bukhtarma, Uba, Ulba, Kurchum, Kardzhil), South-Eastern zone with the Ili River basin, and the Southern zone – basins of Syrdaria, Talas and Chu rivers.

Kazakhstan has significant hydro potential concentrated mainly in the east, south and southeastern parts of the country. On the mountain rivers of the southern regions of the country holds about 65% of hydropower. According to the research of the Republic of Kazakhstan gross hydro potential can be estimated as approximately 170 billion kWh / year, it is technically possible to implement - 62 billion kWh, of which about 8.0 billion kWh of capacity of small hydropower plants [3], [6].

3. Preliminary targets for technology transfer. policy framework

Effective development of power sector is the base for sustainable economy development in Kazakhstan. The main strategic plans and programs for Kazakhstan's' development up to 2015, 2020, such as: "Strategic Plan 2020"[45], "Government program for Acceleration of Industrial and Innovation Development of Kazakhstan (2010-2014)", "Program on power sector development 2010-2014"[46] include tasks on modernization and upgrade of existing, construction of new generating capacities and network; coal industry development. improvement of electric market; involvement into power balance the renewable energy sources (RES); and "Action Plan for alternative and RES development in Kazakhstan for 2013- 2020"[47]. National targets defined in these documents will assist to decrease energy intensity of GDP 10% by 2015 and 25% by 2020 according to" Strategic Plan 2020".

Small hydro power is one of elements of the renewable energy sources (RES) in Kazakhstan. The law on "Support of Use of Renewable energy Sources" [48](below-the RES law) adopted in 2009 classified RES by capacity less 35 MW. The target set for RES share in total electricity consumption will amount more than 1% by 2015; more than 3% by 2020 and electricity generation from RES in amount of 1 billion kWh per year by 2015 (see Table 1).

The target for small hydro power set in the Program named above is the construction of more than 100 MW installed capacity in Almaty, Zhambyl and South Kazakhstan Oblasts by 2015.

[45] GOK Decree #.922 ,dated 01.02.2010
[46] GOK Decree #1129, dated 29.10.2010
[47] GOK Decree # 43, dated 25.01.2013
[48] President Decree #165-I, dated 04.07. 2009

Table 1. Electricity generation from RES by 2015, billion kWh (Source: Government program for Acceleration of Industrial and Innovation Development of Kazakhstan (2010-2014), Program on power sector development 2010-2014).

	Name	2009	Projection				
		fact	2010	2011	2012	2013	2014
1.	Electricity generation from RES, billion kWh	0.37	0.38	0.45	0.60	0.80	1.00

The target for small hydro power set in the Action Plan is aimed to construct 205,45 MW capacity of small hydro by 2020, covering 17 projects with estimated budget of 39 441,85 million KZT(262.9 million USD).

Programs of small hydropower development in Kazakhstan include reconstruction and renovation of previously constructed small HPPs, adding small HPPs to water management projects with already existing water retaining structures with the aim of utilizing waste releases, and construction of new small HPPs for power supply of users in the outlying districts of the power system. The favorable factors for the development of hydro potential are:

- Interest of regional authorities in small hydro;
- Private investors of small hydro are provided with state short-term credits;
- There are some privileges (tax holidays) in realization of investment projects

Rough estimates show that application of small hydro-power plants technology will result in total GHG emission reduction in amount of 914 thousand tons of CO_2 by 2015.

Despite the interest to promote small hydropower plants, Kazakhstan currently has several hundred MW of capacity under construction in the form of large hydroelectric power plants. Despite having national plan and policy Kazakhstan has not performed as expected, thus more RES development with Action Plan is required to meet national RES target.

4. Barrier analysis and possible enabling measures for small hydro power technology transfer

Identification of barriers

As an initial step in the process of barrier analysis, a desk study of policy papers and other pertinent documents was conducted in order to identify the primary reasons why the technology is not currently applied widely, and why neither the private nor public sectors have invested significantly in it. Next, a consultation process was conducted with stakeholders through direct interviews and questionnaires.

After compiling a long list of barriers, a stakeholder workshop was organized, the barriers were screened under the leading of Heads of thematic groups and grouped under different categories (information, social, technological, capacity building, economic/financial, policy/regulatory). A simple method was applied for identification of most important barriers by grouping them into key and non-key barriers and using criteria such as starter, crucial, important, less important and insignificant barriers. At last the key barriers were identified using combination of Logical Problem analysis (LPA) for identification of barriers and market mapping. [5]. The same was done for identification of measures: measures were identified based on grouped barriers. LPA analysis was applied both to identification of barriers and measures accordingly. Market mapping techniques was applied for involving the market players.

For small hydro-power plants technology the barriers were identified in five categories for Kazakhstan: i) economic/financial barriers, ii) policy/regulatory barriers, iii) technology barriers iv) environmental barriers and v) capacity building/information barriers. Examples of LPA analysis are presented at the Figures 1-3 below.

Economic and financial barriers

The financing of the "Program of power sector development 2010-2014" accounts 952656 million KZT (approximately 6344 million USD[49]), including about 1/3 from national budget, other 2/3 are assumed as own resources and loans. According to the "Action Plan on RES development (2011-2020)" the estimated financing for small hydro power is about 263 million USD to be gained from private sources and loans.

In this regards, lack of national budget investment to the RES sub-sector could be mentioned as a financial barrier, this is mostly because of reason that the government currently provides large investments for other social and economic infrastructure, including the modernization of existing power complex and construction of new power plants.

[49] exchange rate used 1USD=150 KZT

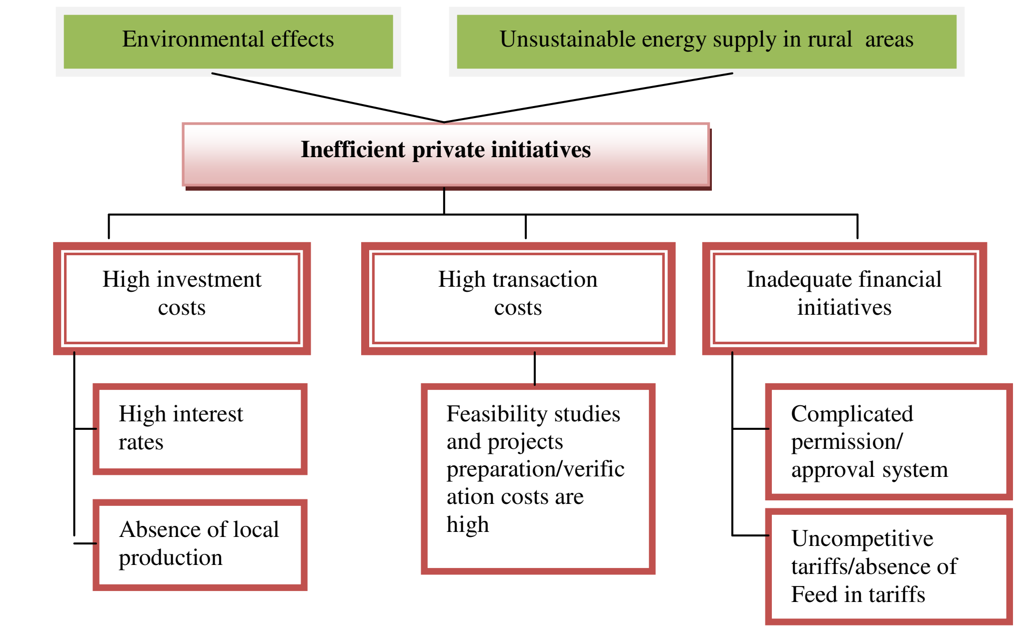


Figure 1: LPA for economic/financial barriers for small hydro-power technology.

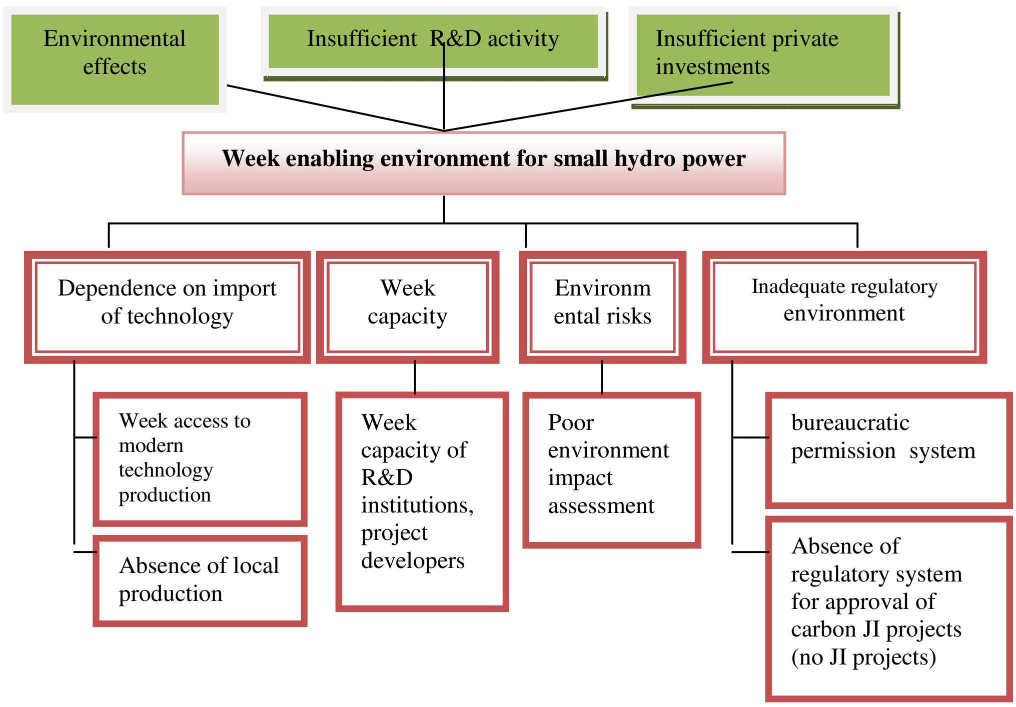


Figure 2: LPA for non-financial barriers of small hydro-power technology.

High investment costs are the main barriers of the technology. Weak access to affordable financial resources and high interest rates (15-17%) for loans in the local banks is other barriers to private sector investments.

Based on the results of market mapping analysis [5] it could be assumed that the current small-hydro power is only imported into the country. The number of market players in the current technology market is low, as existing market opportunities do not provide adequate conditions for involvement of other key players such as suppliers of equipment to the market chain. The generators used for small hydro are purchased in Russia or China, no local industry is available. Along with this, business-extension services are very weak and almost non-functional in the market chain. Enabling environment also does not provide suitable opportunities for development of local market for technology diffusion.

Non-financial barriers

The country has environmentally sound policy and clear strategy regarding the development of RES, including development of small hydro-power plants. Nevertheless, there are a number of barriers impeding technology deployment.

Policy/regulatory barriers

In addition to the RES law the Government adopted the following rules in support of RES project development:

- Rules of purchase of electricity from qualified power generating organizations
- Rules of definition of the nearest point of connection to the grid or thermal networks for renewable energy
- Rules for monitoring of the use of renewable energy
- Rules for feasibility study assessment and approval

There is necessity for further improvement of legislative base for RES including small hydro power for the private sector to construct small hydro-power stations, including regulations on permits, rights and obligations of energy producers and consumers. The mechanism for providing permits for the construction of small hydro-power stations is complicated and needs to be simplified. Possibility to use carbon credits for decrease investment risks ,decreasing payback period to return investments should be studied and included into regulation.

Environmental barriers

The environmental barriers have not all impact, such as impact on river streams which has not been studied in detail.

Technology barriers

The main technological barrier is that small hydro-power technology is only imported into the country and it is necessary to apply more modern technologies for small hydro power.

Capacity building/information barriers:

One of the important barriers is weak capacity of project developers to prepared projects understandable by bankers to get the loans. Another barrier is lack of efficient capacity in the research institutions responsible for providing research/investigation on the potential of small rivers.
The measures to overcome the barriers identified are divided into economic & financial and non-financial.

Economic & financial measures

The government should promote application of small hydro power through support investors by providing long-term and low-interest loan mechanism through parallel actions: support through State Fund "Samruk-Kazyna", private local banks, international funds.

Private initiatives should be supported by the government through subsidy mechanisms (such as tax discounts or exemption from payment for transmission power, innovation grants programs).

By improving technical capacity of R & D institutions and increasing quality of provided services, awareness raising of operating enterprises, population and other stakeholders the government should support with financing these activity more than it is planned in existing Programs.

Non-financial measures

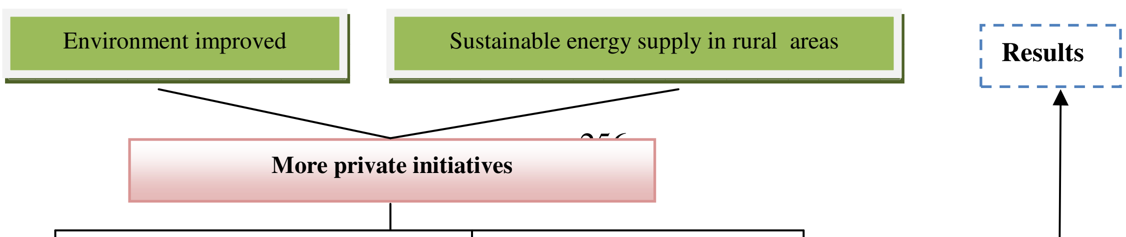
In order to overcome existing non-financial barriers for implementation of small hydro-power technology the following measures are recommended:

- Improvement of legislation and regulation should be introduced to facilitate implementation of small hydro power projects;
- Improvement of coordination between ministries, NGOs, business and other stakeholders;
- Capacity building of respective governmental bodies, companies involved into RES promotion and local bankers must be improved by training;
- Strengthen technical capacity of respective institutions responsible for research activities in order to facilitate the implementation of best international experience and technologies;
- Awareness transfer, demo projects implementation and improvement of information access on modern technologies and on equipment providers;
- Detailed environmental impact assessment, including issues related to future climate change impacts.

It was estimated that the promotion of small and medium-sized power plants will help to reduce CO_2 emissions produced by thermal power plants to 3.2 million tons per year in 2020 and 8.6 million tons per year in 2030.

5. Guide to the Development of a Renewable Energy Action Plan

The Guide to the Development of a Renewable Energy Action Plan was developed in the frame of EBRD “Kazakhstan National Green Growth Plan (KNGGP)" project implemented in 2011-2012. One of its subtasks was dedicated to “National Sustainable Energy Plan”, including the development of the Guidelines on how to establish Kazakhstan Renewable Energy Action Plan.



Introduction of
Feed -in tariffs

Figure 3: LPA for economic/financial measures for small hydro-power technology.

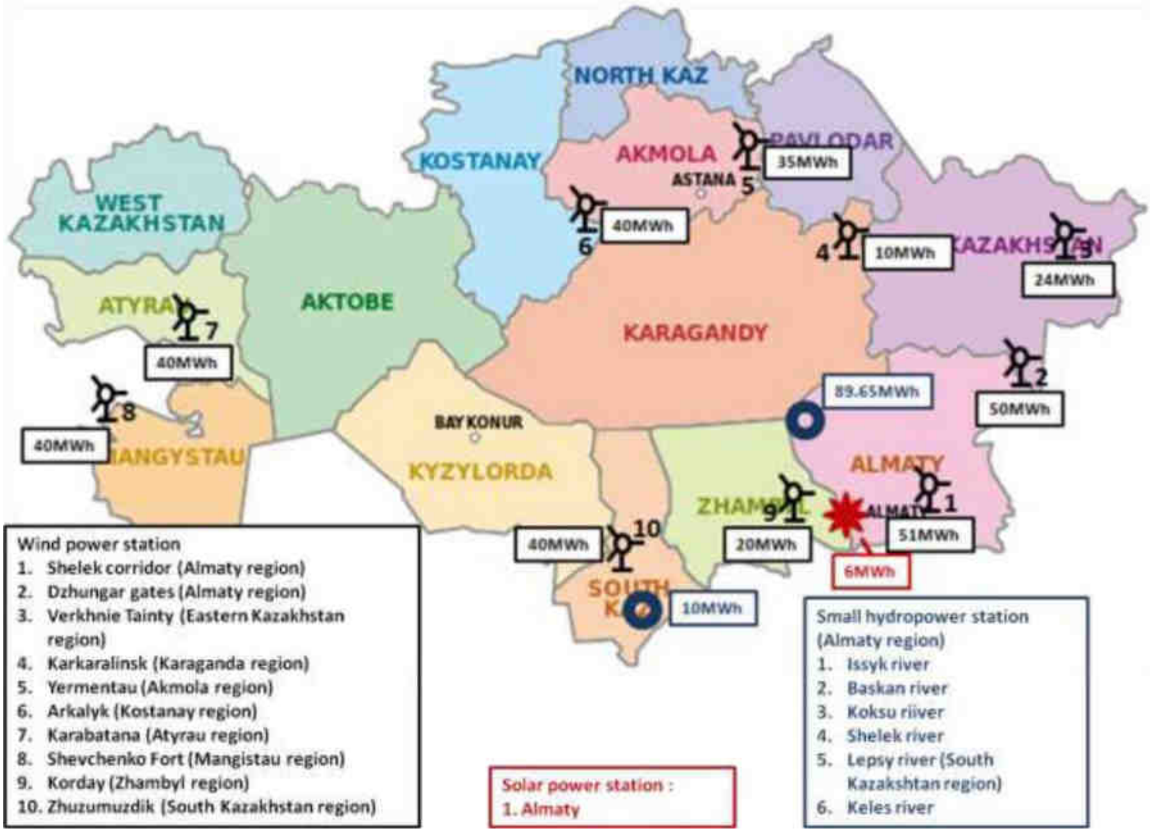


Figure 4: Plan of location of objects on renewable energy sources (**Source: Ministry of Industry and New Technologies (MINT)).**

Kazakhstan's RES mix composition based on strategic scenarios and prioritization in line with the strategic directions has been done to meet the 2020 target. This project was focused on providing guidance for action plans in three specific areas: regional RES development; rural off-grid development and RES industry development. The central factor for domestic RES industry development; key considerations for off-grid RES utilization, estimation of the gross investment costs and required government funds per time-period were defined for Kazakhstan using Korean experience. Developing a domestic RES industry can be a new source of economic growth but requires a strong home market based on supportive policies. The project outcomes are useful for further research and deploying RES technology in Kazakhstan.

The midterm KNGGP report [2] contains the description of global RES market trend including technological, economic and political/legal aspects; Kazakhstan country analysis, benchmark study based on China, United States and Korea experience, Kazakhstan RES development scenario needed to meet Kazakhstan's Renewable Energy targets for 2020 and RES Action Plan taking into consideration regional development, rural off-grid development plan and RES Industry Development Plan. The Action Plan was developed based on the governmental plan of location of objects on RES in Kazakhstan, see Figure 4The Action Plan is also based on international benchmarking and Kazakhstan's current status, it is concentrated on the following three points. First, a regional cost analysis of each relevant renewable energy source will be performed in order to determine which regions can most cost-effectively develop each RES. Wind and solar energy potential have the most regional variation, thus regional cost analysis will center on these two sources. Second, RES sources most suited for distributed generation and off-grid electricity needs will be analyzed to develop a strategy to incorporate RES in powering the vast nation. Finally, the action plan will address how to utilize RES to support the long-standing goal of developing Kazakhstan's manufacturing industry.

Guide to the Development of a Renewable Energy Action Plan contains the following conclusions [2]:

- Kazakhstan RES mix composition per time-period based on preliminary analysis for 2020 has been defined as the following: small hydro power in amount of 0.66 TWh; wind in amount of 0,92 TWh; solar PV in amount of 0.61 TWh; solar-thermal in amount of 0.14 TWh; biomass in amount of 0.17 TWh, in total -2.5 TWh .

- The gross investment costs and required government funds were estimated, in particular the government funds estimates amount as 2,692 Million KZT (equivalent to13,8 Million Euro in 2012) for 2020. The share of SHP from price-weighted perspective is very small in the total gross investment.

-Related industrial development potential-weighted is 3,049 million KZT for 2020(less that 50% of gross investment estimates for the same grade.

- Developing a domestic RES industry can be a new source of economic growth but requires a strong home market based on supportive policies
- The central Factor for domestic RES Industry development includes home market development, Strong local market for RES attracts foreign investment; Local markets can act as a technology test-bed for local manufacturers

- Although marginal costs of renewable energy vary among sites within oblasts, Almaty and South Kazakhstan showed the highest potential for RES development among others.

Observations shown that Kazakhstan's renewable energy resources are promising but the infrastructures to make use of these resources are underdeveloped limiting the amount of RES in the total electricity supply. Experts estimate that the RES has the potential for 2.7 billion kWh of electricity [2].

6. Key findings

It has been observed that strategic directions for renewable energy development reflect national characteristics. Barrier analysis and possible enabling measures for small hydro power technology were identified for Kazakhstan using LPA analysis [5].

The authorities in Kazakhstan showed great interest in the development of small hydro projects as a way to compensate the deficit in electricity demand for South rural areas in the amount of 7 TWh .

It was estimated that promotion of small and medium-sized power plants will help to reduce CO_2 emissions produced by thermal power plants to 3.2 million tons per year in 2020 and 8.6 million tons per year in 2030.

The Guide to the development of Renewable Action Plan was developed including RES mix composition per time-period estimation for 2012-2015-2020, related industrial development potential-weighted was estimated for the same time- period. The conclusions from the Guide are the following:
- Kazakhstan's abundant RES potential can be used for rural off-grid electrification and heating uses more easily than grid extension or conventional energy sources.
- Developing a domestic RES industry can be a new source of economic growth but requires a strong home market based on supportive policies.
- RES may not appear economic enough, however if the cost of externalities in economics are additionally considered - such as the costs to restore the environmental damages and to solve the health problems caused by using traditional energy resources, it is wise to further work on the RES technologies development.
- Kazakhstan’s abundant RES potential can be used for rural off-grid electrification and heating uses

more easily than grid extension or conventional energy sources
- Policy support and financial support strategies must be designed to support home market development
- Continued R&D investment and cooperation with international firms for technology transfer
- Alignment with national energy strategies such as off-grid RES utilization to serve as test-bed for domestic producers

The results of this analysis will provide policy makers in Kazakhstan with the direction needed to decide how much electricity will be produced from each RES. The project outcomes are useful for further research and deploying RES technology in Kazakhstan.

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The effect of electricity consumption from renewable sources on countries' economic growth levels: Evidence from advanced, emerging and developing economies

Professor George HALKOS[1]

Director of Laboratory of Operations Research, Department of Economics, University of Thessaly

Asst Professor Nickolaos TZEREMES

Laboratory of Operations Research, Department of Economics, University of Thessaly

[1] *Contact details of corresponding author*

Tel: 0030 24210 74920
Fax: 0030 24210 74701
e-mail: halkos@uth.gr

Address: Dept of Economics, University of Thessaly Street: Korai 43, City: Volos, Greece

Abstract

This paper uses a sample of 36 countries for the time period 1990-2011 in order to examine the relationship between countries' electricity consumption from renewable sources and Gross Domestic Product (GDP) levels. Several nonparametric techniques are applied to investigate the effect of electricity consumption from several renewable sources including wind, geothermal, solar, biomass and waste on countries' GDP levels. When investigating the whole sample ignoring countries' economic development status, the results reveal an increasing relationship up to a certain GDP level, which after that point the effect of electricity consumption on GDP stabilises. However when analysing separately the 'Emerging Markets and Developing Economies', and, the 'Advanced-Developed Economies', the results change significantly. For the case of Emerging Market and Developing Economies the relationship appears to be highly nonlinear (an M-shape form) indicating that on those countries the levels of electricity consumption from renewable sources will not result on higher GDP levels. In contrast for the case of the advanced economies the results reveal an increasing nonlinear relationship indicating that higher electricity consumption levels from renewable sources results to higher GDP levels. This finding is mainly attributed to the fact that in the advanced-developed economies more terawatts from renewable sources are generated and consumed compared to the emerging market and developing economies, which traditionally their economies rely on non-renewable sources for power generation and consumption.

Keywords: Renewable energy, Economic growth, Local linear estimator, Nonparametric analysis.

1. Introduction

Since the pioneer work by Kraft and Kraft (1978) there has been a growing interest in the literature about the connection between energy consumption and economic growth. Mainly, there are four causal hypothesis regarding this causal relationship (Apergis and Payne 2010a). These are the *growth*, *conservation*, *feedback* and *neutrality hypotheses*[50]. More analytically, the *growth hypothesis* implies a unidirectional causality from energy consumption to economic growth. The *conservation hypothesis* describes a unidirectional causality from economic growth to energy consumption. The *feedback hypothesis* supports the bidirectional causality among energy consumption and economic growth. Finally, the *neutrality hypothesis* describes the case where energy consumption has no significant effect on economic growth and therefore energy conservation policies will not have a significant effect on economic growth.

However it must be mentioned that there is not a clear answer about which hypothesis is correct and the results across the literature are rather mixed failing to establish most of the time the same relationship following Granger causality tests (Soytas and Sari 2006, 2007). However this may be attributed to the fact that most of the studies use different country samples, for different time periods

[50] Ozturk (2010) presents a detailed review of the four hypotheses.

and from different developed stages (Yuan et al., 2008; Halkos and Tzeremes, 2009). Some other studies have focused on a similar manner their research in investigating the relationship between electricity consumption/generation and economic growth[51]. Again when comparing these studies the results provided investigating the causal relationship were mixed (Yoo 2006; Chen et al. 2007)[52].

In contrast with the pre-mentioned studies, in this paper we provide empirical evidence for the *growth hypothesis* analyzing the effect of electricity consumption from renewable sources (RE) on countries' economic growth levels using the local linear estimator (Fan 1992; Fan and Gijbels 1996) without assuming any functional form of the examined relationship (Li and Racine 2007). The structure of the papers is the following. The next section presents the relative literature, whereas section 3 presents the data and the methods used. Section 4 presents the empirical findings from the nonparametric analysis, whereas the last section concludes the paper.

2. A brief literature on the energy consumption economic growth relationship

Ayres (2001) supports the feedback hypothesis and argues that primary resource flows (exergy), such as oil, are not just a result of economic growth but they are its principal factors. Mehrara (2007) investigates the connection between energy consumption and economic growth in oil exporting countries and finds evidence about the conservation hypothesis. Bowden and Payne (2010) analyze the causal relationship between energy consumption and economic growth using a Toda-Yamamoto approach. The authors use renewable and non-renewable energy consumption and as a growth measure they use GDP per sector and confirm the growth hypothesis for residential renewable energy sources (RES) consumption.

Additionally, the neutrality hypothesis explains the commercial and industrial consumption. Ozturk et al. (2010) apply a Pedroni (1999) panel cointegration approach, a panel causality test and the Pedroni (2001) method in order to investigate the causal relationship for 51 countries. The results indicate that energy consumption is cointegrated with GDP. Furthermore, the conservation hypothesis and the feedback hypothesis are confirmed for low and middle income countries respectively. Ozturk and Acaravci (2010a, b) apply an ARDL approach on five Eastern and Southeastern European countries. The authors study the causal relationship between energy consumption and GDP and they find evidence to support the neutrality hypothesis.

In an alternative study, Asafu-Adjaye (2000) argues that there are two contradictory approaches to examine the connection between energy consumption and economic growth. The first approach describes the energy as a limiting factor for economic growth while the second approach assumes a neutral relationship between them. Shi and Zhao (1999) confirm the connection among the rise of energy consumption in China and the slightly declined growth rates and Cropton and Wu (2005) validate their result. Rodriguez and Sachs (1999) argue that intensive-resource economies tend to experience lower growth rates than low-resource economies. Furthermore they explain this paradox with the temporally high growth rates of the intense-resource economy which are considerably above the steady state and they argue that the economy must converge back to its steady state. They demonstrate the case study of Venezuela, which is an oil exporter and an intense-resource country, in order to support the above assumption. Stinjs (2005) further supports the above findings. The author claims that a country rich in natural resources does not necessarily imply a country with high economic growth and they also find that the neutrality hypothesis is valid.

Mehrara (2007) presents four econometric approaches which according to the author are the most widely used in the literature in order to examine this connection. The first approach applies the conventional VAR methodology and assumes stationarity for the variables. The second approach relaxes the stationarity assumption and uses a Granger (1988) two-stage procedure for cointegration. The third approach employs the Johansen (1991) methodology, while the last approach applies panel cointegration and panel error correction models.

The popular concept of sustainable development does not conform with the highly dependence of the global economy on fossil fuels which are considered as one of the main reasons for global warming and climate change. The most widely used fossil fuels are oil, gas and coal and they produce various harmful gases such as CO_2 and SO_2. Moreover as we have already presented, the majority of the literature indicates a connection between energy and economic growth. If we combine this connection with the concept of sustainable development then we can understand that a more environmental-friendly path is needed which can be achieved by using sustainable energy sources.

[51] Ghosh (2002, 2009) for the case of India, Altinay and Karagol (2005) for Turkey, Aqeel and Butt (2001) for Pakistan, Jumbe (2004) for Malawi, Shiu and Lam (2004) for China and Murry and Nan (1996) for East Asian countries.

[52] For an extensive literature review of studies investigating the causal relationship between electricity/energy use and economic growth see Lee (2005, 2006).

Substituting fossil fuels with renewable energy sources (RES) will reduce the emissions and therefore the global pollution. The most important RES are solar, wind, geothermal, biomass, hydroelectricity, wave and tidal energy sources. Apergis and Payne (2010b) mark the significance of this substitution because of three reasons. First, the volatility of oil price might be a destabilizing economic factor. Awerbuch and Sauter (2006) also support this view. They investigate the connection between oil and economic growth and they find the significant effect of price volatility of oil on economic growth. Specifically, a 10% increase in oil price will result in 0.5% loss of the global GDP. This negative effect is contributed to inflation and unemployment.

The second reason of Apergis and Payne (2010b), is that non-renewable energy sources such as fossil fuels cause environmental degradation and contribute to global warming. Third, countries which use RES as their primary fuels are not depending on countries which are "energy-producers". Bowden and Payne (2010) propose a number of incentives for the promotion of RES which include tax credits and renewable energy standards.

Furthermore, international agreements are a significant contributor towards the substitution of fossil fuels with RES. One of the most important international agreements for the promotion of RES and the reduction of greenhouse gases is the Kyoto Protocol which was created through the United Nations Framework Convention on Climate Change (UNFCC). Another important agreement is the Renewable Energy Directive (2009/28/EC) of European Commission which sets objectives for the European Union members. These objectives include among others that the 20% of total energy and the 10% of transport energy to come from RES by 2020[53]. In addition, European country members are encouraged to set individual goals towards 2020.

So far we have presented studies about the relationship of energy and economic growth. It is interesting to examine specifically the relationship between RES and economic growth. Chien and Hu (2008) support the growth hypothesis. They apply Structural Equation Modeling at 116 countries and they examine the relationship between RES and GDP. They decompose GDP and find that RES promotes growth through capital formation but not through trade balance. The conservation hypothesis is supported by Sadorsky (2009a) who applies a panel cointegration approach to study the RES consumption in G7 countries. The findings reveal that GDP per capita has a significant effect on RES consumption. Sadorsky (2009b) finds similar results for 18 developing economies during the period 1994-2003. In particular, the author applies a panel cointegration and a vector error correction model and validates that per capita GDP has a significant positive influence on RES consumption.

Apergis and Payne (2010a) investigate 13 Eurasian countries during the period 1992-2007 using a multivariate panel model. They confirm the feedback hypothesis both in short and long run. Apergis and Payne (2010b) and Apergis and Payne (2012) in similar studies about 20 OECD countries and 80 countries respectively, also validate the feedback hypothesis. Tugcu et al. (2012) apply an ARDL approach to investigate the relationship between RES and non-RES consumption and economic growth for G7 countries. The results confirm the feedback hypothesis for both RES and non-RES consumption. Pao and Fu (2013) investigate the connection between various energy sources including RES and economic growth in Brazil. In all cases they find evidence about the feedback hypothesis. Menegaki (2011) applies a random effects model to investigate the case of 27 European countries to examine the relationship between RES consumption and GDP and finds evidence about the neutrality hypothesis. Yildirim et al. (2012) also support the neutrality hypothesis in a study about RES in USA.

Interesting insights are provided by Chang et al. (2009) who investigate the relationship of energy prices and under different levels of economic growth in OECD countries during the period 1997-2006. The authors apply a panel threshold regression model and they find that on the one hand countries with higher growth rates tend to increase RES consumption when energy prices increase, thus supporting the conservation hypothesis. On the other hand, countries with lower growth rates do not respond to energy prices volatility which supports the neutrality hypothesis. Ocal and Aslan (2013) investigate the relationship among RES and economic growth in Turkey. The authors apply an ARDL methodology and Toda-Yamamoto causality tests. The results from ARLD methodology reveal a negative effect of RES on economic growth. The results from the causality tests show support conservation hypothesis because economic growth seems to affect RES consumption.

3. Data and Methodology

In order to examine the relationship between electricity consumption from renewable sources and economic growth, we use a sample of 36 advanced/developed and emerging

53 http://www.seai.ie/Publications/Statistics_Publications/Statistics_FAQ/Energy_Targets_FAQ/

market/developing economies[54] for the time period of 1990-2011. Table 1 presents diachronically the descriptive statistics of the variables used. As dependent variable real GDP at chained PPPs (in mil. 2005 US $) is used.[55] Our explanatory variable is the renewable energy (RE) derived from electricity consumption generated from renewable sources including wind, geothermal, solar, biomass and waste, and not accounting for cross border electricity supply[56].

As dependent variable real GDP at chained PPPs (in mil. 2005 US $) is used.[57] Our explanatory variable is the renewable energy (RE) derived from electricity consumption generated from renewable sources including wind, geothermal, solar, biomass and waste, and not accounting for cross border electricity supply[58].

Since we cannot assume a specific functional form for the examined relationship we apply nonparametric techniques which are not restrictive to any functional forms. Let the dependent variable (GDP) be denoted by y_i and let the independent variable X_i represents the energy consumption derived from renewable sources. We assume that the examined variables are continuous with a joint density $f(y,x)$, having a marginal density of X_i which can be defined as $f(x)=\int f(y,x)dy$. In this way the conditional density of y_i given X_i can be defined as $f(y|x)=f(y,x)/f(x)$. Then in a nonparametric setting the following regression function will take the form:

$$g(x)=E(y_i|X_i=x) \quad (2)$$

Following Li and Racine (2007, Theorem 2.1, p. 59) the regression function can be written as:

$$g(x)=\frac{\int yf(y,x)dy}{f(x)} \quad (3),$$

thus we can estimate g by replacing the density functions by their nonparametric estimates. Therefore the estimate of the joint density can be computed nonparametrically as:

$$\hat{f}(y,x)=\frac{1}{n|H|h_y}\sum_{i=1}^{n}K\left(H^{-1}(X_i-x)\right)k\left(\frac{y_i-y}{h_y}\right) \quad (4).$$

Where h_y is a bandwidth for smoothing in the y direction, whereas $H=diag(h_1,...,h_q)$. In addition $K(.)$ is a product kernel function and $k(.)$ is a univariate kernel function that satisfies the following conditions:

$$\int k(u)du=1,\ k(u)=k(-u),\ \int u^2k(u)du=\kappa_2>0 \quad (5).$$

In equation (5) $k(u)=\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}u^2}, -\infty<u<\infty$ denotes the Gausian kernel (see for details Li and Racine, 2007, p. 8-11). Moreover, the nonparametric estimate of marginal density of X_i can be defined as:

$$\hat{f}(x)=\int\hat{f}(y,x)=\frac{1}{n|H|h_y}\sum_{i=1}^{n}K\left(H^{-1}(X_i-x)\right)\int k\left(\frac{y_i-y}{h_y}\right)dy= \quad (6),$$
$$=\frac{1}{n|H|}\sum_{i=1}^{n}K\left(H^{-1}(X_i-x)\right)$$

and

$$\int y\hat{f}(y,x)dy=\frac{1}{n|H|h_y}\sum_{i=1}^{n}K\left(H^{-1}(X_i-x)\right)\int yk\left(\frac{y_i-y}{h_y}\right)dy \quad (7).$$
$$=\frac{1}{n|H|}\sum_{i=1}^{n}K\left(H^{-1}(X_i-x)\right)y_i$$

Finally, the local linear estimator (Fan 1992; Fan and Gijbels 1996) can be obtained as:

$$\min_{\{a,b\}}\sum_{j\neq 1,j=1}^{n}\left[Y_j-a-\left(X_j-X_i\right)'b\right]^2K\left(\frac{X_j-X_i}{h}\right) \quad (8).$$

where $K\left(\frac{X_j-X_i}{h}\right)=\prod_{s=1}^{q}k\left(\frac{X_{is}-X_{js}}{h_s}\right)$.

Then let $\hat{g}_{-i,L}(X_i)$ denote the leave-one-out linear estimator of $g(X_i)$ and $\left(\hat{a}_i,\hat{b}_i\right)$ be the solution of (a,b), then $\hat{a}_i\equiv\hat{g}_{-i,L}(X_i)$.

Following Li and Racine (2007, p. 83) the local linear least squares cross-validation approach is introduced by choosing $h_1,...,h_q$ to minimize the objective:

$$CV_{ll}(h_1,...,h_q)=\min_h n^{-1}\sum_{i=1}^{n}\left(Y_i-\hat{g}_{-i,L}(X_i)\right)^2M(X_i) \quad (9),$$

[54]**Advanced-developed countries (23)**: Australia, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Japan, Korea Republic of, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Taiwan, United Kingdom and the United States of America. **Emerging market-developing countries (13)**: Argentina, Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Mexico, Philippines, Poland, Russia, Turkey (IMF Advanced Economies List, 2012, p.179-183).

[55]GDP has been extracted from Penn World Table-PWT 8.0 (Feenstra et al., 2013).

[56]The data has been extracted from the Statistical Review of World Energy and are available from: http://www.bp.com/

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Table 1: Descriptive statistics of the variables used.

Real GDP at chained PPPs (in mil. 2005US$)											
Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Mean	853297	872121.1	879003.5	909376.8	945368.3	988341	1021978	1055837	1068948	1105954	1164976
Std	1432173	1442635	1465812	1516400	1578806	1633468	1691574	1762027	1822407	1906348	1991311
Min	59045.98	59620.46	63567.6	66246.9	70053.45	77840.9	79206.96	81718.01	83765.89	89037.73	92620.03
Max	7963012	7925630	8211395	8469315	8842204	9071050	9430334	9869378	10309118	10807267	11275426
Year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Mean	1185841	1211300	1246252	1306651	1378219	1428579	1500818	1539125	1539425	1596276	1648284
Std	2019557	2066191	2135077	2231294	2327630	2382874	2498548	2564076	2602210	2633978	2748542
Min	95492.48	98469.09	100061.9	98991.92	101895	101978.8	104614.9	100917.8	105678.4	105612.3	103125.7
Max	11368939	11515518	11789128	12196382	12564300	12564300	12898268	13149344	13066677	12597854	13193478
Electricity consumption from renewable sources measured in Terawatt-hours											
Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Mean	3.230311	3.408462	3.636372	3.79314	3.974314	4.130339	4.342958	4.659052	4.980527	5.406078	5.798083
Std	10.36327	10.99121	11.72366	12.09705	12.14691	11.65342	11.96016	12.20117	12.16285	12.55611	12.78047
Min	0.065	0.065	0.063	0.06	0.061	0.059	0.057	0.057	0.058	0.058	0.0809
Max	63.75396	67.67951	72.31031	74.72371	74.81041	71.74429	73.51897	74.74439	74.44078	76.8001	78.15092
Year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Mean	6.05037	6.837621	7.415457	8.448851	9.472582	10.57258	12.05043	13.77112	15.79444	18.62163	21.95844
Std	12.23443	13.76689	14.1046	15.06694	16.20486	18.03482	20.32977	23.57836	26.54562	30.96045	36.7259
Min	0.1171	0.131	0.131	0.2549	0.2758	0.3745	0.4908	0.4938	0.4919	0.492203	0.493381
Max	74.18368	82.80884	83.17178	86.81329	91.14479	100.4533	109.2851	130.3464	148.6917	171.8944	200.0856

where $\hat{g}_{-i}(X_i) = \sum_{l \neq i}^{n} y_l \left(K\left(X_i - X_l\right)/h\right) / \sum_{l \neq i}^{n} \left(K\left(X_i - X_l\right)/h\right)$ which is the leave–one-out kernel estimator of $g(X_i)$ and $0 \leq M(.) \leq 1$ is a weight function.

4. Empirical results

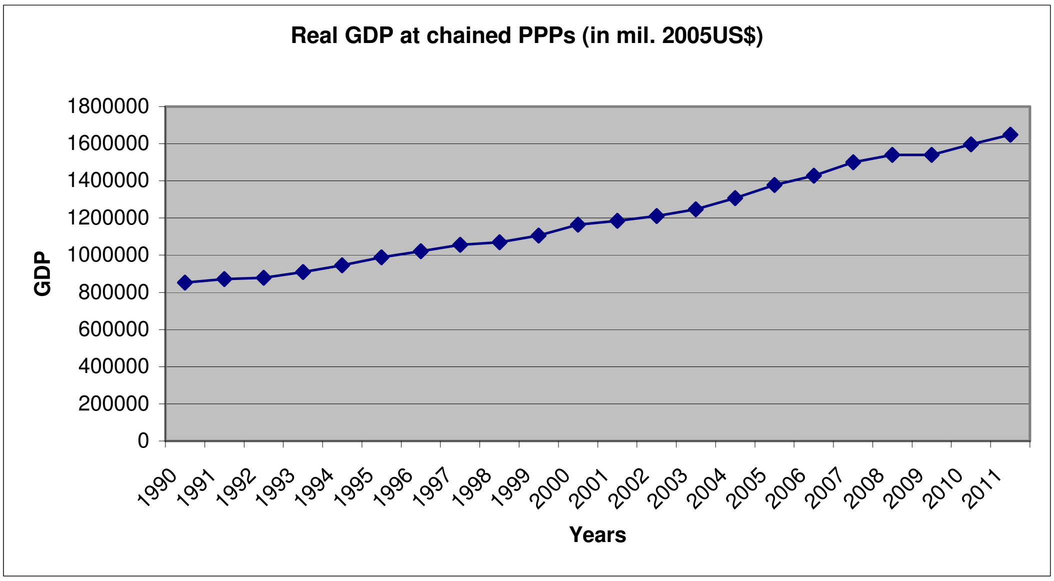
Looking at the diachronical representation of the variables used (Figure 1) we can see an increasing trend for countries' GDP levels (subfigure 1a) and for electricity consumption from renewable sources (subfigure 1b).

More analytically, advanced and developed countries appear to consume diachronically more levels of electricity derived from renewable sources compared to the emerging market and developing countries.

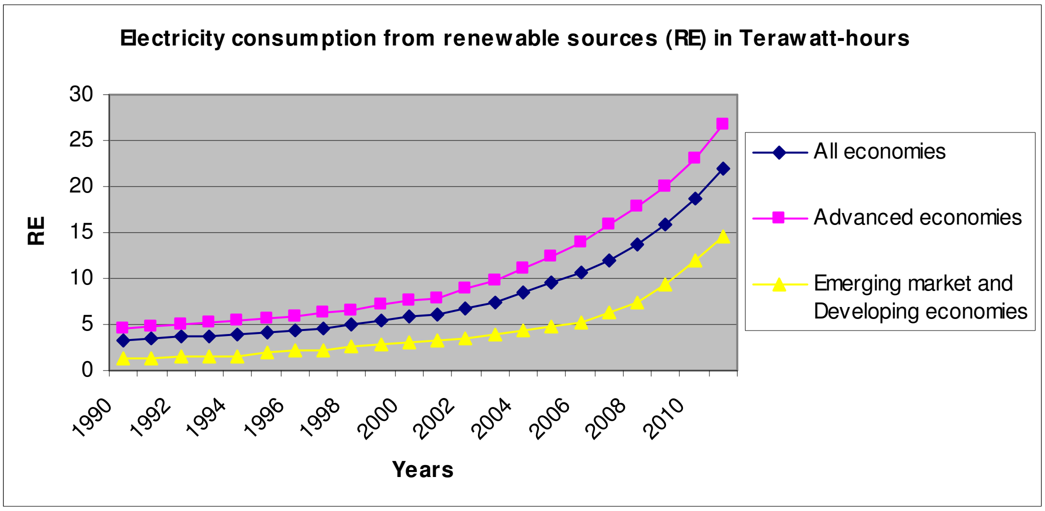
Following the bootstrap algorithms introduced by Racine (1997), Racine et al. (2006) and Racine (2008) we test the significance of the independent variable (RE). Table 2 presents the obtained *p-values* of the nonparametric significance test alongside with the selected bandwidths following the local linear (ll) least squares cross-validation approach introduced by Li and Racine (2007). The results reveal that the electricity consumption from renewable sources (RE) is statistical significant for all the examined cases explaining countries' growth variation. Moreover, the obtained R-squared values signify that the RE variable explains 54% for the advanced and developed countries' economic growth variations in contrast with the emerging market and developing countries which explains only the 20% of their economic growth variations. This finding suggests that developing countries find their comparative advantage shifting to higher polluting production sectors using conventional energy sources (Pellegrini, 2011).

Figure 2 presents schematically the relationship between electricity consumption from renewable sources and countries' GDP levels alongside with asymptotic error bounds. When the full sample (subfigures 2a, 2b) is examined the nonparametric regression line indicates an increasing trend between RE and countries GDP levels. Moreover a similar picture appears in the case of advanced/developed economies. More analytically subfigure 2c presents also the time effect in contrast with subfigure 2d which presents only the effect of electricity energy consumption from renewable sources on countries' GDP levels. The results reveal that the effect of time (Year) has a posit ive effect on countries' GDP levels alongside with RE.

When examining only the effect of RE on advanced economies' GDP levels it appears that the effect is highly positive in a nonlinear manner indicating that for advanced economies electricity consumption from renewable sources can be a source of economic growth.



1a



1b

Figure 1: Diachronical representation of the variables.

Table 2: Results from the local linear nonparametric regression.

Model summary			
	Bandwidth	p-value	R-squared
RE (All economies)	34.01587	0.0254**	0.4036
RE (Advanced economies)	31.82791	0.0000***	0.5460
RE (Emerging Market and Developing economies)	19.07234	0.0411**	0.2022

10%, ** 5%, * 1% significance level*

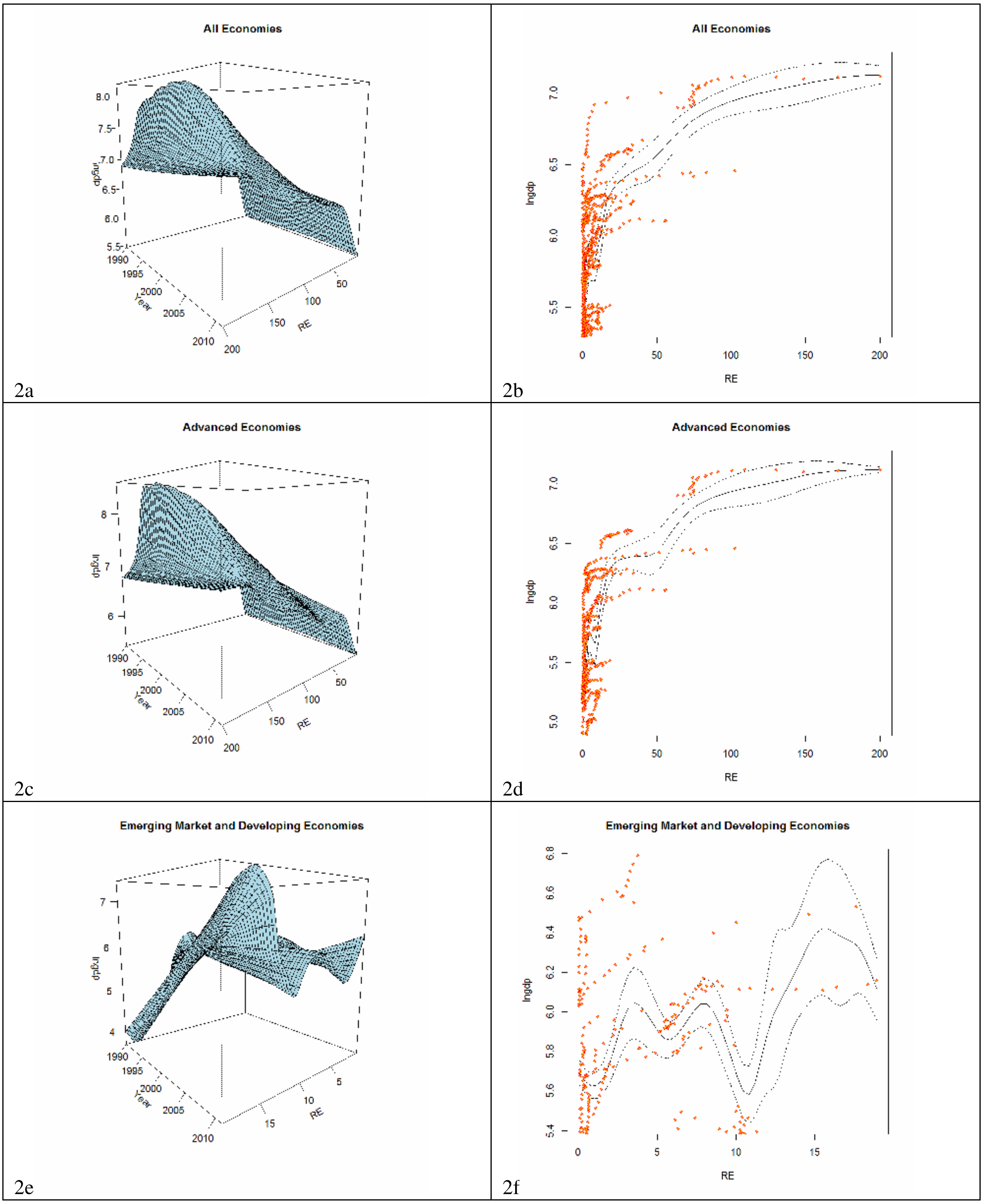


Figure 2: Graphical representation of the effect of renewable electricity consumption (RE) on countries' GDP levels (lngdp).

However we cannot conclude the same in the case of emerging market/developing economies (subfigure 2e, 2f). As reported in subfigure 2e the effect of time is highly positive for developing countries' GDP levels. Moreover it can be said that is more positive to their economic growth levels compared to the developed economies. This is indicated from the highly increasing trend.

However it cannot be justified the same for the RE variable. In fact looking at subfigure 2f a nonlinear relationship can be observed indicated by an 'M' shape up to a consumption level of 10 terawatts per hour. After that consumption level the trend is increasing and then decreasing again forming an inverted 'U' shape. Several authors suggest that this phenomenon is attributed to the inefficient electrification programs using RE for those countries (Haanyika 2006; Urmee et al. 2009).

Moreover, other reasons may be attributed to high cost of transmission and distribution, institutional weaknesses and inappropriate policy framework (Urmee et al., 2009). Finally, Beck and Marinot (2004) suggest that the barriers and lack of implementation of renewable sources in emerging market and developing countries is mainly attributed to a) costs and pricing issues, b) legal and regulatory policies and c) market performance factors. More analytically they suggest that barriers related to cost and pricing involve subsidies for competing fuels, high initial capital costs, difficulty of fuel price risk assessment, unfavourable power pricing rules, transaction costs and environmental externalities.

In addition, barriers to renewable sources related to legal and regulatory aspects include issues related to the lack of legal framework for independent power producers, restriction on sitting and construction, transmission access, utility interconnection requirements and liability insurance requirements. Finally according to Beck and Marinot (2004) barriers related to market performance include lack of access to credit, uncertainty and risk related to perceived technology performance and lack of technical or commercial skills and information.

5. Conclusions

This paper analyses the effect of electricity consumption from renewable sources on countries' economic growth. Based on the *growth hypothesis* our paper applies a local linear estimator in order to analyze the examined relationship both for a sample of advanced/developed and emerging market/developing countries for the period 1990-2011.

The empirical findings reveal a positive relationship for the sample of advanced economies indicating that electricity consumption from renewable sources is a vital contributor to economic growth. However for the developing economies the relationship is nonlinear indicated by an 'M' shape relationship up to a consumption level of 10 terawatts per hour.

However for higher consumption values of 10 TWh the relationship forms an inverted 'U' shape relationship. Mainly this phenomenon is attributed to barriers and lack of implementation of renewable sources based on costs and pricing issues, legal and regulatory policies and market performance factors.

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Combination of Hybrid Wave & Wind Energy Conversion Applied to an Offshore Platform

Ms. Afrokomi-Afroula STEFANAKOU
PhD Candidate of Dept. of Shipping Trade and Transport, University of the Aegean

Dr. Theodoros LILAS
Professor of Dept. of Shipping Trade and Transport, University of the Aegean

Dr. Nikitas NIKITAKOS[1]
Professor of Dept. of Shipping Trade and Transport, University of the Aegean

[1] *Conduct Details of Corresponding Author*

Tel: +30-22710-35201
Fax: +30-22710-35299
e-mail: nnik@aegean.gr

Address: University of the Aegean, Department of Shipping, Trade and Transport. 2A Korai Street, 82100, Chios, Greece.

Abstract

Water scarcity and the resulting desertification is a phenomenon that threatens many areas of the world and our country and this problem becomes especially visible in our islands due to their touristic development and the lack of drinking water in these areas. The climate change exacerbates this phenomenon and the global community tries to face this problem through various measures. Seawater desalination can be an attractive alternative to ensure a secure source of water. However, the energy requirements for that process are high and can be a problem, mainly in isolated areas. Renewable energy sources are the best way to supply energy needs, because can be available near the desalination plant and avoid environmental and availability problems that are associated with fossil fuels. In this paper two forms of renewable energies suited for desalination plant are examined: wind power and wave power. More specifically, the idea of project is based on that a wind turbine which is located in a floating platform combined with a wave energy conversion device close to main platform for producing electricity for a desalination plant's energy needs. The whole project can meet the needs of water demand on islands and it has particular characteristics, as it is floating, autonomous and meet its energy needs in an environmental way, utilizing the wave and wind energy. This floating structure due to this fact can be used in a flexible way, whatever there is need of drinking water on islands or in coastal parts of the mainland. In the paper we are presenting the algorithms and simulation used for the combination of the energy from two different renewable energies under several weather conditions.

Keywords: Floating Platform, Desalination Unit, Wind & Wave energy conversion.

1. Introduction

In recent years the problem of water scarcity is increasingly growing in many of the developing countries as well as the developed world. The 1/3 of the planet faces water scarcity due to mismanagement of water resources and their extensive use. According to data of World Health Organization, about 1.1 billion people do not have access to clean drinking water. The situation does not look promising in the future either, as it has been estimated that the number of people living in areas with absolute water scarcity will increase to 1.8 billion by 2025 [UN-Water 2011].

A prime example so that we can understand the severity of the situation is the statement of the vice-president of the World Bank, Ismail Serageldin, who said "The next World War will be over water." [Mosey, 2009]. It is easy to disregard this as an overstatement, but the significance of water for human life cannot be overemphasized: water is crucial to human life [Macedonio et al. 2012].

Therefore, according to the World Health Organization, most countries which encounter water scarcity are in the Middle East and the Mediterranean basin. The common characteristic of these areas, with regard to climate conditions, is the fairly high temperatures during the whole year, as well as intense drought conditions, which sometimes verge on desertification. Greece is one of seven countries of EE which face scarcity problems together with Malta, Spain, Cyprus, Belgium, Portugal and Italy. So, it is easily understood that situation is particularly critical, as the aforementioned countries have a total population of 130.000.000 residents, i.e a percentage of 27% of the total population of EE.

The use of water in our country is consumed by agriculture (87%), households and tourism (10%) and industry (3%). In our country, the problem is becoming more intense in the islands, due to their ground morphology and the minimum water sources, which usually are not drinkable but brackish. The situation reaches its peak in the summer due to high temperatures, drought as well as the increase in consumption due to tourism in these areas. The situation is not the same in every island. The problems are more intense in the waterless islands of Cyclades and Dodecanese. Also the problem of scarcity is encountered more in small islands and in islands with low touristic development. This fact is expected due to these islands not having the necessary resources in order for some expensive solutions to be financed, but also that in these islands there is a scarcity of drinking water, something that rightly leads to the name deserted islands. As a temporary solution to the problem, the State has chosen, the transfer of water to the islands by ship. However, the amount which is spent on this practice is increasing, as the problem is still unsolved.

In recent years, the desalination technology has greatly developed. Desalination units have already been installed at many island sites. But desalination units consume a high amount of energy and the islands, apart from the problem of water scarcity, also encounter an energy problem, as the autonomous islands are sensitive with low dynamic, whereas they are supplied by diesel machines, which means a dependence on oil, have high costs and great pollutant emissions. So, the solution which is proposed is a combination of desalination units with R.E.S. The desalination of water, which is the conversion process of seawater into drinking water, is a technologically feasible and advantageous solution given that 97% of the planet's water comes from the sea. Desalination seems to be the only solution to effectively deal with the problem of water scarcity.

In this paper two forms of renewable energies suited for desalination plant are examined: wind power and wave power. More specifically, the idea of project is based on that a wind turbine which is located in a floating platform consisted of a four peripheral cylinders grid with a bigger cylinder at the center and combined with a wave energy conversion device close to main platform for producing electricity for a desalination plant's energy needs. The whole project can meet the needs of water demand on islands and it has got particular characteristics, as it is floating, autonomous and meet its energy needs in an environmental way, utilizing the wave and wind energy. This floating structure due to this fact can be used in a flexible way, whatever there is need of drinking water on islands or in coastal parts of the mainland. In the paper we are presenting the algorithms and simulation used for the combination of the energy from 2 different renewable energies. Also, several weather conditions are examined.

2. Desalination

Desalination is a treatment process that removes salts from water. A typical desalination plant consists of a water pre-treatment system, the desalination unit and a post-treatment system. The most important desalination processes are split into two main categories, thermal (or distillation) and membrane processes. [Miller, 2003]. The most widely used thermal processes for seawater desalination are: Multistage Flash Distillation (MFS), Multiple Effects Distillation (MED or ME) and a Vapor Compression (VC) processes. Membrane processes consist of reserve Osmosis (RO) and Electro Dialysis (ED) processes. Electro dialysis is a confined to the desalination or brackish water while reserve osmosis can be used for either brackish or for seawater desalination.

In this specific research, only the method of reverse osmosis is analyzed, as this is the method used more commonly compared to other methods. From all processes of desalination, reverse osmosis holds a prominent position in applications, as it presents remarkable flexibility.

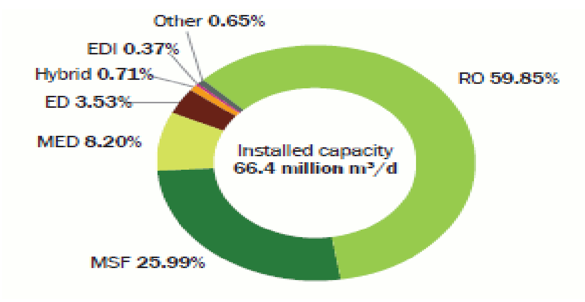

Chart 1: Installed Desalination Capacity by Process [IDA 2011].

Osmosis is the movement of a solvent through a semi-permeable membrane into a solution of higher solute concentration that tends to equalize the concentrations of solute on the two sides of the membrane. Reverse Osmosis is a method of producing pure water by forcing salt water through a semi-permeable membrane (which allows some molecules through, but not others) that salt molecules cannot pass through [Almeida, 2006].

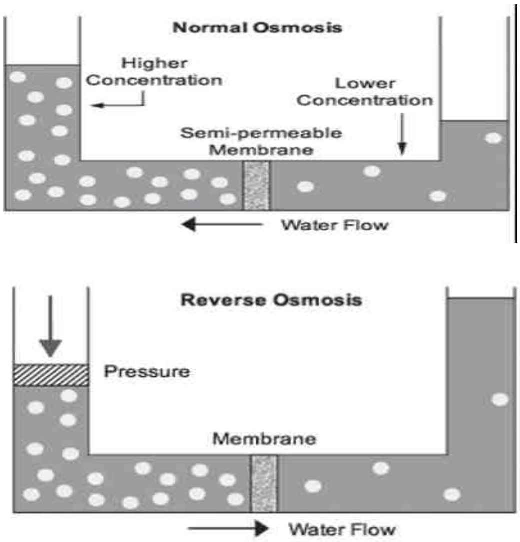

Figure 5: Normal & Reverse Osmosis. Source: Vision Engineer.

3. Desalination Using Renewable Energy Sources

In recent years, the research in the sector of desalination has focused on the combination of desalination units with renewable energy sources, so as to reduce the energy cost and, consequently, the cost of desalinated water. The R.E.S can produce thermal energy (solar panel, geothermal), electrical energy (solar panel, wind turbines) and mechanical energy (wind turbines).

Also, for reliability reasons and continuous operation, the combination of 2 renewable energies is chosen. In this case the system is called hybrid. The general rule is that the technologies of thermal energy with thermal desalination processes should be combined, and electromichanical energy technologies should also be combined with desalination processes that require electrical or mechanical power. The most common applications are the use of reverse osmosis with wind energy or energy which comes from photovoltaic panels and solar energy or geothermal energy with distillation processes.

So, as we can easily understand, the combination of 2 renewable energies in one desalination plant is considered a perfect choice. However, surveys which have been conducted showed that all desalination systems encounter problems when they are associated with R.E.S for the following reasons:

1. The R.E.S systems have not a continuous supply of energy, so they cannot meet the energy demand every time
2. It is not easy for the energy which is supplied by renewable energy systems to be stored for the smooth operation of the installation of desalination systems.
3. The technology of coupling has not been developed to such an extent, so as to provide cheap energy at low cost. [Eltawil, 2009].

But in any case, these coupling problems can be combated if, for example, when R.E.S are combined correctly to the main electrical grid or if a small energy storage system such as batteries is added to autonomous desalination systems.

In general, we would like to say that the best coupling of R.E.S to desalination systems is determined from various criteria such as the system's efficiency, the investment and operational cost, availability of operational personnel, the suitability of the system to the characteristics of the location, the possibility of the future increase of the system capacity e.t.c. [Mathioulakis, 2007].

The selection of the appropriate R.E.S desalination technology depends on a number of factors, including:

- Required quantity of potable water (plant capacity)
- Feed water salinity
- Remoteness
- Availability of grid electricity
- Technical infrastacture
- Type and potential of the local renewable energy source.

Various combinations of R.E.S. and desalination systems have been proposed and implemented, each one with its own characteristics and suitability under certain criteria. [Mathioulakis, 2007- Tzen, 2003].

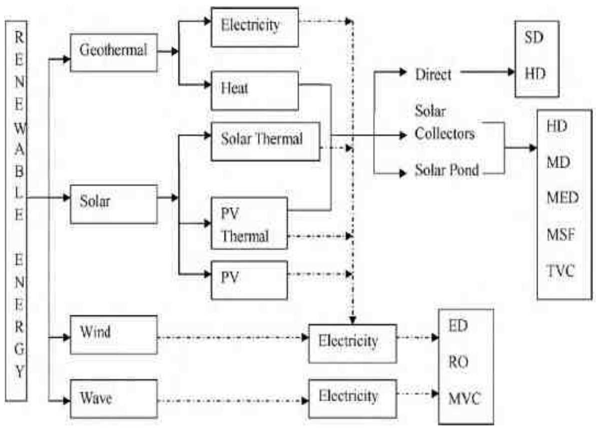

Chart 2: Possible Combinations of Desalination Systems with Renewable Energy. PV= Photovoltaic, SD= Solar Distillation, HD=Humidifications-Dehumidifications, TVC= Thermal Vapor Compression, ED= Electro Dialysis. (Gude, Nirmalakhandan & Deng 2010).

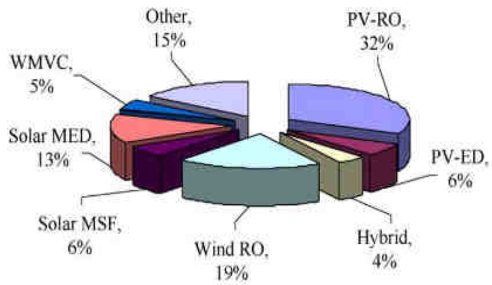

Chart 3: Desalination technologies powered by renewable energy sources [Eltawil, 2009].

3.1 Desalination with Wind Energy

Wind turbines aim to make effective use of the kinetic energy of wind. Wind turbines came back to the foreground of energy technology in the mid-70s, mostly as a consequence of the energy crisis, but also due to environmental degradation. The main application of wind turbines is the production of electricity and its channeling into the central electrical grid or into a local grid.

Nowadays, the coupling of wind turbines with desalination systems is technically feasible. The desalination systems driven by wind power are the most common renewable energy desalination plants.

Wind energy can be an important solution, especially for the coastal areas or islands, in which the wind potential is especially increased. Generally, the wind potential is considered appropriate if the average wind speed is over 5m/sec. On islands, wind energy can be used both for desalination and to meet the energy needs of residents.

So, compared to other forms of renewable energies, wind energy is considered the most advantageous.

Given that reserve osmosis has the lower energy consumption from all desalination processes, its combination with wind energy in coastal areas or in islands with high wind potential for the seawater desalination is considered especially attractive.

Already, many efforts have been carried out in the sector of desalination with reverse osmosis in combination with wind energy [Miranda 2002]. In addition, a prime example of a hybrid system equipped with wind turbine and photovoltaic panels, which is made by the Center for Renewable Energy Sources & Saving which is located in Laurio since 2007[Tzen E. 2007], as also the example of Idriada which is located in the Aegean Sea since 2007 [Nikitakos, 2008].

With regard to the cost of produced water, it is affected by climate conditions, the capacity of the unit, variations of wind speed and by the technology of reverse osmosis.

In any case, in isolated areas for the desalination of brackish water and not for salt water, electro dialysis and not reverse osmosis is preferred, due to the electro dialysis being less sensitive in operation with variable incoming energy, which comes from wind turbines.

3.2 Desalination with Wave Energy

In order to harness the power of the waves, there needs to be a device that transforms the wave energy to a more useful type, usually to mechanical energy, from which e.g. electricity can be made [Mc Cormick, 2007]. At present there are a great number of different concepts for wave energy utilization [Polinder,2005] but no one universally accepted configuration, like the three blade turbine in wind energy industry [Folley, 2007]. Also, there does not exist one single agreed way of classification of the different concepts [Polinder,2005].

Wave energy converters (WECs) can be classified e.g. by their positions (on-shore, near-shore or offshore), by their size (point absorbers, versus large absorbers) or by their operating principle [Falcão 2010].

In this specific research the classifications of WECs will be carried out with based on their position. So, we have the followings:

Nearshore Devices are situated in 10-25 meters of water near the shore. The most common device for this situation is the oscillating water column.

On the other hand *Offshore Devices* are situated in deep water, with typical depths of more than 40 meters. The incidence of wave power at deep ocean sites is three to eight times the wave power at adjacent coastal sites.

The wave energy converting device placed on the sea bed may be completely submerged, it may extend above the sea surface, or it may be a converter system placed on an offshore platform. The visual impact of a wave energy conversion facility depends on the type of device and its distance from shore. Onshore or Nearshore devices could change the visual landscape from one of natural scenery to industrial [Kamargianni, 2010].

Wave powered desalination plants have been under development since the 1970s. The first concept included e.g. the DelBuoy, a point absorber type WEC directly pressurizing seawater [Hicks, 1988]. Even though no concept has so far made a commercial success, there are numerous on-going projects in this field, e.g. CETO and AWEC [OES 2012].

4. Wave & Wind Energy Resource

4.1 Wave Energy Resource

The global wave energy resource is somewhat difficult to determine. Depending on the source, varying figures can be found: 2 TW, 1-10 TW and

3.7 TW [Thorpe, 1999]. Furthermore, a new and thorough report gives a value of 2.11 ± 0.05 TW with the confidence of 95% [Gunn, 2012]. Thus, it can be stated that the global wave energy resource is over 2TW. To give perspective, the global electricity demand in the year 2010 was approximately 21000TWh [BP 2011].

Wave power can be a significant source of energy in the future, at least according to the available global wave resource. But not all of the resource is economically or practically exploitable. Some resources are too small to be of economic benefit and some might consist mainly of violet storms, which are impossible to utilize [Cornett, 2008]. Indeed, the economically exploitable resource has been estimated from 850 TWh [Gunn, 2012] to 2000 TWh [Thorpe, 1999] annually, depending on the state of the technology.

The global distribution of wave power resource is expressed in the following figures. From these figures, two clear observations can be made. First, the areas with the highest wave resource are located in Western Europe, Western North America, Southern Chile, South Africa, Australia and New Zeeland. Second, the least yearly variations in wave power are on the areas on the southern hemisphere.

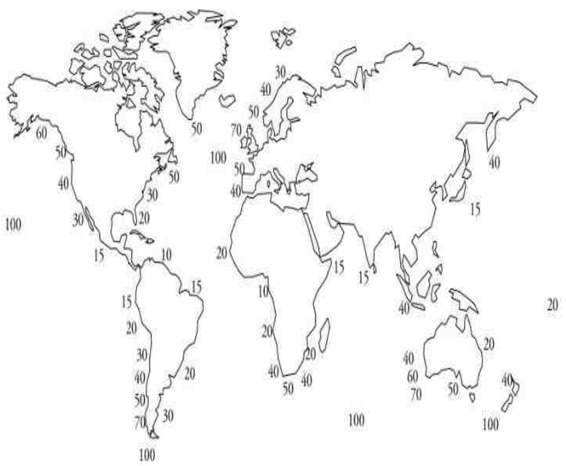

Figure 6: Annual Average Wave Resource (KW/m of wave front). Adapted from Thorpe 1999.

With regard to wave power in Greece, the Aegean Sea has the highest wave power in the Mediteranean, as its wave power ranges between 4-11KW/m. It is worth mentioning that the technical exploitable wave power for the state of EE is 150-230 TWh/year from which the 5-9 TWh/ year corresponds to Greek seas. Thus, it can become easily understandable that our country is characterized by locations, which present special interest for installation of wave devices, such as the locations off the coast of Kimi, the peninsula of Athos e.t.c.

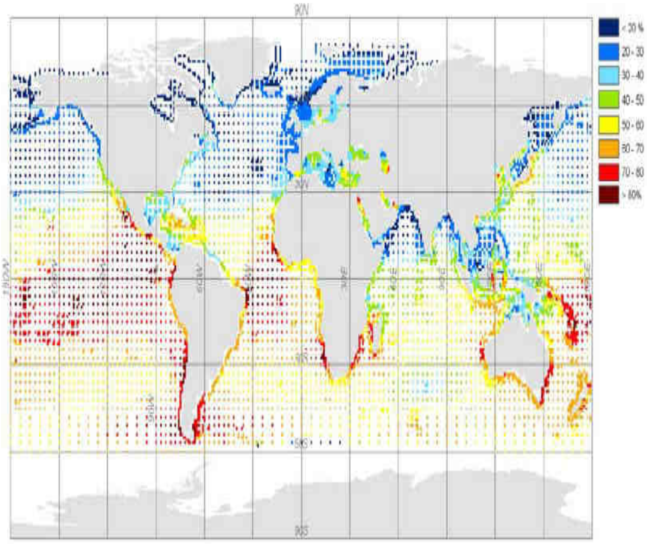

Figure 7: Seasonality of Wave Resource. A high percentage signifies stable wave resource, while low percentage indicates high seasonality. [Mork et all., 2010]

Also, the south Aegean is characterized by a particularly high wave potential and in more detail this is pinpointed between:

- Crete-Kithira and Crete-Kasou, where the wave potential ranges between 6-8KW/m.
- Also, in the straits between Crete-Karpathos and Karpathos-Rhodes where the wave potential is 6 KW/m.
- Finally, in the Ionian Sea, where the wave power on an annual basis varies between the range 4-8 KW/m.

4.2 Wind Energy Resource

Wind energy is the energy which is produced from the exploitation of wind. The wind is caused by the movements of air masses due to the differential pressure and temperature which are generated in the atmosphere by the incoming solar radiation. [Flokas,1997]. The conversion of the kinetic energy of the wind into electricity is made possible through the turbines.

The potential for the increased use of wind energy is huge (figure 4). The estimated potential (onshore and offshore) for the wind energy in Europe is about 4800 TWh per year and worldwide 53000TWh per year.

More specifically, the locations of our planet which are considered especially favorable regarding wind potential, are the those of polar and temperate zones and especially those close to coasts.

In Europe, the locations which are characterized by high average wind speed are Ireland, England, Belgium, Holland, Portugal, France as well as the locations of The Eastern Mediterranean including, our country.

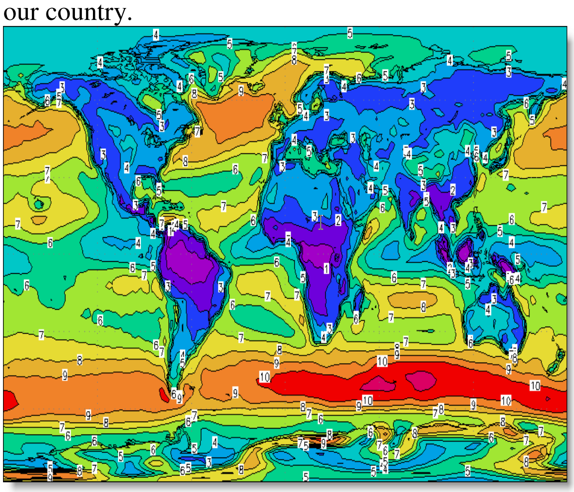

Figure 8: Wind Atlas of the World (wind speed in ms^{-1}). Source: Risoe National Laboratory)

Greece is a country with great wind potential due to its geographical position and its topography. It is considered one of the most favorable counties of the world from the aspect of wind power, which is the strongest in Europe after that of England and Ireland.

In many places throughout the country where measurements have been conducted, positions have been shown with wind potential <6.5 m/sec, where these are indicated for the installation of wind parks. The best places for the installation of wind parks considered are the north Peloponnese, eastern Greece, Crete as well as the islands of the Aegean Sea.

However, nowadays, the scarcity of positions on land, (especially in Europe), the environmental impacts as well as the exploitation of more available wind energy of the sea have led to the exploitation of the wind at deep sea locations. So, more specifically, the Aegean Sea is characterized as one of the best places in Greece, with pretty strong winds, for the installation of offshore wind parks

The wind speed over the open sea is stronger than on land. This is because the wind of the open sea is not obstructed, and the only part of the energy which is lost is due to the friction the wind has with the surface of the sea. In contrast over land, it constantly meets obstacles, such as mountains, forests e.t.c.

5. The Solution of Hybrid Wave & Wind Energy Conversion Applied to an Offshore Platform

5.1 Requirements & Solution Concepts

System's design and development combined research from several scientific domains. The most important requisites we had to satisfy were that the system is friendly to the environment and autonomous. Environment friendly means that it does not have any side effects and autonomous means that the floating platform operates unmanned and that energy comes from renewable source [Lilas, 2007]. The solution focused on the development of the required subsystems, their integration on a suitable floating structure and operation under the supervision of intelligent control system.

From an operational point of view potable water is produced from the sea water desalination unit, which requires energy. This energy is provided by the wind generator and wave device which is placed close to main platform.

Also energy management is very important and has three main targets: (a)System survival in case where there is prolonged period without significant energy input,(b)Extract as much energy as possible from wind and wave and maximize water production, (c) Reduce maintenance cost and problems.

In addition, the research has focused into the following targets:(a) Optimizing energy efficiency of desalination unit over a wide range of water output according to available power, (b) Environmental friendly operation without any chemical additives, [Younos,2005, Rachel, 2003] (c) Design of the floating structure so that to be stable not affected by waves and provides safe operation of all components, (d) Design of control and teleoperation system.

5.2 Design of Floating Platform

The design of the floating structure in order to fulfill some requirements went over the following phases: (a) Survey of studies worldwide for floating wind turbines and state of the art [Sklavounos, 2006, Skaare, 2006], (b) Design of a feasible solution that can fulfill the requirements, (c) Optimization of design characteristics to improve performance and reduce cost, (d)Final stability study and load analysis of optimized design. The optimization targets were to minimize movements from waves, improve the operation conditions for the wind turbine and wave device and withstand extreme weather conditions.

Concerning our project, the first step was to examine the shape and the dimensions of the structure. Also, it was examined which is the appropriate number of peripheral floaters around the central floating structure. So, four peripheral floaters were selected, because this design provides better stability as well as it has construction advantages [Glykas, 2008].So, the final design of floating platform consists of four peripheral floating cylinders with total height 0f 8 meters, and diameter

2 meters each, and a central floating cylinder the diameter of which is 4 meters and height 8 meters as we can see in the figure 5.

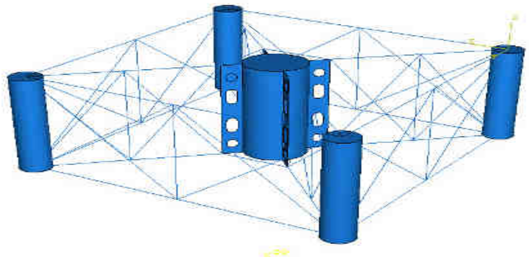

Figure 9: The Tubular Mesh & Cylinders.

In the central floating cylinder will be placed the wind turbine. Also the connection of all cylinders takes place with a tubular mesh. The system has automatic control via GPRS for monitoring and remote control. In addition it is worth mentioning that whole construction can operate even in adverse weather conditions.

5.3 Design of Wind Turbine & Wave Device

It has already been mentioned that the wind turbine is placed at the center of the floating cylinder. The features of this specific wind turbine are the following: (a) It has 30 Kw in power, (b) Variable pitch of blades and (c) variable speed. The role of the wind turbine is to provide energy for the desalination of sea water. So, it becomes understandable that when wind speed is high, the system produce more water, so power consumption increases, whereas when it is low, it decreases. The power supply to the desalination unit is energy that comes from the wind generator and wave device, without using the national supply grid or any kind of diesel generator. In the following chart you can see the power curve of wind turbine.

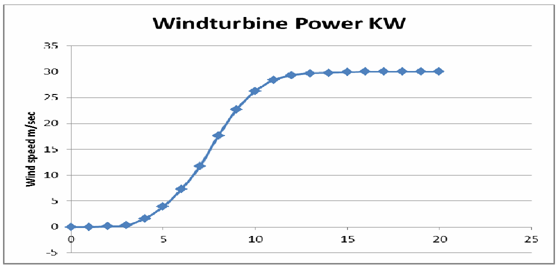

Chart 4: Wind Turbine Power Curve.

Now, with regard to the wave device, a system of wave energy was studied and designed, which was implemented and put into autonomous operation as a trial.

It is worth mentioning that in intervals in which we have "*good wind*" we usually have and strong waves. While the air varies significantly even at 5 minutes intervals, waves remain stable enough for long periods.

The specific wave device has a wave front of 8 meters, and produces hydraulic power 25 Kw, even if the waves have more power. Also, the wave device utilizes the 11% of the available wave energy.

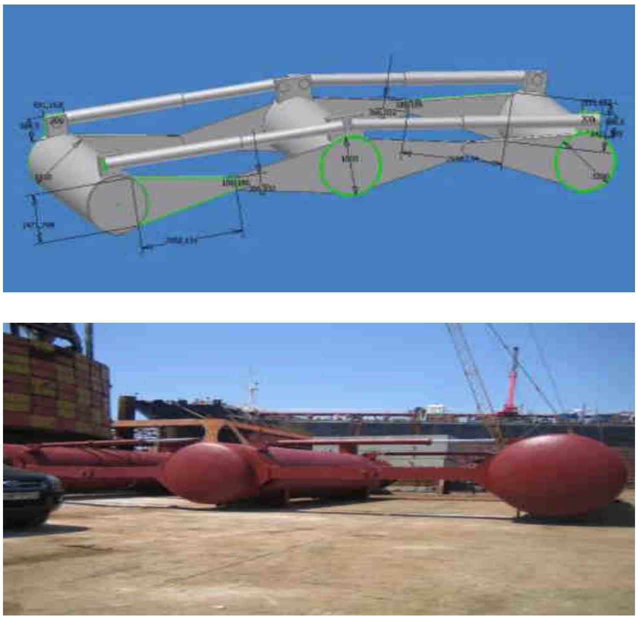

Figure 10: Wave Device.

5.4 Design of Desalination Unit

The desalination unit is installed on the floating platform as well as the control center system for remote operation and the storage tank of potable water.

The method of reverse osmosis was selected as the most appropriate desalination method. The main issues to be environmental friendly were not to treat brackish water which is also scarce, the use of chemicals to treat water and the disposal of brine with chemicals. The whole system performed at Elefsis bay. The reverse osmosis unit operates from 8 Kw up to 25 Kw. Energy storage is small and therefore water production should follow available power, by varying flow and pressure. The water production varies from 1m3/h to 3.5 m3/h.

With regard to the production of water from the combination of wind /wave device (which is still at an experimental phase), we can observe that the production of water is increased, as we can see from the following chart.

It is characteristic that in the case in which only the wind turbine operates, much less water is produced compared with the case in which both wave device and wind turbine operate together. The reason is that, as has already pointed out, waves remain stable enough for long periods compared with the wind, which can vary significantly.

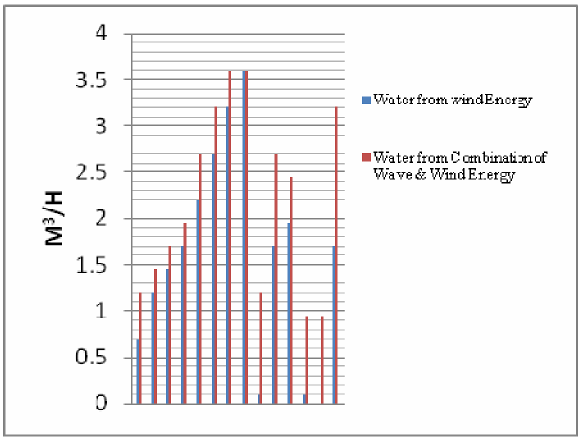

Chart 5: Production of Water.

Conclusions

Seawater desalination can be an attractive alternative to ensure a secure source of water. However, the energy requirements for that process are large and can be a problem mainly in isolated areas. In some locations, particularly in islands, renewable energies can be the most sustainable way to supply the energy needs for desalination, because it can be available close to desalination plants and avoid environmental /availability problems associated with fossil fuels.

Wind and wave power are two of the most abundant forms of renewable energy, which can be used for water desalination. In the last few years wind power technology had impressive developments, and is becoming cost effective compared with fossil fuels alternatives.

Wave power is not yet a fully mature technology and there is a variety of conversion systems currently available and many more are under development. The huge potential of these forms of energy can increasingly be used in desalination systems to meet the growing needs of fresh water in many parts of the world, lacking this precious resource.

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PART III

DAY 3 – 11 OCTOBER 2013

Programs and Projects

New Market Mechanisms under the UNFCC, by Prof. Edoardo CROCI

New Market Mechanisms under the UNFCC

Edoardo Croci
IEFE (Research Center of Economics and Policy of Energy and the Environment) – Università Bocconi

Promitheas - 6th Annual International Scientific Conference On Energy and Climate Change
9 – 11 October 2013, University of Athens, Athens

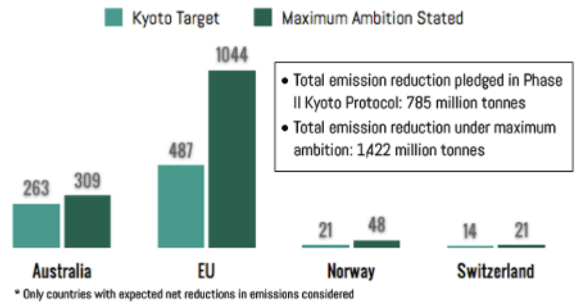
Doha «Climate Gateway» (2012)

- Rules for **KP second committment period (2013-2020)**
- Parties committed to reduce GHG emissions by at least 18 per cent below 1990
- 80 Countries made emission reduction pledges
- Reductions correspond to about **15% of global emissions**
- Defection of the USA, Japan, Canada, New Zealand and the Russian Federation by the KP because of low global commitment
- Some restrictions in using "hot air" (carry over) in second period (max 2%) + political declaration of potential buyers not to use residual credits + no new hot air
- **Work programme for new negotiation track to be concluded by 2015**
- **New legal framework in place in 2020**

Doha agenda

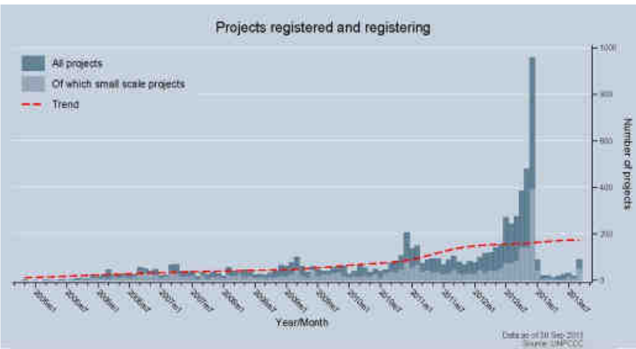
- Annex 1 Parties that have agreed to the second commitment period obligations will review their quantified emission limitation or reduction objective (QELRO) during 2014
- **Only parties with a QELRO under the second commitment period of the Kyoto Protocol are eligible to transfer and acquire second commitment period Kyoto units (CERs, ERUs, AAUs, RMUs)**

Emission reductions 2013-2020 under phase II (million tonnes CO2 eq.)

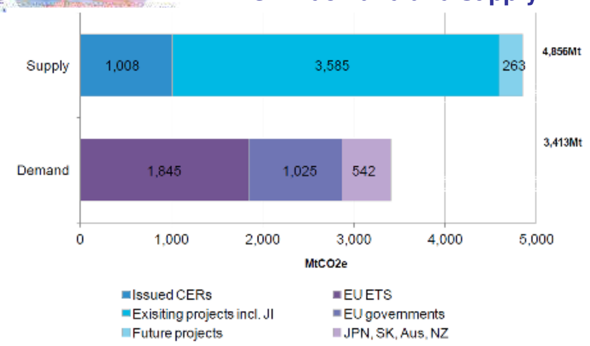


Climate Connect, 2012

CDM under the Kyoto Protocol

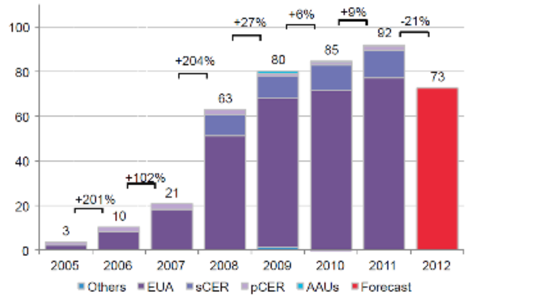


CER demand and supply



Bloomberg, 2012

Volume of carbon markets: institutional markets (billion of euros)



FVA - NMM

At the Durban Conference (decision 2/CP.17) it was decided to conduct two work programmes to:

a) Consider a **framework for various approaches (FVA)**

b) Elaborate modalities and procedures for the **new market based mechanism (NMM)** operating under the guidance of the COP.

The first one is a framework that would leave it up to countries to define their own approaches and methodologies in a decentralized manner, where the UNFCCC will play a role only in providing a platform for exchange of information and a general set of common principles.

The second one refers to an international market mechanism that is set up and governed centrally under UNFCCC.

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FVA

The FVA is a set of components and rules that will ensure that all approaches used for mitigation will meet certain standards, especially from an environmental integrity point of view. The FVA will ensure that all mitigation approaches are integrated, and receive recognition, for UNFCCC compliance. Through the FVA, units created by a **DMM (Domestic Market Mechanism)** in a jurisdiction will qualify, under certain conditions, to be used for compliance with UNFCCC obligations, by a jurisdiction other than the one under which they were created.

The FVA is not concerned with activities that are purely of a domestic nature and do not result in international transfers of units in one way or another.

A fundamental principle should be that all activities that can be effectively regulated at a level other than the international one, should be regulated at that level. Only those activities, which, if not regulated internationally, would affect the integrity of the international climate change regime, should be regulated internationally.

CEPS, 2013

9

New Market Mechanism (NMM)

A new market-based mechanism, operating under the guidance and authority of the COP, is definied to enhance the cost-effectiveness of, and to promote, mitigation actions, bearing in mind different circumstances of developed and developing countries, which is guided by decision 1/CP.16, paragraph 80, and which, subject to conditions to be elaborated, may assist developed countries to meet part of their mitigation targets or commitments under the Convention.

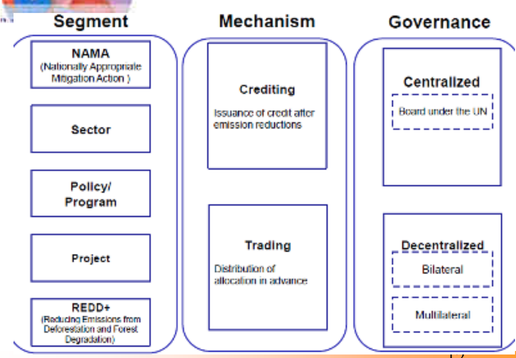
Design of NMM

- Ensure voluntary participation
- Complementing other means of support for NAMAs
- Safeguard environmental integrity
- Careful definition of boundaries to avoid emissions leakage
- Ensuring net decrease / avoidance of GHG emissions
- Assisting country parties to meet their mitigation targets
- Ensure good governance and robust market functioning

Two possible approaches:

- **Project based: compare to BAU scenario**
- **Performance based: compare to relevant lower emitting practices**

New Market Mechanism



Source: IGES, 2012

12

Concerns about FVA -NMM

- **hot air**
- **the potential double counting of credits**
- **the establishment of crediting standards baselines and commonalities of measurement**
- **reporting and verification (MRV)**
- **modalities for linking**

NAMAs

A NAMA specifies voluntary activities of GHG emissions mitigation in developing countries that are not subject to mitigation commitments and can be supported by industrialized country financing technology or capacity building.
2 kinds of NAMAs: developed with domestic resources ("**unilateral NAMA**s") and requesting international support ("**supported NAMA**s").
Financing is thought to be channeled through bilateral or multilateral donors or through facilities officially approved by the COP.
Supported NAMAs could be co-funded through carbon offset credits generated for the amount of emission reductions achieved and traded on the carbon market ("credited NAMAs"). This concept is rather likely to evolve under a new market mechanism scheme.

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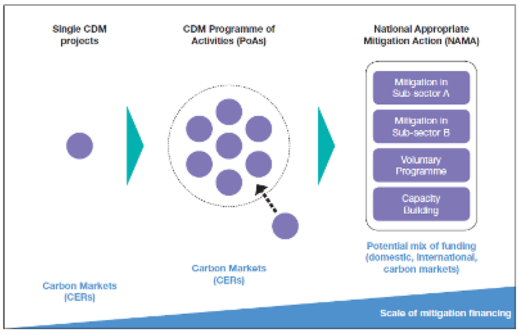
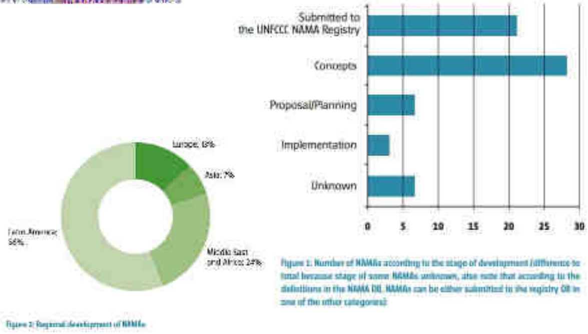
Scale of mitigation financing

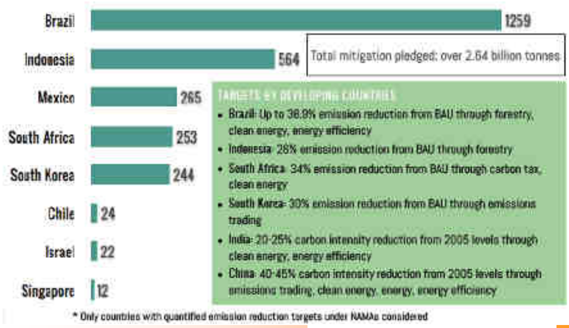


NAMAs



Ecofys, 2013

Emission reduction potential by 2020 under NAMAs announced by developing countries (million tonnes CO2 eq.)



Climate Connect, 2012

REDD

REDD is a mechanism **to create an incentive for developing countries to protect, better manage and wisely use their forest resources**, contributing to the global fight against climate change.
REDD strategies aim to make forests more valuable standing than they would be cut down, by creating a financial value for the carbon stored in trees.
The final phase of REDD involves *developed countri*es paying *developing* countries carbon offsets for their standing forests.
REDD aims at preserving forests so that their formidable economic, environmental and social goods and services benefit countries, communities, biodiversity and forest users while also contributing to important reductions in greenhouse gas emissions.
REDD+ strategies go beyond deforestation and forest degradation, and include the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in reducing emissions.

Tropical deforestation accounts for 12 to 15 percent of annual anthropogenic CO2 emissions (FEEM)

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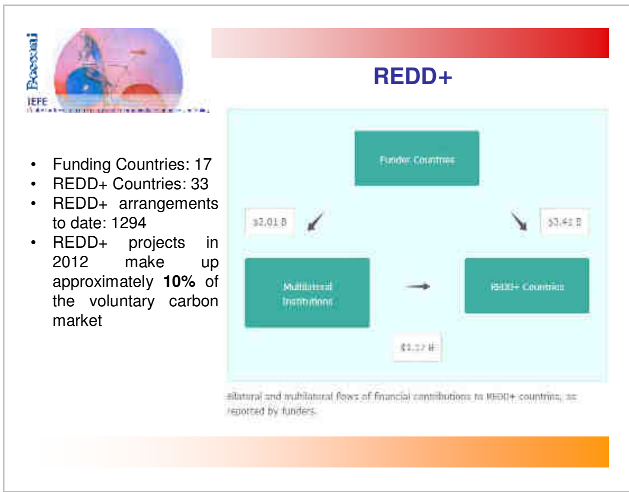
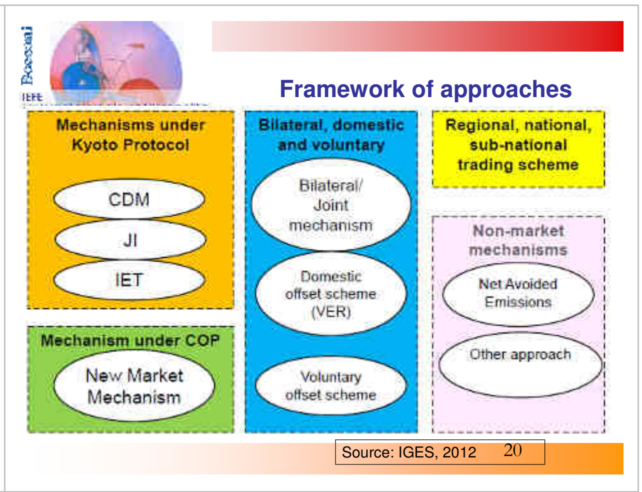

REDD+
• Funding Countries: 17
• REDD+ Countries: 33
• REDD+ arrangements to date: 1294
• REDD+ projects in 2012 make up approximately **10%** of the voluntary carbon market
Funder Countries
Multilateral Institutions
REDD+ Countries


Framework of approaches
Mechanisms under Kyoto Protocol
CDM
JI
IET
Mechanism under COP
New Market Mechanism
Bilateral, domestic and voluntary
Bilateral/ Joint mechanism
Domestic offset scheme (VER)
Voluntary offset scheme
Regional, national, sub-national trading scheme
Non-market mechanisms
Net Avoided Emissions
Other approach
Source: IGES, 2012
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EDOARDO CROCI
edoardo.croci@unibocconi.it
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Energy and Climate Change – The BSTDB experience, by Mr. Roman MATKIWSKY

Energy & Climate Change – the BSTDB Experience

6th Annual International Scientific Conference
On Energy & Climate Change
October 2013

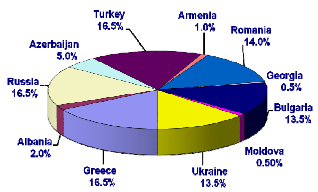
Black Sea Trade & Development Bank

BSTDB At A Glance

- Headquarters: Thessaloniki, Greece
- First Operation: November 1999
- Employees: 100
- Shareholders: 11 countries of the Black Sea Region
- Authorized Capital: EUR 3.5 billion (doubled in 2008)
- Cumulative Portfolio: EUR 2.7 billion (257 projects)
- Active Portfolio: EUR 1.27 billion (106 projects)
- Credit Ratings: A3 by Moody's (August 2013) A-/A-2 from S&P (October 2013).The ratings are 5 notches higher that the average rating of the shareholders. BSTDB is the best rated financial institution in the Black Sea region.

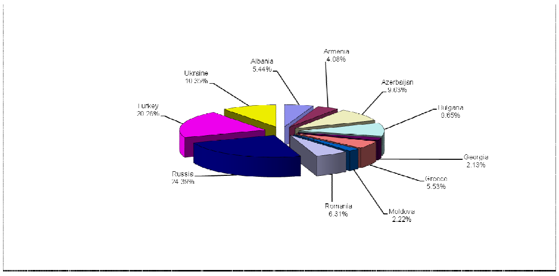
Black Sea Trade & Development Bank

Shareholding Structure



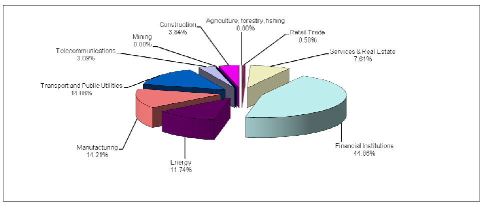
Black Sea Trade & Development Bank

Outstanding Operations by Country (at 31/12/2012)



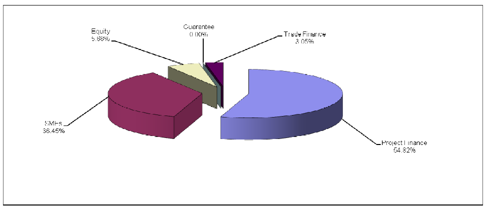
Black Sea Trade & Development Bank

Sectoral Distribution of Projects
(Outstanding Operations at 31/12/2012)



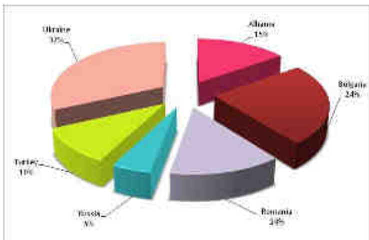
Black Sea Trade & Development Bank

Operations by Product Type
(Outstanding Portfolio at 31/12/2012)



Black Sea Trade & Development Bank

Energy & Infrastructure Portfolio
(at 31/12/2012)



BSTDB: Energy & Infrastructure

Primary Type of Transactions:
- Project Finance
  - Up to 35%
  - Sponsor equity of about 30% and remainder co-financed
- Corporate Finance
  - Well established Corporates with a strong record of healthy IFRS audited financials
- All projects must:
  - Have a solid business plan & IFRS statements
  - Pass KYC, Corporate Governance, and Creditworthiness checks of Sponsor / Borrower
  - Pass due diligence checks (market, financial, technical, EHS, legal, etc.)

BSTDB Energy Portfolio (1)

- BU: Maritza East I
  - Construction of 600MW lignite-fired power plant, owned by AES
  - Participant in EUR 1.1b debt facility
- BU: Suvorovo Wind Farm
  - Construction of 60MW wind farm, with Spanish sponsor
  - Participant in EUR 62m debt facility
- RO: Petrom
  - Corporate loan to largest Romanian oil & gas group to finance various components of strategic environmental program
  - Participant in EUR 275m debt facility

BSTDB Energy Portfolio (2)

- TU: Koprubasi
  - Construction of 74MW Hydro Power Plant
  - Participant in USD 28m debt facility

BSTDB Energy Portfolio (3)

- UA: Alfa Nafta
  - Finance expansion of gas filling station network
  - USD 36m debt facility
- UA: Chornomornaftogaz
  - Support development of existing oil & gas reserves on Black Sea
  - USD 21m debt facility
- UA: Galnaftogaz
  - Finance expansion of gas filling station network
  - USD 44m debt facilites
- UA: Gas Transit
  - Construction of compressor on existing Ananyev-Izmail gas pipeline.
  - Participant in EUR 97m debt facility

BSTDB Experience

- Energy & Climate Change
  - European energy demand is increasing
  - What does it mean for BSTDB - projects
- Conventional Energy
  - Limited number of projects with very long lead times and greater environmental hurdles
- Renewable Projects
  - Explosion of new projects some with questionable viability
  - We have reviewed numerous projects in BU, GR, RO, RU, TU, UA
- Energy Efficiency
  - Sometimes and add-on to existing projects

BSTDB Renewable Energy Experience (1)

- EU and the 20/20/20 Objective
  - By 2020 the EU should produce 20% of energy from renewable sources & 20% more energy efficiency.
- Support Mechanism: FiT vs. GCs vs. Market
  - Feed in Tarrifs (e.g. BU, GR, UA etc)
  - Green Certificate Schemes (e.g. RO, PL)
  - Market (i.e. TU – min. Tariff for Government offtake)
- Reality: Price Increases, Demonstrations, Elections, and Uncertainty
  - Demonstrations in BU & RO. Regulatory changes in RO.
  - Need of restructuring by all parties.
- Size of Differential between Subsidy & Market
  - An important element for bankability

Black Sea Trade & Development Bank

BSTDB Renewable Energy Experience (2)

- BU: NEK payment delays
  - Need of restructuring by all parties and will affect all.
- GR: FiT too lucrative to believe
  - Difficult to believe will remain the same after 2012 Debt default and arrears in RES Account.
- RO: GCs with market mechanism
  - Trying to create GC market with market discipline
  - Recent regulatory changes too much for many to absorb thus creating further uncertainty
- TU: Minimum price guarantee on spot market.

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BSTDB Renewable Energy Experience (3)

'If tariffs are too good to be true' ......they definitely won't last in the long term!

Black Sea Trade & Development Bank

Thank You!

Roman Matkiwsky
Director, Energy & Infrastructure
E: ei@bstdb.org

Black Sea Trade & Development Bank

ENERGY POLICY

AESDS

AT A GLANCE

Title: Armenian Energy System Development Study using the MARKAL-Armenia Integrated Energy System Model

Funding mechanism: Cost Plus Fixed Fee

USAID, Greece Hellenic Aid

Total Cost: 21.449,00 $

USAID Contribution: 21.449,00 $

Duration: 21 months

Start Date: 1/3/2011

Consortium: 16 partners from 11 countries

Project Coordinator: International Resource Group

Project Web Site: N/A

Key Words: energy policy, energy security, diversification of supply, economic competitiveness, energy efficiency, renewable energy, development scenario

THE CHALLENGE

Under the USAID Regional Energy Security and Market Development project, and in conjunction with the joint SYNENERGY Strategic Planning effort undertaken with Greece Hellenic Aid, a strategic planning activity was undertaken, which aimed to develop a comprehensive national energy planning framework to support policy analysis of future energy investment options in Armenia. The analysis provides important insights on how improving energy efficiency (EE) and promoting renewable energy (RE) impacts into three key policy areas: energy security and diversification, economic competitiveness, and climate mitigation.

PROJECT OBJECTIVES

1. **Organizing Planning Team:** Development and mentoring of a Planning Team consisting of representatives from the key energy planning Ministries and leading energy institutions in the country.
2. **MARKAL/TIMES model creation:** Building of a MARKAL/TIMES national model capable of evaluating a wide-range of energy policy and technology options that will influence the evolution of country energy system.
3. **Capacity building:** Participating with other regional experts in this process as part of a network of skilled professionals examining pressing national and regional energy and environmental policy issues.
4. **Evaluation of available data and information:** Overview of local national databases, international data sources if national data is not available, and filling data gaps using experience of similar countries, local and international experts' estimations.
5. **National Markal model development:** Creation of calibrated base year model, making assumptions for the planning horizon, and Reference scenario development, which is representing basic energy strategy of country.
6. **Implementation of additional scenarios:** Development of Energy efficiency scenario based on national energy saving strategy, Renewable energy scenario, which intends realization of RE sources according to RE development roadmap of Armenia, Combination of RE and EE measures, analysis of several cases related to nuclear energy further

development for the development effective policy portfolios which will show impacts of different measures in the future.

7. **Dissemination:** Presentation of results at a National Workshop and dissemination of document among key stakeholders.

METHODOLOGY

The methodology employs least-cost optimization, identifies the most cost-effective pattern of resource use and technology deployment over time, provides a framework for the evaluation of mid-to-long-term policies and programs that can impact the evolution of the energy system, quantifies the costs and technology choices that result from imposition of the policies and programs, and identifies the benefits arising for various policies and programs, such as increase energy security and economic competitiveness, reduced emissions, promotion of energy efficiency, use of renewable energy sources, various pathways of nuclear energy development.

PROJECT PARTNERS	
Ministry of Energy and Natural Resources of Republic of Armenia	AM (Armenia)
Albanian Agency of Natural Resources	AL (Albania)
Faculty of Electrical Engineering in Istocno	BH (Bosnia & Herzegovina)
Faculty of Electrical Engineering in Sarajevo	BH (Bosnia & Herzegovina)
Ministry of Economy and Energy	BG (Bulgaria)
Ministry of Economy, Labour and Entrepreneurship	CR (Croatia)
Hrvatska Elektroprivreda	CR (Croatia)
Energy and Environmental Protection Institute Ltd	CR (Croatia)
World Experience for Georgia	GE (Georgia)
Tbilisi State University	GE (Georgia)
Ministry of Economy, Department of Energy	MC (Macedonia)
Research Center for Energy, Informatics and Materials, Macedonian Academy of Sciences and Arts	MC (Macedonia)
Academy of Sciences of Moldova / Institute of Power Engineering	MO (Moldova)
Transelectrica	RO (Romania)
Electric Power Industry of Serbia	SB (Serbia)
National Academy of Science / Institute for Economic Forecasting	UA (Ukraine)

PROJECTS AND PROGRAMS

VIRTUAL POWER PLANT

AT A GLANCE

Title: Integrating distributed standby generators in a Virtual Power Plant

Estimated duration: 8 months approximately before the operation

Project Coordinator: NKUA – KEPA (HELLAS)

Key Words: virtual power plant, standby generators, ICT

THE CHALLENGE

Power systems with inadequate installed capacity face structural problems in balancing peak demand periods and offsetting the intermittent RES-E production.

Although improving energy efficiency and quality of the provided electricity should be one of the main concerns of the Transmission System Operators (TSOs), the dominant problem is this of meeting high peak demand and facing unexpected disturbances due to unexpected outputs of power stations or other causes.

A solution to this problem is the creation of a Virtual Power Plant (VPP) composed of a number of standby generators interconnected in a smart network and managed in a unified way, so that it responds automatically and appropriately to specific requests of the Distribution Network Operator.

PROJECT IMPLEMENTATION STAGES

The implementation stages before the operation of VPP include the feasibility, technical and economic studies as well as its commercialization. First, an inventory of the installed standby generators, their geographical dispersion and their technical and operational characteristics should be drawn up. The exact characteristics and dimensions of operation of the VPP should be defined, that is the level of control that VPP accepts, the emergency criteria used, the economic criteria implemented, the communication platform characteristics, etc. The institutional context and the tariff policy should be determined. The hard core of the project is the *technical study* for the development, operation and interaction of the ICT platform with both the distributed generators (VPP) and the network (DSO). The *commercial study* will survey the existing market rules, the associated legislative framework.

The implementation includes the determination of legal status (public or private), the realization and testing till the license and the contract.

ORGANISATION

The VPP consists of a fully automated Control Centre (CC) that coordinates the distributed generation and the geographically distributed standby generators.

The CC is equipped with ICT infrastructure for generator dispatch control, real-time monitoring and management, automatic meter reading and financial statement.

The G/S are equipped with devices of synchronisation with the power grid in low or medium voltage, protective relaying, switch gear, metering, PLC for remote management and hierarchical operation.

The various generators are managed and activated by the CC through the appropriate software. Through communication protocol, the VPP is connected with the System Operator. When the System Operator indicates that there is peak power requirement or power disturbance in a certain geographical area, then according to criteria like the location, availability and the installed capacity of the G/S, the appropriate G/S are activated to face the problem.

BENEFITS

Of the most important benefits is the “on call” reserve in case of local overloading, peak power requirements, major generation units’ failure and for offsetting the intermittent RES production. This proposed project is even more attractive due to the low investment costs that are required.
Also, the familiarization with the “smart grid” technologies can be considered as collateral benefit.

LOW CARBON DEVELOPMENT

URBAN-LEDS

AT A GLANCE

Title: Promoting Low Emission Urban Development Strategies in Emerging Economy Countries

Funding mechanism: European Union (EuropeAid/DCI-ENV/2011/269-952)

Total Cost: 6,700,000 €

EC Contribution: 6,700,000 €

Duration: 42 months

Start Date: 1/3/2012

Consortium: UN-HABITAT, ICLEI World Secretariat and 5 ICLEI regional offices in Europe, Brazil, Indonesia, India and South Africa

Project Coordinator: UN-HABITAT/ICLEI World secretariat

Project Web Site: http://urbanleds.iclei.org/

Key Words: Climate change, urban energy planning, Low carbon emissions strategies, integrated approach, local governments

THE CHALLENGE

As unplanned high-carbon urban growth, rising energy costs and increasing demands on service delivery, are putting pressure on local governments it is foreseen that cities which pioneer a low emission development model today will be the ones that attract future investment, reduce energy costs and become the most desired places to live and work.

The Urban-LEDS project, funded by the European Commission, and implemented by UN-HABITAT and ICLEI, has the *objective* of enhancing the transition to low emission urban development in emerging economy countries by offering selected local governments in Brazil, India, Indonesia and South Africa a comprehensive methodological framework (the GreenClimateCities methodology) to integrate low-carbon strategies into all sectors of urban planning and development.

PROJECT OBJECTIVES

1. **Design of Low-Emission Urban Development Strategies:** development of a comprehensive approach for the articulation and implementation of a model Low-Emission Urban Development Strategies (Urban LEDS), applicable to local governments in emerging economies (WP2).
2. **Implementation of Urban-LEDS:** Developing city-specific Urban LEDS program in selected 2 Model Cities in each project countries (WP3).
3. **Assessment of different solutions** (creation of cost curves for mitigation measures) and potential funding models explored before starting with the implementation of actions on the ground during the final year of the project (WP3).
4. Engage with national governments to build synergies with national LEDS processes (WP3).
5. Initiate implementation of priority actions developed within city specific Urban LEDS which will be presented within the scope of Nationally Appropriate Mitigation Actions (Urban NAMAs)
6. Engage with national Satellite Cities in each country to create a multiplier effect by benefitting from the experience of Model Cities.
7. Effectively linking all Model Cities and selected European Partner cities to encourage knowledge sharing and North-South-South cooperation. Study tours, staff exchanges and knowledge sharing seminars will enable the cities to learn from each other.
8. Development of a “Solutions Gateways” to be offered to Model Cities as a basis for contribution to developing their own low carbon action plans. Solutions to be sectoral and cross-sectoral

packages of activities, normally structured along local government responsibilities (e.g. green buildings, sustainable purchasing, ecoMobility…), as well as financial models and technological options for the implementation of selected priority actions.

9. Reporting of local GHG inventories and mitigation actions in the global database of the carbon*n* Cities Climate Registry (cCCR) through globally acceptable and nationally appropriate verification models.
10. Ensure coherence of Urban-LEDS and Urban NAMAs with efforts at the national level.
11. Ensure that mitigation actions of local governments are appropriately integrated in the design and implementation of global climate regime for the post-2012 period.
12. Communication of project outcomes to the global climate community at official UNFCCC events.

Methodology

ICLEI's new GreenClimateCities methodology covers all aspects of policy planning, implementation and monitoring of local climate and energy action managed by the local government.

• **Building on 20 years experience:** ICLEI's 5-milestone process in the Cities for Climate Protection Campaign forms a foundation for the new methodology

• **Focusing on local government role:** Local leadership, guidance and engagement for municipal operations and stimulating action in the wider community.

• **Using simplified methodology:** Three phases – Analyze / Act / Accelerate - each unfolding into three steps - easily communicated methodology, also to non-experts.

• **Encouraging an integrated approach:** Focus on ways to integrate local energy development criteria into the local government (LG) approach - connecting it to the overall sustainable development strategy, targets and indicators.

• **Addressing start-up and advanced levels:** All LGs are encouraged to act, set ambitious yet realistic targets and acting. Every local government can engage on this topic!

• **Towards MRV Local Action:** Measure, Report and Verify greenhouse gas emissions and mitigation actions, and connecting to global reporting and advocacy processes.

Expected Results

- Urban-LEDS concept development including processes for interaction with national governments;
- Identification of feasible solutions for the implementation of a low emission development and a pool of up to 50 technical experts created from LGs, research and business sector;
- Identification of up to **15 appropriate technological and policy-related solutions** for selected priority measures and packaged into investment portfolios, as well as engagement of local governments with private sector;
- Development of capacity and information sharing to allow up to **5 Satellite cities for each country** to create a multipliers effect;
- Enable North-South and South-South flow of information, resources, contacts and learning including through the inclusion of up to **8 European cities linked to the Model Cities**;
- Use of up to **4 national verification models** and **public record of up to 120 verified local climate data** of participating cities to increase the visibility of local climate action at the national and international level and link to UN climate negotiations;
- Intensified interaction between local governments and global climate actors to ensure local governments´ integration in the design and implementation of post-2012 global climate regime.

Project Partners	
UN-HABITAT	
ICLEI World Secretariat	DE (Germany)
ICLEI Africa Secretariat	ZA (South Africa)
ICLEI South Asia Secretariat	IN (India)
ICLEI Southeast Asia Secretariat	PH (Philippines)
ICLEI South America secretariat	BR (Brasil)
ICLEI European Secretariat	DE (Germany)

HELLENIC ASSOCIATION FOR THE COGENERATION OF HEAT AND POWER (HACHP)

CODE2

AT A GLANCE

Title: Cogeneration Observatory and Dissemination Europe 2

Following the successful CODE project that drew attention to the potential of cogeneration in the 27 EU Member States for the first time, the CODE2 project has been developed to investigate how that potential can be achieved.

Duration: 30 months

Start Date: 1/6/2012

Consortium: Partners from 6 countries

Project Coordinator: COGEN Europe (BELGIUM)

Project Web Site: http://www.code2-project.eu

Key Words: cogeneration, CHP, bio-energy CHP, micro-CHP, trigeneration.

COGENERATION

Cogeneration (Combined Heat and Power or CHP) is the simultaneous production of electricity and heat, both of which are used. The central and most fundamental principle of cogeneration is that, in order to maximise the many benefits that arise from it, systems should be based according to the heat demand of the application. Through the utilisation of the heat, the efficiency of cogeneration plant can reach 90% or more.

11% of Europe's electricity and associated heat requirements today are produced using this proven energy efficiency principle. The estimated growth potential for cogeneration is a further 110-120 GW_e which will lead to an improved environment and greater economic competitiveness in Europe. Cogeneration units can be found in different sizes and applications: industry, households and tertiary sector and spans applications with capacities ranging from below 1kw to hundreds of Megawatts. It is a highly efficient energy solution that delivers energy savings and substantial reductions in CO2 emissions. When seriously supported by Member States, realising the potential of cogeneration in Europe will contribute significantly to reaching the strategic climate and energy goals, such as security of supply, energy efficiency and reduction of emissions.

INTRODUCTION TO CODE2

The CODE2 project is co-funded by the European Commission (Intelligent Energy Europe – IEE) and will launch and structure an important market consultation for developing 27 National Cogeneration Roadmaps and one European Cogeneration Roadmap. These roadmaps will be built on the experience of the previous CODE project (www.code-project.eu) and in close interaction with the policy-makers, industry and civil society through research and workshops.

The project aims to provide a better understanding of key markets, policy interactions around cogeneration and acceleration of cogeneration penetration into industry. By adding a bio-energy CHP and micro-CHP analysis to the Member State projections for cogeneration to 2020, the project consortium will propose a concrete route to realising Europe's cogeneration potential.

The CODE2 project jointly funded by the IEE and industry:

- Develops the first clear plan of action for cogeneration in each EU Member State
- Gathers experts and establishes information networks around cogeneration
- Reviews published data and presents conclusions
- Introduces in detail the new EED
- Assesses the EED's impact with national stakeholders
- Does the first specifically micro-CHP and bio-energy CHP analysis

All in all, CODE2 mobilises effort in each of the 27 EU Member State.

Greece is one of the seven pilot member states participating in the CODE2 project, through the Hellenic Association of Heat and Power (HACHP). HACHP is responsible for the countries of Southeast Europe (Bulgaria, Cyprus, Greece, and Romania).

TARGET GROUPS

CODE2 aims to reach the following stakeholders:

- EU and national policymakers and decision-makers, including wider influencer groups
- Potential and existing users of cogeneration, including all capacities of cogeneration. The main focus throughout the project will be to reach the food/drink, paper and hotel sector as well as SMEs
- Local and regional energy agencies in Europe that support the introduction of good energy management practices
- Cogeneration equipment manufacturers and suppliers who seek to grow and strengthen the industry and its supply chain

PROJECT PARTNERS	
COGEN Europe, the European Association for the promotion of cogeneration, is the project coordinator	BF (Belgium)
Hellenic Association for the Cogeneration of Heat and Power (HACHP)	GR (Greece)
Jožef Stefan Institute	SI (Slovenia)
Federazione d' associazioni scientifiche e tecniche (FAST)	IT (Italy)
COGEN Vlaanderen	BF (Belgium)
Energy Matters (Netherlands)	NL (Netherlands)
Berlin Energy Agency	DE (Germany)
KWK kommt	DE (Germany)

ENERGY POLICY

IMPACT OF RES

AT A GLANCE

Title: Impact of RES Implementation on Technical and Economic Characteristics of Regionally Integrated Armenian Energy System

Funding mechanism: Cost Plus Fixed Fee

USAID

Total Cost: 87.223.568,80 AMD (~158.588,31 €)

USAID Contribution: 87.223.568,80 AMD

Duration: 30 months

Start Date: 1/1/2010

Consortium: N/A

Project Coordinator: Tetra Tech ES., Inc

Project Web Site: http://www.armesri.am

Key Words: power system, isolated regime, regional integration, generation cost

THE CHALLENGE

This study addresses the analysis of economic aspects of regional integration of Armenian power system including assessment of the export/import potential, economic efficiency, testing of regimes for their technical feasibility and development of recommendations to maximize the positive impact of integration. For each of the considered regimes of the power system operation, impacts of new renewable resources were analyzed. Study also included the results of calculations of the ecological indicators and the estimations of the portion of the balance produced from Own Resources.

PROJECT OBJECTIVES

1. **Development of Armenian Power system models via GTMax:** Develop the national economic simulation models of Armenia power system using GTMax software in order to evaluate energy technologies, such as hydro, wind, etc. It includes hour-by-hour system simulation model, which represents all major system components, such us transmission links, generating units with detailed reflection of their operational cost information.
2. **Economic evaluation of renewables**: Conduct economic evaluation of renewable impacts on operational cost of Armenia power system for specified models
3. **Development of economic simulation models of regional power systems:** Develop the regional economic simulation models of Armenia and neighbor countries power systems, reflecting current and potential conventional and renewable generating units for 2015 and 2020 models.
4. **Economic simulation of the regional market**: Demonstrate the benefits that can be achieved (and conversely, those that are foregone) through inadequate levels of integration. Assessment of system generation costs in the mode of non-synchronous operations. Evaluate the economic impacts of parallel operation of systems and cost impact of economic dispatch of the regional system.
5. **Feasibility study of the project**: Analysis of adequacy of the proposed transmission investment projects in order to achieve all benefits suggested by the regional integration and prioritized list of recommended investment projects, which would promote the regional integration.

Methodology

The costs reduction of the internal electricity consumption in Armenia is assumed to be the efficiency criterion (including own generation, and import where applicable) in this study. The GTMax weekly commercial dispatch software was used as a tool for the optimization of calculations. Multi-option calculations were performed to cover all possible regimes applying various system constraints based on the analysis of the situation in Armenia and power systems of the neighboring countries and considering their development trends. Analyses were made to assess advantages of regional integration and isolated regimes. The Isolated regime study results were then compared with those of the integrated study yielding the economic efficiency expected due to the regional Integration of Armenia.

Obtained Results

The results showed that under the existing generation structure, the export-import transactions for 2015 and 2020 are allowed to have reduced costs of generation for internal consumers by 5.8-7% compared to the optimal isolated regime or by $11.4-$13.8 million and by 6.5-7.6% compared to the optimal isolated regime or by $16.6-$19.4 million respectively. Introduction of wind power brings to the deterioration of efficiency indicators in the result of which generation price for the internal consumers will amount to $0.8/MWh (increase of costs is $5 million) and $2.5/MWh (increase of costs is $17.5 million) with commissioning of 40 MW by 2015 and additional 160 MW by 2020 respectively. In all observed cases, integration brings positive economic effects, i.e. decreased total generation cost for Armenia. In case of ANPP decommissioning by 2020, the total generation costs will increase by $95-$122 million per year compared to the option of ANPP life extension.

For the most possible scenarios in 2015 and for all scenarios in 2020, CO_2 emissions decrease in the case of integration in range of 5-26%, 37-270 Gg respectively.

Project Partners	
Tetra Tech ES, Inc.	USA

Projects and Programs

MADATool

At a Glance

Title: The Mitigation / Adaptation Development and Assessment Tool (MADAT).

Project Coordinator: NKUA – KEPA (HELLAS)

Key Words: mitigation, adaptation, development, assessment, tool.

The Challenge

The development and implmentation of converging mitigation/ adaptation policy mixtures among countries with less experience in this process, emerges as a key priority for the next years.

Participation to the global efforts to develop a global Emission Trade Scheme (ETS) before 2013 and to the economic benefits of the New Market Mechanisms (NMMs) that are developed under the UNFCCC framework necessitates the development of a tool that can facilitate the afrementioned countries to be benefited out of this effort.

Tool Description

The MADATool consists of a database, based on data collected from official national sources, a process of scenario structuring, based on the policy makers assumptions, a flexible energy model (LEAP) that run sand gives results even with gaps in the database and finally, of a credible multi – criteria evaluation method (ClimAMS) that results the best mixture.

Characteristics

The MADAT is characterised as a credible (due to the database sources and the AMS check), complete (includes both development of scenarios and assessment of their results), friendly (LEAP is one of the most user friendly softwares, regarding countries with limited available data) and flexible (AMS is using both assumptions and data when filling the sub-criteria, and LEAP operates even with data gaps) tool.

Benefits

Considering that the users need to have a certain background, including knowledge on climate change issues and access to official data and information, it can be used by policy and decision makers, market stakeholders, academicians and even researchers.

As a tool, it can be used as data and/or information source, for development and/or optimatization and/or assessment of policy portfolios, for monitoring the policy implementation progress and even for comparative analysis on regional scale.

It can be used in national/ international funding programs, in the National Communication to UNFCCC, for National Development and/or Action plans and finally, in research.

CLIMATE CHANGE

ORIENTGATE

AT A GLANCE

Title: A structured network for the integration of climate knowledge into policy and territorial planning

Funding mechanism: South-East Europe. Transnational Cooperation Programme

Structural Funds/ European Regional Development Fund (ERDF)

Total Cost: 4.382.300,00 €

EC Contribution: 3.231.955,00 €

Duration: 30 months

Start Date: 1/7/2012

Consortium: a total of 33 project partners including 19 financing partners, 11 associates, 3 observer from 13 countries

Project Coordinator: Euro-Mediterranean centre for Climate Change (Italy)

Project Web Site: http://www.orientgateproject.org/
Key Words: climate change, adaptation, environmental risks, vulnerability indicators.

THE CHALLENGE

Many SEE countries are exposed to a rise in sea level, with a greater risk of disaster affecting densely populated areas and the most developed coastal areas. Already disadvantaged rural areas face increased water stress as a result of altered precipitation, runoff and recharge patterns and rates, saltwater intrusion into coastal aquifers, higher domestic water demand, and higher demand for water in the agricultural sector for crop irrigation. The decline in ecosystem services is further exacerbated by a deterioration in water quality, land and ecosystem losses, and a decline in wild and farmed fish stocks.
Progress in adapting to climate change in SEE is hindered by fragmented and uncoordinated data services, patchy risk assessment procedures, and the low uptake of the available knowledge in territorial development and other climate-sensitive sectors. There is therefore an urgent need to overcome the barriers that prevent efficient exploitation of the knowledge produced by the scientific community, enabling that knowledge to be taken into account appropriately in the formation of policies and the development of strategies. There is therefore much to be gained from putting into practice a set of coordinated activities that build on existing knowledge and make it more widely available.

PROJECT OBJECTIVES

The OrientGate project aims to coordinate climate change adaptation efforts in SEE countries by building a lasting partnership between communities that produce knowledge and experimental studies, and communities that apply that knowledge. The project:

1. develops a comprehensive and consistent methodology for assessing the risks arising as a result of climate variability and change;
2. harmonises risk assessment and communication on the part of hydrometeorological services;
3. encourages the use of acquired climate adaptation knowledge and experience in territorial planning and development; and
4. enhances capacity to reconcile the risks and opportunities inherent in environmental changes, including rising temperatures.

METHODOLOGY

The assess of the risks arising as a result of climate variability and change will be carry out through the implementation of six pilot studies in areas with specific climate vulnerability, developed by the project's three thematic centres:

•**Forestry and Agriculture:** Activities include the review of existing studies in order to reveal knowledge gaps. In addition, relevant policies will be reviewed in order to identify the constraints they place on climate change adaptation. Two pilot studies will be carried out: Adapted forest management at LTER Zöbelboden (Austria), Climate change adaptation measures in Romanian agriculture.

•**Drought, Water and Coasts**: The aim is to demonstrate the use of the harmonised and integrated indicators of climate variability and change for evaluating the impacts, and then for assessing those risks requiring the development of adaptation strategies in different sectors. Three pilot studies will be carried out: Climate change adaptation in the new water regime in Puglia region, Italy; Effects of climate change on the wetland ecosystems of Attica region, Greece; Water resources and the use of hydroelectricity, Italy

•**Urban Adaptation and Health**: The main objective is to enhance the understanding and knowledge of the staff of municipalities on climate change adaptation aspects, and to encourage urban settlements in SEE to assess the feasibility of implementing known adaptation policies and measures already developed for use on a larger scale (regional, national and ecosystem). One pilot study will be carried out: Vulnerability assessment in Budapest and Veszprém.

EXPECTED RESULTS

The core output to be developed by OrientGate is a set of web tools, designed to provide access to data and metadata from climate observations and simulations that will be available through a data platform connected to the European Climate Adaptation Platform (CLIMATE-ADAPT).

Other project results include:

- six pilot studies of specific climate adaptation exercises developed by the project’s three thematic centres (Forestry and Agriculture; Drought, Water and Coasts; Urban Adaptation and Health);
- capacity-building seminars and workshops; and a working partnership among the hydrometeorological services of SEE countries.
- support to the implementation of climate change adaptation plans in SEE, identifying a flexible methodology for assessing climate vulnerability and risk related to different territorial frameworks, and for integrating these assessments into regional planning.

PROJECT FINANCING PARTNERS	
Euro-Mediterranean Centre on Climate Change	IT (Italy)
Forest Department, Federal Ministry of Agriculture, Forestry, Environment and Water Management	AT (Austria)
Ministry of Regional Development and Public Works	BG (Bulgaria)
National Institute of Meteorology and Hydrology	BG (Bulgaria)
Gradiška Local Development Agency	BiH (Bosnia and Herzegovina)
Hydrometeorological Service of Republika Srpska	BiH (Bosnia and Herzegovina)
Attica Region	GR (Greece)
Center for Technological Research of Crete	GR (Greece)
Goulandris Natural History Museum, Biotope Wetland Centre	GR (Greece)
City of Koprivnica	HR (Croatia)
Meteorological and Hydrological Service	HR (Croatia)
Hungarian Meteorological Service	HU (Hungary)
Regional Environmental Center	HU (Hungary)
Autonomous Province of Trento	IT (Italy)
Department for the Environment, Territory and Sustainability Policies, Basilicata Region (CNR-IMAA as subcontract)	IT (Italy)
Macedonian Hydrometeorological Service	MK (Former Yugoslav Republic of Macedonia)
Environmental Protection Agency of Covasna	RO (Romania)
National Meteorological Administration	RO (Romania)
Republic Hydrometeorological Service	RS (Serbia)

Project Associated Partners	
Regional Council of Shkodra	AL (Albania)
Forest Service, Federal State Government of Upper Austria	AT (Austria)
Ministry of Environment, Energy and Climate Change	GR (Greece)
Municipality of Komotini	GR (Greece)
13th District of Budapest	HU (Hungary)
Municipality of Veszprém	HU (Hungary)
Ministry of the Environment, Land and Sea	IT (Italy)
Region of Puglia, Mediterranean Department	IT (Italy)
General Department of Foreign Economic Activity and European Integration, Odessa Regional State Administration	UA (Ukraine)
Odessa State Environmental University	UA (Ukraine)
Vilkovo City Council	UA (Ukraine)

Project Observering Partners	
Federal Hydrometeorological Institute	BiH (Bosnia and Herzegovina)
Union of Italian Provinces	IT (Italy)
Ministry of Sustainable Development and Tourism	ME (Montenegro)

RESOURCE EFFICIENCY

RE-SEEties

AT A GLANCE

Title RE-SEEties: Towards resource efficient urban communities in SEE

Funding mechanism: South East Europe Transnational Cooperation Programme

Total Cost: 2,249,103.66 €

EC Contribution: 1,530,086.57 €

Duration: 24 months

Start Date: 1/10/2012

Consortium: 22 partners from 9 countries

Project Coordinator: The Local Government of Budapest District 18, Pestszentlőrinc-Pestszentimre, Hungary

Project Web Site: http://www.re-seeties.eu/

Key Words: Resource efficiency, waste management, sustainable growth, analyze, forecast

THE CHALLENGE

Europe is facing problems of excessive energy consumption and uncontrolled waste production, and these trends are expected to increase in the future. In South East Europe (SEE), these problems are manifested also through resource inefficiency as well as lack of coordination and awareness regarding how to use resources more consciously.

There is an urgent need to address these challenges, which requires more innovative approaches on the part of governments and citizens alike.

PROJECT OBJECTIVES

MAIN OBJECTIVE: to improve the integrated policy-making and strategic planning competences of SEE municipalities in the fields of energy efficiency, renewable energy and waste valorization.

The purpose is to change consumption patterns and support changing demands with innovative solutions, tools and incentives. This will be achieved through the following SUB-OBJECTIVES:

1. FORECAST– analysis of current and future energy use and waste production at municipality level, to develop the baseline data for strategic planning.

2. TECHNOLOGY – application of sustainable energy and waste technologies in the urban context, to determine strengths, weaknesses, and potential synergies between waste and energy measures for the creation of a roadmap/priority list.

3. CHANGING BEHAVIOUR – addressing various target groups related to resource efficiency, offering solutions and alternatives for waste and energy.

4. POLICY – development of innovative policy-making tools, practices and incentives for resource efficiency target groups.

5. SYNTHESIS – synthesis of project findings in the form of an integrated toolkit for SEE municipalities, building on existing sustainability strategies and tools, to help them become resource efficient urban communities.

6. ENDORSEMENT – ensuring wider uptake of project results in SEE and EU, and endorsement at all policy-making levels.

METHODOLOGY

The RE-SEEties project specifically focuses on the two major elements linked to resource efficiency – energy and waste – in an integrated manner. The purpose of this is to shed light on challenges related to excess energy consumption and waste production, and also to highlight opportunities, such as the benefits of awareness raising for energy saving, and waste valorization.

In order to achieve these goals of resource efficiency, it is clear that city leaderships have a major role to play in influencing and incentivizing changed behaviours at local and regional levels. Therefore, municipal actors are the core focus of the RE-SEEties project. Eight SEE cities and regions were selected to design and implement these new resource efficiency strategies. These cities and regions were selected due to their existing policy- and decision-making competencies, and are supported by a consortium of professional institutions having expertise and dissemination power in the field.

PROJECT PARTNERS	
The Local Government of Budapest District 18, Pestszentlőrinc-Pestszentimre	HU (Hungary)
CENTRE RENEWABLE ENERGY SOURCES AND SAVING	GR (Greece)
National Research Council of Italy Institute of Methodologies for Environmental Analysis	IT (Italy)
MUNICIPALITY OF AIGALEO	GR (Greece)
Municipality of Potenza	IT (Italy)
Energiaklub Climate Policy Institute applied Communication	HU (Hungary)
City of Nitra	SK (Slovakia)
Harghita Energy Management Public Service	RO (Romania)
Scientific research centre Bistra Ptuj	SI (Slovenia)
City of Skopje	MK (Former Yugoslav Republic of Macedonia)
North-West Croatia Regional Energy Agency	CR (Croatia)
Macedonian Center for Energy Efficiency	MK (Former Yugoslav Republic of Macedonia)
Harghita County Council	RO (Romania))
Association of Towns and Communities of Slovakia	SK (Slovakia)
Energy Centre Bratislava	SK (Slovakia)
City Municipality Ptuj	SI (Slovenia)
City of Ivanic-Grad	CR (Croatia)
ZELS - Association of local self government of Republic of Macedonia	MK (Former Yugoslav Republic of Macedonia)
Province of Potenza	IT (Italy)
ICLEI - European Secretariat GmbH	DE (Germany)
MINISTRY OF ENVIRONMENT, ENERGY AND CLIMATE CHANGE	GR (Greece)
Institute of Sociology at Hungarian Academy of Sciences	HU (Hungary)

Resources consumption forecasting and efficiency in South East Europe: the RE-SEEties experience

Mr. Christos NAKOS[1], Mr. Vasilis PAPANDREOU, Ms. Stavroula PAPAGIANNI

Researchers from the Centre of Renewable Energy Sources and Saving, Athens, Greece

Dr. Monica SALVIA, Dr. Senatro Di LEO, Dr. Filomena PIETRAPERTOSA

Researchers from the Institute of Methodologies for Environmental Analysis, National Research Council of Italy

Mr Hrvoje MARAS, Mr Velimir ŠEGON, Mrs Vesna KOLEGA

Researchers from the North-West Croatia Regional Energy Agency, Croatia

Mr. Sashe PANEVSKI, Ms. Zoja TAREVSKA

Researchers from Macedonian Center for Energy Efficiency, FYROM

[1] *Contact details of corresponding author*
Tel: +306974746987
e-mail:cnakos@cres.gr
Address: 19th km Marathonos Ave, 19009, Pikermi Attiki Greece

Abstract

Resource efficiency, which aims at producing more value while using less material and adopting different consumption patterns, has a primary role in shifting the economy towards sustainable growth and is one of the key issues of the European Commission's Europe 2020 strategy ([1]). The Roadmap to a Resource Efficient Europe ([2]) aims to direct the European economy towards sustainability by 2050, setting priorities and key resources, removing the barriers and providing milestones to be achieved by 2020. Cities and local governments can play a key role in complying with such ambitious targets on resources as decision makers, planning authorities, managers of municipal infrastructure, and role models for citizens and businesses. This research was carried out in the framework of the on-going RE-SEEties project "Towards resource efficient urban communities in SEE" ([3]) funded by the SEE programme, which aims to turn SEE cities into resource efficient urban communities, focusing on urban energy systems and waste management. The aim of this paper is to select the most suited set of methods for analysing and forecasting energy consumption and waste production at urban scale (e.g. [4]). As a result, it will provide local administrators and citizens an opportunity to learn on successful experiences and identify simple and innovative solutions to improve the current and future management of energy and waste management, taking a step forward towards resource efficiency at urban level.

1. Introduction

Resource efficiency and sustainability of energy systems are common priorities within the Europe 2020 Strategy. The depletion or erosion of endogenous resources as well as the growing dependence of the European economy on imported resources, either direct such as fuels and materials or embedded in imported goods, increase the environmental and economic pressure, as outlined in the EC's communication "A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy" (COM/2011/21) ([2]). To this end, the EC Roadmap to Resource Efficient Europe sets key priorities to direct the European economy towards sustainability by 2050 through resource efficiency policies in numerous areas, such as energy, transport, climate change, industry, commodities, agriculture, fisheries, biodiversity and regional development. The Roadmap aims to increase resource productivity, secure access to raw materials, decouple economic growth from resource use and its environmental impacts, enhance competitiveness and promote security of supply, sustainable supply and recycling. This approach is expected to be adopted not only at EU and Member State level, but also at other levels, such as businesses and consumers.

In Europe's resource efficient strategy the aim is to promote sustainable economic growth that is based on high levels of employment, innovation, inclusion and social cohesion ([1]). The main aspects that should be managed involve:

- changes in consumption aspects,
- further promotion of energy efficiency,
- the use of waste as a resource,
- resource efficiency through innovation,

- use of economic tools, such as elimination of inefficient subsidies and correct price setting.

At the same time, it is argued that resource efficiency can help achieving economic, social and environmental goals in a more secure manner and, under proper circumstances, at lower long term cost. Economic growth can be achieved directly through less resource usage, recycling and reuse of materials, as well as substitution of resource inputs with more efficient and environmentally friendly alternatives. Moreover, the resource efficiency concept provides a competitive advantage due to the innovative technologies and behavioral patterns and models that are developed in its context. Apart from improved competitiveness, resource efficiency can improve security of supply and market stability of various resources. In this way sectors such as agriculture, forestry and fisheries are safeguarded, while the changes in existing and the creation of new markets (e.g. renewable energy, recycling etc) can provide new employment opportunities and job creation.

The EU-wide and national challenges on climate and energy issues have also been acknowledged at regional and local level. Many local authorities have already committed themselves to improve the quality of life of citizens through sustainable urban development. Many initiatives are being carried out in this directions at European level, among which the Covenant of Mayors ([5]) (the mainstream European movement involving local and regional authorities, voluntarily committing to meet and exceed the European Union 20% CO_2 reduction objective by 2020 through enhanced energy efficiency and cleaner energy production and use), Energy Cities ([6]) (the European Association of local authorities promoting energy efficiency, renewable energy and distributed generation), CONCERTO ([7]) (the initiative launched by the EC to support local communities in developing and demonstrating concrete strategies and actions that are both sustainable and highly energy efficient).

Moreover, several so-called Smart City initiatives (e.g. [8-10]) have arisen Europe-wide to help cities to start planning their future in a new way: adopting a comprehensive multi-sector approach and accelerating innovation to become more sustainable and resilient. These initiatives aim to demonstrate that the citizens' quality of life and local economies can be improved through innovation towards energy efficiency and reduction of carbon emissions.

2. The role of local administration

Arguing that environmental issues can be confronted in strictly national level fails to address interdependencies on global level, as well as the complexities emerging from globalization. In the same sense that environmental problems cannot be spatially isolated, they cannot be dealt with solely in distinct policymaking levels ([11]). During the process of globalization, a reallocation of capacities, which originally belonged to national states, has been transferred to transnational and regional level ([12]).

Transnational level refers to transnational centers of political power and authority, such as the European Union or global institutions, the World Bank, the OECD and the IMF. Furthermore, transnational municipal networks, such as C40, ICLEI, Metropolis, UCLG, play a significant role in the transition towards more sustainable cities by organizing the experience gained from different urban planning examples and offering a functioning channel to communicate the global climate agenda among cities ([13], [14]).

Regional level on the other hand, refers to regional administration and key actors in the market and the civil society. The rescaling of power and responsibilities between different levels of policy and decision making establishes a new framework for urban planning in which cities obtain the key role. Cities are regarded as the main driving forces of economic growth and as centers of economic, political and social innovation, where competitiveness is initially fostered and later diffused to the whole economy. As the context has changed, urban and regional governments appear to have the opportunity to become strategic partners of business through public private partnerships. Moreover, the city is the active scene where NGOs and civil society initiatives intervene and try to influence decision making processes. Also, assuming that political participation is higher in municipal level and that local governance consists of strong democratic institutions, then the city-level approach far outweighs the national one in terms of accountability. That is the case especially if local administrations are equipped with the necessary fiscal capacity, authority, autonomy and the ability to cooperate with the private sector. City governments and municipal planners should adapt and harmonize energy policies and goals with their general strategic framework aiming to prevent simultaneous contradictory target setting (e.g. [15], [16]). As a consequence, the policy making in national level is gradually shifting by enabling certain policy instruments to activate the creative potential that resides dormant at urban level. To extend the effectiveness of regional strategies in compliance with national and transnational regulation, the development of human capacity is required. Along this line municipalities may opt in institutionalizing knowledge relating to sustainability inside branches or units of their administration.

In Europe, more than two thirds of the population lives in urban areas, accounting for over 70% of global carbon dioxide emissions from energy consumption. The municipal government plays a leading role in the transition pathway towards a sustainable future due to: the relevance of urban carbon emissions, the local implications on climate change vulnerability, the increasing awareness about the impact of the local community's behavior in tackling carbon emissions. As a conclusion, cities are emerging as the less contradictory platform to implement effective plans and strategies regarding climate change mitigation and adaptation in accordance with national objectives and international commitments.

Two main aspects should be therefore considered regarding local governments. First, decision making on policy issues is a complex process, addressing major energy challenges and requiring a deep understanding of the pathways along which municipal energy systems can emerge and develop over time. Comprehensive methodologies and engineering tools can support energy systems analysis and planning, in order to enhance the use of endogenous resources and renewable energy, increase energy efficiency and energy saving; reduce the environmental impact of anthropogenic activities, improve air quality (GHG and local air pollutants), define fair costs of goods and services. Second, in order to meet the resource efficiency targets, decision makers have to consider tapping into behavioral transformation strategies. Behavior change is of central importance in bringing about significant reductions in energy end use and reduction of waste, although in most cases this issue is often treated separately and secondary to technological development.

3. Tools to support resource efficiency at urban scale

As depicted in the previous chapter, the enhanced role of local governments in addressing resource efficiency highlights the need for the formulation of effective policies and strategies at local level. Hence, appropriate long term planning methods and tools are necessary for achieving and preserving resource efficiency in the optimum way in terms of cost and benefits. A necessary first step towards long term resource planning is the understanding of resource consumption dependent factors and the forecasting of resource consumption based on the evolution of these factors. The main forecasting techniques regarding energy and waste are presented hereafter, drawing mainly from ([17]) and ([18]).

3.1. Energy forecasting

There are two general approaches with respect to energy demand forecasting methods. The first is solely dependent on the analysis of statistical data while the other refers to the implementation of some kind of systems analysis.

The very first step towards energy demand forecasting and common for all methods is the collection of historic energy consumption data. Ideally, energy consumption/demand data should be disaggregated by sectors and commodities/fuels. Common sectors at city level are:

- Buildings (public, residential, commercial)
- Industry (incl. industrial buildings)
- Transportation
- Utilities and auxiliary services (water, waste-water, etc)

Energy demand is commonly split into three main categories:

- Heating-cooling
- Transport
- Electricity

Historical data provide invaluable insights regarding the structure of the energy system of the city, enabling the identification of priority areas and proper development of energy planning. Furthermore, they provide strong indications of energy consumption trends and provide the basis for further statistical analysis of consumption patterns and behaviors. Simple data analysis provides useful energy consumption indicators such as energy intensity, per capita consumption, consumption per square meter for buildings, RES share etc. Such indicators are necessary in setting policy targets, monitoring performance and efficiency of measures and compare with best practices.

In reality however, there is generally a lack of historic data for energy consumption at city level. It is usually possible to find adequate data on the consumption of energy for municipality authority activities (buildings, municipal vehicles, utilities and auxiliaries etc) and sometimes industry, but rather difficult on the consumption of energy from residencies, businesses and transport. Therefore, a bottom up engineering analysis is useful to produce disaggregated historical data from aggregate figures. For example, a very first estimation of energy consumption for passenger transport can be produced based on the stock of various types of passenger cars and realistic assumptions on utilization rates and energy consumption per km.

The adequate identification of energy demand drivers and the evaluation of each driver's importance is a crucial (yet not always easy) step in the forecasting process. Forecasting of energy demand is almost always dependent on exogenous input, estimations or a priori assumptions of the drivers' values. In general, the main energy demand drivers at city level are the following:

- Demographics
- Building stock and city expansion planning
- Current and future infrastructure
- City's economic structure (e.g. industry)

- Income, expenditure and energy commodity prices
- Environmental parameters (e.g. temperature)

Consumers' behavior pattern is also an important aspect. As new energy efficient technologies are more and more deployed in modern cities shifting final demand downwards, the significance of consumer's behavior is increasing. It is rather hard to quantify the effects of consumers' behavior change based on statistical energy demand data, as the parameters that affect demand are multiple and often interrelated, while rebound effects may also be significant.

In practice, simple ad-hoc forecast methods are widely used to provide future energy demand estimates. Such methods are based on the use of simple relations and indices, such as growth rates, elasticities, specific energy intensity and growth trends. In this respect once the relevant figure is calculated from historical data, the energy consumption can be calculated, based on estimates or forecasts of the change in the driver e.g. GDP projections. These simple methods are used for short and mid-term forecasts. They are also often used in more complex models for providing estimates for modules with no or limited system representation. However, they do not provide proper insights on energy demand and are strongly related to the user's own perspective.

Econometric models are also widely used for the forecasting of energy demand. They are based on the hypothesis that energy demand is (mainly) a function of a number of (predefined) independent variables (drivers). The parameters of the energy demand function are calibrated via regression analysis on statistical data. There are numerous econometric studies on energy demand forecasting and a great number of models have been proposed. Econometric analysis can be either general in scope (e.g. analysis of total energy demand) or focused on specific demand sectors or economic activities, (e.g. analysis of electricity consumption). In addition, the complexities of the proposed econometric models as well as the methods for statistical analysis vary significantly. Madlener et al ([12]) provide a comprehensive presentation of recently developed econometric models for energy demand estimation.

Since econometric analysis is based greatly on the analysis of historic data, there are certain limitations to its use. First, its reliability depends on the existence of data; the poorest the data series the less efficient becomes the model. Second, while econometric analysis works quite well in relatively stable situations it fails to capture structural changes or changes due to significant deployment of new technologies. Therefore it is best suitable for short to medium term analysis of stable systems.

A well established and widely used method for projecting energy demand is the use of energy system analysis models. The necessity in the development of such models derives from the need to incorporate technological and structural changes in the analysis of the energy demand in the medium and long term. Methods to model consumers' behavior can also be integrated into such models. Energy systems models are largely used for the analysis of policies at national/state level. However, the same principles apply for the analysis of the energy system at city level, provided that adequate information is available.

System models are either **simulation models** that calculate a set of variables based on exogenous input of independent parameters (i.e. they have zero degree of freedom) or **optimization models** that provide the optimum path based on an objective (e.g. by minimizing system's costs) of a system's evolution. Usually, various scenarios are set in order to provide indications of the system's evolution under different possible future conditions or sensitivity analysis over certain parameters. In this respect they provide system evolution projections, rather than simply forecasts.

Energy system models are generally categorized as bottom-up and top-down models. Another categorization distinguishes between techno-economic models, optimization models and hybrid models ([18]).

Top-down models focus on an aggregated level of analysis of the interactions of the energy sector with the rest of the economy. In this respect econometric models might be considered as top-down models. Top down models are characterized by a rather poor representation of technical characteristics that affect the energy system and hence the energy demand.

Bottom-up models, also called engineering-economy models, provide a rather detailed representation of the energy system. Energy demand is calculated based on engineering relations for each system's component that relate fuel consumption with fulfillment of useful energy needs.

Input-Output models are based on the analysis of macroeconomic accounts and energy statistics. They are actually an accounting method providing insights to economic-energy interactions between sectors through their economic transaction. By incorporating energy statistics analysis (e.g. energy intensity per sector) energy transactions may be estimated. The I/O models are suitable for providing energy demand projections for stable conditions, since they are static models and are poor in incorporating structural or technological changes.

More recently, sophisticated models for high-level energy policy analysis have been developed, which combine top-down and bottom-up characteristics. **Hybrid I/O models** are also available that combine the I/O method with process analysis techniques.

For urban energy systems analysis, sectorial (e.g. residential heat) bottom up models combined with simple methods of forecasting are mostly used mainly due to lack of resources, data and prioritization.

In general, the model analysis of future evolution of urban energy systems is done through the development of various scenarios. In terms of energy demand forecasts different evolution paths of a number of drivers may be examined in order to estimate the effects in demand. As an example a typical scenario of low, mid and high economic growth may provide insights of how energy demand, energy investments and consequent energy consumption and GHG emissions will evolve, hence resulting in a more comprehensive policy making process. In case of more elaborated models scenarios may also differentiate as for a specific target, i.e. GHG reduction or energy efficiency reduction target. In this respect the assessment of efforts, i.e. investments, to achieve the various targets may be estimated.

3.2. Waste forecasting

Waste is a pressing environmental, social and economic issue. Increasing consumption and economic development continue to generate large amounts of waste - while more effort is required to reduce and prevent it. While waste was viewed as disposable in the past, today it is increasingly recognized as a resource; this is reflected in the waste management shift away from disposal towards recycling and recovery ([19]).

Sufficient capacity for future waste generation is crucial as investments in related infrastructure are high and require comprehensive and well-targeted coordination and long-term planning ([20)]. To this end, accurate forecast of waste generation is an indispensable step in planning municipal solid waste management (MSW) systems ([21]).

Forecast data serve as a basis in the development of existing waste management infrastructures, as well as their further improvement and optimization in terms of sustainability. In particular, MSW forecasting is needed to:

- quantify the waste potentials of the main materials -- such as organic material, paper and cardboard, plastics and compounds, glass or metals
- achieve accurate and reliable waste information in relation to:
    - MSW collection system
    - Land demand for landfilling waste
    - Incinerators capacity evaluation

On the other hand, inaccurate forecasts may cause problems, such as creating insufficient or excessive waste disposal infrastructure (transportation, processing, incineration or landfilling). To improve waste forecasting for planning, it is necessary to understand the socio-economic factors that influence the amounts and composition of municipal solid waste ([22]). Amounts of MSW vary significantly between regions and over time and their forecasting is usually aggravated by rapidly changing parameters of waste management systems, especially in the areas of rapid economic development ([21]).

Although capacity planning of waste processing facilities and infrastructure requires an idea of the future demand, little is known about how to estimate the quantity of future MSW streams ([22]).

Up to now, most of these decision support tools for waste management planning use the current amount of waste generation as the given input parameter. Thus the impacts of demographic, social and economic dynamics as well as other factors (e.g. consumption patterns or waste prevention) are not taken into consideration for the accurate assessment of future waste generation ([23]).

The majority of national or regional Waste Management Plans (WMPs) do not include forecasts as regards MSW generation and treatment capacity. Therefore, future under-capacity for treatment of MSW might still be an issue of concern in some regions ([20]).

Even in WMPs that include projections, the quality of forecasting municipal waste generation and treatment varies considerably among the EU Member States and their regions. In most cases information included is general and concentrates on projections of generation. The methodology is rarely explained, and modeling scenarios are rarely included.

In practice, different methods are used to calculate the quantities of waste expected to arise within a municipality/region for management during the period of the plan. Waste forecasts usually deal with three primary waste sectors ([20]):

- household
- commercial
- industrial (usually not including industrial non-hazardous sludges, hazardous industrial waste or industrial waste arisings that are currently managed by the industries themselves on site)

The choice of the method for forecasting MSW usually depends on the following criteria ([24]).

- Amount and quality of available data (e.g. generation of waste, social-economic indicators)
- Type of the data (e.g. continuous or random data)
- Relationships of various parameters of waste generation and social-economic indicators
- Expected changes in the field of waste management.

As reported in ([25]), there is a wide spectrum of accepted forecasting methods ranging between **qualitative methods**, using judgmental knowledge and emphasizing methods from social sciences (e.g. interviews), and **quantitative methods**, based on statistical or econometric procedures. Choosing among the available methods often depends on the required prognosis horizon. In particular, quantitative methods (e.g. for consideration of seasonal variability) are preferred for short-term forecasting, whereas qualitatively orientated methods could be preferred for long-term forecasts, requiring assumptions about discontinuous developments.

In Figure 1 the main forecasting methods applied to assess future waste quantities are represented.

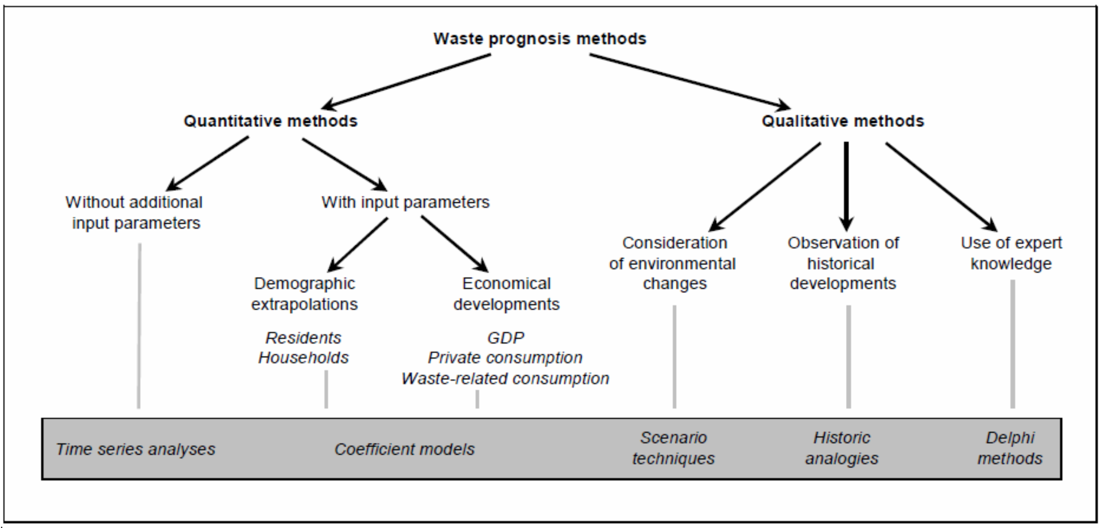

Figure 1 Waste prognosis methods ([25]).

4. The RE-SEEties experience

Europe is facing problems of excessive energy consumption and uncontrolled waste production and these trends are expected to increase in the future. As a matter of fact, in 2009 the EU produced only 48% of its energy needs, causing an increasing dependency on imports for all fossil fuels, reaching in the same year 83.5% for oil and 64.2% for gas ([26]). Fossil fuels represent three quarters of our energy mix today (16% coal and other solid fuels, 37% oil and 24% gas) whereas nuclear accounts for 14% and renewable energy sources (RES) have increased up to 9%. On the other hand, the overall energy sector is currently responsible for 80% of all EU greenhouse gas emissions, contributing heavily to the overall emissions of local air pollutants.

In South East Europe (SEE), these problems are manifested also through resource inefficiency as well as lack of coordination and awareness regarding how to use resources more consciously. There is an urgent need to address these challenges, which requires more innovative approaches on the part of governments and citizens alike.

The RE-SEEties project ([27]) *"Towards resource efficient urban communities in SEE"* was thought with the long-term vision of contributing to turn South East European cities into more resource efficient urban communities. The main objective is to improve the integrated policy-making and strategic planning competences of SEE municipalities in the field of energy efficiency, RES and waste valorisation, for the purpose of changing consumption patterns and supporting changing demands with innovative solutions, tools and incentives.

The main idea is integrating waste and energy solutions to shed light on challenges related to excess energy consumption and waste production, and also to highlight opportunities, such as the benefits of awareness raising for energy saving and waste valorization.

The focus is on city leaderships, which has a major role to play in influencing and incentivizing changed behaviors at local and regional levels. Municipal actors are the core focus of the RE-SEEties project. Eight SEE cities and regions were selected to design and implement these new resource efficiency strategies. These cities and regions are supported by a consortium of professional institutions having expertise and dissemination power in the field.

This will be achieved through multi-faceted actions in terms of:

- FORECAST– analysis of current and future energy use and waste production at municipality level, to develop the baseline data for strategic planning.
- TECHNOLOGY – application of sustainable energy and waste technologies in the urban context.

- CHANGING BEHAVIOUR – addressing various target groups related to resource efficiency, offering solutions and alternatives for waste and energy.
- POLICY – development of innovative policy-making tools, practices and incentives for resource efficiency.
- SYNTHESIS – synthesis of project findings in the form of an integrated toolkit for SEE municipalities, to help them become resource efficient urban communities.
- ENDORSEMENT – ensuring wider uptake of project results in SEE and EU, and endorsement at all policy-making levels.

The activities started with a careful analysis of the European state-of-art regarding methodologies, technologies, planning processes as well as resources forecasting techniques applicable at local level ([27] and [28]). The next step dealt with the development and adaptation of an initial methodological framework with criteria for assessment. In parallel, the strategy building process has been set up in terms of case study profiles, elaboration process with peer reviews, interim results assessed against the initially set up criteria for assessment, finalization of the criteria integrated SEE methodological toolkit towards resource efficiency. Finally, the project partner cases will be converted into local strategies and action plans (measures, budgetary forecasts and policy recommendations).

5. Conclusions

In this paper we have outlined the key role that cities and local governments can play in complying with the set of targets for a more resource efficient and sustainable Europe. Achieving these targets on resources, energy and waste will also enhance security of energy supply, adaptation and mitigation of climate change and protection of the environment.

Local governments have legislative and purchasing power that they can use to implement change in their own operations and in the wider community. As a matter of fact, they play a multiple role as decision makers, planning authorities, managers of municipal infrastructure, and role models for citizens and businesses.

With such capacity, local governments can become beacons for change in their region or country, demonstrating the effectiveness of policies and local action. Moreover, as early leaders among local governments take initiative, others can follow and improve upon the early efforts, replicating and implementing good practice and successful examples. Local governments can also play a key role as facilitators of change, particularly in terms of raising awareness and facilitating community and business actions by a range of stakeholders.

The basic aim of this paper was to present a comprehensive selection of the most suitable methods for analyzing and forecasting energy consumption and waste production in urban scale. This selection of methods can be used as a background input for regional and local authorities when strategic planning issues regarding energy and waste are concluded.

In addition, local administrators and citizens are given an opportunity to learn from successful experiences and identify simple and innovative solutions to improve the current and future management of energy and waste management systems, taking a step forward towards resource efficiency at urban level.

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SDR

AT A GLANCE

Title: Sustainable Development reporting: international and Russian experience research

Funding mechanism: Coordination and support actions

Expected value : 500.000 €

Duration: 36 months

Start Date: 1/1/2012

Project Coordinator: Financial University under the Government of Russian Federation

Key Words: climate change, **Sustainability, Sustainable Development Reporting, Indicators of Sustainability, research** needs and gaps

THE CHALLENGE

EU has formulated a long-term strategy to coordinate the policies for economically, socially and environmentally sustainable development. The solution of this problem requires the creation of the necessary information base and reliable tools to evaluate success of individual companies, regions and countries in achieving of sustainability goals. Sustainable Development Report (SDR) provides information for such assessment. The project aims to assess the current level of disclosure and the SDR quality of the Russian companies in comparison with international best practice for sustainable performance measures purposes.

PROJECT OBJECTIVES

1. ***Evaluation of available data and information***: The study was based on the analysis of SDR published on official websites of the largest Russian companies. The analysis of international corporate reporting best practice was based on analytical reviews prepared by leading consulting companies and analytical agencies, such as PrciewaterhouseCoopers, E&Y, KPMG and Russian Union of Industrialists and Entrepreneurs. SD Index provided by Interfax-Era (Russia) was used for purpose of comparative analysis.
2. **Choice and implementation of appropriate model(s) for emerging economies:** Selection of the most appropriate model for the development of SDR was based on the international best practice research, existing conditions and the reliability of input data.
3. **Development of scenarios:** Implementation of scenarios for SDR practice development under international standards and guidelines in order to bridge the communications gap between reporting companies and the financial community and to evaluate companies` sustainability performance.
4. **Evaluation of policy portfolios:** Evaluation of the SDR policy based on key criteria:
5. availability and completeness of SDR; transparency of information, application of international standards and guidelines; existence of an independent assurance; disclosure of information on environmental issues activities.
6. **Prioritization of research needs and gaps:** Evaluation of current level sustainability information disclosure of Russian companies due to international standards and guidelines requirements.

7. **Training:** the results of the research were presented at the 1st International Conference «Climatic policy, sustainable development and green finance», roundtables held by Financial University under the Government of Russian Federation jointly with KPMG, scientific workshops will be developed as part of the Financial University under the Government of Russian Federation MSc programs.
8. **Dissemination:** Final outcomes will be presented to the Government of Russian Federation, Russian Union of Industrialists and Entrepreneurs, at international and national Conferences and workshops. Scientific editions are also foreseen.

Methodology

The methodology was based on a study of context, drivers and best sustainable reporting practice. The research was to identify trends in the preparation of SDR by Russian companies, the definition and analysis of key patterns characteristic of this type of reporting, compared with the global trends. It helps identify possible ways of improving and developing the practice of sustainable development in Russia.
The following key methodological criteria of SDR analysis were used: availability, transparency and completeness of SDR; application of international standards and guidelines; an independent assurance; disclosure of information on environmental issues activities and related risks.

Expected Results

There are following primary results of the research:

1. The project had outlined that the most part of Russian companies can be more effective in SD strategy disclosure.
2. Transparency of the companies in the field of sustainable development is growing - 40% of the largest Russian companies report on their activities in the field of sustainable development.
3. Almost all providing SDR companies include aspects of economical use of natural resources. At the same time the issues on reducing the harmful environmental impact should be not just shown but evaluated in their reports.
4. Expected positive correlation between company sustainability and financial performance.
5. GRI standard is applicable and useful for SDR in the Russia

Project Partners	
Financial University under the Government of Russian Federation	RU (Russia)
Russian Union of Industrialists and Entrepreneurs	RU (Russia)
KPMG Corporate Governance and Sustainability Group	RU (Russia), UK (United Kingdom)
Interfax -ERA	RU (Russia)
EY Sustainability & Cleantech Group RU	RU (Russia), UK (United Kingdom)
Energy Center of Business school Skolkovo RU (Russia) Russian sustainable development initiatives	RU (Russia)
Kazan(Volga Region) Federal University	RU (Russia)
Project Finance Division (LNG, Gas processing and Energy projects) -JSC Gazprom	RU (Russia)
Federal Grid Company of Unified Energy System JSC FGC UES University of Portsmouth	RU (Russia) UK (United Kingdom)

CLIMATE CHANGE PROGRAMME ARMENIA

"IMPROVING ENERGY EFFICIENCY IN BUILDINGS" UNDP-GEF/00059937 PROJECT, ARMENIA

AT A GLANCE

Country: Armenia

Title: Improving Energy Efficiency in Buildings

Funding mechanism: Grant

Global Environment Facility: $1,045,000

Co-financing Government of Armenia: $2,350,000

Duration: 60 months

Start Date: 2010

Implementing Agency: UNDP Armenia

Project Web Site: www.nature-ic.am
www.beeca.net

Key Words: climate change, energy efficiency, energy saving, GHG emission reduction, buildings

THE CHALLENGE

The project is being implemented in Armenia under the UNDP-led GEF Global Framework for Promoting Low Carbon Buildings with a primarily focus on two thematic approaches promoted by the Global Framework:
a) Promotion and increased uptake of high quality building codes and standards; and
b) Developing and promoting energy efficient building technologies, building materials and construction practices.
The funding offered by the GEF will help Armenia to learn from experiences and best practices from countries with similar energy efficiency (EE) in buildings projects.

PROJECT COMPONENTS

1. Design and enforcement of new mandatory EE Building Codes and Standards: methodology, institutional capacities and accountability;
2. Quality control, testing and certification of EE materials and appliances: standards for internal QA/QC and testing/certifying laboratories;
3. Outreach, training and education on integrated building design, including curricula improvement and professional development for architects and engineers, and outreach for investors and tenants;
4. Piloting integrated building design approach: at least one building designed and constructed using an integrated building design approach and energy savings/greenhouse gas emissions reductions in pilot building monitored and reported.

METHODOLOGY

The methodology that is implemented is consisted of successive steps that aim to develop, transfer and implement the necessary high quality knowledge for the development and assessment of climate change mitigation benefits and opportunities for promoting corresponding low carbon development policies and measures. Thus the project has well balanced goals from legislation improvement, institutional capacity building, private sector and scientific community involvement, to public awareness rising. The project has also is a part of similar project network implemented in neighboring countries, providing opportunity for exchange of experience and lessons.

Expected Results

The expected results of the project are reversed existing trends and reduced consumption of electrical and thermal energy and associated GHG emissions in new and restored primarily residential buildings in Armenia through:

- Development and supporting adoption of new building code and certification schemes for construction materials;
- Introduction of regulatory environment for promotion of improved skills and capacity among industry professionals;
- Introduction of the principles of integrated building design in Armenian construction practices from the stage of building design through construction, to proper maintenance of the buildings;
- Building capacity of architects and engineers on the integrated building design approach;
- Increasing market demand for energy efficient buildings through real estate professionals trained on the concepts of energy performance of a building;

Demonstration of benefits and incremental costs of integrated building.

Project Partners
Ministry of Urban Development of the Republic of Armenia
Ministry of Nature Protection of the Republic of Armenia
Ministry of Energy And Natural Resources of the Republic of Armenia
National Institute of Standards, Armenia
Scientific Research Institute of Energy, Armenia
Yerevan State University Of Architecture And Construction
Kirsty Maguire Architect Ltd, GB
Research Institute of Building Physics of Russian Academy of Architecture and Buildings Sciences, RF
Armenia Renewable Resources and Energy Efficiency Fund

Capacity Building Activities for Mitigation/Adaptation Mixtures

At a Glance

Title: Integrating distributed standby generators in a Virtual Power Plant

Estimated duration: 8 months approximately before the operation

Project Coordinator: NKUA – KEPA (HELLAS)

Key Words: virtual power plant, standby generators, ICT

The Challenge

Recognizing that combat of climate change is nowadays one of the most triggering problems that the majority of scientists and climate change policy makers has to deal with, KEPA promotes -through capacity building activities- the knowledge transfer for developing and assessing M/A policy mixtures and portfolios, in order to equip policy and decision makers with the appropriate tools and the most updated information.

Mitigation/Adaptation policy mixtures constitute the necessary instruments for policy makers to combat Climate Change in a way that promotes their economic perspective development. And this combination of policies defines the Green Economy issue.

Project Activities

The International Training Seminar on Climate Change policies is a one-week training activity aiming to offer a holistic approach to the problems which policy makers from countries with emerging economies face in fulfilling their needs for such policies.

Participants will have the opportunity to get updated on international policy trends and how to collect official and credible data, to be familiarized with scenario development method, to select policy mixtures according to their needs by using LEAP (Long-range Energy Alternatives Planning system) and finally, to learn how to assess them by using AMS (a multi-criteria analysis method).

LEAP is a widely-used tool in the world today with over than two thousand users in more than 190 countries for energy and environment policy analysis. LEAP has been adopted as the tool of choice by numerous countries wishing to plan their energy systems to meet sustainable development goals.

The AMS method is a multi-criteria method for evaluating climate change policy instruments or policy mixtures, with suitable modification for evaluating their interaction as well, which is developed in KEPA.

The seminar is mainly addressed to policy and decision makers but is also open to economists, researchers and engineers from Europe and Asia (Mediterranean, Black Sea and Central Asia region). It is organized by (Energy Policy and Development Centre of National and Kapodistrian University of Athens) in cooperation with the US center of Stockholm Environment Institute in Massachusetts

It will be held from 11th to 15th of November 2013 in the premises of KEPA, and there are plans to establish two annual seminars according to the level of expertise of the participants, so to cover the needs of everyone.

The training sessions are climate change policy, introduction to LEAP and data collection, training in LEAP at the presence of its developer, assessment of M/A policy portfolios (again at the presence of its developer) and structuring reports.

The cost of the Seminar is 800€ and includes tuition fees, training material, temporary LEAP license, networking and welcome dinner and farewell dinner.

The next capacity building activity that KEPA is preparing is the scientific and business workshop “Paving pathways on Energy Efficiency”.

This workshop will give the opportunity to stakeholders to discuss the potential of several important issues on M/A. NZEB, EE lighting, Waste Management, NMM related to emissions reduction, VPP and finally, RES in the Hellenic, Albanian and broader regional market are the topics that can help green economy activities to be developed in the region.
It will take place the last week of January 2014 at the Convention Centre of Hotel “Bourazani” in Epirus of Greece, close to the boarders with Albania.

ORGANISATION

Those interested can seek information by contacting Ms. Anna Flessa for the International Training Seminar (tel. +30 210 727 5718, e-mail: aflessa@kepa.uoa.gr)
And Ms Aliki-Nefeli Mavraki for the Scientific and Business Workshop (tel. +30 210 727 5827, e-mail: anmavraki@kepa.uoa.gr) or by addressing KEPA Secretariat (tel. +30 210 727 5732, +30 210 727 5809, e-mail: epgsec@kepa.uoa.gr) .
voltage,” technologies can be considered as collateral benefit.

ENERGY

C-ENERGY+

AT A GLANCE

Title: Connecting Energy NCPs Plus A Pro-Active Network of National Contact Points in the Seventh Framework Programme under the Energy Theme

Funding mechanism: Coordination and support action (Coordinating) FP7

FP7, Funding Scheme

Total Cost: 1,159,209 €

EC Contribution: 999,996 €

Duration: 44 months

Start Date: 1/5/2010

Consortium: 21 partners from 21 countries

Project Coordinator: APRE, Italy

Project Web Site: http://www.c-energyplus.eu/

Key Words: network coordination, knowledge exchange, client support.

THE CHALLENGE

Strengthening the competitiveness of the European energy sector, in the face of severe global competition, is an important objective of Energy Theme of FP7, providing the capability for European industry to attain or maintain world leadership in key energy technologies. The National Contact Points (NCPs) of FP7 play an important role in the Framework Programmes as providers of information and assistance to potential participants (applicants) of new projects and beneficiaries in on-going projects. However, the NCP structures, resources & experience vary greatly from country to country. C-Energy+ aims to further improve the homogeneity and consistency of the services offered by Energy NCPs across Europe, and thus raise the average quality of proposals submitted in the field, the competitiveness of Energy industry in Europe, and the level of international cooperation among energy stakeholders.

PROJECT OBJECTIVES

Project Management:
Smooth and timely implementation of all activities.

Networking & Transnational Collaboration:
Improve the quality of the Energy NCP network and cooperation between researchers and companies (especially SMEs) through workshops and brokerage events.

Capacity building for NCPs:

Enhance the quality of the knowledge about FP7 and the Energy EU policies, especially among less experienced NCPs, and increase the overall performance of the network.

Communication and Dissemination:

Raise awareness of the Energy NCP Network among potential participants of FP7 as well as EU organisations.

METHODOLOGY

The activities are broken down into work packages (numbered 1-4 above) and further into tasks. Assigned 'leaders' of these tasks and work packages ensure the project activities are monitored and managed effectively. The project is built around three technical work packages supplemented by one devoted to the project's management. These work packages are closely coordinated so as to achieve the objectives of C-ENERGY+.

EXPECTED RESULTS

Management
- 5 consortium meetings during the project lifecycle to help establish real partnership

Networking & Transnational cooperation:
- Two workshops organised jointly with the Enterprise Europe Network on the Energy theme
- Two International brokerage events addressing researchers and SMEs
- Enhanced cooperation with Energy NCPs from ICPC countries (i.e. beyond Europe).

Capacity building for NCPs
- Four training sessions for Energy NCPs
- 15 on-the-job training visits for Energy NCPs
- A mapping of the participation in the Energy Programme of FP7

Communication and Dissemination
- Development of the project website
- Cooperation with other Networks and European Technology Platforms (ETPs)
- Promotional materials, including project leaflet
- The project e-newsletter (at least 3 issues)

PROJECT PARTNERS	
AGENZIA PER LA PROMOZIONE DELLA RICERCA EUROPEA (APRE)	Italy
AGENCE DE L'ENVIRONNEMENT ET DE LA MAITRISE DE L'ENERGIE (ADEME)	France
INSTYTUT PODSTAWOWYCH PROBLEMOW TECHNIKI POLSKIEJ AKADEMII NAUK (IPPT PAN)	Poland
FORSCHUNGSZENTRUM JUELICH GMBH (FZJ)	Germany
ETHNIKO IDRYMA EREVNON (EKT/NHRF)	Greece
MINISTERIE VAN ECONOMISCHE ZAKEN, LANDBOUW EN INNOVATIE (EL&I)	Netherlands
TURKIYE BILIMSEL VE TEKNOLOJIK ARASTIRMA KURUMU (TUBITAK)	Turkey
LUXINNOVATION GIE LUXINNOVATION	Luxembourg
MINISTARSTVO ZNANOSTI, OBRAZOVANJA I SPORTA (MZOS)	Croatia
SIHTASUTUS ARCHIMEDES (Archimedes)	Estonia
OESTERREICHISCHE FORSCHUNGSFOERDERUNGSGESELLSCHAFT MBH (FFG)	Austria
MALTA COUNCIL FOR SCIENCE AND TECHNOLOGY (MCST)	Malta
RESEARCH PROMOTION FOUNDATION (RPF)	Cyprus
AGENCE BRUXELLOISE POUR L'ENTREPRISE (BEA)	Belgium
VEREIN EURESEARCH (EURESEARCH)	Switzerland
CENTRO PARA EL DESARROLLO TECNOLOGICO INDUSTRIAL (CDTI)	Spain
THE ICELANDIC CENTRE FOR RESEARCH (RANNIS)	Iceland
MINISTARSTVO PROSVETE, NAUKE I TEHNOLOSKOG RAZVOJA (MSTD)	Serbia
FUNDACAO PARA A CIENCIA E A TECNOLOGIA (FCT),	Portugal
THE FAROESE RESEARCH COUNCIL (GRANSKINGARRADID) (FARC)	Faroe Islands
LATVIJAS ZINATNES PADOME (LCS)	Latvia