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Energy and Climate Change

PROCEEDINGS

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Energy Policy and Development Centre (KEPA)
National and Kapodistrian University of Athens

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Contents

Under the aegis of the Serbian Chairmanship

9TH INTERNATIONAL SCIENTIFIC CONFERENCE

ENERGY AND CLIMATE CHANGE

AGENDA

Wednesday, 12 October 2016

Green Investment Perspectives Forum

Venue: Athens University History Museum – Tholou 5, Plaka

09:00 – 09:30

Registration

09:30 – 10:30

Session 1: Green Investments Perspectives

Chair

Amb. Traian CHEBELEU
Deputy Secretary General BSEC-PERMIS

Prof. Dimitrios MAVRAKIS
Director of KEPA, National and Kapodistrian University of Athens, Hellas

Welcome Address

Prof. Georgios ZOGRAFOS
Vice Rector – Health and Social Policy Issues, National and Kapodistrian University of Athens, Hellas

Opening

Mr. Panagiotis KOUROUMPLIS
Minister of Interior and Administrative Reconstruction, Hellas

Video-message

Mr. Ramu DAMODARAN
Chief of United Nations Academic Impact (UNAI)

Keynote speaker

Amb. Traian CHEBELEU
Deputy Secretary General BSEC-PERMIS

P R O M I T H E A S The Energy and Climate Change Policy Network

Policy statements

H.E. Mr. Lucian FATU
Ambassador at the Embassy of Romania to the Hellenic Republic

Dr. Miltiadis MAKRYGIANNIS
Deputy Secretary General, Parliamentary Assembly of the Black Sea Economic Cooperation

Mr. Leonidas PAPAKONSTANTINIDIS
Counselor for Economic and Commercial Affairs, Hellenic Ministry of Foreign Affairs

Mr. Igor IVANCHENKO
Secretary A for Commercial and Economic Affairs, Embassy of Ukraine to the Hellenic Republic

Prof. Dimitrios MAVRAKIS
Director of KEPA, Coordinator of the "BSEC - Green Energy Network"

10:30 - 11:00
Tour of Athens University History Museum (Coffee break)

11:00 – 14:30
Session 2: Green Investments Perspectives

Chair
Amb. Traian CHEBELEU
Deputy Secretary General BSEC-PERMIS

Prof. Dimitrios MAVRAKIS
Director of KEPA, National and Kapodistrian University of Athens, Hellas

Speakers

Mr. Christos DIMAS
President, Hellenic-Russian Chamber of Commerce – Hellas

Mrs. Ioanna SAMPRAKOU
Vice-President of the Hellenic Association of Computer Engineers - Hellas

Dr. Antonios MOUNTOURIS
Head of Corporate Environmental Management & Sustainable Development Department, HELLENIC PETROLEUM - Hellas

Mrs. Theodora ANTONAKAKI
Scientific Secretary, Climate Change Impacts Study Committee, Bank of Greece - Hellas

Mr. Dimitrios BAIRAKTARIS
Research Fellow of Central Union of Municipalities (K.E.D.E.)

Mr. Nikos STAMOU
Investment Promotion Manager, Enterprise Greece - Hellas

Mr. Nicholas SOFIANOS
Research Coordinator and Member of the BoD, Institute of Energy for SE Europe (IENE) - Hellas

Mr. Michalis SFAKIANOS
AppArt – Hellas

P R O M I T H E A S The Energy and Climate Change Policy Network

Thursday, 13 October 2016

Scientific Paper presentations

09:00 – 09:30
Registration

09:30 – 11:30
Session 3: Energy - Climate Change Policies

Chair

Prof. Krzysztof WARMUZINSKI
Institute of Chemical Engineering, Polish Academy of Sciences, Poland

Prof. Konstantinos KARAGIANNOPOULOS
National Technical University of Athens, Hellas

Speakers

"*Energy security performance in Japan: past and future*" by Dr. Kenichi MATSUMOTO, Nagasaki University - Japan

"*Climate Change Justice – an Australian Perspective*" by Dr. Evgeny GUGLYUVATYY, Southern Cross University - Australia

"*An econometric model for energy demand forecasting in transport & buildings sectors for the EU countries*" by Prof. Athanasios DAGOUMAS, University of Piraeus - Hellas

"*Profitable pathways to sustainable electrical systems - Regulative and political conditions in four countries*" by Prof. Thor Oivind JENSEN, University of Bergen - Norway

"*Assessment of the acceptance of energy systems transformations*" by Dr. Diana SCHUMANN, Forschungszentrum Juelich GmbH - Germany

"*Investigating controversies between coexisting building and environmental regulations in Greece*" by Mr. Themis CHATZIGIANNOPOULOS, Aristotle University of Thessaloniki - Hellas

11:30 – 12:00 Coffee break

12:00 – 13:30
Session 4: Energy - Climate Change

Chair

Prof. Kenichi MATSUMOTO
Nagasaki University, Japan

Prof. Konstantinos KARAGIANNOPOULOS
National Technical University of Athens, Hellas

"*Effective Forest Finance to Enhance Climate Change Mitigation, Adaptation and Biodiversity: Lessons from Global Environment Facility Finance*" by Prof. Kenichi MATSUMOTO, Nagasaki University, Japan

"*Gaining insight on climate policy transfer: Opportunities and Challenges*" by Ms. Aikaterini PAPAPOSTOLOU, National Technical University of Athens - Hellas

"*Day-Ahead Economic Dispatch for Oil Shale Power Plants in Deregulated Electricity Market*" by Dr. Nadežda DEMENTJEVA, Eesti Energia AS - Estonia

National and Kapodistrian University of Athens
KEPA

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"Snow Cover Digital Elevation Models Using Unmanned Aerial Vehicle and Total Station" by Eng. Charbel ABOU CHAKRA, St. Joseph University - Lebanon

"Inserting end-users behaviour into forward looking energy efficiency modelling" by Dr. Popi KONIDARI, National and Kapodistrian University of Athens - Hellas

13:30 - 14:30 Lunch break

14:30 – 16:30
Session 4: Renewable Energy Sources

Chair

Prof. Thor Oivind JENSEN
University of Bergen - Norway

Prof. Milton TYPAS
National and Kapodistrian University of Athens

Speakers

"Balancing Intermittent renewables - The potential of Pumped Hydro Power Storage" by MSc Andrea IMMENDOERFER, "Pforzheim University - Institute for Industrial Ecology INEC" - Germany

"A Decision Support Model for Site Selection of Offshore Wind Farms" by Ms. Afrokomi-Afroula STEFANAKOU, University of Aegean - Hellas

"Solar Energy: Jobs and Technology" by Ms. Hanne Sjovold HANSEN, Bergen University College / University of Oslo" - Norway

"Feasibility assessment of geothermal pellet production from agricultural residues in medium-sized municipality in north Greece" by Mr. Konstantinos A. LYMPEROPOULOS, Democritus Universitiy Thrace - Hellas

P R O M I T H E A S The Energy and Climate Change Policy Network

Friday, 14 October 2016

Brokerage event

09:30 – 10:00
Registration

10:00 – 11:30 Session 6: Programs and Projects

Chair

Prof. Andonaq Londo LAMANI
Polytechnical Univeristy of Tirana - Albania

Prof. Evaggelos DIALYNAS
National Technical University of Athens, Greece

Speakers

"CertifHy: Developing a European Framework for the generation of guarantees of origin for green hydrogen"
by Mr. Wouter VANHOUDT, HINICIO - Belgium

"Public Participation in Developing a Common Framework for Assessment and Management of Sustainable Innovation (CASI)"
by Mr. Ventseslav KOZAREV, Applied Research and Communications Fund (ARC Fund) - Bulgaria

11:30 – 12:00 Coffee break

12:00 – 13:30 Session 6: Programs and Projects *(continued)*

Chair

Prof. Andonaq Londo LAMANI
Polytechnical Univeristy of Tirana - Albania

Prof. Katherine M. PAPPAS
National and Kapodistrian University of Athens, Hellas

Speakers

"DAFNI Network of Sustainable Aegean and Ionian Islands - The Smart Islands Initiative"
by Mr. Konstantinos KOMNINOS, Network DAFNI - Hellas

"HORIZON2020 – Climate Action"
by Dr. Angeliki-Eleni VROCHIDOU, PRAXI Network – Hellas

"Project proposals of BSEC-Green Energy Network"
by Ms. Aliki-Nefeli MAVRAKI, National and Kapodistrian University of Athens - Hellas

"4 Horizon2020 calls looking for co-operation"
by Ms. Eleni-Danai MAVRAKI, National and Kapodistrian University of Athens - Hellas

"Proposing cooperation on Horizon open calls for Climate Action"
by Dr. Popi KONIDARI, National and Kapodistrian University of Athens - Hellas

Closing remarks
by Prof. Dimitrios MAVRAKIS, KEPA

National and Kapodistrian University of Athens
KEPA

P R O M I T H E A S The Energy and Climate Change Policy Network

Conference

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P R O M I T H E A S — The Energy and Climate Change Policy Network

List of participants

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5	Mrs.	Angeliki	Boura	Ministry of Foreign Affairs, Hellas
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9	Prof.	Athanasios	Dagoumas	University of Piraeus, Department of International and European Studies, Hellas
10	Dr.	Nadežda	Dementjeva	Eesti Energia AS Energy Trading, Estonia
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14	Dr.	Evgeny	Guglyuvatyy	Southern Cross University, Australia
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30	Mr.	Ekaterine	Lortkipanidze	Embassy of Georgia in Hellenic Republic
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39	Mr.	Ioannis	Ntroukas	EPA Attikis, Hellas
40	Mr.	Leonidas	Papakonstantinidis	Hellenic Ministry of Foreign Affairs, Hellas
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43	Mrs.	Jenny	Passari	National and Kapodistrian University of Athens Energy Policy and Development Centre (KEPA)
44	Mr.	Dan	Pericleanu	Embassy of Romania in Hellenic Republic
45	Mr.	Sergei	Prokhorov	Embassy of Russian Federation in Hellenic Republic
46	Mrs.	Ioanna	Sambrakou	Ministry of Infrastructures, Transports and Networks, Hellas

47	Dr.	Diana	Schumann	Forschungszentrum Juelich GmbH, Germany
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49	Mr.	Nicholas	Sofianos	Institute of Energy for SE Europe (IENE)
50	Mr.	Nikos	Stamou	Enterprise Greece Invest & Trade, Hellas
51	Mrs.	Afrokomi	Stefanakou	University of Aegean, Hellas
52	Mr.	Nikolaos	Stratigeas	ANAPLASI Consulting Engineers S.A., Hellas
53	Dr.	Ioannis	Tsipouridis	ELETAEN, R.E.D. Pro Consultants S.A., Hellas
54	Prof.	Milton A.	Typas	National and Kapodistrian University of Athens, Department of Biology
55	Mrs.	Evi	Tziola	AppArt, Hellas
56	Mr.	Sergey	Vagin	Embassy of Russian Federation in Hellenic Republic
57	Mr.	Wouter	Vanhoudt	HINICIO, Belgium
58	Dr.	Angeliki-Eleni	Vrochidou	PRAXI Network, Hellas
59	Prof.	Krzysztof	Warmuzinski	Institute of Chemical Engineerging, Poland
60	Ms.	Fumiko	Yanagida	Embassy of Japan in Hellenic Republic
61	Prof.	Georgios	Zografos	National and Kapodistrian University of Athens, Hellas

Session 1: Green Investments Perspectives

Opening speech by Prof. Georgios ZOGRAFOS

Vice Rector of the National and Kapodistrian University of Athens, Hellas

Excellencies, Ladies and Gentlemen and distinguished colleagues,

On behalf of the National and Kapodistrian University of Athens, the oldest and most prominent Greek university, I cordially welcome you to our university and the opening of the 9th International Scientific Conference on *"Energy and Climate Change"*.

The Conference is organized by the Energy Policy and Development Centre (KEPA) of our University under the aegis of the Serbian Chairmanship in Office of the Black Sea Economic Cooperation Organization and the United Nations Academic Impact to which KEPA is a member.

The conference aims to contribute to the common international effort to build scientific research that will allow our societies to confront the Climate Change challenge and support the successful implementation of the Paris Agreement which is about to enter into force. As scholars and scientists, we have to work together through research and knowledge transfer to propose the best solutions and practices to our societies.

In this context I would like to convey to you all the efforts of our university to become a *green paradigm* by taking concrete measures to shorten its carbon footprint. We are in the process of introducing natural gas for heating, reactivating our co-generation units, introducing LED lighting, smart energy saving applications and most important examining possible ways of transforming our buildings into near zero energy consuming ones.

It is an ambitious target, taking into account the magnitude of our installations but we should not avoid undertaking the necessary measures that will finally allow us to become a green paradigm for our society. Our university is interested and activated in issues of energy and climate change policy and particularly of promoting energy efficiency and renewable energy sources. After all we constitute the first public institution that has built the first public bioclimatic and smart building in our country fifteen years ago, meaning the building of KEPA, and we can take advantage of the lessons learned from this experience. Simultaneously, the Horizon 2020 research project HERON about incorporating the preferences of end-users in energy modeling and whose coordinator is the Energy Policy and Development Centre (KEPA), is also one of these activities.

At this point, I would like to express my sincere gratitude to the Permanent Secretariat of the Black Sea Economic Cooperation Organization and to thank the Deputy Secretary General ambassador **Traian Chebeleu** for his participation in this occasion. As university, we support the efforts of PERMIS to mobilize the academic community in our region on the critical issues of Mitigation and Adaptation to Climate Change and on the associated issues of Energy Efficiency and Renewable Energy. The European Union has released the biggest research and innovation program of the world, which is the Horizon 2020 and in the coming years with the additional support of the BSEC we are ready to develop and promote concrete proposals in a wide range of available programs among the EU member states, the associated countries and other countries worldwide on the basis of scientific excellence.

We recognize the efforts of the Energy Policy and Development Centre (KEPA) of our university to develop the "BSEC Green Energy Network" under the auspices of the BSEC organization. We have a huge potential, both in human resources and infrastructure in our schools and faculties and I am determined to take the advantage through the established experience of KEPA and its PROMITHEAS network in the EU, BSEC and Asia and its participation in the United Nations Academic Impact Initiative, that the cooperation with the regions of the Black and Caspian Seas, the Central Asia, the Asia – Pacific and Africa without excluding any other area or country will widen.

I am looking forward to a fruitful conference and I cordially wish you success in all your activities.

Ομιλία κ. Παναγιώτη ΚΟΥΡΟΥΜΠΛΗ, Υπουργού Εσωτερικών και Διοικητικής Ανασυγκρότησης

Η καταστροφική επέλαση του τυφώνα Μάθιου στην Καραϊβική και οι πρόσφατες πλημμύρες και πυρκαγιές στην Ελλάδα υπενθυμίζουν ότι η κλιματική αλλαγή είναι απειλή πραγματική και άμεση. Δυστυχώς, τόσο το πολιτικό σύστημα όσο και η κοινή γνώμη έχουν καθυστερήσει να αντιληφθούν το μέγεθος και την πολυπλοκότητα αυτής της πρόκλησης, η οποία **μακροπρόθεσμα συνιστά μεγαλύτερο πρόβλημα από την οικονομική κρίση**. Είναι ανάγκη να ληφθούν μέτρα μετασχηματισμού τόσο της κοινωνικής συμπεριφοράς όσο και της οικονομίας μας, σύμφωνα με τις αποφάσεις στη διαμόρφωση των οποίων έχουμε συμμετάσχει στην Ευρωπαϊκή Ένωση και στον ΟΗΕ.

Η Συμφωνία του Παρισιού αποτελεί ένα σημαντικό βήμα για την αντιμετώπιση της κλιματικής αλλαγής, που όμως πρέπει να ενισχυθεί και να υλοποιηθεί εντός στενού χρονικού ορίζοντα. Δεν υπάρχουν περιθώρια εφησυχασμού για καμία χώρα και για κανένα πολίτη. Γνωρίζετε όλοι ότι ο στόχος που συμφωνήθηκε στο Παρίσι, για συγκράτηση της ανόδου της μέσης παγκόσμιας θερμοκρασίας στους 2 βαθμούς Κελσίου, κάθε άλλο παρά βέβαιο είναι ότι θα επιτευχθεί. Από τις πολιτικές ηγεσίες απαιτείται εγρήγορση, στενή διεθνής συνεργασία και επιτάχυνση των προσπαθειών μείωσης και προσαρμογής. Υπάρχει ανάγκη για διαμόρφωση ενός αποτελεσματικού διεθνούς θεσμικού πλαισίου για την παραγωγή και διάχυση νέας γνώσης και κυρίως για την εξασφάλιση και κατανομή των αναγκαίων οικονομικών πόρων για τον λεγόμενο πράσινο μετασχηματισμό της παγκόσμιας οικονομίας.

Ίσως από τα πλέον σημαντικά εμπόδια που αντιμετωπίζουμε είναι η διάχυση της ανάγκης αντιμετώπισης αυτών των προβλημάτων μέσα στην κοινωνία μας. Είναι ανάγκη υφιστάμενες βέλτιστες πρακτικές και τα οφέλη από την αποδοχή τους να μεταφερθούν στις τοπικές κοινωνίες. **Ο ρόλος που μπορεί να παίξει η Τοπική Αυτοδιοίκηση στην αντιμετώπιση της κλιματικής αλλαγής και στον πράσινο μετασχηματισμό των τοπικών οικονομιών είναι απολύτως καθοριστικός**, τόσο σε εθνικό όσο και σε περιφερειακό επίπεδο.

Σε τοπικό επίπεδο υπάρχει μεγάλο περιθώριο δράσης, που ξεκινά από την εξοικονόμηση ενέργειας και την ενσωμάτωση φωτοβολταϊκών σε κτίρια και δίκτυα, και φθάνει στην ενίσχυση των προσπαθειών για την επανεκκίνηση της οικονομικής ανάπτυξης σε τοπική κλίμακα, καθώς όλες αυτές οι δράσεις στηρίζονται στην εκμετάλλευση του τοπικά παραγόμενου πλούτου.

Η ενεργειακή αναβάθμιση των δημοσίων κτιρίων, που αποτελεί χρηματοδοτούμενο ευρωπαϊκό στόχο, είναι ένα πρώτο βήμα. Πρέπει να τονιστεί ότι, συμβάλλοντας στην αντιμετώπιση της κλιματικής αλλαγής, οι Δήμοι και οι Περιφέρειες θα αποκομίσουν άμεσα οφέλη από την εξοικονόμηση ενέργειας, αλλά και από την ενίσχυση της τοπικής οικονομίας και απασχόλησης. Αρχίζοντας από την αναβάθμιση υφιστάμενων βιοκλιματικών κτιρίων μπορούμε, καθώς η ευαισθητοποίηση των πολιτών θα αυξάνεται, να επεκταθούμε στους τομείς των μεταφορών και της βέλτιστης αξιοποίησης των απορριμμάτων, τα οποία παραμένουν στο επίκεντρο του ενδιαφέροντος της Ε.Ε.

Το ΥΠΕΣΔΑ προσβλέπει στην ενεργοποίηση της ιδιωτικής πρωτοβουλίας για την ανάληψη έργων μεσαίου μεγέθους, ενώ θα επιδιώξει να εντάξει έργα μικρότερης κλίμακας στον υφιστάμενο σχεδιασμό του για την προώθηση της κοινωνικής οικονομίας. Κατ' αυτόν τον τρόπο προωθείται παράλληλα η μακροπρόθεσμη στόχευση του Υπουργείου για συνευθύνη και συμμετοχή των πολιτών στην πολιτική προστασία.

Η αντιμετώπιση της κλιματικής αλλαγής είναι κατεξοχήν ζήτημα διεθνούς και περιφερειακής συνεργασίας. Για αυτό τον λόγο **επιζητούμε ενεργά την καλή συνεργασία με όλες τις χώρες του Οργανισμού Οικονομικής Συνεργασίας του Εύξεινου Πόντου**. Οφείλουμε να συνεργαστούμε στενά σε ζητήματα όπως οι πυρκαγιές, οι πλημμύρες και η δορυφορική επισκόπηση. Επιπλέον, να προωθήσουμε την τεχνική και επιστημονική συνεργασία με ανταλλαγές καλών πρακτικών και τεχνογνωσίας. Ευελπιστώ ότι το ΚΕΠΑ θα συνεχίσει να συμβάλλει σε αυτή την κατεύθυνση και ότι μέσω του Πράσινου Δικτύου Ενέργειας του ΟΣΕΠ θα μπορέσουμε να κάνουμε αποφασιστικά βήματα συνεργασίας στην περιοχή αυτή.

Για την αντιμετώπιση της κλιματικής αλλαγής στην περιοχή μας η διεθνής πολιτική δέσμευση είναι δεδομένη και οι μηχανισμοί χρηματοδότησης υπαρκτοί. Απομένουν η ανάληψη πρωτοβουλιών και η υλοποίηση τους. Ως αρμόδιο υπουργείο, **το ΥΠΕΣΔΑ δεσμεύεται ότι θα διαβουλευθεί με τις δημοτικές και περιφερειακές Αρχές, με τη Γραμματεία του ΟΣΕΠ, το Κέντρο Ενεργειακής Πολιτικής και Ανάπτυξης του Πανεπιστημίου Αθηνών και όλους τους ενδιαφερόμενους φορείς, με σκοπό την επιτάχυνση και τον συντονισμό των δράσεων σε τοπικό επίπεδο.** Σε αυτή την προσπάθειά μας θα αναζητήσουμε πολιτική και οικονομική στήριξη από την Ε.Ε., τον ΟΗΕ αλλά και άλλους διεθνείς χρηματοδοτικούς οργανισμούς.

Όταν κινδυνεύει ο ίδιος ο πλανήτης μας, το εθνικό συμφέρον κάθε χώρας ταυτίζεται με το διεθνές. Κατά το παρελθόν, κάθε χώρα του Οργανισμού Οικονομικής Συνεργασίας του Εύξεινου Πόντου έχει πληρώσει βαρύ τίμημα για να υπηρετήσει τους εθνικούς της στόχους. Σήμερα, για πρώτη φορά είμαστε σε θέση να πετύχουμε όλοι τον απώτερο στόχο μας, και δη άνευ τιμήματος. Έχουμε χρέος απέναντι στους πολίτες μας να το επιδιώξουμε ως πρώτη προτεραιότητα.

Σας ευχαριστώ

Opening by Mr. Panagiotis KOUROUMPLIS, Minister of Interior and Administrative Reconstruction

The devastating onslaught of Hurricane Matthew in the Caribbean and the recent floods and fires in Greece are a reminder that climate change is a real and immediate threat. Unfortunately, both the political system and public opinion have been slow in understanding the size and complexity of this challenge, which is, in the long-term, of much greater importance than the economic crisis. It is necessary to take measures that will transform our social behavior and economy, according to decisions in the formulation of which we have participated in the European Union and the UN.

The Paris Agreement is an important step in tackling climate change, but it must be augmented and implemented within a narrow timeframe. There is no room for complacency for any country and for any citizen. You are all aware that the target agreed in Paris, to restrain the rise in average global temperature to 2°C, is far from certain that it will be achieved. Vigilance, close international cooperation and accelerating the mitigation and adaptation efforts are required from political leaders. There is a need to establish an effective international regulatory framework for the production and dissemination of new knowledge and, most importantly, for securing and allocating the necessary financial resources for the so-called green transformation of the global economy.

Perhaps the most significant obstacle that we are facing is the dissemination of the necessity to address these problems in our society. Existing best practices and the benefits of their acceptance must be transferred to local communities. The role that can be played by local government in tackling climate change and in the green transformation of local economies is absolutely crucial, both at national and regional level.

At the local level, there is considerable scope for action, starting from energy savings and integration of PV in buildings and networks, all the way to strengthening of efforts to restart growth on a local scale, since all these actions are based on making use of locally produced wealth.

The energy upgrade of public buildings, which is a funded European target, is a first step. It should be underlined that, by tackling climate change, the municipalities and regions will reap direct benefits from energy savings, but also from support of the local economy and employment. Starting from the upgrading of existing bioclimatic buildings, we can, as awareness grows, expand to the areas of transport and optimal utilization of waste, which remain at the heart of EU interest.

YPESDA[1] looks forward to the activation of private sector initiatives in undertaking medium-sized projects, while it will seek to include smaller-scale projects in its existing programme to promote social economy. Thus, the Ministry promotes at the same time its long-term goal of co-responsibility and participation of citizens in civil protection.

Tackling climate change is predominantly a matter of international and regional cooperation. For this reason, we actively seek close cooperation with all the countries of the Black Sea Economic Cooperation Organization. We must work together closely on issues such as fires, floods and satellite monitoring. Furthermore, we should work on promoting technical and scientific cooperation through exchange of best practices and expertise. I hope that KEPA will continue to contribute in this direction through the Green Energy Network of BSEC and that will be able to make decisive steps for cooperation in this region.

The political commitment is granted and the funding mechanisms already exist for addressing climate change in our region. All that remains is the undertaking of initiatives and their implementation. As competent ministry, YPESDA commits to consulting with municipal and

[1] Hellenic Ministry of Interior and Administrative Reconstruction

regional authorities, with the BSEC PERMIS, the Energy Policy and Development Centre of the University of Athens and all the stakeholders, so as to accelerate and coordinate actions at local level. In this effort, we will seek political and financial support from the EU, the UN and other international financial institutions.

When the entire planet is in danger, the national interest of each country coincides with the international. In the past, each country of the Black Sea Economic Cooperation Organization has paid a heavy price in pursuit of national objectives. Today, for the first time, we are all in a position to achieve our ultimate objective, indeed without paying a price. It is our duty towards our citizens to pursue that as a first priority.

Thank you

Video – message from Mr. Ramu DAMODARAN

Chief of United Nations Academic Impact,
Secretary of the United Nations Committee on Information

I am delighted to have this opportunity to share a message with the International conference on Energy and Climate Change.

And I am indebted to my distinguished friend and colleague Dimitrios Mavrakis for having invited me to speak to you.

Prof. Mavrakis describes himself as as an aspiring pirate. And I think that's a fair description for all the countless women and men who have brought the frontiers of scientific inquiry to the shores of climate change, its challenges, its' dangers and also its inherent possibilities.

Because just as pirates wander into waters unknown to them, often at peril to their own lives and well-being, they too have confronted enemies. Enemies which have been spurred by the moment, but enemies which have also been fostered through history.

And that aspect, if you will, of benign piracy is one which I think animates the scientific dimension in the business communities' view towards the ideas of Energy and Climate Change.

It's particularly fitting, that this conference takes place in Athens, the home several centuries ago of Hippocrates, who spoke of climate being an essential determinant of human health, human happiness and indeed human intelligence.

One has just to wander to the Acropolis, to see the scientific design when it was first constructed, the way its columns are aligned to shelter the construction from the perils of wind and of storm, and yet, bring into it as much of the beneficial sun and the energy from the sun as possible.

A practice that flowed into later times in historic Greece, when as cities began to be depleted in the supplies of fuel and energy essential to their survival, they began to construct their own dwellings and indeed the entire grids of the city in a southern face, so that they could optimize the benefits that they would get from solar power and benevolence.

That metaphor has taught us well over these past centuries and today, we have a formidable combination; the scientific community as I suggested, the commercial community, which is responsible for the provision and the creation and the marketing of energy and, if you will, the two important communities that have come to their own in the twentieth and twenty-first centuries: the global political and the global popular communities.

Political, because it is governments alone who can decide themselves and working with each other to give effect to what they decide, at the United Nations, must be done to address climate change. Popular, because governments are animated ultimately by the will, the determination and the wishes of their people, and when people are aware and informed of the dangers they face and are all apprised of the solutions that they can foster, it is they who put pressures on their government.

Many of the deliberations that you will have in the next couple of days will, of necessity, be very specific, very scientific and to that extent, perhaps a little abstruse, even esoteric, for the ordinary woman and man – and I count myself as one - to understand.

My very respectful request to all of you, is at the end of each one of your papers, which is going to be rooted deeply in fact and research, please let us know how what you have discovered, or what your findings are, can make a tangible difference to the life of people everywhere.

Because that ultimately is what you are trying to do, that is what the United Nations tries to do and together, we can have a wonderful, meaningful and above all, a far-sighted partnership, just as secure and just as assured as the abundance of clean and sustainable energy that animates our planet.

Thank you

Opening by Amb. Traian CHEBELEU

Deputy Secretary General BSEC-PERMIS

Mr. Minister,

Mr. Vice-Rector,

Dear Professor Mavrakis,

Distinguished Participants,

I feel particularly privileged to address this distinguished audience and, on behalf of the Secretary General of the Permanent International Secretariat of the Black Sea Economic Cooperation Organization (BSEC), Ambassador Michael Christides, to convey warm greetings to the participants in this 9th International Scientific Conference on “Energy and Climate Change”.

At the same time I convey warm greetings to the organizers of this event, the prestigious Energy Policy and Development Centre (KEPA) of the National and Kapodistrian University of Athens, directed with an impressive professionalism and eagerness to achieve concrete results by Professor Dimitrios Mavrakis.

We are honoured that this important annual event takes place under the auspices of BSEC. It offers an excellent framework for getting acquainted with the latest scientific and technological developments related to the green energy and for connecting decision makers, prestigious academic and research institutions, and market stakeholders from the BSEC Member States and from other states interested in the regional cooperation in this area.

These scientific conferences have made significant contributions to the knowledge transfer and development on energy and climate change issues in the BSEC Region. The papers prepared by the participants and the discussions have been very valuable for our organization, 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 our Member States in these fields.

In fact, one of the sectors we are more active in is the Energy sector. This is quite understandable, considering the significance of our region in what concerns production and distribution of energy to the world markets.

Today, a vital component of the area of “Energy” is the “Climate Change”.

Indeed, energy efficiency, energy conservation, alternative-renewable sources of energy are at present, especially after the last COP21 meeting in Paris in December 2015, very much on the forefront of the agendas of all our Member States.

Through the activity of our Working Group on Energy, consisting of representatives of Ministries in charge of Energy, BSEC endeavors to develop and promote common policies and practices.

One of the priorities of our Organization is to support the efforts of our 12 Member States for ensuring sustainable energy, including the elaboration of a BSEC Green Energy Strategy with the view to promoting renewable energy sources, energy efficiency and environmentally friendly technologies.

In this regard, one of the most important developments is the establishment of the ***BSEC – Green Energy Network***, among administrative bodies and centers and organizations promoting renewable energy sources, energy efficiency measures and policies.

We are very glad and thankful to KEPA for agreeing to operate the Network under the supervision of BSEC. This an important tool for exchanging information and for sharing know-how and good practices among our Member States, which had set for themselves, in the strategic document guiding the activities of the Organization - *BSEC Economic Agenda 2012* -, the task of taking gradual steps to materialize the vision of transforming the BSEC Region into a model for clean energy by the year 2050.

The Network numbers today 45 members, and remains open to participation of other interested parties from BSEC Member States, and from States and International Organizations that have Observer or Sectoral Dialogue Partner status with BSEC.

This year the Scientific Conference has a special importance for us as it opens with this one day Green Investment Forum. Its importance stems from the fact that the BSEC Member States should reduce their reliance on fossil fuels, save more energy and use more renewable sources.

Generally speaking, investment in renewable energy is growing. It is true that this sector is still relatively young and challenged by high costs. Oil and gas are still available and at convenient prices. They will continue to be an important part of the energy mix in the foreseeable future.

In some Member States there is a downward spiral of renewable energy investments. The interest of investors for renewable energy decreased significantly. Can this spiral be inverted? It can, we believe, and we should do our best for this to happen.

At the same time, in the light of the results of COP 21, de-carbonization requires massive efforts involving governments, business and banking sectors, NGOs - all working together for comprehensive change and for having energy from renewable sources to take a steadily increasing part of the energy mix of our Member States.

Consequently, a BSEC Green Energy Investment Forum to discuss all these and other related issues could stimulate and facilitate action in these directions.

We are very hopeful that this initiative of KEPA will be followed by similar Forums, on a yearly basis, in various BSEC Member States, which could be of a great help for identifying national and regional projects and for encouraging investment opportunities in the BSEC Member States. We could also think to devote some of the activities of the future Forums for expert training in green energy promotion and investments through workshops or seminars.

The efforts we are undertaking in this direction have a distinct importance in enabling all countries to combat climate change effectively and boost the transition towards resilient, low-carbon economies, whilst promoting fair and sustainable development.

With these thoughts, I wish the participants useful networking and fruitful exchanges.

Opening by Mr. Lucian FATU

Ambassador of Romania in Athens

Dear Deputy Secretary-General,

Dear Professor Mavrakis,

Distinguished participants,

I am honoured to address the International Scientific Conference organized by Athens University, and grateful for the invitation. Energy and climate change is an ongoing topical issue on the BSEC agenda, with the aim to harness the national Government and NGO actions around the Black Sea and add the value of regional cooperation and BSEC expertise.

I would like to first present the main priorities of Romanian Government regarding energy policy: completion of the national energy strategy and initiating a process of adopting it through political consensus; encouraging energy efficiency programs, especially in the residential areas which have significant potential for energy savings. In this regard, are operational programs financed from structural funds targeting the energy sector will be launched; encouraging the production of primary energy resources from both domestic conventional sources (coal, oil, natural gas, uranium) and renewables; stimulating natural gas transactions in a centralized and transparent manner as way to help develop a functioning market profile.

The second issue that I want to mention is that Romania welcomes the commitment and determination of EU Member States for the ratification of the Paris Agreement. On 4 October 2016, the European Council adopted the decision on the ratification of the Paris Agreement. This agreement establishes the framework for global action on climate change after at the last G20 Summit (4-5 September, China), we noted the joint announcement of the US and China to ratify the Paris Agreement, the emissions of two states representing approx. 38% of total greenhouse gas generated globally. Regarding the ratification process at national level, Romania has speed up the procedures internally and Government adopted in September, the draft law of ratification. It is to be debated in Parliament for adoption. Although the Government can not impose deadlines, Romanian side will try to accelerate the adoption procedure in Parliament. Romania's main obligations under the Paris Agreement, in terms of reduction of emissions of greenhouse for the period 2021-2030 are: reducing emissions of greenhouse gases by 43% by 2030 compared to 2005 under the EU ETS; participation in the EU's effort to reduce emissions of greenhouse by 30% by 2030 compared to 2005 in non-ETS sectors, including transport, agriculture, construction, management of emissions from waste.

Romania is among the countries with high potential for renewable energy, and this resource is a real opportunity for economic recovery. If Romania exploits the full potential of solar energy in our country, we could get almost half the volume of hot water and about 15% share of thermal energy for heating. An so I reached to the third issue that I want to mention. Romanian Ministry of Environment launched in September this year, the „Green Home" program, both for the population and businesses. Through this program, applicants receive financing through the Environment Fund Administration for the installation, replacement or additional conventional heating systems with those using green energy sources. The budget assigned for the entire country is aprox. 20,9 mil. euro, of which 13,3 mil. are for individuals and 7,6 mil euro for businesses.

As a Member State of the European Union, Romania was involved responsibly in the international effort aimed at addressing climate change. By nature of its business, the environment and climate change plays an important role in meeting their obligations.

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

Thank you.

Opening by Mr. Miltiades MAKRYGIANNIS

Deputy Secretary General, Parliamentary Assembly of the BSEC-PABSEC

Ladies and Gentlemen,

Distinguished participants,

Firstly, I would like to congratulate the Energy Policy and Development Center as well as the International Secretariat of the BSEC, for their initiative to organize the 1st "Green Investment Forum", in the context of the 9th International Scientific Conference on "Energy and Climate Change".

I would like also to express our gratitude to Professor Mavrakis for his efforts to maintain active and strong the cooperation between the Parliamentary Assembly of the Black Sea Economic Cooperation and the KEPA.

The establishment of Networks of cooperation between national administrative bodies and/or centers and organizations from the BSEC Member States mandated to promote Renewable Energy Sources, Energy Efficiency measures and Green Investment policies developed by the Energy Policy and Development Center and the BSEC is of great importance.

The Parliamentary Assembly of BSEC has always been placing emphasis to the issue of energy efficiency, green energy, environmental protection and green investments. Our Assembly has debated many times on energy issues and environmental challenges and has adopted several Reports and Recommendations. These documents outline the basic strategy of our Parliamentary Assembly on this issue.

The main point to all these documents is that national Parliaments have to pay more attention to policies and programmes that achieve a better balance between development and environmental concerns and explore more effective approaches on global climate change and green challenges. National Parliaments should take leadership role in promoting deeper understanding of green development issues entailing serious social, economic, and even security implications and bring their contribution to facilitating more informed decision making regarding this all-encompassing challenge.

Parliamentarians should also mobilise public opinion with a view to avert dangerous human interferences. They can reinforce green development policies and legislation and they can enhance international cooperation on the basis of common but differentiated responsibilities under the international instruments. Furthermore, to contribute effectively towards a transition to a development model that results in sustaining well-being of people by ensuring environmentally friendly, inclusive economic growth or increasing efficient consumption of natural resources and sustainability of ecosystem services.

The role of the parliaments is especially important in order to forge the laws, guidelines, frameworks and incentives that will allow efficient implementation of national and international engagement on the challenge of green development and global climate change.

Parliaments' role is also important in order to improve legislation regulating the internal energy markets with a view to providing and creating a fully effective, competitive and stable common energy market in the region and to adopt necessary regulations or laws aiming at the measures on ensuring security of energy supply and consumption in the BSEC member states.

Black Sea countries are endowed with an invaluable natural heritage, but fragile enough to be threatened by numerous environmental challenges. In order to overcome inefficiency and fragmentation there is a need for "greening" the Black Sea through environmental governance. This strategic policy implies the incorporation of the horizontal environmental perspective into all sectoral policies, with a view to achieving legal compliance, efficiency, legitimacy, and networking.

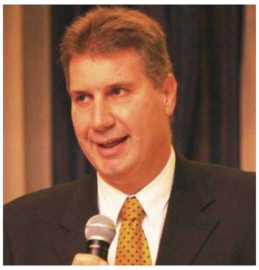
The BSEC presents important steps towards the incorporation of environmental approaches in the economic and social development of its member states. However, despite the notable progress so far, the environmental problems are mainly tackled at the national level, even though they have transboundary impacts. Collective multilevel action can be triggered by the BSEC and PABSEC; their institutional and diplomatic role is essential for the strengthening of horizontal actions for the environment, the allocation of financial resources and the management of projects that need sufficient political and technical support, if they are to succeed.

The countries of the Black Sea region need to implement multilateral environmental agreements and establish a more strategic environmental cooperation in the area. In this framework, multilevel cooperation could be implemented in several issues.

In the Recommendations adopted by the Parliamentary Assembly of the Black Sea Economic Cooperation it is underlined that no effective action could be taken today without stronger international cooperation and solidarity. Cooperation at the trans-national, regional and local levels is of significant essence for efficient and effective address to the issue of green development. BSEC states along with the international organisations and civil society must engage in a constructive dialogue which produces tangible results. The international community must demonstrate its capacity to provide people with secure livelihood and individuals, in their turn, must and do care for the environment.

Once again, on behalf of the International Secretariat of the Parliamentary Assembly of the Black Sea Economic Cooperation, I thank you for the invitation and I wish success to your works.

Opening by Mr. Leonidas PAPAKONSTANTINIDIS

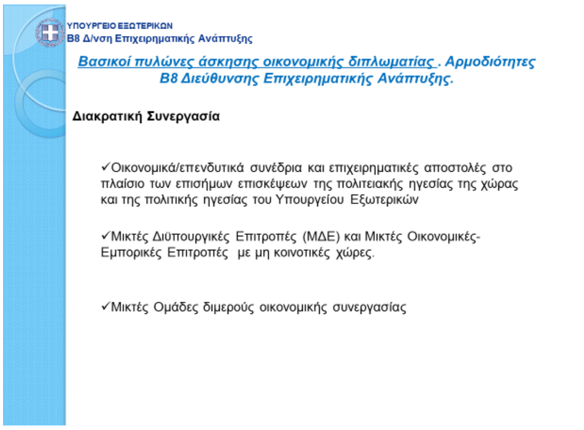


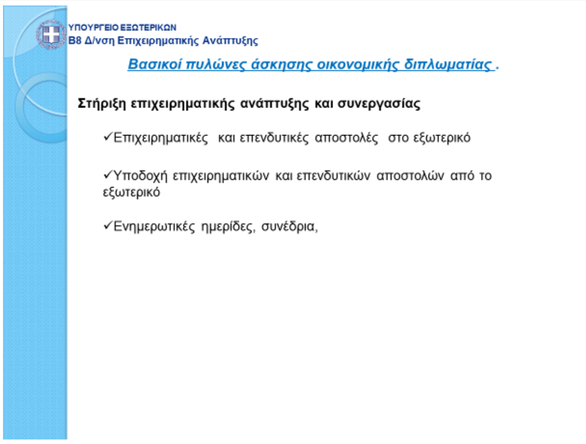
Councelor for Economic and Commercial Affairs,
Hellenic Ministry of Foreign Affairs

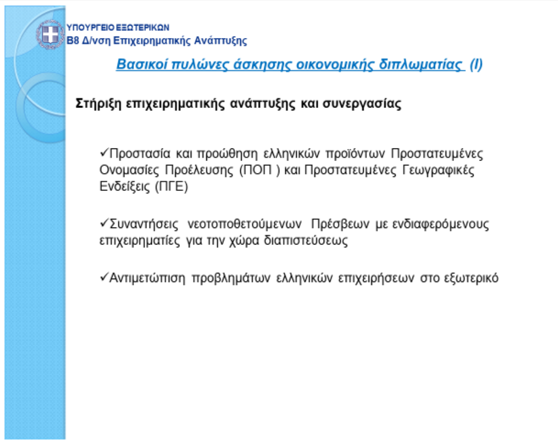
B8 Directorate for Business Development: Mission & Responsibilities

B8 is responsible for the support of Greek firms to international markets through various supporting activities, which, among others, include:

- Monitoring trade and economic developments around the world and informing regularly the Greek business community on important developments;
- Recording the companies' activities, priorities and problems they face in foreign markets and supporting them in cooperation with our Embassies and Economic and Commercial Offices abroad;
- Analising the potential of Greek products to enter new markets or increase their market share;
- Undertaking appropriate initiatives to promote selected products, services or sectors by organizing events, seminars etc in Greece and sending accordingly promotional material to support events organized by our Diplomatic Authorities abroad;
- Cooperating with various professional organizations (Chambers, Associations etc) in order to facilitate business contacts abroad and develop or increase their exports;
- Organizing or coordinating trade missions, accompanying the President, the Prime Minister, the Minister of Foreign Affairs etc during their official visits abroad;
- Informing entrepreneurs on updates of European - international funding programmes;
- Organizing for the stuff of Economic and Commercial Offices educational seminars on specific fields of economic diplomacy.







(all presentations are uploaded at: http://www.promitheasnet.kepa.uoa.gr)

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Β8 Δ/νση Επιχειρηματικής Ανάπτυξης

Βασικοί πυλώνες άσκησης οικονομικής διπλωματίας (I)

Συνεργασία με συλλογικούς και κλαδικούς φορείς

- ✓Μνημόνια Συνεργασίας
- ✓Σχεδιασμός και υλοποίηση κοινών δράσεων στο εσωτερικό
- ✓Διοργάνωση από κοινού δράσεων ενίσχυσης εξωστρέφειας των ελληνικών επιχειρήσεων στο εξωτερικό

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Β8 Δ/νση Επιχειρηματικής Ανάπτυξης

Βασικοί πυλώνες άσκησης οικονομικής διπλωματίας (II)

Πρόγραμμα ανάπτυξης σχέσεων των ελληνικών επιχειρήσεων στο εξωτερικό.

- ✓Θεματικές εκδηλώσεις προώθησης ελληνικής επιχειρηματικότητας στο εξωτερικό για επιλεγμένους κλάδους σε επιλεγμένες αγορές
- ✓Συνεργασία με απόδημο ελληνισμό

Επιχειρηματική πληροφόρηση

- ✓Έρευνες αγοράς – κλαδικές μελέτες
- «Διαδικτυακή Πύλη «**agora**» www.agora.mfa.gr
- ✓Ημέρες πληροφόρησης επιχειρηματιών σε Αθήνα και περιφέρεια σε συνεργασία με φορείς των Περιφερειών και κατά περίπτωση με τα συναρμόδια Υπουργεία

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Β8 Δ/νση Επιχειρηματικής Ανάπτυξης

Βασικοί πυλώνες άσκησης οικονομικής διπλωματίας (II)

Οργάνωση Γραφείων ΟΕΥ & Σύστημα Διαχείρισης Ποιότητας

✓Συστηματική παρακολούθηση των εξελίξεων και των τάσεων στις διεθνείς αγορές σε συνάρτηση με την ελληνική επιχειρηματική παρουσία και συνακόλουθη στελεχειακή κατανομή και χωροταξική αναδιάταξη των Γραφείων

✓Εκπαίδευση Στελεχών των Γραφείων

Διοργάνωση σεμιναρίων για τα Γραφεία ΟΕΥ για θέματα εξωστρέφειας, προσέλκυσης επενδύσεων, ΑΠΕ, πιστοποίησης και σήμανσης προϊόντων, υψηλής τεχνολογίας, εξαγωγικών πιστώσεων , ΠΟΠ/ΠΓΕ κ.λπ. με τη συμμετοχή **εκπροσώπων επιχειρηματικών φορέων** και **συναρμόδιων Υπουργείων**

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Β8 Δ/νση Επιχειρηματικής Ανάπτυξης

Οι δράσεις που συμβάλλουν στην επίτευξη των στόχων της οικονομικής διπλωματίας

- «**Hosted Buyers Program**» της **HELEXPO**
  - ✓ προσκλήσεις εμπορικών επισκεπτών και δυνητικών νέων πελατών από αγορές-στόχους
  - ✓ συνεργασία με διοργανωτές διεθνών εκθέσεων στο εσωτερικό
- **Στήριξη πρωτοβουλιών άλλων φορέων** στη διοργάνωση επιχειρηματικών αποστολών, συμμετοχών σε εκθέσεις, προωθητικών εκδηλώσεων κ.λπ. Στο εξωτερικό

  π.χ. *Enterprise Greece*, Εμπορικά και Βιομηχανικά Επιμελητήρια, Αποκεντρωμένες Διοικήσεις, επιχειρηματικοί σύνδεσμοι και ενώσεις

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Β8 Δ/νση Επιχειρηματικής Ανάπτυξης

Οι δράσεις που συμβάλλουν στην επίτευξη των στόχων της οικονομικής διπλωματίας

- Ανασχεδιασμός και περαιτέρω αξιοποίηση **διαδικτυακής πύλης AGORA**
- **Αξιολόγηση και εφαρμογή του συστήματος Διαχείρισης Ποιότητας (ΣΔΠ) των Γραφείων Ο.Ε.Υ** κατά ISO

Κεντρικοί στόχοι:

- ✓ Βέλτιστη γεωγραφική κατανομή και στελέχωση των Γραφείων Ο.Ε.Υ
- ✓ Διαρκής βελτίωση εσωτερικής οργάνωσης και παρεχόμενων υπηρεσιών

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Β8 Δ/νση Επιχειρηματικής Ανάπτυξης

AGORA
HELLENIC REPUBLIC
MINISTRY OF FOREIGN AFFAIRS
http://agora.mfa.gr

Η διαδικτυακή πύλη AGORA
http://www.agora.mfa.gr

- **Ενημέρωση ιστοσελίδας** από 59 Γραφεία ΟΕΥ
- **Πληροφόρηση** της επιχειρηματικής κοινότητας της χώρας μας μέσω καταχωρήσεων εμπορικών, οικονομικών και επενδυτικών πληροφοριών (βλ. επόμενες διαφάνειες)
- **Πρόσβαση** σε στοιχεία επικοινωνίας περισσότερων από 2.500 αλλοδαπών επιχειρήσεων

ΥΠΟΥΡΓΕΙΟ ΕΞΩΤΕΡΙΚΩΝ
Γενική Γραμματεία Διεθνών Οικονομικών Σχέσεων
Β8 Διεύθυνση Επιχειρηματικής Ανάπτυξης

Ευχαριστώ για την προσοχή σας

Opening by Mr. Volodymyr SHKUROV

Ambassador of Ukraine in the Hellenic Republic

Dear Chairman, dear prof. Mavrakis!

Dear participants and guests!

First of all, let me express my sincere gratitude for kind invitation extended to me to participate in the Conference! Unfortunately, I was not able to be present at this event by myself due to my very tight schedule for this day because of previous engagements.

I would like to welcome all the participants of *Green Investment Forum* and to wish a fruitful and constructive discussions.

The issue of global climate changes remains to be at the center of international topics over the past decades as an urgent threat to the Earth's ecology and economic development of all mankind. In this context, the signing in June 1992, by representatives of 176 countries of the UN Framework Convention on Climate Change (UNFCCC), became as clear evidence of common understanding of the need to find out ways of developing common activity aimed at protection and preservation of the environment.

The ongoing efforts to take control over the climate changes is now moved to a new stage. Our main objective is achieving transition to utilization of energy sources with low carbon content, introduction of technologies with low emission of gas, reducing the creation of greenhouse effect, as well as development of renewable energy sources. Both in developed and developing countries, we need to develop programs conducive to climate protection. We must cooperate tightly with financial and investment community, as their decisions, especially regarding energy systems, steering technical development and can play an important role in achieving our goals. More actions we have to do to mitigate the effects of climate change.

To this regard, it should be noted that the Government of Ukraine is an active member of the process of international negotiations on climate change. Representatives of Ukraine participate in the Conferences of the Parties and the Subsidiary Bodies of the Framework Convention on Climate Change. The Government of Ukraine cooperates also with the World Bank in terms of development national strategy for joint implementation of projects. The Global Environment Facility funds through the United Nations Development Program projects that may reduce barriers in implementation of the mitigation of climate change.

Along with Ukraine's participation in international events on global climate change, Ukraine maintains bilateral cooperation with several countries and organizations.

I consider our today's event as an important tool and an integral part of overall international efforts to achieve this goal.

Therefore, on behalf of the Ukrainian side and on my own name, I would like to wish all participants of today's conference a fruitful and productive work.

Thank you

Opening by Prof. Dimitrios MAVRAKIS

Director of KEPA, National and Kapodistrian University of Athens, Hellas

Honorable Minister,

Excellences,

Distinguished guests and participants,

Climate Change occurs faster than we thought. Last August was the warmest one in the last 136 years of modern record keeping according to NASA suggesting that Climate Change occurs faster than we expect.

The observed concentrations of CO_2 particles per million in the atmosphere have reached the 402.25 ppm, in August 2016, while the relevant value in August 2015 was 398.93 ppm.

This corresponds to an annual growth rate of 2.94 ppm/yr that compared to 0.96 ppm/yr in 1959 defines an astonishing increase of 32.65%, while the threshold for keeping the average global temperature increase below the 2^{o}C threshold, compared to pre-industrial period, corresponds to 480ppm CO_2, following the Copenhagen Accord in 2009.

In this context, it is worth mentioning that if we want to remain under this threshold the amount of CO_2 that we can emit in the future, is less than 1000Gt, starting from 2012. This is the so called "budget" to spend.

To make a long story short this approach requests, according to the United Nations Environment Programme, that if we want to have a likely chance to remain under the 2^{o}C we should reach i) the peaking point of global emissions around 2030, ii) carbon neutrality between 2050 and 2070 and iii) total global GHG emissions to net zero level between 2080 and 2100.

We are at the last quarter of 2016 and the questions are whether we have developed and implemented the appropriate tools to meet the aforementioned milestones before the extinction of the continuously decreasing budget and further how efficient are we in confronting the existing obstacles that hinder us to achieve our targets.

On 5 October 2016, it was announced by UNFCCC that the threshold for entry into force of the Paris Agreement was achieved and it will enter into force on 4 November 2016.

As a result, the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA 1) will take place in Marrakech Climate Change Conference, in conjunction with the Conference of the Parties (COP 22) and the twelfth session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP 12), from 7-18 November 2016.

The Paris Agreement that will enter into force in less than one month is based on a bottom up approach where the signatory parties through their Nationally Determined Contributions (NDCs), define their commitments to contribute in keeping the 2^{o}C, even 1.5^{o}C, threshold, in the context of the aforementioned milestones.

The news sound good but the problem is that regardless of the implementation of the undertaken commitments the said threshold of the 2^{o}C target will not be achieved. Estimations made by UNFCCC and based on the submitted INDCs lead to the conclusion that even if the parties could meet their commitments the temperature will increase by more than 3^{o}C.

The situation is becoming worst for someone strolling through the undertaken NDCs, since it is obvious that most of the developing countries suffer from lack of awareness, knowledge and funds to implement them.

Regardless of their declarations the reality is that the huge majority of human population does not understand the nature, the complexity and the magnitude of the climatic threat and this ignorance is reflected to the policies that their leaders implement, especially when these policies request behavioral changes or financial costs.

Given the anthropogenic character of the challenge and its relation to the way the global economy functions, it is obvious that it is necessary to develop and implement the international institutional and financing mechanisms leading to the transformation of the current polluting economies into green ones.

Combating Climate Change is a multidimensional problem but its hard core is the emitted anthropogenic GHG emissions that are strictly related with the persisting profile of the globalized economic development. This is a situation that should be reflected in all efforts to resolve it.

A bottom up approach, as it is defined in the Paris Agreements will be vague, till the so far developed Framework for Various Approaches will be incorporated, improved drastically and financed under the supervision of UNFCCC.

The various components of the New Market Mechanisms should be integrated in the improved Framework for Various Approaches in our efforts to minimize the negative repercussions of our delay to implement the appropriate policies. Nationally Appropriate Mitigation Actions and Land Use, Land Use Change and Forestry programmes have no serious chances to succeed if they will not secure their financing through a reliable emission crediting or trading international mechanism.

I think that it has to be clear that any resulting effort to confront climate change is related with the complementary implementation of both the undertaken commitments and of the fast development and implementation of the foreseen mechanisms under the framework for various approaches.

Having in mind the rate with which humanity consumes the remaining "budget", this integrated process should be established before 2030 if we intend to restrain the temperature increase between 2^o and 3^oC or even worst to climb to 4^oC.

Since the extreme weather phenomena as outcome of the emerging climate change will increase in both the intensity and the number these topics will increase their importance in our every day's priorities of life.

But we have to remember that the sooner we take the proper decisions the less the social and economic cost to pay for their implementation and bigger the likely chance to avoid unthinkable disasters.

Concerning now the region of the Black Sea Economic Cooperation countries our experience shows that in most of them despite their submitted INDCs there is a gap in knowledge, financing sources and social awareness, that hinders their implementation.

Based on the results of a four years project, financed by the EU, that concerned the development of climate change policies for twelve countries of the region, a huge potential of wealth for the countries of the region was revealed from combining RES, Energy Efficiency improvements and smart technologies in efforts to mitigate their CO_2 emissions and support their economic development.

The member states of BSEC in an serious effort during the last years, under the supportive coordination of the Permanent International Secretariat, try to increase their level of cooperation for Adaptation and Mitigation policies. Such an effort will allow them to overcome existing handicaps and to confront more efficiently threats of regional character as those related to forest fires and river floods and further to that to facilitate the exchange of best practices and knowledge for handling large scale destructions caused by extreme weather phenomena.

For more than twenty years we promote regional cooperation on energy and climate change issues mainly among the countries of the EU and the member states of BSEC while in the last ten years we are proud for the bond of cooperation that we have developed with colleagues and research institutes from countries of Asia, America, Africa, and Pacific Ocean. We are honored by the level of cooperation we have developed with BSEC and the United Nations Academic Impact and we do hope that next year during the 10^{th} anniversary of this conference we will have the means to invite some of these distinguished colleagues to participate in it.

During these years, we have developed a scientific network among countries of BSEC and EU promoting scientific cooperation, the PROMITHEASnet. We organize an annual scientific conference, we edit an international bi-lingual scientific journal, we circulate an international newsletter worldwide to 170 countries, we edit every two years the "Energy View of the BSEC countries". We organize national seminars, workshops and conferences in the countries of our network members and coordinate competitive R&I programmes financed by the EU and finally we promote scientific cooperation and knowledge transfer worldwide.

We are honored that we coordinate the "BSEC – Green Energy Network" under the guidance of PERMIS that aims to increase the level of cooperation among scientists, policy makers and market stakeholders on RES and Energy Efficiency activities.

In this content I would like to inform you that we have started an effort, together with PERMIS, to promote competitive project proposals under the lead of PERMIS targeting RES and Energy Efficiency financed from national and international sources. Further to that this session defines the beginning of an initiative to establish a rotating green investment forum to all BSEC member states providing the opportunity and encouraging the extrovert behavior of our economies.

Here in Athens we invite the Greek academic institutions, policy makers, green enterprises and banks to join us in the next fora that we will organize in the countries of BSEC and find means and ways to cooperate and make green business with their counter partners.

I wish I have had more support in this effort to promote green economy in our region but as it always happens a long trip starts always with a first step and this step in most of the cases is difficult. But with the support of the PERMIS we have already started and you are invited to join us in our next stop in Istanbul.

Thank you

Session 2: Green Investments Perspectives

Opening by Mr. Christos DIMAS

President of Hellenic-Russian Chamber of Commerce, Hellas

Ladies and gentlemen,

First of all, I would like to thank the organizers and particularly Prof. Mavrakis and wish them success to their Forum.

Let me refer to some key facts regarding green economy for global community, Greece and Russia. The last one due to my capacity as President to the Hellenic Russian Chamber of Commerce.

I. For Greece. Despite the progress made in the past, Greece is not yet an attractive country regarding the investment in renewable energy sector. According to a study of Ernest Young, Greece is the fortieth and the last in ranking concerning the attractiveness of the investments in Renewable Energy Sources. The study is based on a number of factors such as:

- The long term energy needs and the extent to which they can be met by Renewable Energy Sources (RES),
- The extent to which current policies encourage such development of RES;
- The existence of basic conditions such as networks, long term contracts and financing;
- The overall investment climate and the macroeconomic stability.

Given the very good potential of RES in Greece it is extremely disappointing the above ranking. Unfortunately, certain factors have prevented or delayed attracting new investments, as well as the on time implementations of mature projects and promote new technologies in the renewable energy sector. Among these factors are:

- The institutional framework which last August finally became a reality (law in Greece);
- The bureaucracy
- The lengthy licensing procedures and
- The overall macroeconomic environment with limited access to finance and of course the high cost of financing.

It is very impressive the example of Argentina. Despite the huge difficulties with its economy, Argentina and its new government with the proper policies succeed to attract important investments even in the renewable energy sector.

But in any case, concerning Greece, I am optimistic.

II. Regarding now the picture globally. There are certain very positive elements.

1. The Paris Agreement on the climate,
2. The fact of the ratification of the Paris Agreement by China and United States which as it is known are the most difficult parties for such a task.
3. It is clear that the emerging markets are transforming their energy policy at an unprecedented rate. Last year, for the first time, investment in RES, in developing countries surpassed those in developed, particularly in Latin America.
4. The measures that have been taken or will be taken by the major oil producer countries towards the coming changes in the energy sector.

   An example for that is Saudi Arabia. The country announced that it is ready to create a huge fund to mitigate the future risks due to the coming changes in the energy sector.

III. And where Russia stands among all these changes and developments?

1) Russia is the first gas producer in the world and the second oil producer next to S. Arabia.

2) The country is the sixth largest producer of renewable energy in the world, although it is the 56th when hydroelectric energy is not taken into account. 16% of Russia's electricity is generated from hydropower and less than 1% is generated from other renewable energy sources combined. To complete the picture the 68% for electricity is from thermal power and 16% from nuclear power.

3) Until recently the development of renewable energy in the energy policy of Russia has been given relatively little attention. And this is the resulst of many reasons, primarily because of the huge reserves of traditional energy oil and gas. In recent years the situation began to change significantly with certain initiatives from the Russian government.

4) In any case, Russia has a huge potential in renewable energy development. A strong renewable energy sector will allow Russia

    a. to reduce government spending to support the electricity sector;

    b. to create new jobs and reduce the risks of the energy sector related to the transformation of the global energy market.

5) The plans of the government is to increase the share of renewable energy in the overall energy balance up to 2.5% by 2020, but they need to stick on it firmly, in order to surpass its complete dependence from oil and gas exports. There is already a trend on that. In 2013 the gas exports were the 71% of the total amount and in 2015 the figure was 62%. Certainly, a lot has to be done in the next period of time.

But Russia has a big card in its hands as far as concerns the future of global green economy and the formation of sustainable development.

Russia can play a crucial role on that.

It has vast natural capital and critically important ecosystem services that contribute to the sustainability of the biosphere and provide economic benefits to all mankind. It has vast areas untouched by economic activity, colossal forests and wetlands, fresh water resources and biodiversity are, all major potential contributors to the formation of the new economy in the world.

That means that Russia will continue to be a world key energy player even in the new energy era provide that the country will take all the necessary steps and coordinate properly its national efforts for this task. A task which is not – in any case – an easy process for Russia.

I wish to all of you success to your efforts and a very good networking within the works of the conference.

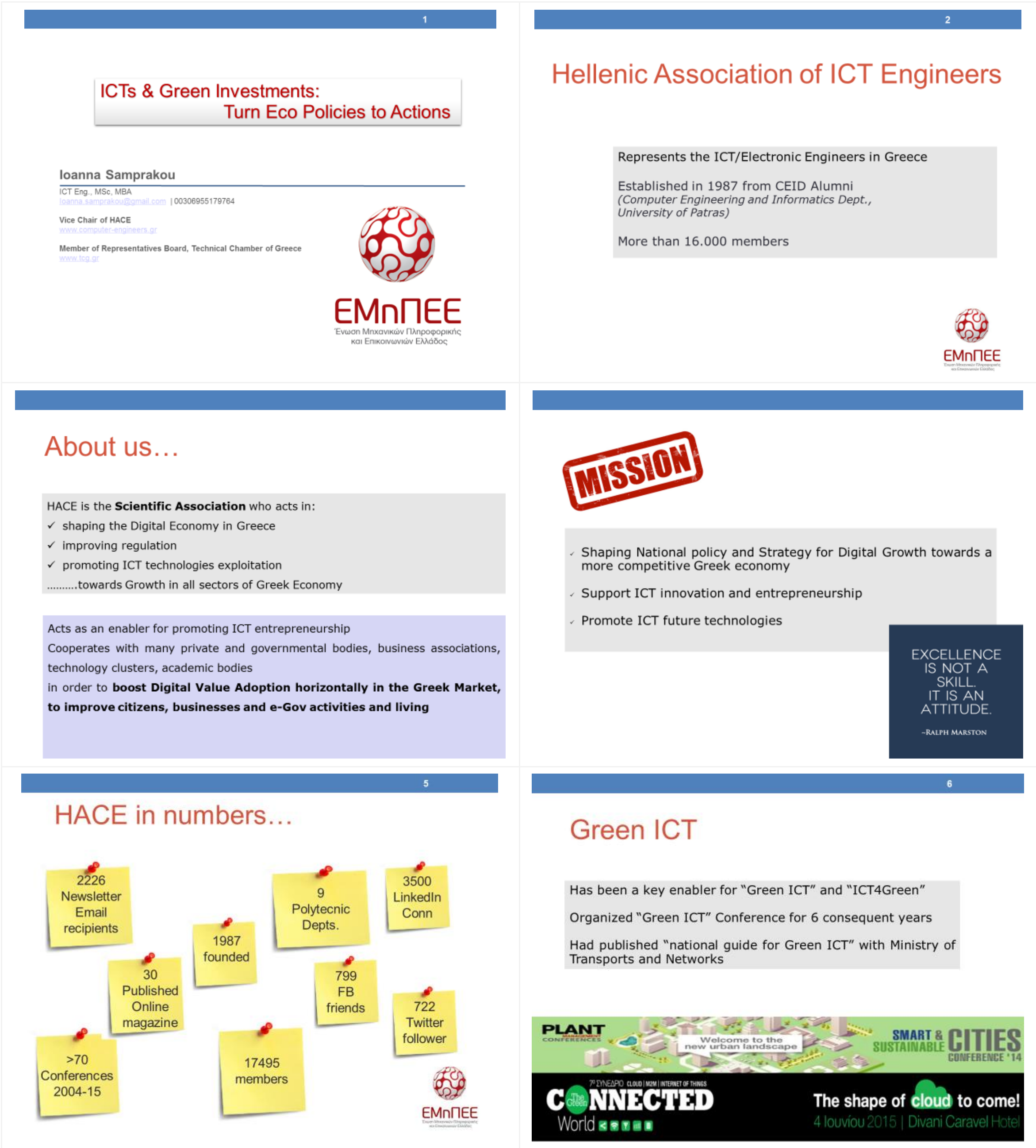
Thank you

ICTs & Green Investments: Turn Eco Policies to Actions

by

Mrs. Ioanna SAMPRAKOU

Vice-President of the Hellenic Association of Computer Engineers, Hellas



Cooperations and EU Projects

- FICTE
- IEEE
- Student bodies such as: EESTEC, IAESTE, IEEE Student Branches)
- HAMAC
- SEPE
- GRECA
- EEKT
- Member of EC AIoT (alliance for large scale IoT Projects)
- Corallia
- Science Parks
- Start-ups Manifesto (ex. Commissioner Kroes)
- Participated in drafting the "Digital Growth Strategy 2021"
- Participated in drafting the "National Broadband Plan"
- Organizes a number of Technology Seminars & Conferences
- ....

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Green Investment Policies

Need the ICT "touch" & "smartness" to be really and efficiently Implemented

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OECD

***ICT innovation** is a key element to spur **green growth** in the economic crisis and recovery.*

Information and communication technologies (ICTs) can improve environmental performance and address climate change across the economy.

The biggest gains for smarter environmental and economic strategies and applications are in **power generation and distribution, buildings and transportation** – three areas which contribute to the bulk of greenhouse gases.

Further environmental benefits of ICT applications are evident in areas such as **water management, biodiversity protection, pollution reduction**.

However, OECD suggests that most government and business initiatives are still following business-as-usual paths and do not sufficiently tap the sector's innovation potential.

…a whole set of applications of ICT

- Sensors and devices used in IoT
- IoT's applications on the renewable energy side
- Home automation
- Smart Farming
- Smart Grids
- Smart Shiping
- Predictive maintenance
- Smart Transports
- Smart logistics
- Smart transports (ITS)
- Smart metering

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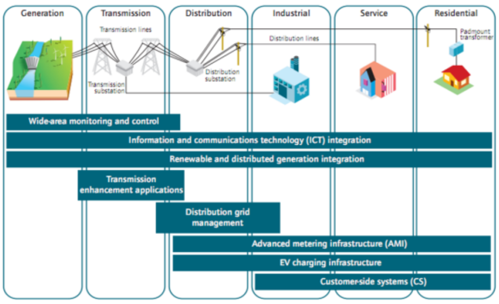
ICT applications in Smart Grids



Mapping "smart" to "grid"

Electricity sector challenges	ICT applications
Generation	
Renewable energy generation	• Smart meters • Vehicle-to-grid (V2G) and grid-to-vehicle (G2V)
Distributed, small-scale electricity generation	• Virtual power plants • Vehicle-to-grid (V2G) and grid-to-vehicle (G2V) • Smart meters
Transport (Transmission & Distribution)	
Transmission and distribution grid management	• Sensor-based networks • Embedded systems and software • Integrated software systems and application programming interfaces (APIs) • Smart meters • Communications protocols, including machine-to-machine communications (M2M)
Storage	
Storage capacities (physical and logical)	• V2G, G2V and vehicle-to-home (V2H) • Smart meters • End-user interfaces
Retail	
Dynamic and real-time pricing for electricity consumption and distributed generation	• Smart meters • End-user interfaces
Consumption	
Electricity conservation and energy-efficiency	• End-user interfaces • Smart meters • Electricity data intelligence
(Automated) demand management	• End-user interfaces • Smart meters • Communications protocols, including M2M • Smart building technologies • Smart electronic devices • Data centres and cloud computing
Integration of electric vehicles (and renewable energy sources)	• End-user interfaces • Smart meters • V2G, G2V • Communications protocols, including M2M • Integrated software systems and APIs
Facilitate access to electricity in developing countries (Electrification)	

EU Smart meter rollout

The EU aims to replace at least **80% of electricity meters** with **smart meters by 2020** wherever it is cost-effective to do so.

Smart metering and **smart grids** rollout can **reduce emissions** in the EU **by up to 9%** and annual **household energy consumption** by similar amounts.

To measure cost effectiveness, EU countries conducted cost-benefit analyses based on guidelines provided by the European Commission.

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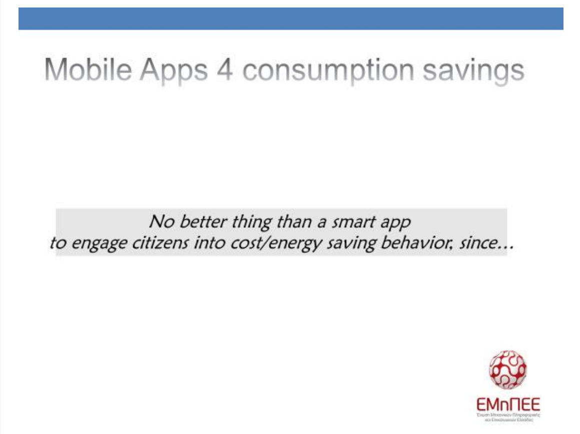
Smart metering deployment

(EC report)

- ~**200 million smart meters for electricity** and **45 million for gas** will be rolled out in the EU by 2020. This represents a potential **investment of €45 billion**
- by 2020, it is expected that **almost 72% of European consumers will have a smart meter for electricity**.
- About **40% will have one for gas**
- on average, smart meters provide **savings of €160 for gas and €309 for electricity per metering point** (distributed amongst consumers, suppliers, distribution system operators, etc.)
- as well as an average energy saving of 3%.


Mobile Apps 4 consumption savings
No better thing than a smart app
to engage citizens into cost/energy saving behavior, since…
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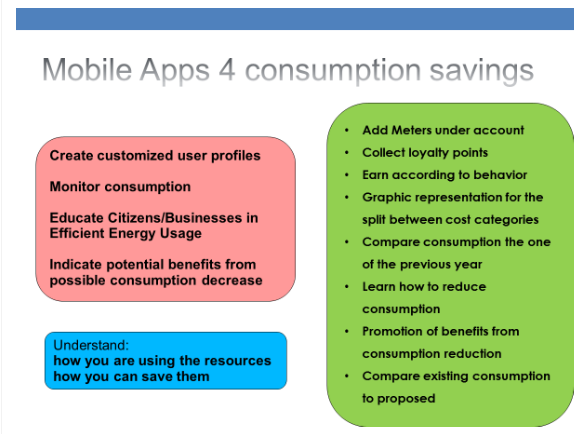
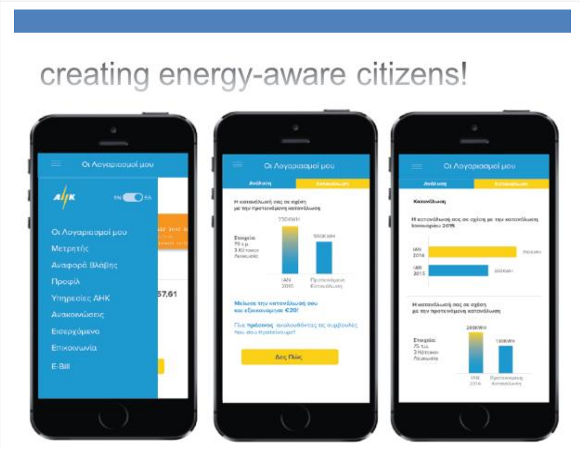
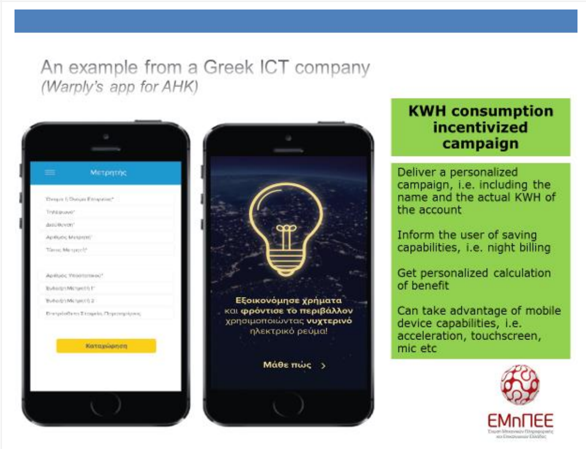

Mobile Apps 4 consumption savings
Create customized user profiles
Monitor consumption
Educate Citizens/Businesses in Efficient Energy Usage
Indicate potential benefits from possible consumption decrease
Understand:
how you are using the resources
how you can save them
Add Meters under account
Collect loyalty points
Earn according to behavior
Graphic representation for the split between cost categories
Compare consumption the one of the previous year
Learn how to reduce consumption
Promotion of benefits from consumption reduction
Compare existing consumption to proposed


creating energy-aware citizens!


An example from a Greek ICT company
(Warply's app for AHK)
KWH consumption incentivized campaign
Deliver a personalized campaign, i.e. including the name and the actual KWH of the account
Inform the user of saving capabilities, i.e. night billing
Get personalized calculation of benefit
Can take advantage of mobile device capabilities, i.e. acceleration, touchscreen, mic etc
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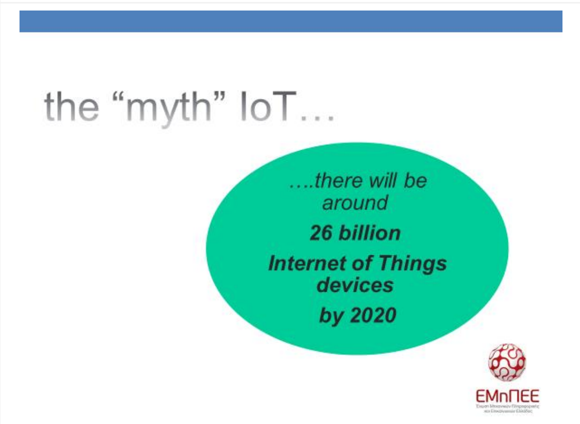
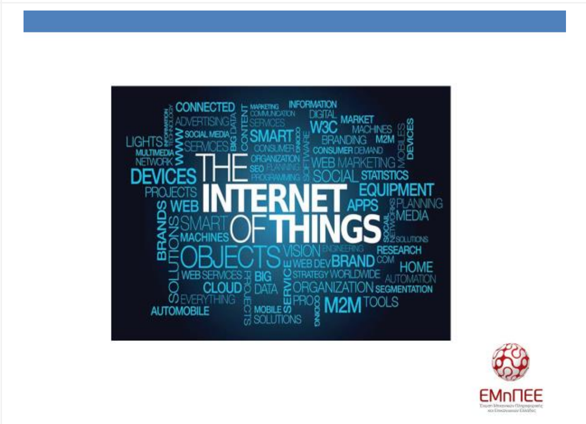
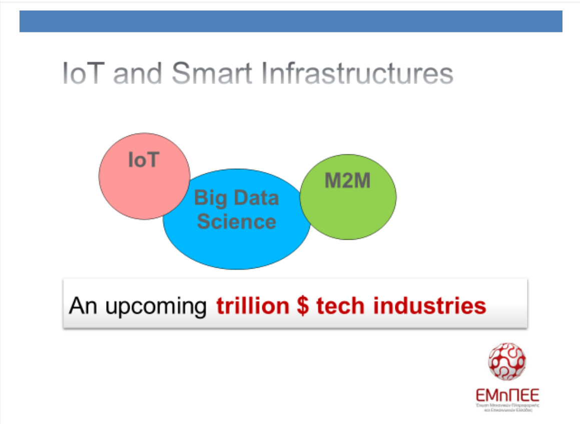
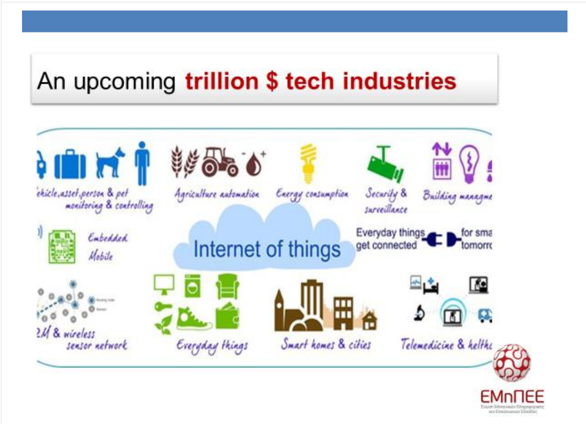

the "myth" IoT…
….there will be around
26 billion
Internet of Things devices
by 2020
EMnΠΕΕ


THE INTERNET OF THINGS
EMnΠΕΕ


IoT and Smart Infrastructures
IoT
Big Data Science
M2M
An upcoming trillion $ tech industries
EMnΠΕΕ


An upcoming trillion $ tech industries
Agriculture automation
Energy consumption
Security & surveillance
Internet of things
Everyday things get connected
Everyday things
Smart homes & cities
Telemedicine & helthcare
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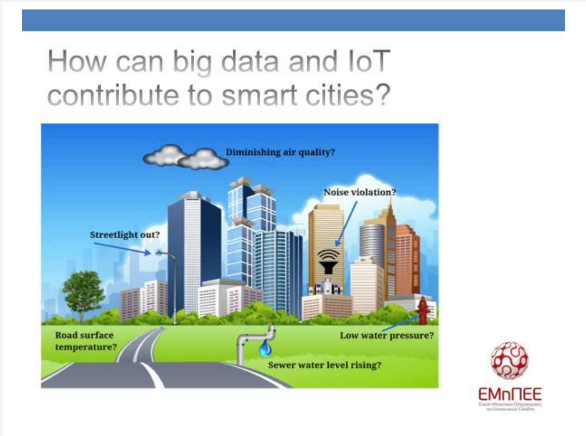
Building Smart Cities with the concept of IoT
The Internet of Things
Smart City – A Combination of Vertical Solutions
• Smart Transportation & Public Transport
• Smart Ticketing
• Signage
• Geo-Services
• Communication Gateways
• …
• Public Safety & Security
• Surveillance & Security
• Emergency Services
• Public Infrastructure
• …
• Smart Well-being
• Healthcare
• Elderly living
• Smart Energy / Smart Grid
• Smart Building
• Smart Water Management
• Smart Retail
• …
EUROTECH


How can big data and IoT contribute to smart cities?
Diminishing air quality?
Noise violation?
Streetlight out?
Road surface temperature?
Low water pressure?
Sewer water level rising?
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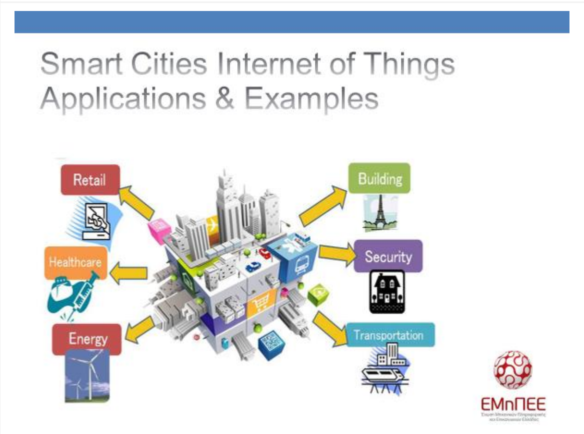
Smart Cities Internet of Things Applications & Examples
Retail
Building
Healthcare
Security
Energy
Transportation
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SenseOne: a Greek IoT champion
buildingSense
• a portfolio-level solution for remote monitoring and control of buildings resource efficiency
• Software-as-a-Service
• Provides personalized, real time monitoring and control experience by applying data streaming techniques up to one second intervals
Using the best of breed M2M and cloud-based technologies, addresses diverse M2M connectivity needs
IoT applications for:
✓ water resources management (hydroSense)
✓ electric vehicles (evSense)
✓ contract farming (agroSense)
✓ energy efficient vessels (vesselSense)
✓ smart cities (citySense)
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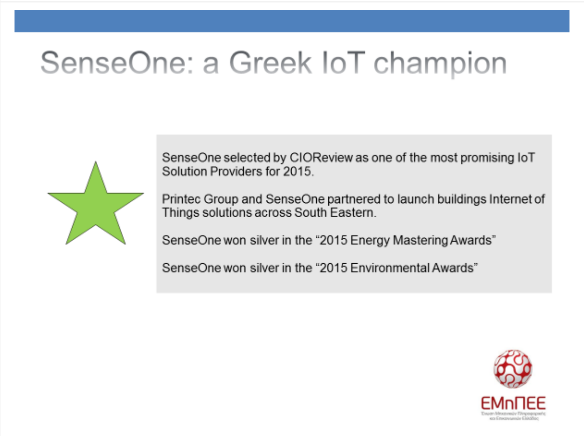
SenseOne: a Greek IoT champion
SenseOne selected by CIOReview as one of the most promising IoT Solution Providers for 2015.
Printec Group and SenseOne partnered to launch buildings Internet of Things solutions across South Eastern.
SenseOne won silver in the "2015 Energy Mastering Awards"
SenseOne won silver in the "2015 Environmental Awards"
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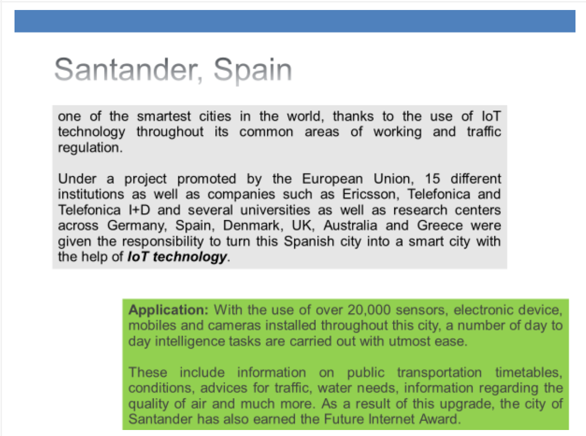
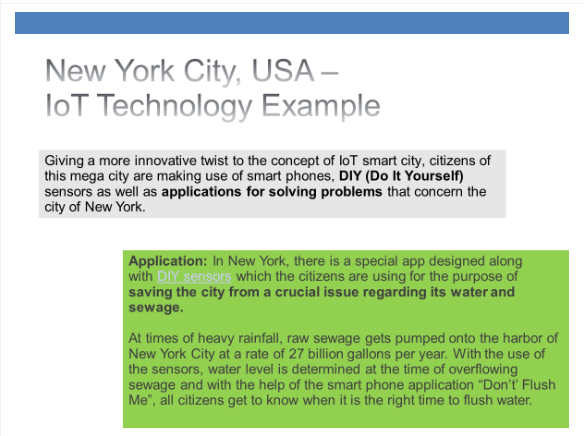
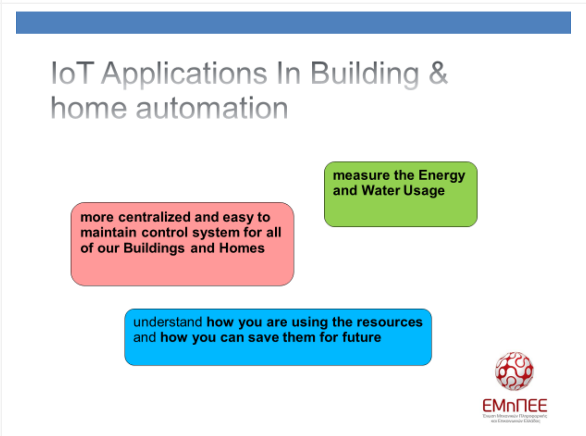

Santander, Spain
one of the smartest cities in the world, thanks to the use of IoT technology throughout its common areas of working and traffic regulation.
Under a project promoted by the European Union, 15 different institutions as well as companies such as Ericsson, Telefonica and Telefonica I+D and several universities as well as research centers across Germany, Spain, Denmark, UK, Australia and Greece were given the responsibility to turn this Spanish city into a smart city with the help of IoT technology.
Application: With the use of over 20,000 sensors, electronic device, mobiles and cameras installed throughout this city, a number of day to day intelligence tasks are carried out with utmost ease.
These include information on public transportation timetables, conditions, advices for traffic, water needs, information regarding the quality of air and much more. As a result of this upgrade, the city of Santander has also earned the Future Internet Award.


New York City, USA – IoT Technology Example
Giving a more innovative twist to the concept of IoT smart city, citizens of this mega city are making use of smart phones, DIY (Do It Yourself) sensors as well as applications for solving problems that concern the city of New York.
Application: In New York, there is a special app designed along with DIY sensors which the citizens are using for the purpose of saving the city from a crucial issue regarding its water and sewage.
At times of heavy rainfall, raw sewage gets pumped onto the harbor of New York City at a rate of 27 billion gallons per year. With the use of the sensors, water level is determined at the time of overflowing sewage and with the help of the smart phone application "Don't' Flush Me", all citizens get to know when it is the right time to flush water.


IoT Applications In Building & home automation
measure the Energy and Water Usage
more centralized and easy to maintain control system for all of our Buildings and Homes
understand how you are using the resources and how you can save them for future
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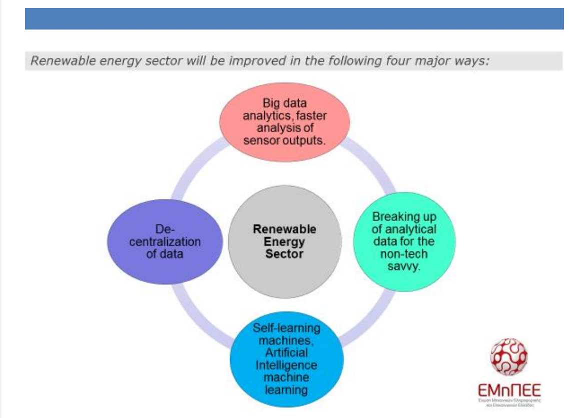
IoT in Renewable Energy:
Energy Meets Internet of Things


Renewable energy sector will be improved in the following four major ways:
Big data analytics, faster analysis of sensor outputs.
De-centralization of data
Renewable Energy Sector
Breaking up of analytical data for the non-tech savvy.
Self-learning machines, Artificial Intelligence machine learning
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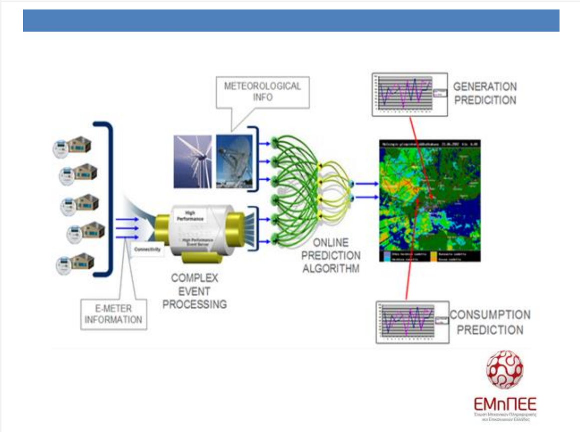
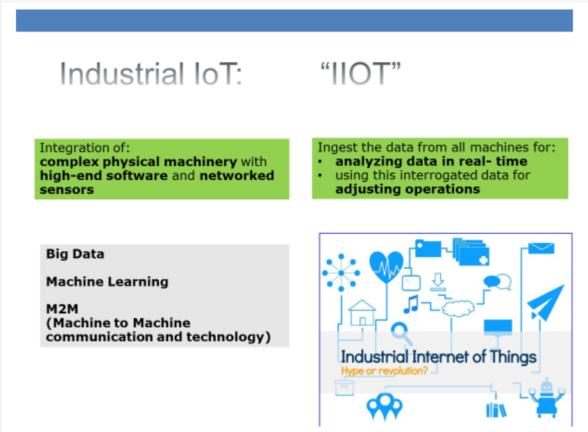
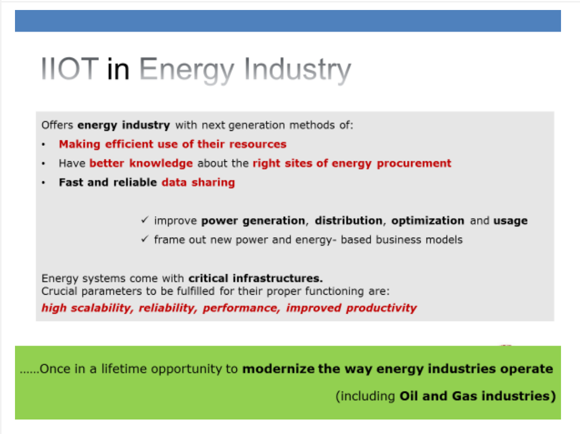
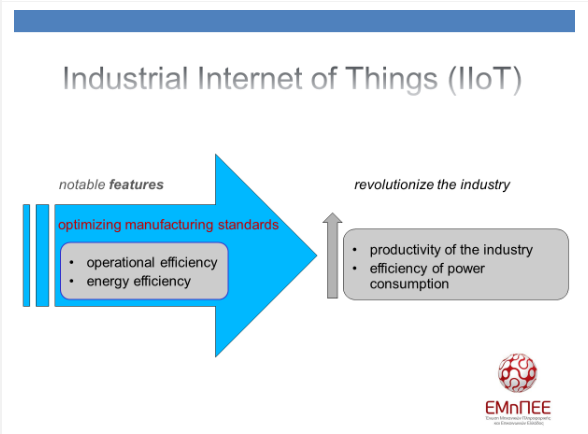
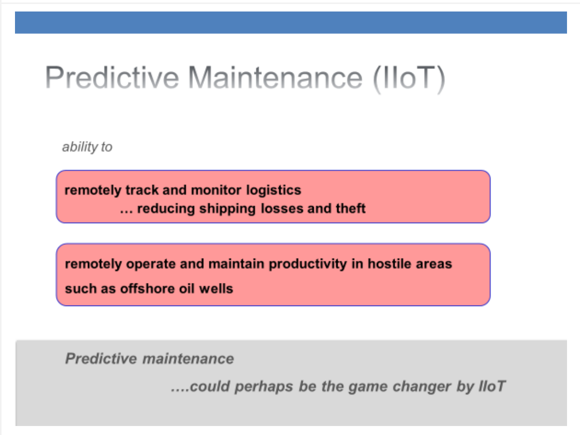
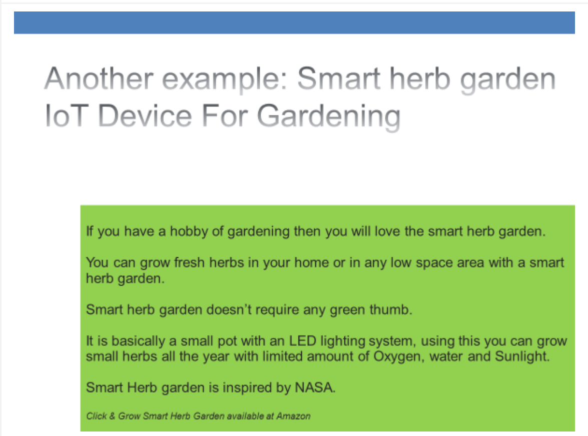

METEOROLOGICAL INFO
GENERATION PREDICTION
ONLINE PREDICTION ALGORITHM
COMPLEX EVENT PROCESSING
E-METER INFORMATION
CONSUMPTION PREDICTION
EMnΠEE


Industrial IoT: "IIOT"
Integration of: complex physical machinery with high-end software and networked sensors
Ingest the data from all machines for:
• analyzing data in real- time
• using this interrogated data for adjusting operations
Big Data
Machine Learning
M2M
(Machine to Machine communication and technology)
Industrial Internet of Things
Hype or revolution?


IIOT in Energy Industry
Offers energy industry with next generation methods of:
• Making efficient use of their resources
• Have better knowledge about the right sites of energy procurement
• Fast and reliable data sharing
✓ improve power generation, distribution, optimization and usage
✓ frame out new power and energy- based business models
Energy systems come with critical infrastructures.
Crucial parameters to be fulfilled for their proper functioning are:
high scalability, reliability, performance, improved productivity
......Once in a lifetime opportunity to modernize the way energy industries operate
(including Oil and Gas industries)


Industrial Internet of Things (IIoT)
notable features
revolutionize the industry
optimizing manufacturing standards
• operational efficiency
• energy efficiency
• productivity of the industry
• efficiency of power consumption
EMnΠEE


Predictive Maintenance (IIoT)
ability to
remotely track and monitor logistics
... reducing shipping losses and theft
remotely operate and maintain productivity in hostile areas
such as offshore oil wells
Predictive maintenance
....could perhaps be the game changer by IIoT


Another example: Smart herb garden
IoT Device For Gardening
If you have a hobby of gardening then you will love the smart herb garden.
You can grow fresh herbs in your home or in any low space area with a smart herb garden.
Smart herb garden doesn't require any green thumb.
It is basically a small pot with an LED lighting system, using this you can grow small herbs all the year with limited amount of Oxygen, water and Sunlight.
Smart Herb garden is inspired by NASA.
Click & Grow Smart Herb Garden available at Amazon

Funding Opportunities

EMnΠΕΕ

Connecting Europe Facility

Energy

EMnΠΕΕ

1. CEF 2016 Energy Calls:

Up to **€800 million** is foreseen to be allocated under the 2016 CEF Energy Work Programme for grants managed by INEA.

The 2016 CEF Energy Calls for Proposals will finance projects of common interest in the energy sector, namely in electricity and gas.

https://ec.europa.eu/inea/en/connecting-europe-facility/cef-energy/calls/2016-cef-energy-calls-proposals

EMnΠΕΕ

1. CEF 2016 Energy Calls:

2016 CEF Energy Call 2 **(CEF-Energy-2016-2)** (indicative budget: €600 million)	30 June 2016	8 November 2016
CEF Synergy: Transport and Energy **(CEF-Synergy-2016-1)** (indicative budget: €40 million)	28 September 2016	13 December 2016

EMnΠΕΕ

2. HORIZON 2010:

INEA is running parts of Horizon 2020, the EU's €77 billion research and innovation programme for 2014-2020, in the areas of **transport and energy.**

Horizon 2020 societal challenges		
Smart, green and integrated transport	Secure, clean and efficient energy	Cross-cutting activities
•€2.9 billion in 2014-2020, of which €722.5 million in 2016-2017 : •Mobility for Growth •Green Vehicles •Automated Road Transport	•€3.8 billion in 2014-2020, of which € 664.38 million in 2016-2017: •Competitive Low Carbon Energy	Cross-cutting activities •Smart Cities & Communities (€131.5 million in 2016-2017 from *Secure, clean and efficient energy* budget)

EMnΠΕΕ

2. HORIZON 2010:

Competitive Low-Carbon Energy
Project proposals under nine topics in the area of **renewable energy sources, smart grids and storage and decarbonisation of fossil fuels**. The total call budget is €189.3 million.

Mobility for Growth
17 topics with a total budget of **€216.2 million** are open for research and innovation proposals in the fields of aviation, waterborne transport, road safety, **green urban mobility, transport logistics and infrastructure**, as well as research supporting policy making.

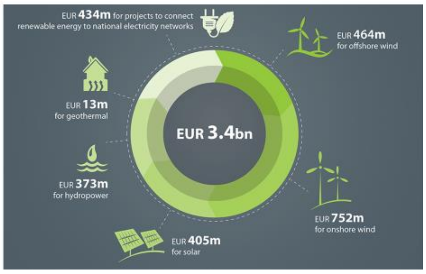
Automated Road Transport
Project proposals on automated driving systems for passenger cars, trucks and urban transport, as well as the **underlying digital infrastructure**, can be submitted under three topics with a total budget of €50 million.

Smart Cities and Communities
A call for proposals is open for **Smart Cities** and Communities lighthouse projects. *Lighthouse* cities should develop intelligent, user-driven and demand-oriented city solutions that could be replicated in other urban districts across Europe, with the involvement of *follower* cities. The total budget is €69.5 million, of which €12 to €18 million will be allocated to individual projects (indicative).

EMnΠΕΕ

3. EIB – EFSI (Junker Plan)

Renewable financing in 2015 by the EIB totalled EUR 3.4 billion and included



Finance for climate action

Over
90 bn 5-year
climate action lending (2010-2014)

Making a difference
Our 2014 lending supports:

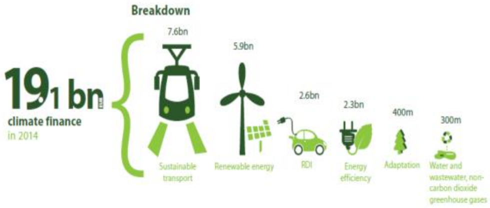
545 million additional passengers per year travelling by public transport

27 million people benefiting from more reliable and resilient drinking water

3 000 GWh of energy savings

12 000 GWh of electricity generated from renewable sources per year, powering over 1 million homes

Finance for climate action



Finance for climate action

InnovFin – EU finance for innovators

In support of research and innovation in private sector investments, often key players in forming adaptation strategies, the Risk-Sharing Finance Facility financed some 114 projects to the tune of EUR 11.3bn, acting as a catalyst for a further EUR 37.2bn in private investment in European innovation. Its successor InnovFin is set to double this, with more than EUR 24bn of financing by 2020. Funded by Horizon 2020, InnovFin is demand driven and technology neutral with the potential to support low-carbon technologies and first-of-a-kind demonstration projects (e.g. renewable energy and smart grids sectors).

Almost **15 bn** invested in **innovation** over the past five years (2010-2014)

4. EBRD

European Bank for Reconstruction and Development

In 2015, **€9.4 billion** in 381 projects

Promotes transition to market economies by investing mainly in the private sector

Encourages environmentally sound and sustainable development

4. EBRD

Power and Energy

Focus areas include transmission and distribution, safety upgrades and investing in **renewables**

Natural Resources

The Bank finances a range of **natural resources industries**

4. EBRD – Natural Resources

Natural resources, including oil, mining and gas, is a vital sector for many transition countries.

EBRD focuses its efforts on **improving environmental**, social, corporate governance and transparency standards, as well as **enhancing energy efficiency and energy security**.

Cleaner production and supply.
EBRD will support the **cleaner production and distribution of natural resources** through **greater energy and resource efficiency**, for example by reducing gas flaring or investing in cleaner transport fuels or fuel switching from coal to gas.

In the case of coal-fired generation, the low-carbon transition necessitates a fundamental shift away from coal as a source of electricity and heat. Accordingly the Bank will not finance investment in this sector except in rare and exceptional circumstances, where there are no feasible alternative energy sources.

4. EBRD – Natural Resources

4. EBRD – an example…

Akfen Holding CFO Kadri Samsunlu looks back at 10 years of partnership with the EBRD:

"The EBRD has helped us focus on financial, social and ***environmental sustainability****."*

"Our greatest focus currently is on Akfen Renewable Energy, a subsidiary where the EBRD and the IFC hold stakes."

"We have a strong pipeline of hydro, wind and solar power plants at the development stage and the plan is to take it to 1000 MW."

4. EBRD – Power & Energy

The EBRD's vision for the energy sector is of a partnership between industry, governments and consumers that **delivers the essential energy needs** of **societies and economies** in a manner that is **sustainable**, **reliable** and at the **lowest possible cost**

Rethinking energy systems. Recognizing the rapid changes new technologies are stimulating in the energy sector, EBRD supports the evolution of energy systems towards a model focused on empowering consumers, investing in smart grids, driving demand-side efficiency and opening up new business models for both efficient energy supply and consumption.

The low carbon transition. In the context of a growing climate challenge, promotes the transition to a low-carbon energy sector. The efficiency agenda that is relevant to all the EBRD's activities will be central to this approach, as will growing support for renewable energy sources and policy dialogue to promote the move to prices that reflect all costs, including those of externalities.

Energy efficiency and demand side measures. The EBRD will work across the entire value chain in the energy sector to promote efficiency and to work through the energy sector to stimulate efficiency among consumers and innovative ways to manage and reduce demand.

Big data analytics, faster analysis of sensor outputs:

When you have **so many data to crunch in so less time**, so small enough that you cannot possibly arrive at a conclusion in time for an action, big data is the key.

In renewable energy sector, for an efficient operation, **a humongous amount of data** is being transferred and analyzed to get optimized outputs.

With the **big data analysis** and the **cloud storage capabilities**, companies and startups **in the energy side of things will get to faster results and ultimately, better efficiency**.

Breaking up of analytical data for the non-tech savvy

If you were to be a non-engineer and still own or manage a renewable energy farm, things could get wildly complicated for you.

With all the kilowatts per hour data, actual energy-apparent energy mumbo-jumbo, you could easily get lost in the wilderness.

Hence, all the data that is being processed should have to be converted to user understandable data, like, graphs, pictograms, pie charts etc.

Decentralization of data

The downside of **using big data for analysis is storage capabilities**, be it the cloud or the old school hard disk storage on site, is very limited as when compared to the data that it collects and stores.

Large data storage means large space occupation, larger security risk and subsequently the **economic and energy costs that accompany this**. All the essential data should be kept for the future calculations and usage trends.

The conventional way to store the said data would be on a centralized server, but that is in the past.

With the advancement in the decentralization of database techniques, all essential data could be stored in individual data holding centers.

Self-learning machines, Artificial Intelligence machine learning

If you had seen the movie called 'Person of Interest', you know how important this machine learning and artificial intelligence is going to get in the coming days.

In the terms of the energy sector, this will be used in the prediction of the future load and computing the real-time big data and storage of the said data.

The decision to be made so as to keep what data and delete the rest cannot be humanly done within an acceptable time limit. Hence leaving the mundane tasks to the AI.

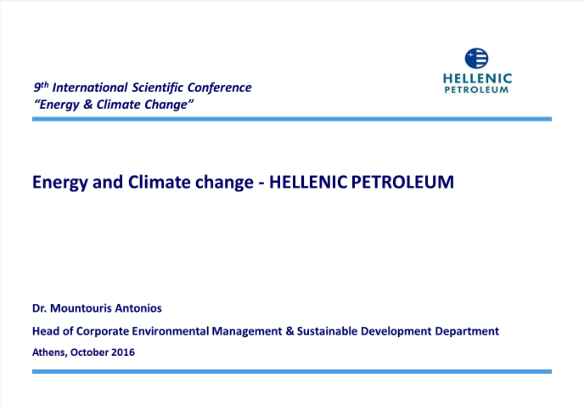
In due course of time, all the computing decisions could be made entirely by the AI for most efficient operation of said sectors. Here's hoping Terminator doesn't become a reality, though.

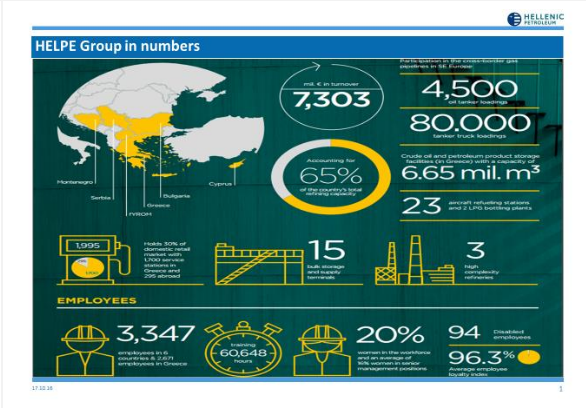
Energy and Climate Change – Hellenic Petroleum

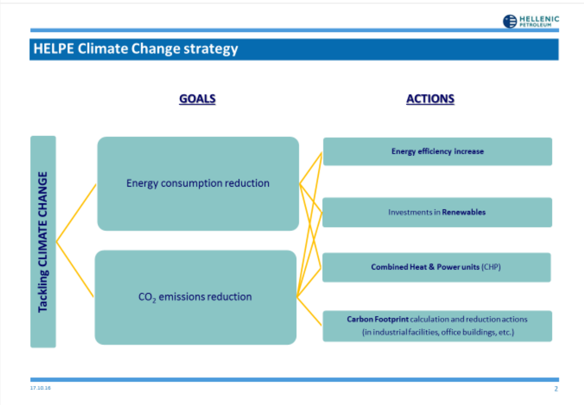
by

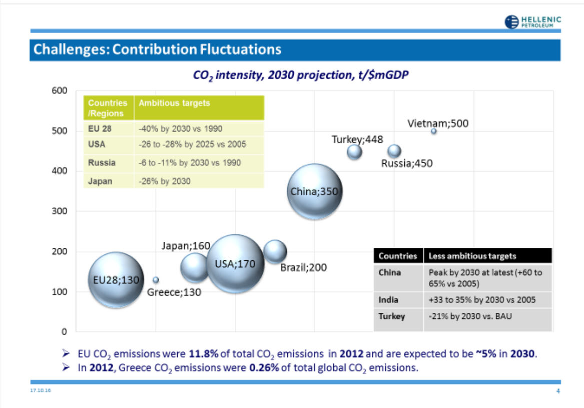
Dr. Antonios MOUNTOURIS

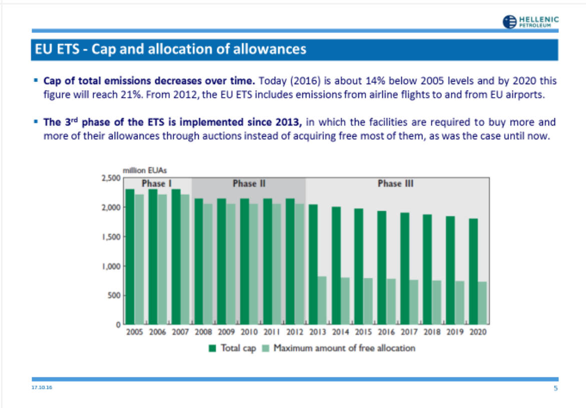
Head of Corporate Environmental Management & Sustainable Development Department,
HELLENIC PETROLEUM, Hellas

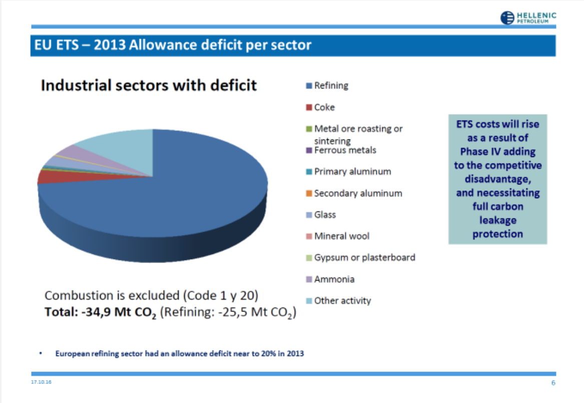


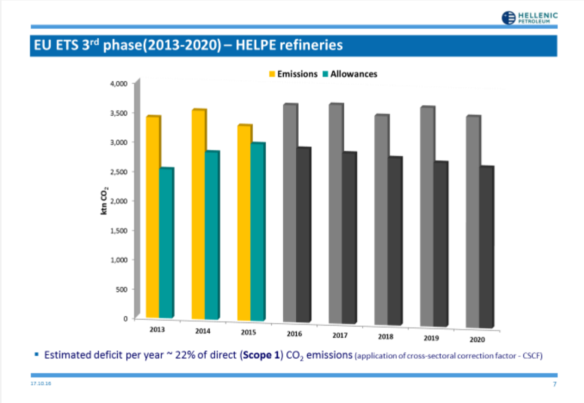


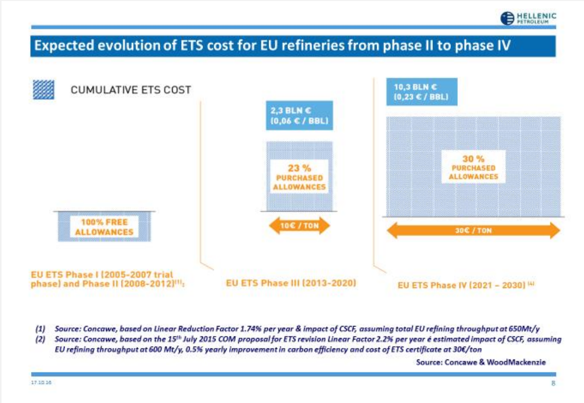


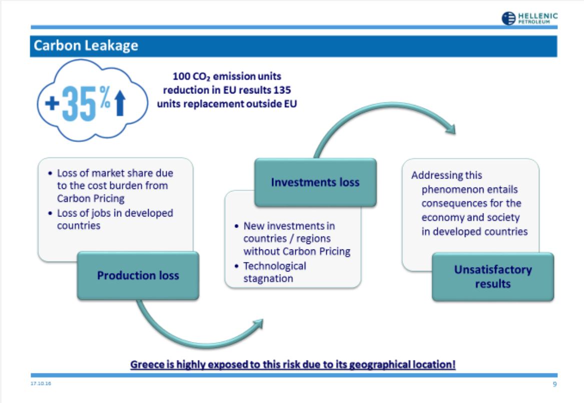


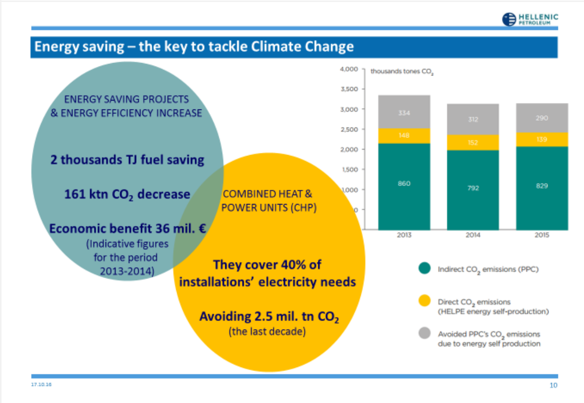


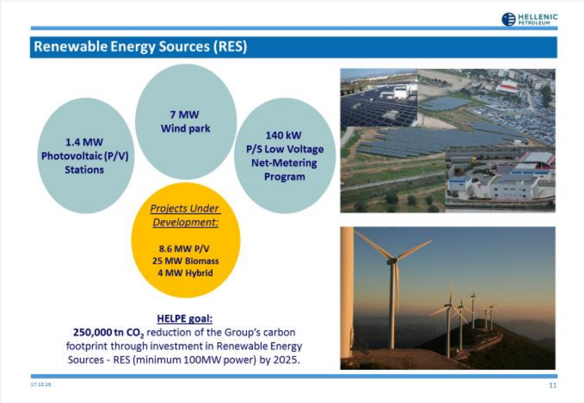

EU ETS – 2013 Allowance deficit per sector
Industrial sectors with deficit
Refining
Coke
Metal ore roasting or sintering
Ferrous metals
Primary aluminum
Secondary aluminum
Glass
Mineral wool
Gypsum or plasterboard
Ammonia
Other activity
ETS costs will rise as a result of Phase IV adding to the competitive disadvantage, and necessitating full carbon leakage protection
Combustion is excluded (Code 1 y 20)
Total: -34,9 Mt CO_2 (Refining: -25,5 Mt CO_2)
European refining sector had an allowance deficit near to 20% in 2013

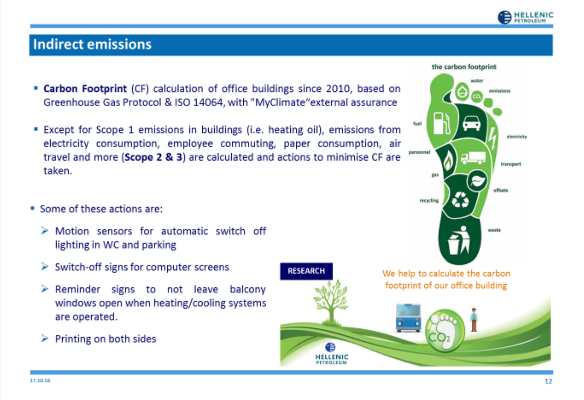

EU ETS 3rd phase(2013-2020) – HELPE refineries
Emissions
Allowances
ktn CO_2
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2013
2014
2015
2016
2017
2018
2019
2020
Estimated deficit per year ~ 22% of direct (Scope 1) CO_2 emissions (application of cross-sectoral correction factor - CSCF)

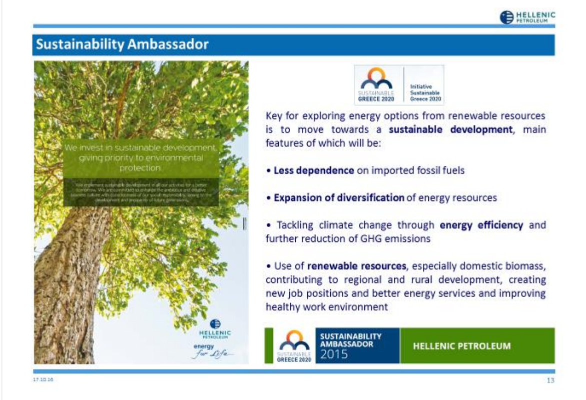

Expected evolution of ETS cost for EU refineries from phase II to phase IV
CUMULATIVE ETS COST
2,3 BLN €
(0,06 € / BBL)
10,3 BLN €
(0,23 € / BBL)
100% FREE ALLOWANCES
23 % PURCHASED ALLOWANCES
30 % PURCHASED ALLOWANCES
10€ / TON
30€ / TON
EU ETS Phase I (2005-2007 trial phase) and Phase II (2008-2012)
EU ETS Phase III (2013-2020)
EU ETS Phase IV (2021 – 2030)
Source: Concawe & WoodMackenzie

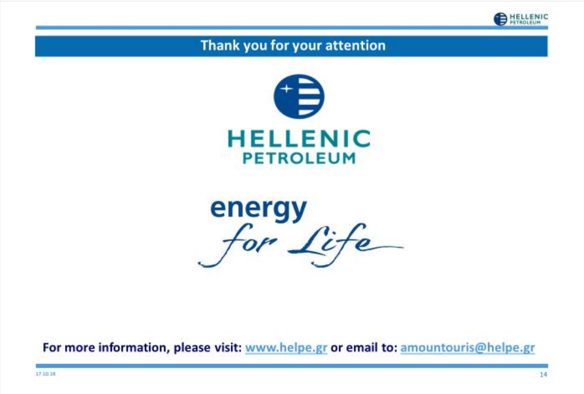

Carbon Leakage
+35%
100 CO_2 emission units reduction in EU results 135 units replacement outside EU
Loss of market share due to the cost burden from Carbon Pricing
Loss of jobs in developed countries
Production loss
Investments loss
New investments in countries / regions without Carbon Pricing
Technological stagnation
Addressing this phenomenon entails consequences for the economy and society in developed countries
Unsatisfactory results
Greece is highly exposed to this risk due to its geographical location!

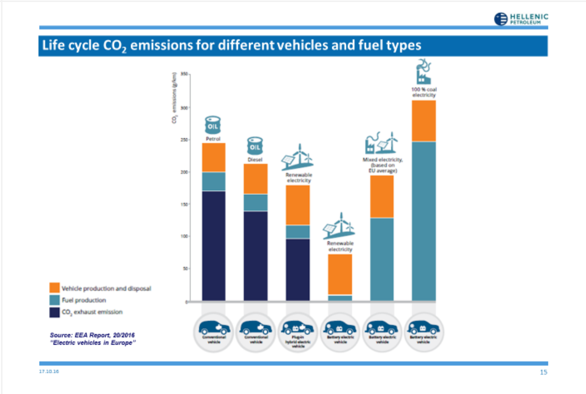

Energy saving – the key to tackle Climate Change
ENERGY SAVING PROJECTS & ENERGY EFFICIENCY INCREASE
2 thousands TJ fuel saving
161 ktn CO_2 decrease
Economic benefit 36 mil. €
(Indicative figures for the period 2013-2014)
COMBINED HEAT & POWER UNITS (CHP)
They cover 40% of installations' electricity needs
Avoiding 2.5 mil. tn CO_2
(the last decade)
thousands tones CO_2
860
792
829
2013
2014
2015
Indirect CO_2 emissions (PPC)
Direct CO_2 emissions (HELPE energy self-production)
Avoided PPC's CO_2 emissions due to energy self production


Renewable Energy Sources (RES)
1.4 MW Photovoltaic (P/V) Stations
7 MW Wind park
140 kW P/S Low Voltage Net-Metering Program
Projects Under Development:
8.6 MW P/V
25 MW Biomass
4 MW Hybrid
HELPE goal:
250,000 tn CO_2 reduction of the Group's carbon footprint through investment in Renewable Energy Sources - RES (minimum 100MW power) by 2025.


HELLENIC PETROLEUM
Indirect emissions
Carbon Footprint (CF) calculation of office buildings since 2010, based on Greenhouse Gas Protocol & ISO 14064, with "MyClimate"external assurance
Except for Scope 1 emissions in buildings (i.e. heating oil), emissions from electricity consumption, employee commuting, paper consumption, air travel and more (Scope 2 & 3) are calculated and actions to minimise CF are taken.
Some of these actions are:
Motion sensors for automatic switch off lighting in WC and parking
Switch-off signs for computer screens
Reminder signs to not leave balcony windows open when heating/cooling systems are operated.
Printing on both sides
the carbon footprint
RESEARCH
We help to calculate the carbon footprint of our office building
17.10.16
12

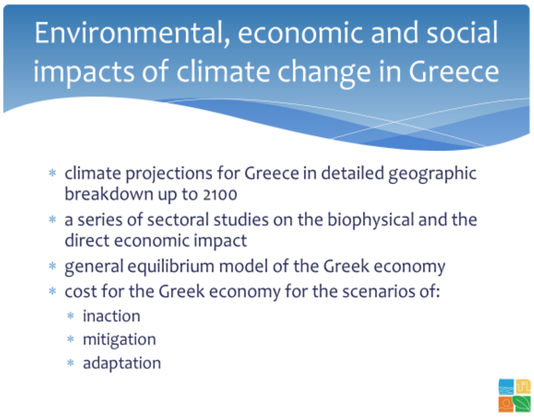

HELLENIC PETROLEUM
Sustainability Ambassador
We invest in sustainable development giving priority to environmental protection
Key for exploring energy options from renewable resources is to move towards a sustainable development, main features of which will be:
• Less dependence on imported fossil fuels
• Expansion of diversification of energy resources
• Tackling climate change through energy efficiency and further reduction of GHG emissions
• Use of renewable resources, especially domestic biomass, contributing to regional and rural development, creating new job positions and better energy services and improving healthy work environment
SUSTAINABILITY AMBASSADOR 2015
HELLENIC PETROLEUM
17.10.16
13

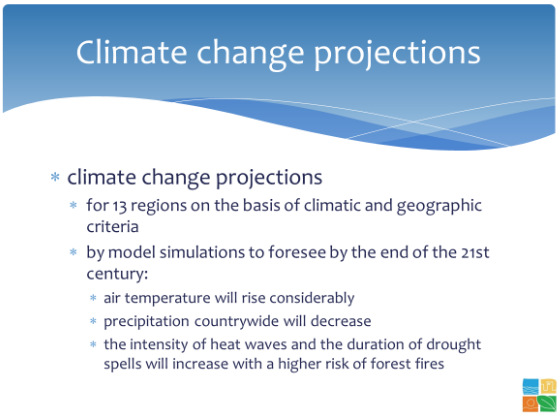

HELLENIC PETROLEUM
Thank you for your attention
HELLENIC PETROLEUM
energy for Life
For more information, please visit: www.helpe.gr or email to: amountouris@helpe.gr
17.10.16
14

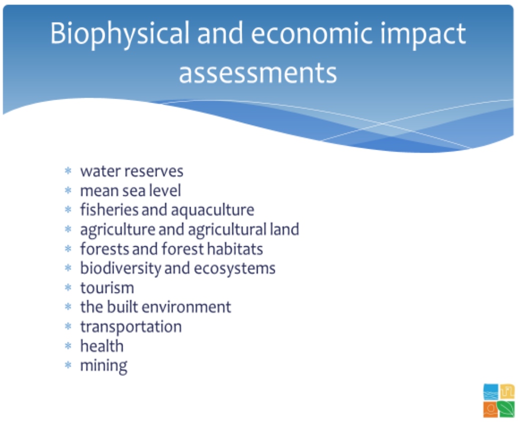

HELLENIC PETROLEUM
Life cycle CO2 emissions for different vehicles and fuel types
Vehicle production and disposal
Fuel production
CO2 exhaust emission
Source: EEA Report, 20/2016 "Electric vehicles in Europe"
17.10.16
15

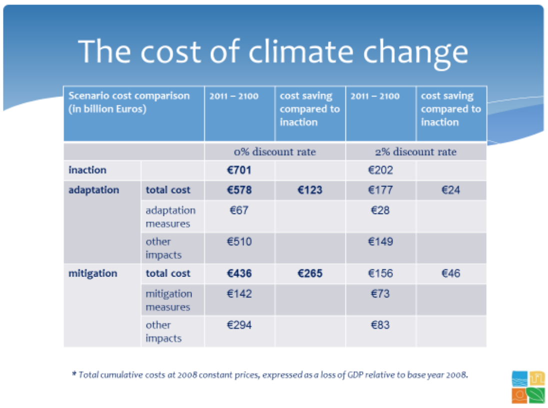
The environmental, economic and social impacts of climate change in Greece

by
Mrs. Theodora ANTONAKAKI
Scientific Secretary, Climate Change Impacts Study Committee, Bank of Greece, Hellas









Scenario cost comparison (in billion Euros)		2011 – 2100	cost saving compared to inaction	2011 – 2100	cost saving compared to inaction
		0% discount rate		2% discount rate	
inaction		€701		€202	
adaptation	total cost	€578	€123	€177	€24
	adaptation measures	€67		€28	
	other impacts	€510		€149	
mitigation	total cost	€436	€265	€156	€46
	mitigation measures	€142		€73	
	other impacts	€294		€83	

The symptosis

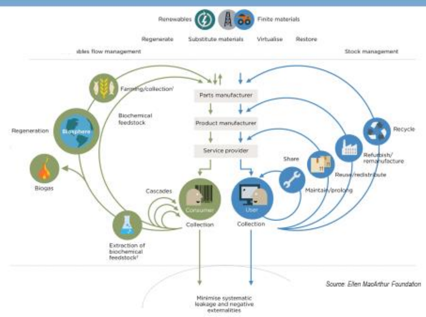
- environmental crisis & economic crisis
- current economic crisis constrains financing of mitigation and adaptation policies
- adaptation policies could be an opportunity for new lines of economic activity and growth, part of the strategy for an exit from the crisis

Sustainable Development Goals

- crucial social dimensions of climate change
  - increase in poverty and migration
  - lower income population groups lack the resources to address the problems and finance measures for adaptation

Closing the loop

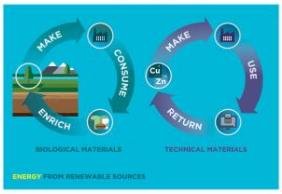
Circular Economy



Source: Ellen MacArthur Foundation

Circular Economy Principles

- Preserve and enhance natural capital (control finite stocks and balance renewable resources flows)
- Optimise resource yields (circulate products, components and materials in use at the highest utility)
- Foster system effectiveness (reveal and design out negative externalities)



Source: Ellen MacArthur Foundation

Current and future work

- Climate change adaptation
  - Supporting and driving adaptation policy implementation in Greece through the Climate Change Adaptation Observatory
- Economic policy and climate change
  - Research on the effects of climate change on economic policy, including monetary policy
- Circular economy
  - Public event on the 24th November

The CCISC on the web

- Thank you!
- CCISC webpage
  http://www.bankofgreece.gr/pages/en/klima
  (shortcut banner on www.bankofgreece.gr)
- for more information and copies of the reports please contact us at:
  climatechange@bankofgreece.gr

The Renewable Energy Sources in local - regional administration level

by

Mr. Dimitrios MPAIRAKTARIS

Research Fellow of Central Union of Municipalities (K.E.D.E.), Hellas

The continuing objective of the Local Government is to play an active role in the development of the country and especially the Greek Region, undoubtedly the energy related issues should be a concern. A regional or local authority can take on important initiatives αs far as the energy development of a site is concerned by acting as an energy consumer, as an energy producer and supplier, as well as an energy instrument for energy mobilization and proliferation.

Renewable Energy Sources are (constitute) an indigenous energy source, with growth potentials both at national and local level. Renewables contribute significantly to the energy balance, helping to reduce the dependency of the expensive imported oil and to enhance-strengthen the security of their energy supply. At the same time, furthermore renewables contribute to the environmental protection, as it has now been stated that the energy sector is principally responsible for the environmental pollution.

Taking into consideration the high level of interdependence between the regional economy, local employment, the energy supply and the local development, it is necessary to clearly define that the role of the Local Government should be clearly defined, especially as far as the development of RES is concerned. The role of the Local Government is significantly important. Firstly because the Government plans and implements the spatial planning at a local level and secondly because, it should ensure the implementation of the development projects in accordance with the criteria of environmental protection. Moreover, the Local Government constitutes is a large end-user and therefore, the amount of energy consumption is an important factor that should not be overlooked.

Energy issues are regarded as top priority, both politically (public support and consensus from the local community) and in terms of regional development due to the economical impacts on employment, quality of life and the environment.However, the projects that have been implemented so far by the Local Government should be regarded only as an indication of the interest and the desire to implement projects, rather than as a measure of its capabilities or its active participation in the RES sector. This is because Local Government is able to demonstrate initiatives and actions with a wider application.

SAVING IN MUNICIPAL BUILDINGS

In systems and in **building's energy saving and rational energy use techniques** (eg installation and rational use of electrical energy efficient systems and energy management systems). They significantly contribute at the reduction of energy demand (heating, cooling and lighting), but also at the increase of the efficiency of RES. **Implementation RES** provided respectively:

- either centrally (eg district heating / cooling with biomass or geothermal, electricity supply by photovoltaics, wind and other renewable energy systems)
- either individually, at a building's level (eg passive and active solar systems, geothermal heat pumps, photovoltaic systems)

PHOTOVOLTAICS IN BUILDINGS

Greece has considerable potentials for development and implementation of P/V systems due to the high solar energy potential. The ability to generate and supply electricity to both remote and in residential areas without having environmental impact makes the use of photovoltaic systems in our country significantly attractive.

Today there are several users, especially in remote areas, that lack of grid, to which photovoltaic systems is considered the most appropriate solution.

HEATING WITH BIOMASS

District heating is the supply of space heating and hot water in a set of buildings, a settlement, a village or a town, by a central heating plant. The heating is transferred from the station to the heated buildings by a network of insulated pipes. Few initiatives have been taken by the municipalities of our country.

EXPLOITATION OF URBAN SOLID WASTE (MSW)

The energy recovery of MSW is one of the most important ways of integrated management of MSW in terms of sustainable functioning of the cities, in accordance with the Local Agenda 21. Today in Greece, a large portion of MSW is uncontrollably rejected in landfills. While only a small portion of them, who have direct commercial value (newspapers, aluminum cans, etc.) is systematically recycled by municipalities in cooperation with the institutionally established recyclers. Nowadays in Greece, there are no energy recovery applications in the management of MSW. However there are two (2) Units that operate the Composting Unit (photo) of the Municipality of Kalamata and the Engineering Unit Sorting at the Landfill of Liosia.

GEOTHERMAL

In Greece, the most common application of geothermal energy concerns the heating of the greenhouses. Other applications are related to the district heating in buildings, the combination of heat pumps in buildings, fish farms, drying agricultural products, water desalination (sea or even geothermal water) and others. Today in Greece, geothermal applications, apart from the thermal baths, include (a) the heating of glasshouses (for the production mainly vegetable and rose) in Nigrita Sidirokastro, in Lagada in Nymphopetra in Nea Apollonia, Nea Triglia, Lesvos (Polichnitos), and Milos, (b) heating soil for development of asparagus in New Erasmio and Nigrita, (c) the production of drinking water by desalinating seawater in Kimolos.

ELECTRICITY SUPPLY OF SETTLEMENTS WITH RENEWABLE ENERGY SOURCES

Nowadays in Greece, there are several applications of electricity supply of settlements by RES such as the one in Gavdos island. Moreover, there is a significant number of autonomous systems for the supply of individual houses or other buildings that use similar technology. As for the small islands of Greece, the majority of which are not connected to the national grid, the use of renewable energy is a viable alternative as for their electricity supply.

ENERGY MANAGEMENT BUILDINGS

The Energy Management of the building is a systematic, organized and continuous activity that consists of a planned set of administrative, technical and financial actions.

More specifically it should include: energy inspection; Energy monitoring; maintenance of infrastructure; energy saving. Such successful examples were the Saving (εξοικονομώ) programs that were applied during the previous programming period. To conclude with, the Greek Municipalities are going to play a significant role in terms of Energy Saving:

1. As energy consumers: In energy efficiency measures in municipal buildings; In the measurement and control of energy consumption. An important priority to the Regional or Local Authorities, at their facilities and operation of (buildings, pumping stations, wastewater treatment plants, swimming pools and sports centers)

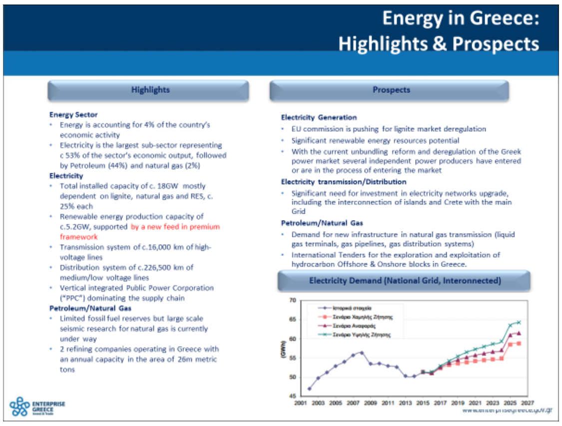
2. Energy consumption of municipal facilities: Energy Savings potentials through: Proper maintenance of the network; Intelligent building management; The use of energy efficient street lighting; Install motion detector lighting in public areas. Actions with intense focus on the contribution of the Local Authorities to the environmental protection, the climate change and to a dynamic local development with emphasis on the employment through energy saving investment programs and utilization-exploitation of RES in all functions and facilities of the municipalities.

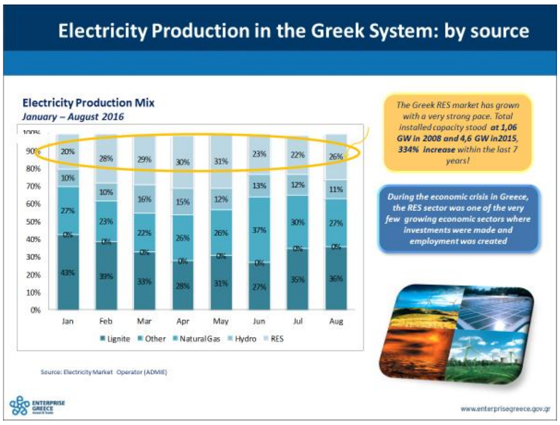
Green Investments in Greece

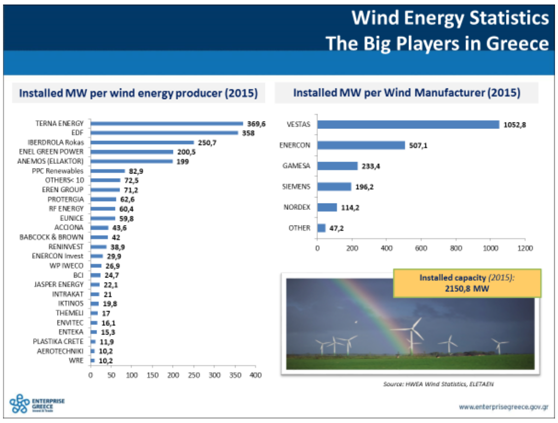
by

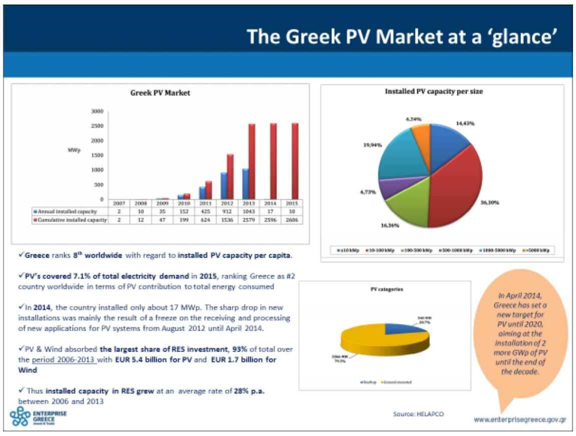
Mr. Nikos STAMOU

Investment Promotion Manager, Enterprise Greece, Hellas








The Greek PV Market at a 'glance'
Greek PV Market
MWp
2007 2008 2009 2010 2011 2012 2013 2014 2015
Annual installed capacity 2 10 35 152 425 912 1043 17 10
Cumulative installed capacity 2 12 47 199 624 1536 2579 2596 2606
Installed PV capacity per size
14,43%
19,94%
6,73%
16,36%
36,30%
≤10 kWp 10-100 kWp 100-500 kWp 500-1000 kWp 1000-5000 kWp >5000 kWp
✓Greece ranks 8th worldwide with regard to installed PV capacity per capita.
✓PV's covered 7.1% of total electricity demand in 2015, ranking Greece as #2 country worldwide in terms of PV contribution to total energy consumed
✓In 2014, the country installed only about 17 MWp. The sharp drop in new installations was mainly the result of a freeze on the receiving and processing of new applications for PV systems from August 2012 until April 2014.
✓PV & Wind absorbed the largest share of RES investment, 93% of total over the period 2006-2013 with EUR 5.4 billion for PV and EUR 1.7 billion for Wind
✓ Thus installed capacity in RES grew at an average rate of 28% p.a. between 2006 and 2013
PV categories
Rooftop Ground-mounted
In April 2014, Greece has set a new target for PV until 2020, aiming at the installation of 2 more GWp of PV until the end of the decade.
Source: HELAPCO
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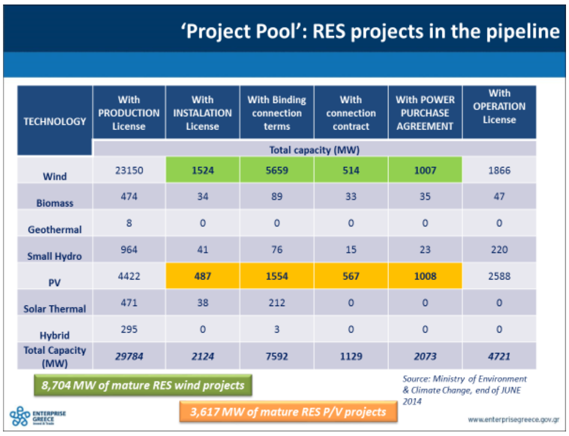
'Project Pool': RES projects in the pipeline
TECHNOLOGY | With PRODUCTION License | With INSTALATION License | With Binding connection terms | With connection contract | With POWER PURCHASE AGREEMENT | With OPERATION License
Total capacity (MW)
Wind 23150 1524 5659 514 1007 1866
Biomass 474 34 89 33 35 47
Geothermal 8 0 0 0 0 0
Small Hydro 964 41 76 15 23 220
PV 4422 487 1554 567 1008 2588
Solar Thermal 471 38 212 0 0 0
Hybrid 295 0 3 0 0 0
Total Capacity (MW) 29784 2124 7592 1129 2073 4721
8,704 MW of mature RES wind projects
3,617 MW of mature RES P/V projects
Source: Ministry of Environment & Climate Change, end of JUNE 2014
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THE GREEK INVESTMENT PROPOSAL
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The strengths of the Greek RES market create a very attractive business opportunity
• Bound by EU regulations and Kyoto Protocol agreements
• National target for RES at 20% on final energy consumption by 2020, 2% above the mandatory levels of 2009/28/EC, 40% electricity production from RES –NEW TARGETS FOR PV
• 20 – year PPA (power purchase agreement)-Revised Feed in Premium compensation scheme for RES electricity producers ratified this summer and activated after 2017
• Ideal conditions for wind and solar energy, in 2012 the average capacity factor of wind parks was estimated at 26%, coupled with increased productivity of new wind turbines leading to enhanced performance
• The system operator deploys a long term plan for the development of the electricity network, strengthening the network and facilitating additional energy capacity through RES
• The installation cost for wind parks in Greece is considerably lower, compared with other renewable energy technologies (EUR 1,200/kW in the interconnected system, EUR 1,400/kW in the non interconnected islands)
• Highly-skilled, world-renowned RES personnel available for hiring
• Availability of investment incentives, depending on project scale and tech
Projects with rewarding cash flows and attractive Returns on Investment
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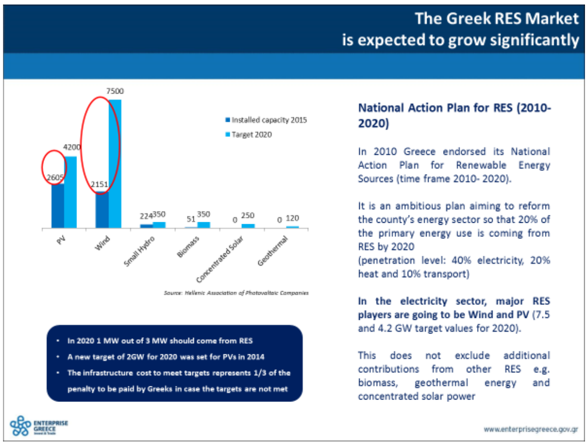
The Greek RES Market is expected to grow significantly
Installed capacity 2015
Target 2020
PV 2605 4200
Wind 2151 7500
Small Hydro 224 350
Biomass 51 350
Concentrated Solar 0 250
Geothermal 0 120
Source: Hellenic Association of Photovoltaic Companies
• In 2020 1 MW out of 3 MW should come from RES
• A new target of 2GW for 2020 was set for PVs in 2014
• The infrastructure cost to meet targets represents 1/3 of the penalty to be paid by Greeks in case the targets are not met
National Action Plan for RES (2010-2020)
In 2010 Greece endorsed its National Action Plan for Renewable Energy Sources (time frame 2010- 2020).
It is an ambitious plan aiming to reform the county's energy sector so that 20% of the primary energy use is coming from RES by 2020 (penetration level: 40% electricity, 20% heat and 10% transport)
In the electricity sector, major RES players are going to be Wind and PV (7.5 and 4.2 GW target values for 2020).
This does not exclude additional contributions from other RES e.g. biomass, geothermal energy and concentrated solar power
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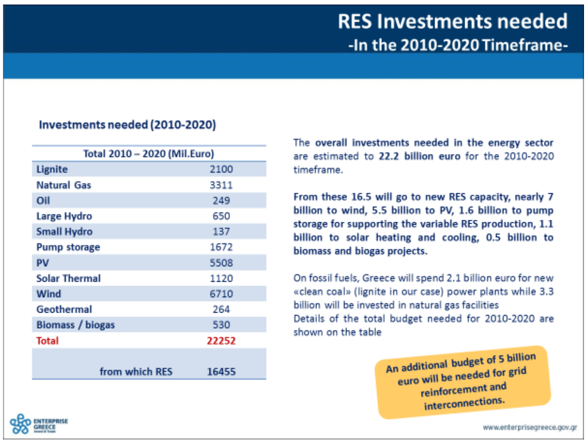
RES Investments needed
-In the 2010-2020 Timeframe-
Investments needed (2010-2020)
Total 2010 – 2020 (Mil.Euro)
Lignite 2100
Natural Gas 3311
Oil 249
Large Hydro 650
Small Hydro 137
Pump storage 1672
PV 5508
Solar Thermal 1120
Wind 6710
Geothermal 264
Biomass / biogas 530
Total 22252
from which RES 16455
The overall investments needed in the energy sector are estimated to 22.2 billion euro for the 2010-2020 timeframe.
From these 16.5 will go to new RES capacity, nearly 7 billion to wind, 5.5 billion to PV, 1.6 billion to pump storage for supporting the variable RES production, 1.1 billion to solar heating and cooling, 0.5 billion to biomass and biogas projects.
On fossil fuels, Greece will spend 2.1 billion euro for new «clean coal» (lignite in our case) power plants while 3.3 billion will be invested in natural gas facilities
Details of the total budget needed for 2010-2020 are shown on the table
An additional budget of 5 billion euro will be needed for grid reinforcement and interconnections.
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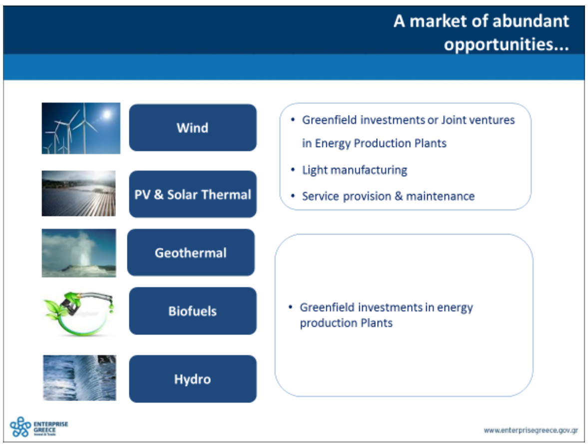
A market of abundant opportunities...
Wind
PV & Solar Thermal
Geothermal
Biofuels
Hydro
• Greenfield investments or Joint ventures in Energy Production Plants
• Light manufacturing
• Service provision & maintenance
• Greenfield investments in energy production Plants
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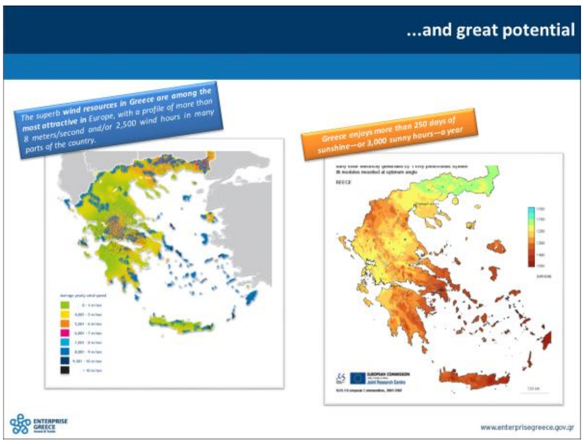
...and great potential
The superb wind resources in Greece are among the most attractive in Europe, with a profile of more than 8 meters/second and/or 2,500 wind hours in many parts of the country.
Greece enjoys more than 250 days of sunshine—or 3,000 sunny hours—a year
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...and a supportive
funding framework...
✓Customised funding programmes run by international financial institutions (EIB, EIF, EBRD, IFC, Black Sea Bank, etc.) in cooperation with Greek banking institutions
✓New Development Fund to support RES investments through guarantees & loans
✓The European Fund for Strategic Investments (EFSI/ "Juncker plan")
✓Availability of investment incentives, depending on project scale and tech, through the new investment law
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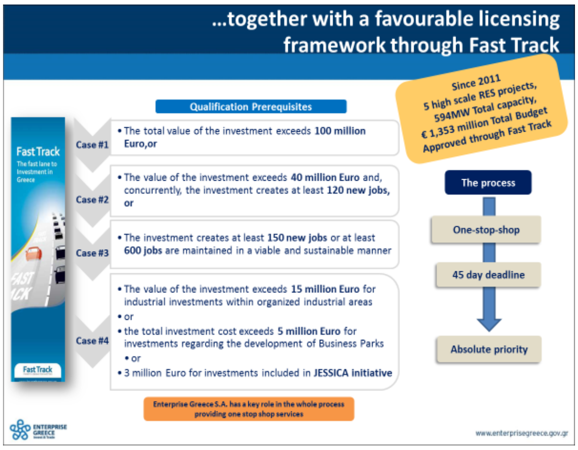
...together with a favourable licensing
framework through Fast Track
Since 2011
5 high scale RES projects,
594MW Total capacity,
€ 1,353 million Total Budget
Approved through Fast Track
Qualification Prerequisites
Fast Track
The fast lane to Investment in Greece
Case #1
• The total value of the investment exceeds 100 million Euro,or
Case #2
• The value of the investment exceeds 40 million Euro and, concurrently, the investment creates at least 120 new jobs, or
Case #3
• The investment creates at least 150 new jobs or at least 600 jobs are maintained in a viable and sustainable manner
Case #4
• The value of the investment exceeds 15 million Euro for industrial investments within organized industrial areas
• or
• the total investment cost exceeds 5 million Euro for investments regarding the development of Business Parks
• or
• 3 million Euro for investments included in JESSICA initiative
The process
One-stop-shop
45 day deadline
Absolute priority
Enterprise Greece S.A. has a key role in the whole process providing one stop shop services
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Global players in the Greek RES market...
Vestas
unigea
CONERGY
EDISON
enova
EGL
IBERDROLA
Enel
energies nouvelles
Eurus Energy
sunvault
Gamesa
ENERCON
SMA
acciona
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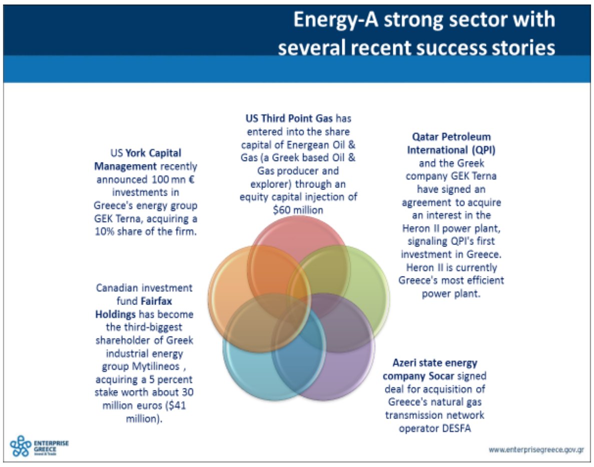
Energy-A strong sector with
several recent success stories
US Third Point Gas has entered into the share capital of Energean Oil & Gas (a Greek based Oil & Gas producer and explorer) through an equity capital injection of $60 million
US York Capital Management recently announced 100 mn € investments in Greece's energy group GEK Terna, acquiring a 10% share of the firm.
Qatar Petroleum International (QPI) and the Greek company GEK Terna have signed an agreement to acquire an interest in the Heron II power plant, signaling QPI's first investment in Greece. Heron II is currently Greece's most efficient power plant.
Canadian investment fund Fairfax Holdings has become the third-biggest shareholder of Greek industrial energy group Mytilineos , acquiring a 5 percent stake worth about 30 million euros ($41 million).
Azeri state energy company Socar signed deal for acquisition of Greece's natural gas transmission network operator DESFA
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ENTERPRISE
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Invest & Trade
Enterprise Greece (www.enterprisegreece.gov.gr) is the official agency of the Greek State, under the supervision of the Ministry of Economy, Development and Tourism (www.mindev.gov.gr), to promote investment in Greece, exports from Greece, and make Greece more attractive as an international business partner.
In order to enhance our services to our customers (Greek and foreign investors and businessmen), we started since 2009 to compile a projects portfolio, which currently consists of more than 600 projects from both the public and the private sectors of the Greek economy.
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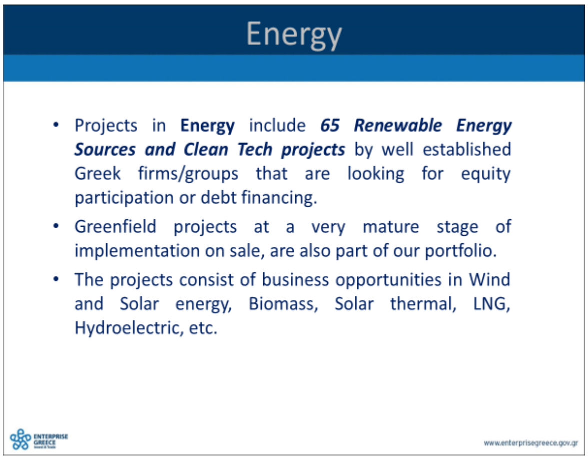
Energy
• Projects in Energy include 65 Renewable Energy Sources and Clean Tech projects by well established Greek firms/groups that are looking for equity participation or debt financing.
• Greenfield projects at a very mature stage of implementation on sale, are also part of our portfolio.
• The projects consist of business opportunities in Wind and Solar energy, Biomass, Solar thermal, LNG, Hydroelectric, etc.
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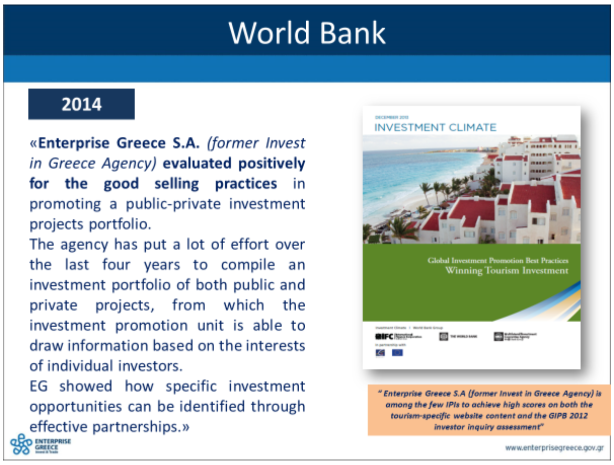
World Bank
2014
«Enterprise Greece S.A. (former Invest in Greece Agency) evaluated positively for the good selling practices in promoting a public-private investment projects portfolio.
The agency has put a lot of effort over the last four years to compile an investment portfolio of both public and private projects, from which the investment promotion unit is able to draw information based on the interests of individual investors.
EG showed how specific investment opportunities can be identified through effective partnerships.»
INVESTMENT CLIMATE
Global Investment Promotion Best Practices
Winning Tourism Investment
" Enterprise Greece S.A (former Invest in Greece Agency) is among the few IPIs to achieve high scores on both the tourism-specific website content and the GIPB 2012 investor inquiry assessment"
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Decarbonization in S.E. Europe

by

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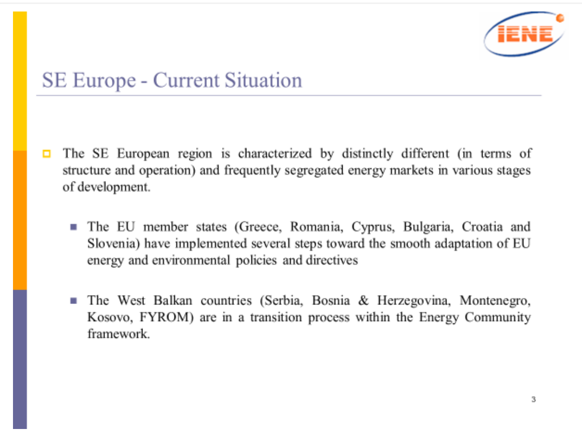
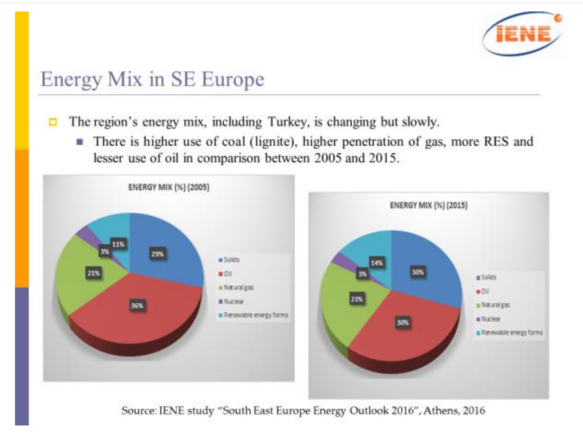
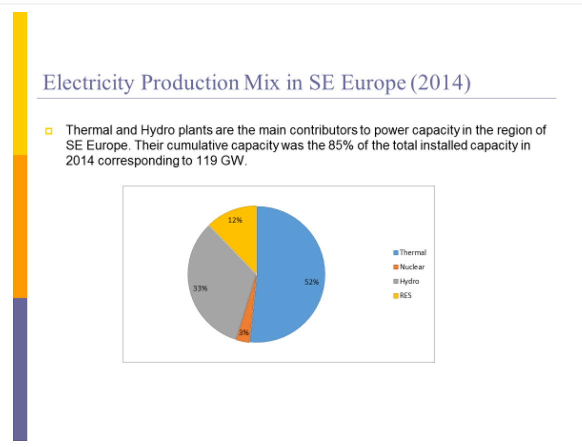
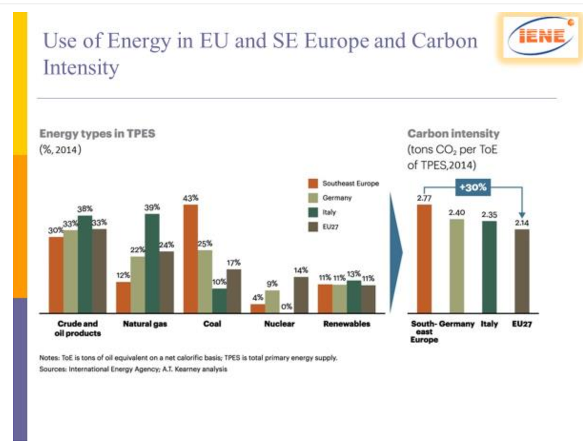
Research Coordinator and Member of the BoD, Institute of Energy for S.E. Europe (IENE), Hellas



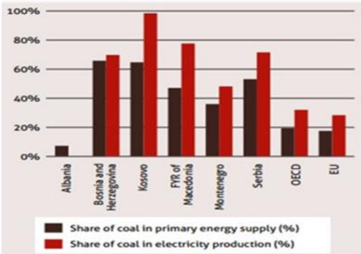






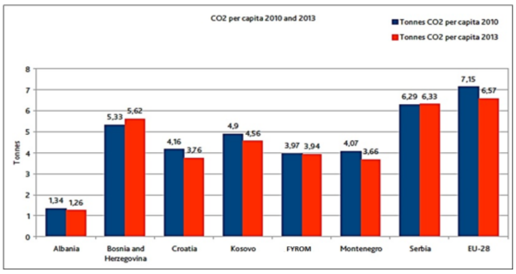
Coal's share of primary energy supply and electricity production in the Western Balkans, EU and OECD

- The West Balkans in particular, have strong carbon-intensive economies.



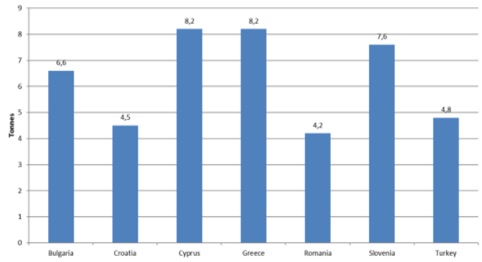
CO2 per capita in most of SEE countries and EU 28 (in 2010 and 2013)

As can be seen from the Figure below, the CO2 per capita for the West Balkan countries and contracting parties of the Energy Community, their levels are for most of them well below the EU-28 average.



CO2 per capita in the EU member states and Turkey in 2013

In the case of the SE Europe's member states, they are very near or above the EU-28 average. Notably, Greece and Cyprus show much higher gas emissions on account of high levels of lignite use in the case of Greece and fuel oil (for power generation) in the case of Cyprus.



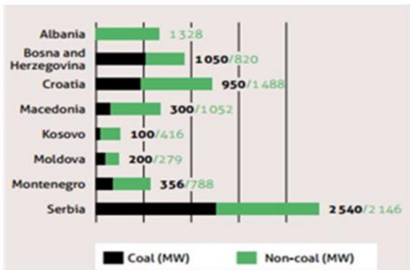
Challenges and Trends Towards SE Europe's Decarbonization (I)

- It is generally recognized that lignite and coal will continue for some years to contribute to power generation in SE Europe, but at a decreasing rate in the long term, say by 2040. However, over the next 10 - 15 years, according to IENE estimates the share of solid fuels is anticipated to increase steadily in several countries of the region (most notably in Serbia, Kosovo, Croatia, Bosnia & Herzegovina, Montenegro and Turkey), as they will struggle to meet increased demand. In addition, gas will continue to gain share in the energy mix, at least over the next 15 years in Europe and in the SE European region in particular, mainly because of its environmental friendly characteristics, its increased availability, the higher demand for gas-fired electricity and the expected socio-economic development.
- Furthermore, there will be significant opportunities in the future to expand solar PV generation as well as solar thermal and energy efficiency.
- The potential for regionally transmitted pumped hydropower storage, to provide reservoir and dispatchable services would greatly benefit regional cooperation and lower overall electricity cost.

Challenges and Trends Towards SE Europe's Decarbonization (II)

- FYROM and Serbia are the second most coal dependent countries after Kosovo, with 76% and 64.8% respectively of their electricity generated from coal in 2014. For comparison, the EU generated 26.1% of electricity from coal in 2013. Future proposed lignite-based coal-fired power plants in Bosnia and Herzegovina and Serbia would not be in line with EU climate targets, and would downgrade the solar PV, wind, hydropower, and biomass opportunities in the region.
- FYROM's energy sector faces substantial challenges to comply with EU policies or targets. Trading regionally would also benefit neighboring countries to complement networks in Kosovo, Serbia, and Albania and build a fully decarbonized electricity system.
- Effective climate change policies in SE Europe have not been implemented so far, but there is still room for change in order to avoid becoming further "locked in" to the use of fossil fuels. In recent years, only the Stanari coal-fired power plant in Bosnia and Herzegovina has been built, while plans for the Plomin C plant in Croatia were cancelled. Also, the PPC's Ptolemais V lignite-fired power plant in Northern Greece is currently under construction. More coal-fired power plants planned in Bosnia and Herzegovina, Kosovo, Montenegro and Serbia. However, renewables as well as energy efficiency should increase their share, as there is room for further future development.

Share of Coal in Planned Electricity Generation Capacity



Challenges and Trends Towards SE Europe's Decarbonization (III)

- The massive potential of roof-top solar (both solar thermal and PV) continues to be undermined across the region, and the potential for consumer-owned energy generation or municipality-owned electricity generation whose benefits stay within the community remains largely unrealized.
- hydropower is one of the most important indigenous energy resources for electricity generation for most countries of SE Europe and therefore it is an energy source of great strategic importance, which can contribute the most toward the COP 21 environmental goals.
- The use of solid biomass, mainly for domestic heating, rises by 20%, and wood stoves are made cleaner and more efficient. Biomass use is relied on efficient, sustainable forest management and reforestation, and none of the wood is imported.
- Enhancing energy security through the development of local energy sources, including lignite, coal and RES and hence the diversification of their energy mix will become a major policy driver for several countries in the region, especially in the Western Balkans
- In the case of SE Europe, where economic development, largely based on the utilization of indigenous lignite/coal resources, will have to be reconciled with COP 21 commitments. Therefore, the planning of clean-cut and compatible long-term energy and economic strategies, maximizing the economic and social benefits in long-term, becomes a real challenge. To this end, a lot more analytical and assessment work needs to be undertaken before introducing realistic policies, which will aim both towards economic and social development but will also help achieve minimal environmental consequences.

IENE

Thank you for your attention

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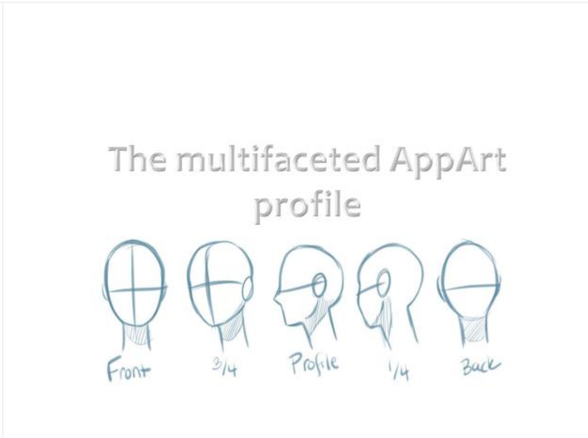
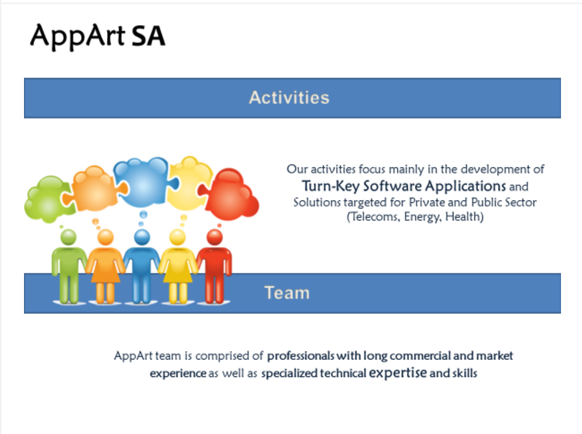
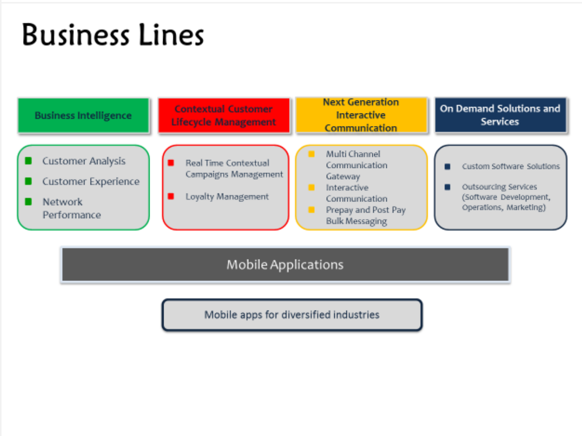
The multifaceted AppArt profile

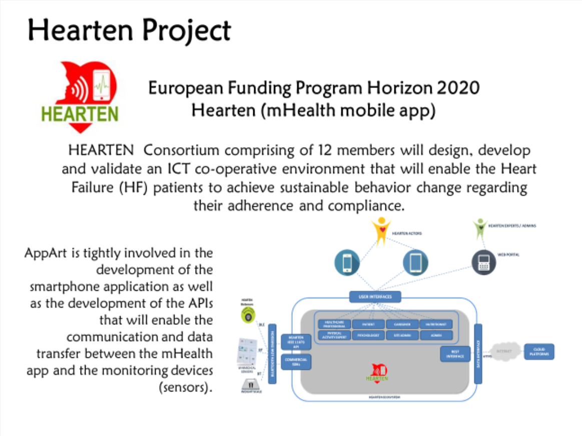
by

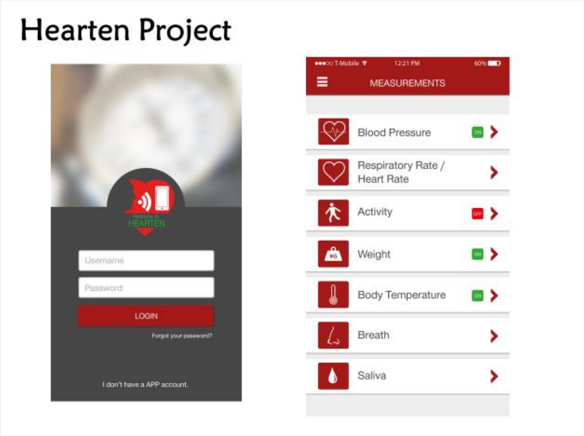
Mr. Michalis SFAKIANOS, AppArt, Hellas

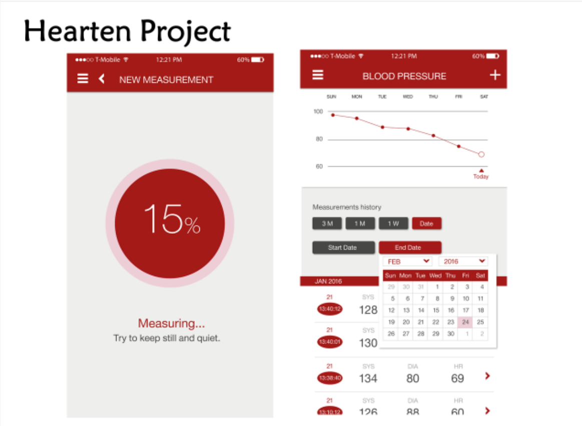


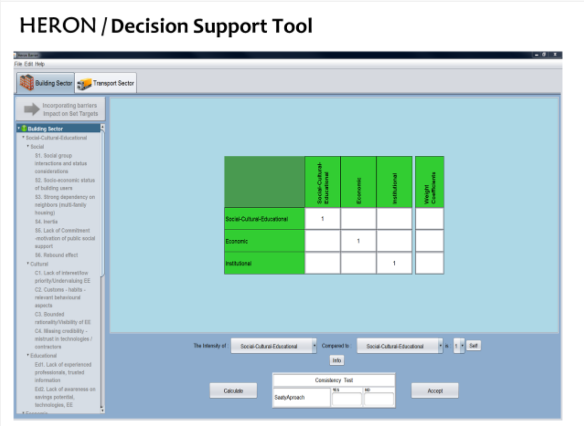


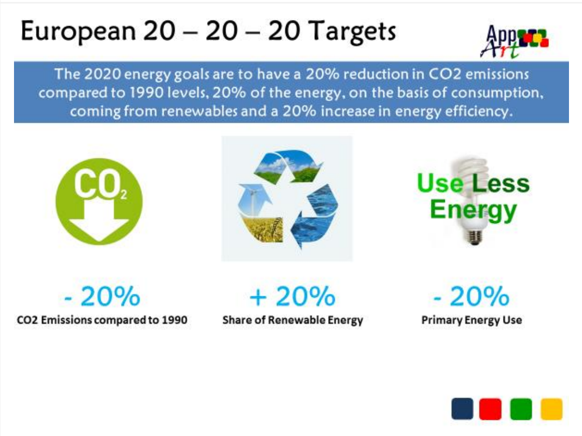



Hearten Project
HEARTEN
European Funding Program Horizon 2020
Hearten (mHealth mobile app)
HEARTEN Consortium comprising of 12 members will design, develop and validate an ICT co-operative environment that will enable the Heart Failure (HF) patients to achieve sustainable behavior change regarding their adherence and compliance.
AppArt is tightly involved in the development of the smartphone application as well as the development of the APIs that will enable the communication and data transfer between the mHealth app and the monitoring devices (sensors).


Hearten Project
HEARTEN
Username
Password
LOGIN
Forgot your password?
I don't have a APP account.
MEASUREMENTS
Blood Pressure
Respiratory Rate / Heart Rate
Activity
Weight
Body Temperature
Breath
Saliva


Hearten Project
NEW MEASUREMENT
15%
Measuring...
Try to keep still and quiet.
BLOOD PRESSURE
Measurements history
3 M
1 M
1 W
Date
Start Date
End Date
128
130
134
80
69

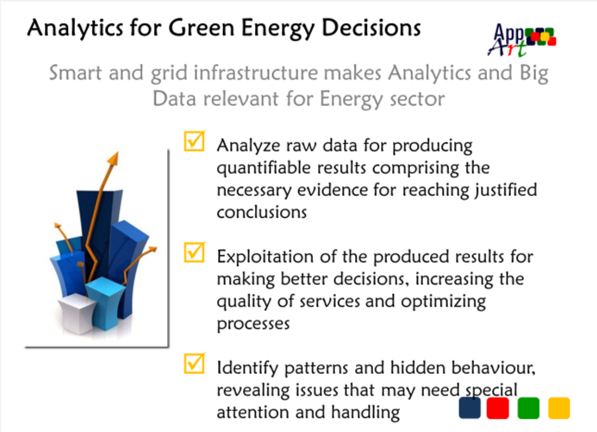

HERON / Decision Support Tool
Building Sector
Transport Sector
Calculate
Accept

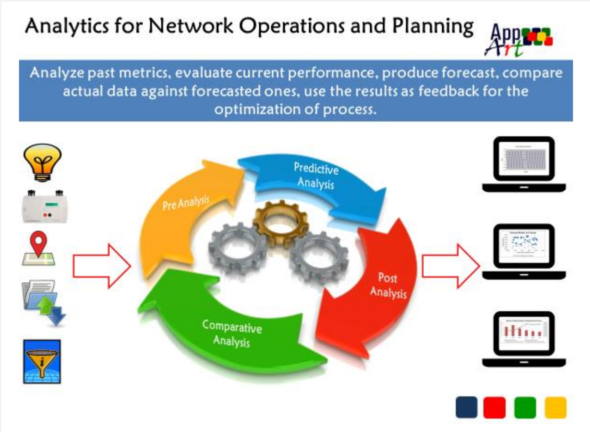

European 20 – 20 – 20 Targets
The 2020 energy goals are to have a 20% reduction in CO2 emissions compared to 1990 levels, 20% of the energy, on the basis of consumption, coming from renewables and a 20% increase in energy efficiency.
CO2
Use Less Energy
- 20%
CO2 Emissions compared to 1990
+ 20%
Share of Renewable Energy
- 20%
Primary Energy Use

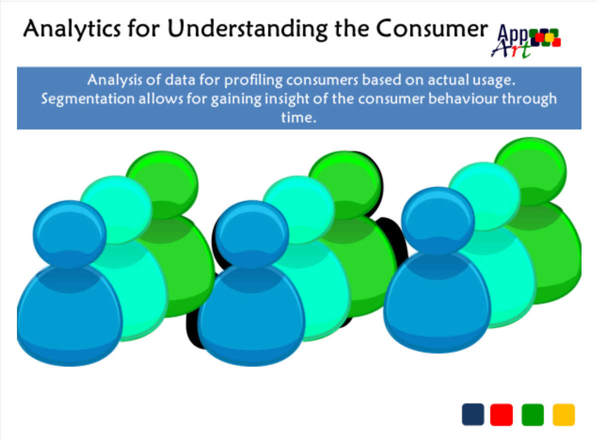

Using New Technologies
Energy efficiency and conversation requires educated and engaged consumers. Smart energy infrastructure is now able to provide all data required to be used for increasing awareness and engagement through technology.


Utilizing our Experience
We utilize our experience to transfer and adapt proven, in other industries, solutions for the purposes of Energy sector as well.
We provide the actual tools for:
• Understanding the consumer
• Interact with the consumer
In order to:
Educate the consumer
Engage the consumer

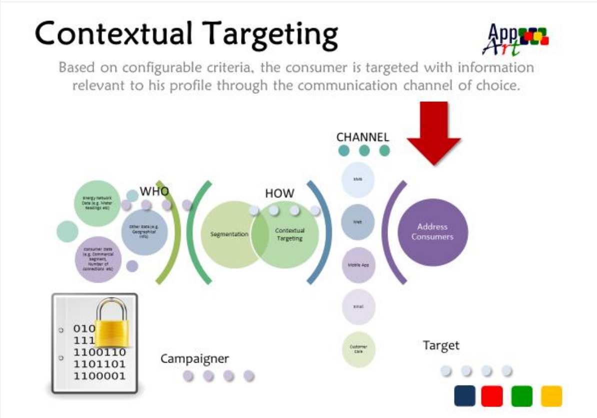

Analytics

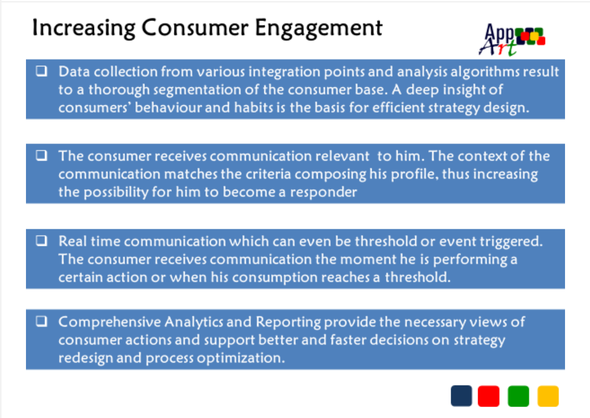

Analytics for Green Energy Decisions
Smart and grid infrastructure makes Analytics and Big Data relevant for Energy sector
Analyze raw data for producing quantifiable results comprising the necessary evidence for reaching justified conclusions
Exploitation of the produced results for making better decisions, increasing the quality of services and optimizing processes
Identify patterns and hidden behaviour, revealing issues that may need special attention and handling

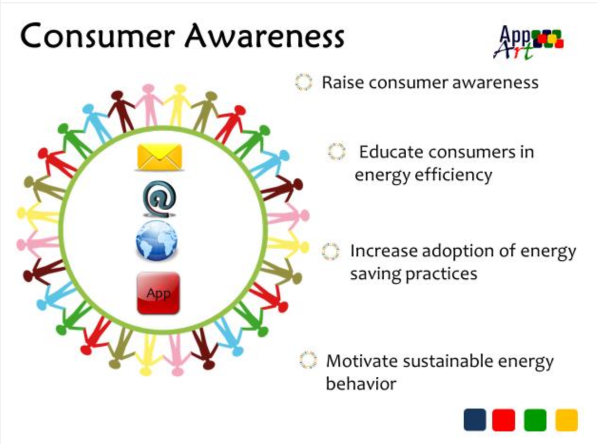

Analytics for Network Operations and Planning
Analyze past metrics, evaluate current performance, produce forecast, compare actual data against forecasted ones, use the results as feedback for the optimization of process.
Predictive Analysis
Pre Analysis
Post Analysis
Comparative Analysis

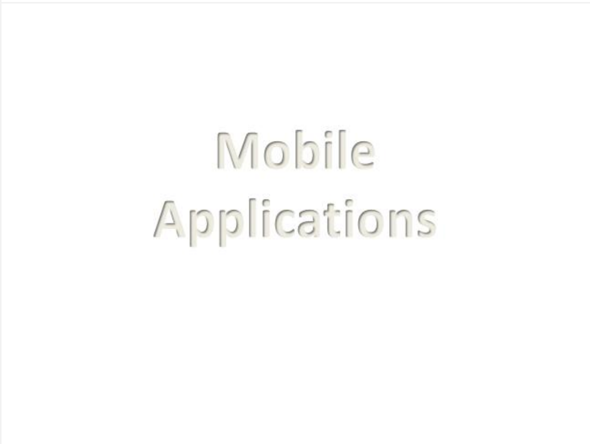

Analytics for Understanding the Consumer
Analysis of data for profiling consumers based on actual usage. Segmentation allows for gaining insight of the consumer behaviour through time.


Multi Channel Contextual Campaigns Management


Contextual Targeting
Based on configurable criteria, the consumer is targeted with information relevant to his profile through the communication channel of choice.
CHANNEL
WHO
HOW
Segmentation
Contextual Targeting
Address Consumers
Campaigner
Target


Increasing Consumer Engagement
Data collection from various integration points and analysis algorithms result to a thorough segmentation of the consumer base. A deep insight of consumers' behaviour and habits is the basis for efficient strategy design.
The consumer receives communication relevant to him. The context of the communication matches the criteria composing his profile, thus increasing the possibility for him to become a responder
Real time communication which can even be threshold or event triggered. The consumer receives communication the moment he is performing a certain action or when his consumption reaches a threshold.
Comprehensive Analytics and Reporting provide the necessary views of consumer actions and support better and faster decisions on strategy redesign and process optimization.


Consumer Awareness
Raise consumer awareness
Educate consumers in energy efficiency
Increase adoption of energy saving practices
Motivate sustainable energy behavior
App


Mobile Applications

New Communication Channels

Consumers have evolved! Reach consumer through Mobile App and Web

Self Care Mobile Application

Smart City

Smart Cities

Raising awareness and engagement of individual consumers will lead to the greater target of achieving smart city targets through the use of internet of things technology and smart grid infrastructure

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Session 3: Energy – Climate Change Policies

Energy security performance in Japan: past and future

by

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Abstract

Japan is poor in energy resources and the large amount of its oil import is from the Middle East. Therefore, Japan has serious energy security issues. This study aims to understand the historical transition of energy security performance in Japan and observe the future energy security based on energy scenarios.

Energy security performance is evaluated using three indicators based on the Shannon-Wiener diversity index: S1: evaluating diversity of primary energy sources; S2: applying energy imports in S1; S3: applying country risks of energy exporters in S2. These indicators focus on energy supply, the most frequently considered aspect in energy security studies. Using these indicators, we first evaluate Japan's past energy security performance based on the statistical data. We then evaluate the prospective energy security performance based on four energy scenarios. These scenarios consider climate mitigation in the future.

During the period of rapid economic growth, the indicators declined, because the dependence on oil increased. However, after the oil shocks, the indicators improved, because the share of oil has decreased and those of natural gas and nuclear power have increased. Observing S2 and S3, they generally continued to be flat from mid-1980s until the early-2010s because of the dependence on imports of natural gas and coal. After 2010, all the indicators declined tremendously due to the shutdown of nuclear power plants. The results of the scenario analysis suggest that using no nuclear power is unreasonable from the energy security perspective. The best scenario among the four is that balancing energy technologies.

1. Introduction

The self-sufficiency rate of energy (including nuclear and renewable energy) was 6% in 2013 in Japan. The country highly depends on fossil fuels – these accounted for more than 80% of energy supply before the Fukushima Daiichi nuclear disaster and at present account for more than 90%. These fossil fuels are mostly imported and are mainly sourced from the politically unstable Middle East. Because energy demands in emerging countries (e.g., China and India) are increasing and these countries are trying to secure their energy supply, it will be more difficult for Japan to rely on cheap imported fuels in the near future. Thus, producing its own energy sources and reducing dependence on energy import are essential.

Nuclear energy has been one of energy sources that can reduce dependence on fossil fuels. However, the Fukushima nuclear disaster changed the situation, highlighting the safety issues of using nuclear energy. Thus, at the time of writing, only one nuclear power plant (Sendai nuclear power plant in Kyushu) is in operation.

As an alternative energy source, renewable energy will be one of the most important elements in securing Japan's national energy supply and solving other environmental issues such as climate change and air pollution. Although multiple national policies were introduced to diffuse renewable energy after the oil shocks in the 1970s, renewable energy other than hydropower accounted for only a small percentage of total primary energy supply. After the Feed-in Tariff (FIT) scheme, launched in 2012, the share of renewable energy increased larger than the historical trend.

In April 2014, the latest version of the Basic Energy Plan, which was developed after the Fukushima nuclear disaster, was endorsed by the government. The purpose of the plan was to completely revise the energy strategy of Japan, particularly reducing dependency on nuclear power, considering the Fukushima nuclear disaster. The policy prioritizes energy security, but also considers economic efficiency and the conservation of the environment, all with a strong focus on safety (3E+S).

In transitioning toward a sustainable society, Japan faces many challenges. The main challenges of energy policies can be summarized as follows. In the Basic Energy Plan, no best energy mix is defined. To establish a sustainable society, the plan indicates that the share of renewable energy should be increased. However, no numerical targets exist for renewable energy. In addition, coal-thermal power is still considered an important baseload power. Furthermore, the position of the government regarding nuclear power is not clear. As mentioned above, the plan indicates that nuclear power is an ‘important’ baseload power source and, at the same time, that dependency on it should be reduced. The energy structure also closely relates to energy security. Since Japan imports most energy resources, energy costs and a stable energy supply may be at risk if Japan continues to rely on imported fossil fuels.

Many types of research on energy security have been implemented in the literature, reviewing different countries and regions, different methods, and different periods. In particular, there are many studies focusing on Asian countries, but few for the case of Japan.

Shin et al. (2013) analyzed energy security in the Korean gas sector using a model approach (quality function deployment and system dynamics) from the past to the future (1998-2015). Ren and Sovacool (2014, 2015), Wu (2014) and, Yao and Chang (2014) targeted China. Ren and Sovacool (2014) applied the DEMATEL method for analyzing energy security from availability, affordability, acceptability, and accessibility (4As). Ren and Sovacool (2015) applied Analytic Hierarchy Process to evaluate energy security with respect to low-carbon energy. Wu (2014) examined China's energy security strategies by focusing on overseas oil investment, strategic petroleum reserves, and unconventional gas development in the 11th and 12th Five-Year Program. Yao and Chang (2014) also used the 4As approach and evaluated the transition of energy security performance by areas of rhombus made by the 4As in the past (1980-2010). Chuang and Ma (2013) evaluated energy policy in Taiwan using energy security indicators composed of six indicators of four dimensions in the past (1990-2010) and also the future energy policy in terms of energy security using both a modeling approach and the indicators. Martchamadol and Kumar (2012) evaluated energy security in Thailand from the past to the future (1986-2030). The authors applied five-dimensional (19 indicators in total) indicators, using statistical data for the historical analysis and a scenario approach for the future analysis within the evaluation. Thangavelu et al. (2015) used an optimization model for exploring a long-term energy mix for society with high energy security and low carbon in the future in Indonesia. Ang et al. (2015a) evaluated historical energy security (1990-2010) in Singapore using 22 indicators of three dimensions. The authors also conducted scenario analysis for the future (until 2035) based on a business-as-usual projection. Sharifuddin (2014) evaluated energy security in five Southeast Asian countries (Malaysia, Indonesia, Philippines, Thailand, and Vietnam) using 35 indicators representing 13 elements grouped into five aspects of energy security in three periods (2002, 2005, and 2008). Selvakkumaran and Limmeechokchai (2013) evaluated the future energy security (until 2030) with respect to oil security, gas security, and sustainability in three Asian countries (Sri Lanka, Thailand, and Vietnam) using a model approach. Similarly, Matsumoto and Andriosopoulos (2016) used an economic model for evaluating the future energy security (until 2050) in three East Asian countries (Japan, China, and Korea) under climate mitigation scenarios. There is also a special issue on Asian energy security from Energy Policy (volume 39 issue 11) in 2011. In the special issue, Takase and Suzuki (2011), using the long-range energy alternatives planning software system, analyzed future energy pathways, which have impact on energy security, in Japan. The authors mainly focus on energy structures in the future under different nuclear power development and greenhouse gas emission abatement.

As shown in the above-mentioned literature, there are many studies on energy security focusing on Asian countries. However, the studies targeting Japan are few, although energy security is an important issue for Japan as mentioned in Section 1.1.

In terms of methodology for evaluating energy security, most studies apply some sort of 'indicators' to statistical data or results of model or scenario analysis. However, different definitions, dimensions, or indexes have been used in each study (see for example Ang et al. (2015b) for a comprehensive review of energy security studies), meaning that there are no consistent definitions or evaluation methods for energy security performance. When evaluating energy security of countries, the most important factor is the availability of energy as it is included in the indicators in most of the related studies (Ang et al., 2015b). Furthermore, considering that such indicators are used by policymakers to establish energy policy in a country, a simple and comprehensible methodology is preferable.

The purpose of this study is to evaluate energy security performance in Japan from the history to the future, using comprehensive energy security indicators. For the past, statistical data are used, while for the future, energy scenarios are used. Long-term historical analysis is important to understand what contributes for improving energy security. In addition, the scenario analysis for the future can show how energy mix that considered under energy policy or scenarios in Japan can contribute (or not contribute) to improve energy security.

2. Methods

2.1 Energy security indicators

In order to analyze the historical transition of energy security performance and energy security performance in the future, three energy security indicators are used (Lehl, 2009). The proposed indicators enable the analysis of energy security in the past and the future, and the presented results facilitate the formulation of energy policy recommendations. The first indicator (S1, eq. 1) evaluates the diversity of energy sources based on the Shannon-Wiener index, which is an indicator for evaluating diversity. Diversity is important for maintaining energy security, because the probability of compensating for the loss of a primary energy source by other energy sources will increase, thus preserving energy security. However, concerning the energy security of countries, it is important to consider where the energy sources come from. In general, domestic energy is safe but a procurement risk exists for imported energy. In addition, similar to diversity of energy sources, diversity of the origin of imported energy contributes to energy security. The second indicator (S2, eq. 2) considers the import dependence of each country on its energy sources, as well as its energy imports by origin. In this indicator, all of the energy exporters are treated equally. However, energy security will be worse if energy sources are imported from politically and economically unstable countries. Thus, the third indicator (S3, eq. 6) extends the second one by incorporating a country-risk factor associated with a country's energy imports origins. By definition, the values of three indicators will be S1 ≥ S2 ≥ S3, and they are not comparable.

$$S1 = -\sum_{i=1}^{N} p_i \ln(p_i) \tag{1}$$

$$S2 = -\sum_{i=1}^{N} c2_i p_i \ln(p_i) \tag{2}$$

$$c2_i = \left(1 - m_i\left(1 - \frac{S_{i2}^{m}}{S_{i2}^{max}}\right)\right) \tag{3}$$

$$S_{i2}^{m} = -\sum_{j=1}^{M} m_{ij} \ln(m_{ij}) \tag{4}$$

$$S_{i2}^{max} = -M\frac{1}{M}\ln(\frac{1}{M}) \tag{5}$$

$$S3 = -\sum_{i=1}^{N} c3_i p_i \ln(p_i) \tag{6}$$

$$c3_i = \left(1 - m_i\left(1 - \frac{S_{i3}^{m}}{S_{i3}^{max}}\right)\right) \tag{7}$$

$$S_{i3}^{m} = -\sum_{j=1}^{M} A_j m_{ij} \ln(m_{ij}) \tag{8}$$

$$S_{i3}^{max} = -M \frac{1}{M} \ln\left(\frac{1}{M}\right) \qquad (9)$$

$$A_j = \frac{r_j}{\max_j r_j} \qquad (10)$$

where i: types of primary energy; j: origin of primary energy imports; p: share of primary energy; m: share of imports; r: risk indicator; N: the number of primary energy types; M: the number of the origin of primary energy imports

2.2 Historical data

To calculate the three indicators for the past (1978-2014), we obtained the data from the following data sources. First, primary energy demand in each country (to calculate the share of primary energy pi) is from the Energy Balances of OECD Countries (IEA, 2015b). Since the types of primary energy are broad in the database, they are aggregated into 10 types of primary energy (i.e., coal, oil, gas, nuclear, hydro, PV, wind, geothermal, biomass, and other renewable energy). Primary energy imports by origin (to calculate the share of imports mij) in each country are from the Coal Information (IEA, 2015a), Oil Information (IEA, 2015c), and Natural Gas Information (IEA, 2015d). Finally, the risk indicator is obtained from the World Governance Indicators (World Bank, 2015). Since the original data range from approximately -2.5 to 2.5 , they are normalized (the scale of 0 to 1). The smaller the values, the larger the country risks to secure energy supply.

Among these databases, natural gas imports by origin and risk indicators do not cover the data before 1992 and 1995, respectively. To cover a sufficient time span for the analysis, we complemented the missing data by using the data in the closest existing year (i.e., 1993 and 1996, respectively).

Total primary energy demand has largely increased from 1960 to the present (Fig. 1). After its peak in early 2000s, the total demand tended to decline. The large increase in the total primary energy demand are mainly due to increases in oil demand. However, after the oil shocks in the 1970s, oil demand did not increase, but rather tended to decrease. Until the early 1980s, coal and oil occupied the largest part of primary energy demand, but after that the shares of nuclear and natural gas increased. Hydropower, which is for power generation, was used constantly during the observed periods. The share of other renewable energy sources has increased recently, although these percentages are still small compared to traditional energy sources. After the Fukushima nuclear disaster, the trend has tremendously changed. Because all nuclear power plants were shut down and most of them have not been resumed, the share of nuclear power was reduced to almost zero. Although total primary energy demand is getting smaller in recent years, such a decline in demand could not compensate for the shut-down of nuclear power plants. This decrease in primary energy supply is compensated for by increases in coal and natural gas. As a result, the share of fossil fuels rose to more than 90%. Although the introduction of renewable energy, particularly PV, has increased after the FIT was implemented in 2012, the share is still very small.

Figure 2 shows how much Japan depends on foreign energy sources. During the observed period, almost 100% of oil was imported. Dependence on imported coal and natural gas was not great from the 1960s to the early-1970s. However, the dependence on imports is rising over time, increasing to almost 100% for these two fossil fuels, similar to oil.

2.3 Scenario analysis

For the scenario analysis, energy scenarios developed by the Institute of Energy Economics, Japan (IEEJ; IEEJ, 2015a,b). These scenarios target the year 2030.

IEEJ’s energy scenarios were developed using their econometric model considering future uncertainties. Four scenarios, hereafter called ES1-4 scenarios, were developed particularly focusing on the power generation mix (renewable energy and nuclear power). Table 1 shows the overview of the scenarios. The ES1 scenario assumes to use more renewable energy and no nuclear power, while the ES4 scenario uses less renewable energy and more nuclear power.

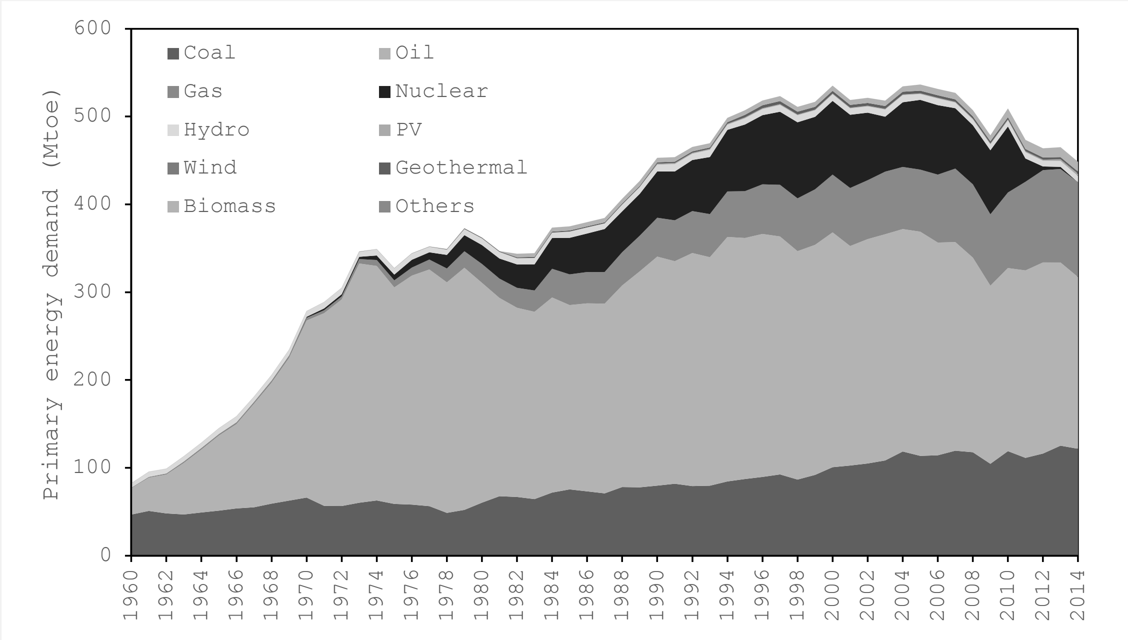

Figure 1: Primary energy demand. "Others" means other renewable energy. Source: IEA (2015b).

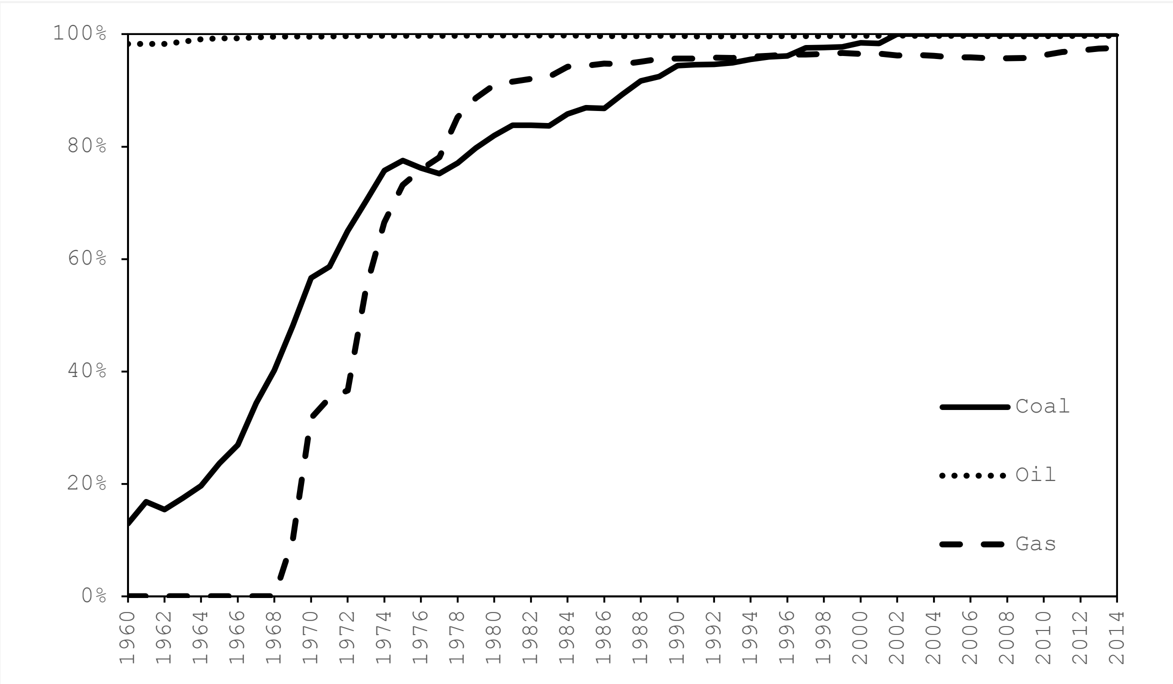

Figure 2: Dependence on import of fossil fuels. Source: IEA (2015b).

The ES 2 and 3 scenarios are in between the two. Nuclear power plants meeting the regulatory standards will operate for 40 years in the ES2 scenario, while power plants passing the special inspection extend their operating periods in the ES3 and 4 scenarios. Power generation by renewable energy will be 2.1 to 4.1 times higher than the current level. Since it is not possible to fully replace nuclear power plants, which comprise baseload power, with renewable energy, the share of thermal power is higher in the low-nuclear scenario. Consequently, ES4 shows lower CO_2 emissions and higher GDP than the other scenarios. Figure 3 shows the primary energy structure under the four scenarios.

Table 1: Overview of the IEEJ's energy scenarios. Source: IEEJ (2015a,b).

		ES1	ES2	ES3	ES4
Power generation mix	Renewable energy (%)	35	30	25	20
	Thermal (%)	65	55	50	50
	Nuclear (%)	0	15	25	30
	Power generation (PWh)	1.1	1.2	1.2	1.2
Economy	Power generation costs (JPY/kWh)	21.0	19.0	16.4	14.8
	Real GDP (trillion JPY)	684	690	693	694
Energy	Self-sufficiency ratio (%)	19	25	28	28
Environment	CO_2 emissions (percent change from 2005 level)	-20	-24	-26	-26

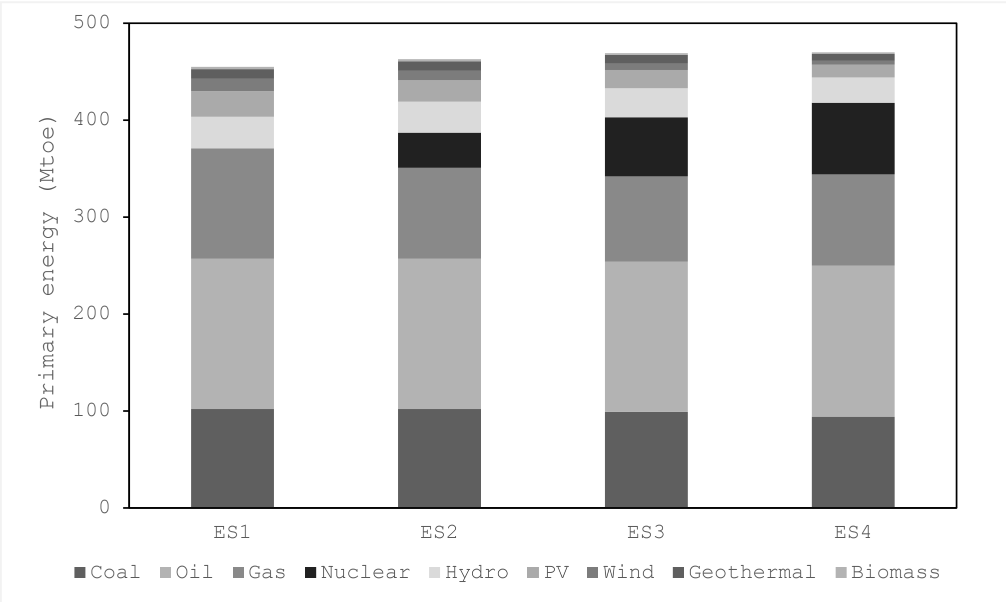

Figure 3: Primary energy structure under the IEEJ's energy scenarios. Source: IEEJ (2015a, b).

3. Results and discussion

3.1 Historical trend of energy security performance

Figure 4 shows historical trends of energy security performance evaluated by three indicators. In the early stage of the analysis (from 1978 to early 1980s), all of the three indicators have increased. This is due to a decrease in the share of oil, and an increase in the share of natural gas and nuclear power in the primary energy structure (see also Fig. 1). This trend is brought about by the oil shocks. However, the trends are different in terms of various indicators after that. The S1 indicator has continuously increased until the early 2010s, while the S2 and S3 indicators (in which energy imports and country risks were taken into account) generally continued to be flat, or become even slightly worse, in the same period.

The S1 indicator purely measures diversity of primary energy. During the corresponding period, the share of oil continuously decreased, while the share of natural gas and nuclear power continuously increased. In addition, the share of renewable energy increased. These effects in total increased the diversity of the primary energy structure. In the case of the S2 and S3 indicators, the dependence on imports cause the indicators to be flat from the 1980s to the 2000s. As shown in Fig. 2, the import of natural gas sharply increased until 1980 and slowly but continuously increased after that. The import of coal also increased from 1978 to the present. Such increases in imports offset the increases in value by diversifying energy sources. For the country risk indicator, because same values are used until 1996, country risk affects the energy security indicator only when the share of import by origin changes.

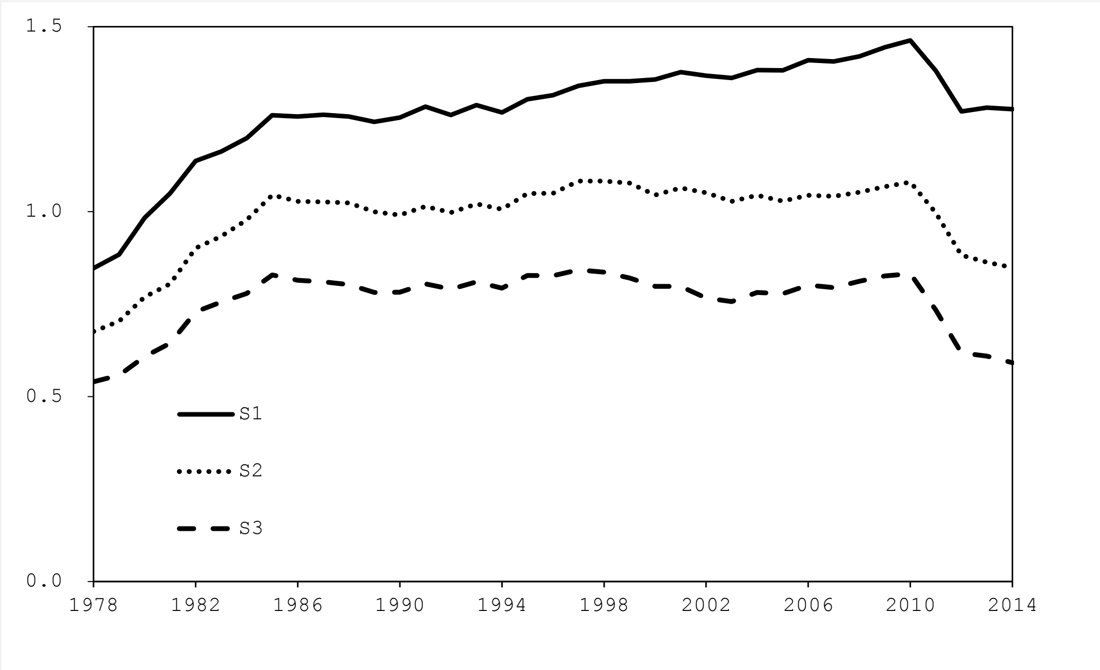

Figure 4: Historical energy security performance in Japan.

If more fossil fuels are imported from higher-risk countries, the energy security indicator declines. From 1996, the situation is similar to that of before 1996 since the country risk indicator does not change greatly. In the case of coal, imports from Australia and Indonesia increased from the mid-1990s to 2000s, while those from Canada and the US decreased. Australia, Canada, and the US are countries with lower risk, while Indonesia is a country with high risk. With regard to oil, imports from Saudi Arabia, which is a higher-risk country, increased, while small decreases were observed in some countries in the same period. For natural gas, imports from Australia, Qatar, and Russia increased, while those from Brunei and Indonesia decreased. Australia is a country with lower risk as indicated above, while Brunei and Qatar are in the middle, and Indonesia and Russia are countries with higher risk. Comparison between the S2 and S3 indicators suggests that import is a more influential factor in determining the values than the country risk factor.

Finally, after 2010, all the indicators declined tremendously due to the shutdown of nuclear power plants after the Fukushima nuclear disaster. During this period, the decrease in the use of nuclear power was compensated for by fossil fuels, particularly natural gas. This change caused a reduction in the diversity of the primary energy structure.

The above results suggest that the diversity of energy structure is the primary factor in determining the performance of energy security. In addition, imports (total imports and diversity of the origin of imports) are also an important factor. As the country risk indicator, does not seem to affect the performance in this study, it might be due to the fact that the risk indicator changes only slightly over time. Therefore, if an incident, such as a war or a civil war, largely changes the situation of a country, it can affect the energy security performance.

3.2 Comparison of scenarios

In analyzing the scenarios, primary energy sources in the original references were aggregated into the sources treated in the historical analysis, although the scenarios do not include the “others” (other renewable energy). Because the share of “others” is very small, this difference does not affect the comparison between the historical and scenario analysis. Note that since only primary energy structure is available from the references, historical data are applied for energy imports and country risk indicators.

When calculating the S2 indicator, we assume that fossil fuel production in the latest year is kept in the future (to calculate the coefficient c2i). This means that fossil fuel production does not change in 2030 from the current level (production of the 10-year average is used) and the fossil fuel demand that cannot be fulfilled by the production is imported. Similar to the S2 indicator, this assumption on the coefficient (c3i) is also considered for calculating the S3 indicator.

Figure 5 shows the results under the IEEJ's scenarios. Since the same assumption is applied for imports and country risk indicators for all the scenarios, the differences by scenario are similar for each indicator. The results suggest that ES2 and 3 scenarios are the highest (the second scenario is slightly higher than the third one for the S1 indicator, while the third one is slightly higher than the second one for the other two indicators), while the ES1 is the lowest. As Table 1 and Fig. 3 showed, the ES1 is the extreme scenario, which uses no nuclear power at all. It means that the primary energy structure is biased toward fossil fuels, although the use of renewable energy is larger than in the other scenarios. The ES2 and 3 have more balanced primary energy structures, particularly for important energy sources (energy sources with larger shares), compared to the other two. ES4 also looks to have balanced energy structure, but the large share of nuclear power reduces the share of renewable energy that consists of several energy types. Consequently, the ES2 and 3 scenarios have more diversified primary energy structures. Observing the S2 and S3 indicators, because import and country risk factors affect evaluation against fossil fuels, the scenarios with higher shares of fossil fuels tend to be more greatly affected.

Comparing the above results with the historical analysis, the values in the four scenarios are higher than those in the historical analysis for all the indicators, meaning that the energy security performance is expected to improve under the given future scenarios. For the three scenarios using nuclear power (ES2-4), use of nuclear power as well as increase in renewable energy contributes to improving energy security performance. Comparing the primary energy structure in this scenario (Fig. 3) with the historical one (Fig. 1), the decrease in nuclear power is compensated for by greater use of renewable energies. In addition, although the total share of fossil fuels remains almost the same, the structure is more balanced by using more natural gas and less oil.

4. Conclusion

Because Japan is poor in energy sources and because its energy situation will be tougher in the future, securing its energy supply will be a more significant issue. In this paper, we first evaluated changes in the historical energy security performance and then analyzed energy security in the future under several energy scenarios.

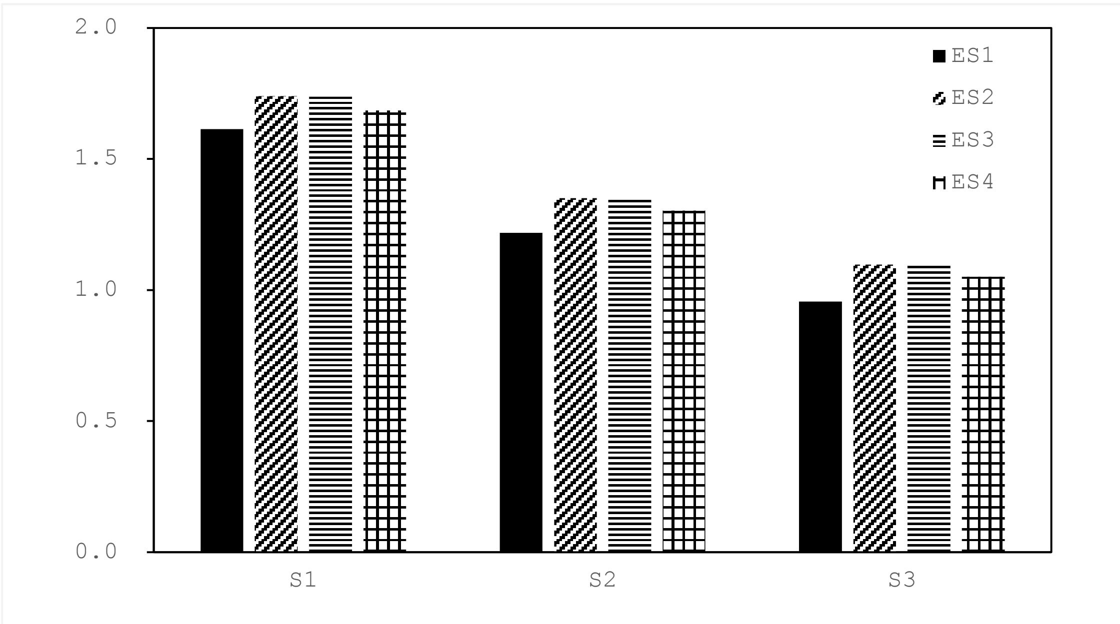

Figure 5: Future energy security performance under the IEEJ's scenarios.

From the historical analysis, it was shown that energy security performance evaluated by three energy security indicators improved over time, although the indicators S2 and S3 were almost flat from the late 1980s to the early 2010s. However, energy security declined from 2011 due to the Fukushima nuclear disaster. This means that diversity of primary energy sources, including nuclear power, is important for high energy security performance. From the scenario analysis, energy security will improve under the future scenarios considered in this study. It is suggested that energy balances mentioned above and also energy saving can improve the energy security performance of Japan compared to the historical situation.

To further improve energy security, additional measures can be considered. First, an increase in the share of renewable energy is necessary to balance primary energy structure. This will also decrease dependence on imported fossil fuels. However, if the share of unstable renewable energy increases too much, power system stability will be affected. Therefore, increases of stable renewable sources (e.g., medium- and small-hydro, biomass, and geothermal power) are expected. In addition, introducing energy storage systems will reduce the influence of increasing unstable renewable energy, although such storage systems will generate an additional cost. Next, with regard to energy imports, balancing the origin of imported energy and reducing imports from high-risk countries will also contribute to improvements in energy security, although these affect only the indicators S2 (only the former) and S3. Last but not least, reducing energy demand (energy saving) is also an important factor for improving energy security performance. By reducing energy demand, energy supply from fossil fuels can be reduced. This will contribute to balancing primary energy sources (increasing the share of renewable energy sources), balancing the origin of energy import, and reducing energy imports from high-risk countries.

Acknowledgments

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Climate Justice Concepts for a Global Treaty – an Australian Perspective

by

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Abstract

Concerns for justice, are widely considered in international climate negotiations as central to effective responses to climate change. However, there is a debate as to what crucial notions of justice need to be reflected in a global climate change treaty. There are various climate justice concepts discussed extensively in literature. Yet, there is no agreement on what concepts should be implemented as guiding into the global climate change treaty. This study uses Delphi method to identify the climate justice concepts that would be most appropriate for the global climate treaty. The attitudes of various countries on climate justice often vary significantly. Accordingly, the Delphi study is focused on Australian experts only to determine what climate justice concepts shall be implemented in the global climate treaty from the Australian perspective. The Delphi study makes use of a group of Australian experts to verify, update and assess importance of the justice concepts essential for climate change treaty. This paper reports upon the conducted study and presents its findings.


Climate Justice Concepts for a Global Treaty – an Australian Perspective
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Background
Presently, many nations acknowledge the need to curb climate change. The question is how to best accomplish this task.
Greenhouse gas (GHG) emissions are not constrained by national borders. Therefore, there is no doubt that global warming is impossible to solve by any one nation alone.
Paris UN climate conference 2015 resulted in an agreement endorsed by nearly 200 countries to keep temperatures below 1.5 degrees
2


Background
Global debate on GHG reduction and climate change adaptation demonstrates that a vital point of the discussion concerns justice.
The climate change impacts justice due to the diverse and far-reaching effects that undermine the realisation of an array of human rights.
Thus, identifying justice concepts that needs to be discussed and implemented in climate change agreement is essential
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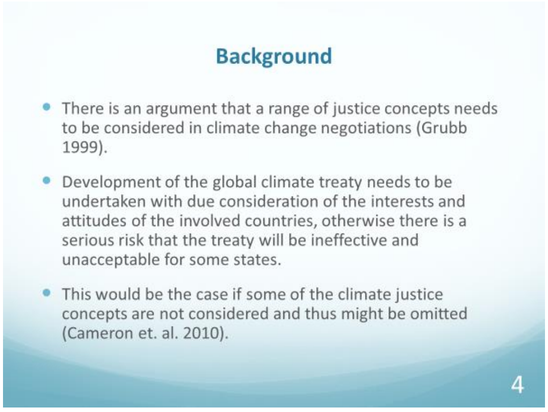
Background
There is an argument that a range of justice concepts needs to be considered in climate change negotiations (Grubb 1999).
Development of the global climate treaty needs to be undertaken with due consideration of the interests and attitudes of the involved countries, otherwise there is a serious risk that the treaty will be ineffective and unacceptable for some states.
This would be the case if some of the climate justice concepts are not considered and thus might be omitted (Cameron et. al. 2010).
4


Justice concepts
There is no mutual agreement on precisely what justice concepts the global climate change treaty should incorporate.
However, there are numerous ideas and concepts discussed in the literature and endorsed by various authors, institutions and organisations.
Climate justice can be explored through its principle or concepts, for example Bali Principles of Climate Justice include 27 concepts.
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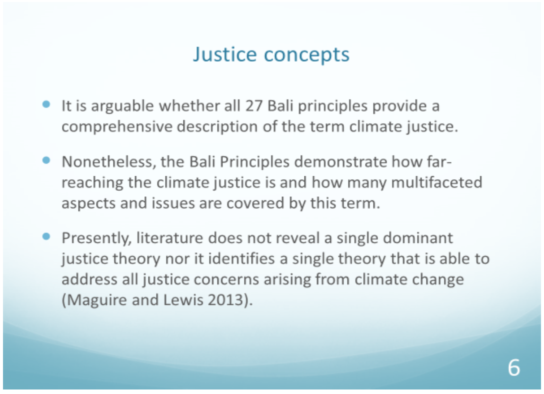
Justice concepts
It is arguable whether all 27 Bali principles provide a comprehensive description of the term climate justice.
Nonetheless, the Bali Principles demonstrate how far-reaching the climate justice is and how many multifaceted aspects and issues are covered by this term.
Presently, literature does not reveal a single dominant justice theory nor it identifies a single theory that is able to address all justice concerns arising from climate change (Maguire and Lewis 2013).
6

Justice concepts

- The climate change inferences are multifaceted and necessitate consideration of a broad array of justice concepts.
- Therefore, the international climate negotiation shall rely upon a full range of the related justice concepts in order to develop a treaty that would be considered as effective and just by all or most of the involved parties and would produce fair outcomes.

7

Justice concepts

- This study's aspiration is to identify all essential justice concepts and distinguish those frequently discussed in the context of global climate change agreement.
- The list of the concepts is cautiously developed by adjusting the concepts commonly discoursed in academic literature and complementing them with the concepts used by the UNFCCC.

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Justice concepts

1. Distributive Justice *(developed countries should pay for GHG reduction and developing countries should be compensated for their GHG reduction efforts)*
2. Corrective Justice (*developed countries have caused the most damage and should thus bear the main burden of GHG mitigation*)
3. Retributive justice (*polluter pays principle, those who cause a problem are responsible for fixing it*)
4. Intergenerational Justice (*present generations have major obligations to future generations including clean environment*)
5. A rights-based approach (*humanity have rights to a stable climate*)
6. Common but differentiated responsibility (*countries have common but differentiated responsibilities*)
7. Capacity Pay Principle (*burden of climate change should be shared on the basis of capability to pay for climate change*)
8. Procedural justice (*concerned with the fairness and transparency of the processes used to make decisions related to climate change*)
9. Consequentialist approach (*just solutions need to be economically efficient in order to minimise burdens on those who pay the costs, while maximising total welfare across the globe*)
10. Capabilities approach (*focusing on whether or not people have the different capabilities necessary to build a fully functioning life*)

9

The Delphi study

- The Delphi technique is a process for forecasting future events by means of a series of questionnaires combined with controlled-opinion feedback.
- Aim of the most Delphi applications is the examination of ideas as well as creation of appropriate information for decision-making.
- The Delphi method is a structured process for accumulating knowledge from a pre-selected group of experts via a series of surveys. The method is equipped to handle a complex problem or task in a systematic way.

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The Delphi study

- The two-round Delphi study was conducted targeting a group of 31 experts, who were selected to represent different viewpoints between the specialists from various disciplines related to climate change justice.
- The membership of the panel is perhaps the most critical point in using the Delphi.

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The Delphi study

- The effective selection of the panel not only maximises the quality of responses, but also provides the results of the study credibility with the wider audience.
- The group of experts composed academics from various fields including economics, law and policy, political science and others.

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The Delphi study

- The Delphi study was prepared using two rounds with questionnaires and the invitation letters which were sent via email to the experts' addresses.
- The 14 experts responded to the first round representing Australia wide and internationally recognised specialists bringing high level of expertise to the study.
- In the questionnaire for the first round, the respondents were asked to think of the potential concepts necessary for international climate change treaty and then to verify and update the proposed 10 concepts form the Australian perspective.

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The Delphi study

- The second question seeks participants' views on importance of those concepts. Experts were asked to weigh these concepts in terms of importance of consideration in the process of negotiation and development of international climate change agreement.
- The experts were asked to weigh each concept based on a standard rating scale 1-5, where -1 indicating not at all important or considered least necessary concept and -5 indicating extremely important, and/or most critical concept.

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The Delphi study

- During the first round, panel members were asked to add any concepts or suggestions which they believed would be imperative for the climate change treaty.
- There were none of the concepts identified as unnecessary by more than 50 percent of the participants.
- Interestingly, the lowest desirability was associated with the concept which is frequently prioritised by economists and policy-makers, namely, consequentialist approach.

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First round results

Intergenerational Justice -	4.5
Distributive Justice -	4.21
Capacity Pay Principle -	4.15
Procedural justice	4.14
Common but differentiated responsibility	4
Corrective Justice	3.46
Retributive justice	3.38
Capabilities approach	3.31
A rights-based approach	3.31
Consequentialist approach	2.75

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First round results

- 15 additional concepts identified by the experts were presented for consideration of the panel members in the second-round questionnaire with the view of obtaining further weighting/comments from experts.
- Only 'ecological justice' is considered to be essential for climate change policy evaluation by more than 50 percent of experts.
- The 'ecological justice' has been named by three experts as essential concept during the first round of the Delphi study.

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Results

Intergenerational Justice -	4.5	90%
Distributive Justice -	4.21	84.2%
Capacity Pay Principle -	4.15	83%
Procedural justice	4.14	82.8%
Common but differentiated responsibility	4	80%
Ecological justice	4	80%
Corrective Justice	3.46	69.2%
Retributive justice	3.38	67.6%
Capabilities approach	3.31	66.2%
A rights-based approach	3.31	66.2%
Consequentialist approach	2.75	55%

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Results

- The findings of the Delphi study provide a set of justice concepts from Australian perspective that could reinforce the utility of the assessed concepts in the context of the global climate change treaty.
- However, further research on the climate justice concepts and its implementation into global climate treaty is needed in order to conclude on the reliability and efficacy of the findings of this study.
- Moreover, the utility of such approach could be further enhanced through a range of comparable Delphi studies conducted in other countries.

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Conclusion

- Further research in this direction would facilitate a common understanding of climate justice and its concepts, besides such inquiry will be an indispensable source of information, essential for productive efforts towards global climate change treaty.

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Questions?

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An econometric model for energy demand forecasting in transport & buildings sectors for the EU countries

by

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Abstract

This paper presents an econometric model that provides the mathematical reflection of energy consumption as a function of GDP, household income and any other relevant economic factors for the EU countries. It provides the aggregate energy demand econometric functions for 8 countries: Belgium, Bulgaria, Estonia, Germany, Hellas, Italy, Serbia, UK, for the transport and buildings sector, namely residential and tertiary sectors. The models have been designed to have the same or similar explanatory variables, in order to capture the differences among countries and sectors. The required data have been collected from two official EU sources, namely the EUROSTAT and the ODYSSEE databases. The variables have been accessed and evaluated from the EUROSTAT and ODYSSEE databases towards their suitability if predicting energy demand in the transport and buildings sector. The model results are aligned with the expectations, concerning the sign of the coefficients. This concerns all main variables, namely price variables have a negative sign, while economic activity, stock, Heating Degree Days and population variables have a positive sign. Moreover, all models that were selected showed a high R square (R2), which is a strong indicator of the reliability of those models. The models can be used from the national experts/modellers to form their scenarios towards examining socio-economic factors at Energy efficiency policies in the EU.

1. Introduction

This paper is an outcome of the WP4.3 of the HERON project. According to the description of the WP4.3, the task aims at providing: "The mathematical reflection of energy consumption as a function of GDP, household income and any other relevant economic factor will be defined by UoA0KEPA. The necessary functions will be used in the LEAP modelling to illustrate the future evolution of energy consumption in buildings and transport. This report provides the aggregate energy demand econometric functions for the 8 countries: Belgium, Bulgaria, Estonia, Germany, Hellas, Italy, Serbia, UK, for the transport and buildings sector, namely residential and tertiary sectors. The models have been designed to have the same or similar explanatory variables, in order to capture the differences among countries and sectors. The datasets for all above mentioned databases are available for the period from 1990 to 2013. However, there are variables for some countries where data are available for earlier period e.g. in 1980s or even earlier for macro variables such as population, while there exist other variables with availability for more recent data, e.g. even the current year 2015 for energy prices data. Considering that the estimation of econometric variable requires full datasets or incomplete datasets where missing data/observations can be filled with a justifiable clarification. Therefore, the majority of the econometric models estimated at this section, have been estimated with datasets for the period 1990-2013.

2. Data Sets

The required data have been collected from two official EU sources, namely the EUROSTAT and the ODYSSEE databases. The ODYSSEE database is part of the ODYSSEE-MURE project, which is co-ordinated by ADEME with the technical support of Enerdata, Fraunhofer, ISIS and ECN. A network of 33 partners from 28 countries participate to the ODYSSEE MURE project, usually national Efficiency Agencies or their representatives within the European network of energy efficiency agencies (« EnR »). It is supported by the Intelligent Energy Europe programme and is part of the activity of the EnR Club. The ODYSSEE database is managed by Enerdata that contains detailed energy efficiency and CO_2-indicators with data on energy consumption, their drivers (activity indicators) and their related CO_2-emissions. The variables that have been accessed and evaluated from the EUROSTAT and ODYSSEE databases towards their suitability if predicting energy demand in the transport and buildings sector are in Tables 1 and 2.

The methodology, for elaborating with the data, towards estimating the parameters of the econometric equations, is the following:

- The above-mentioned variables are collected and stored in a database for the needs of this study;

Table 1: List of variables from the ODYSSEE database, that have been accessed and elaborated towards creating the econometric models.

Sector	ODYSSEE database variables
Macro variables	Total final consumption Population Number of households GDP at exchange rate GDP at 2005 purchasing power parities Final energy intensity Final energy efficiency index
Transport sector	Final consumption of transport Stock of cars Registration of new cars Annual distance travelled by cars Total passenger traffic
Tertiary sector	Final consumption of tertiary sector Value added of tertiary Floor area of tertiary Employment of tertiary
Residential sector	Final consumption of residential Final consumption of residential with climatic correction Total stock of dwellings Floor area of dwellings (average) Heating degree-days Stock of appliances Rate of equipment ownership for air conditioning

Table 2: List of variables from the EUROSTAT database, that have been accessed and elaborated towards creating the econometric models.

Sector	EUROSTAT database variables
Macro variables	Real GDP per capita Population Value added by economic sector GDP deflator Harmonized Index for Consumer Prices
Transport sector	Final consumption of transport Gasoline prices Diesel prices
Tertiary sector	Final consumption of tertiary sector Value added of tertiary Electricity prices Gas prices
Residential sector	Final consumption of residential Gas prices Electricity prices Number of households Average people per household

- Data handling process aims at bringing the data in similar formats, filling missing data if this can be justified and creating new variables, combining the initial ones.
- Statistical analysis of the data, e.g. descriptive statistics, t-tests etc
- Visualization of data, providing graphs at can be seen in the following section.

Figures 1-15 present the graphical representation of the evolution of critical variables for the transport, tertiary, residential sector as well for the macro-economy. This enables an initial visual interpretation of the energy demand evolution in correlation with other variables.

2.1 Transport variables

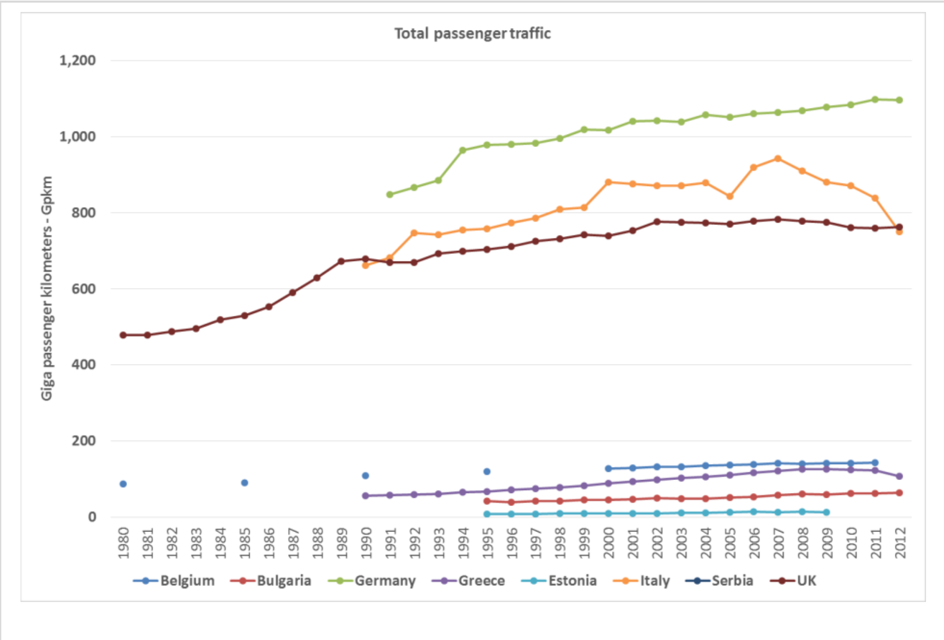

Figure 1: Evolution of the total passenger traffic in Giga passenger kilometers (Gpkm) for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

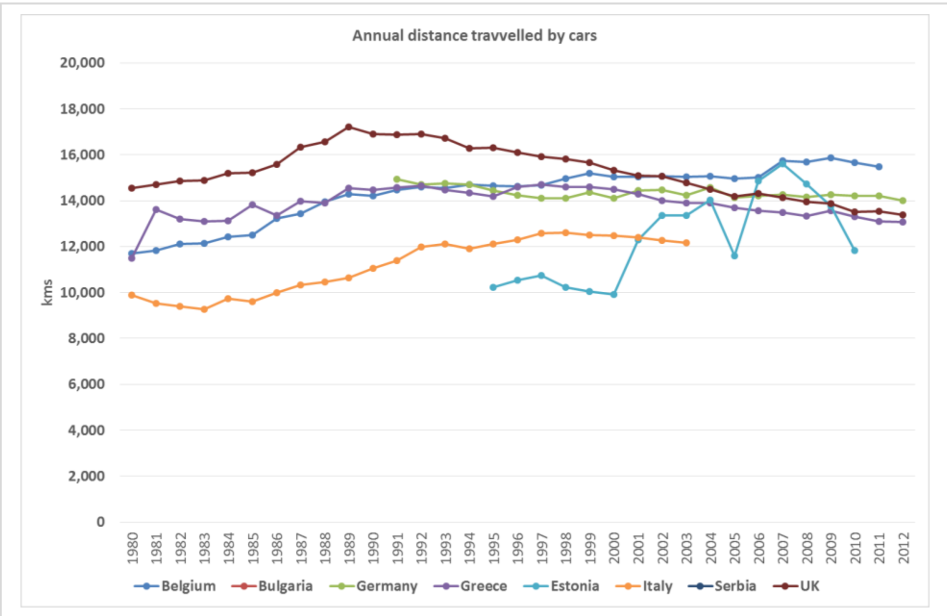

Figure 2: Evolution of the annual distance travelled by car in kilometers (km) for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

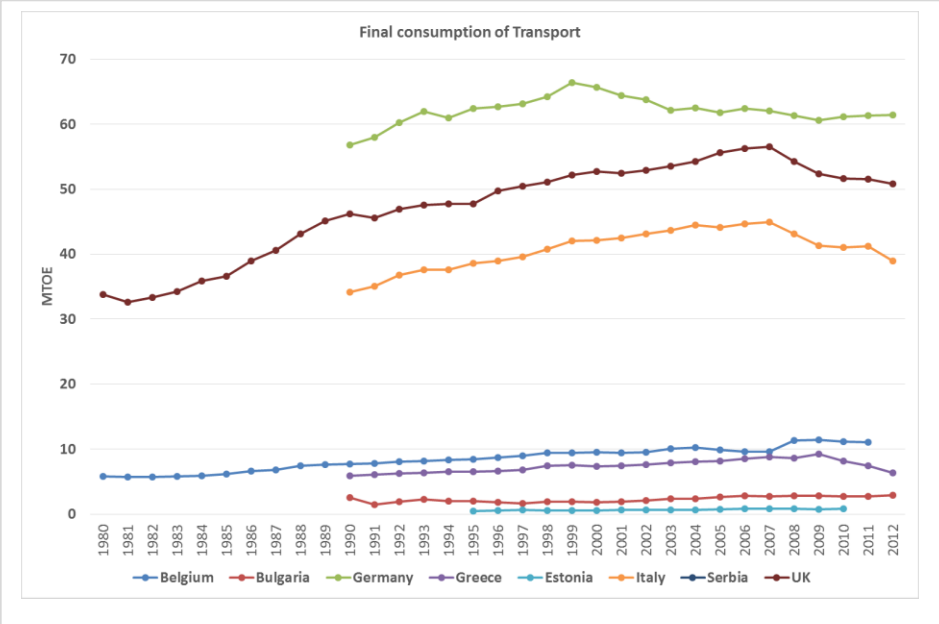

Figure 3: Evolution of the stock of cars in thousands for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

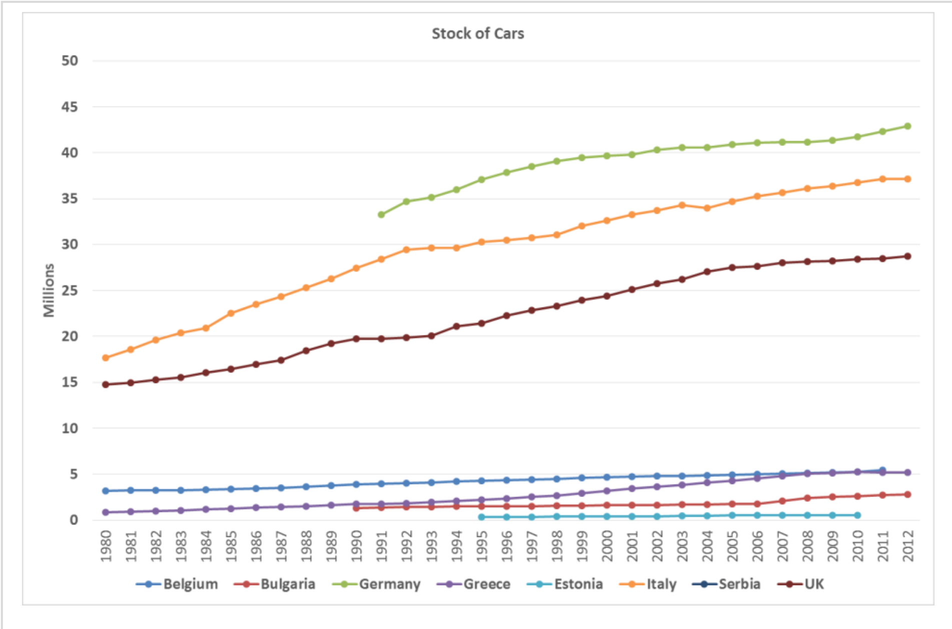

Figure 4: Evolution of the final consumption for the transport sector in Millions Tons of Oil Equivalent (MTOE) for 8 specific EU countries over the period 1980-2012, source: ODYSSEE database.

3. Methodology

This section provides the econometric models for the aggregate energy demand for 8 specific European countries for the transport and buildings sector. As mentioned above the lack of historical data for Serbia does not enable the estimation of the relevant econometric models for this country.

In general the datasets for all above mentioned variables are available for the period from 1990 to 2013. However, there are variables for some countries where data are available for earlier period e.g. in 1980s or even earlier for macro variables such as population, while there exist other variables with availability for more recent data, e.g. even the current year 2015 for energy prices data. Considering that the estimation of econometric variable requires full datasets or incomplete datasets where missing data/observations can be filled with a justifiable clarification.

2.2 Tertiary variables

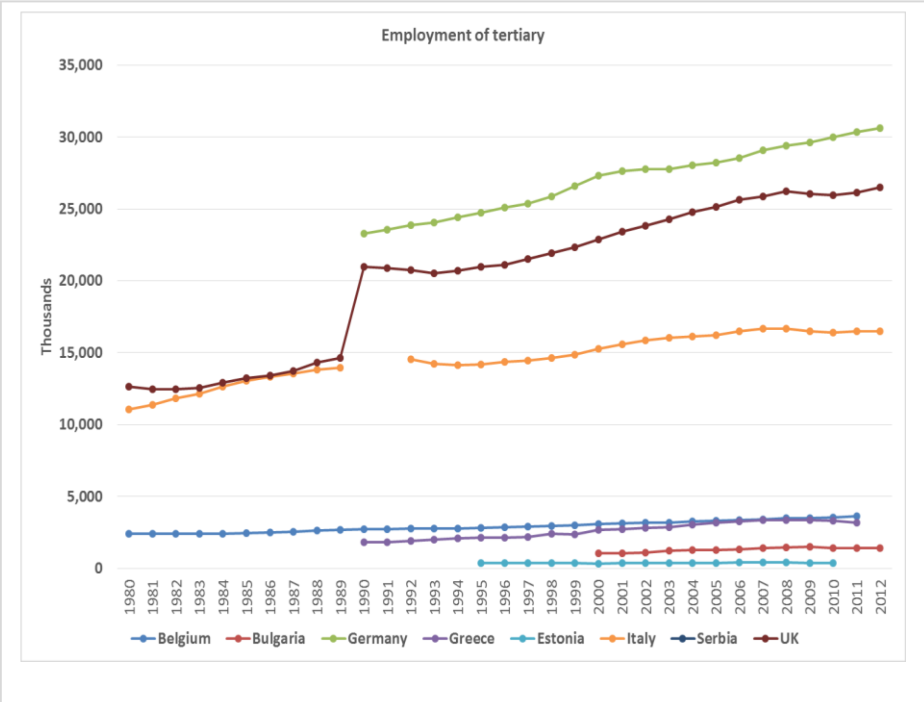

Figure 5: Evolution of the employment for the tertiary sector in thousands for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

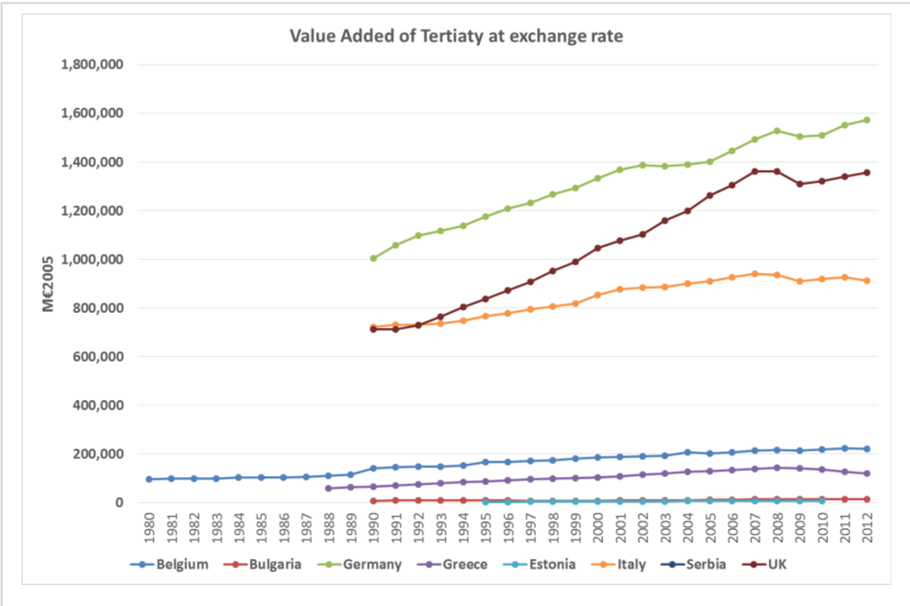

Figure 6: Evolution of the value added for the tertiary sector at exchange rate in Million 2005 Euros for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

Therefore, the majority of the econometric models estimated at this section, have been estimated with datasets for the period 1990-2013. From the 8 countries examined in this report, Germany, UK, Italy, Belgium and Greece are considered as countries with high availability and quality of their corresponding datasets. The same happens also for Estonia, however very few data exist before 1995 and also after 2010, leading to estimates with a smaller dataset.

Concerning Bulgaria, although it has a detailed dataset for the majority of variables

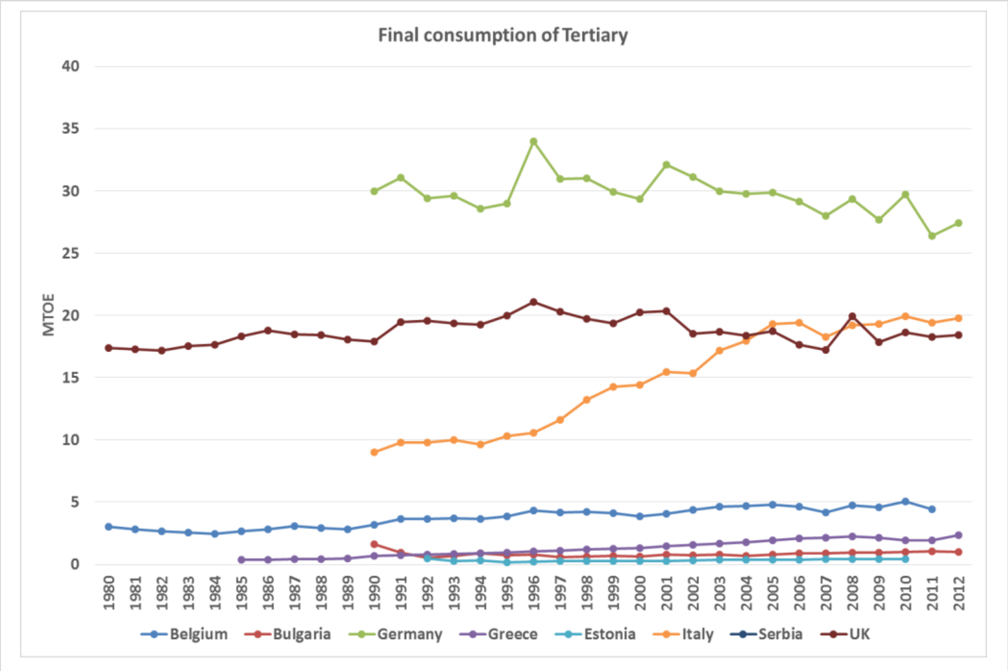

Figure 7: Evolution of the final consumption for the tertiary sector in Millions Tons of Oil Equivalent (MTOE) for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

2.3 Residential variables

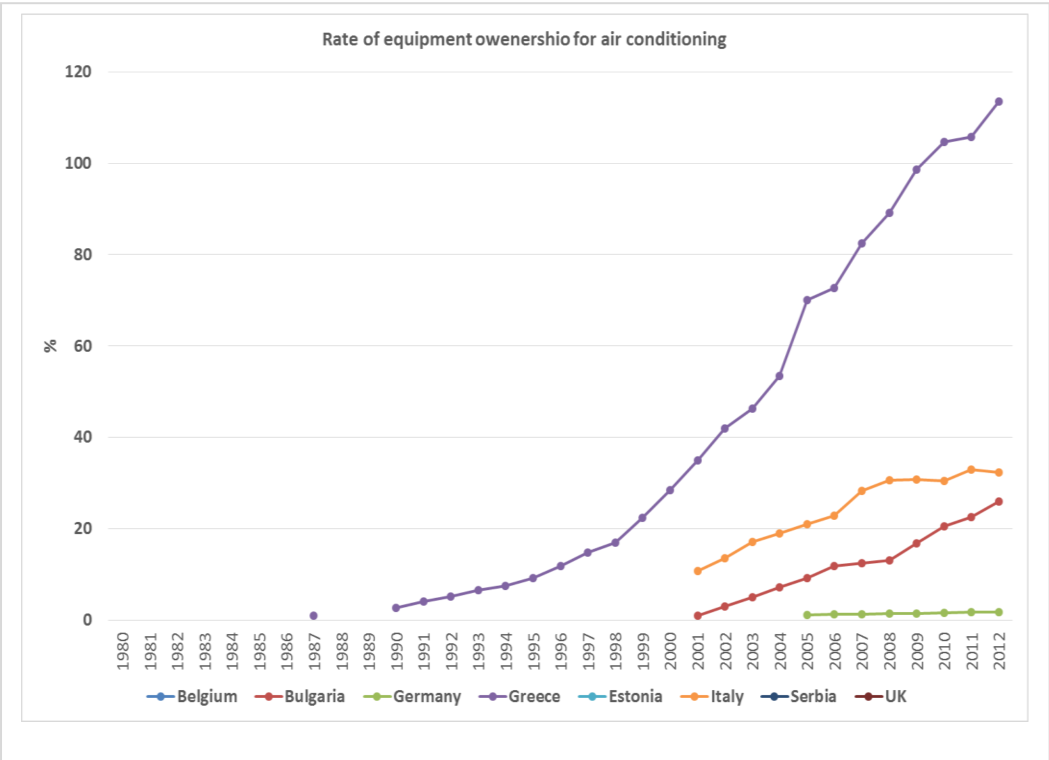

Figure 8: Evolution of the rate of equipment ownership for air conditioning in % for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

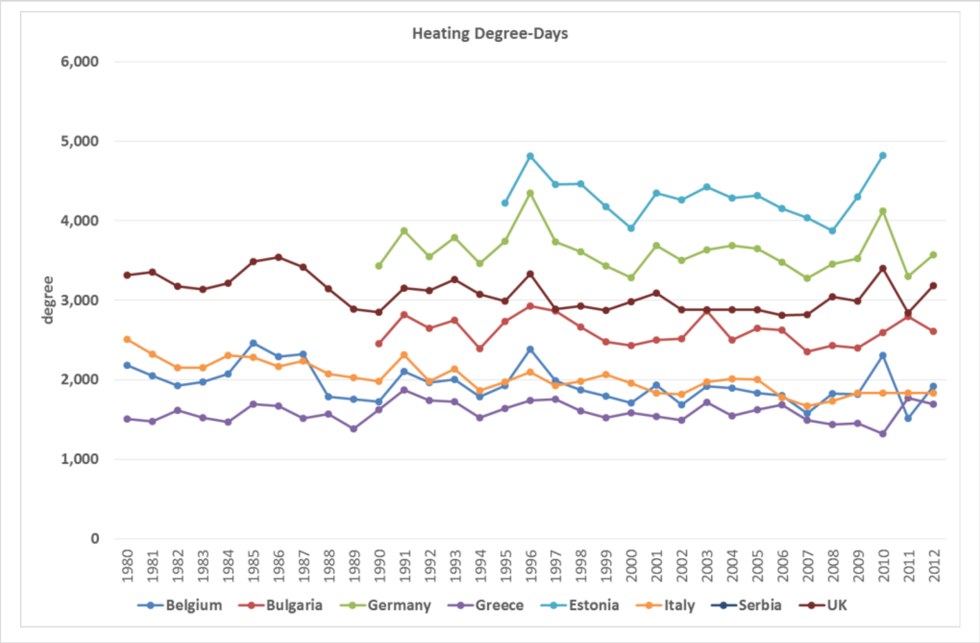

Figure 9: Evolution of the Heating Degree-Days (HDD) in degree-days for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

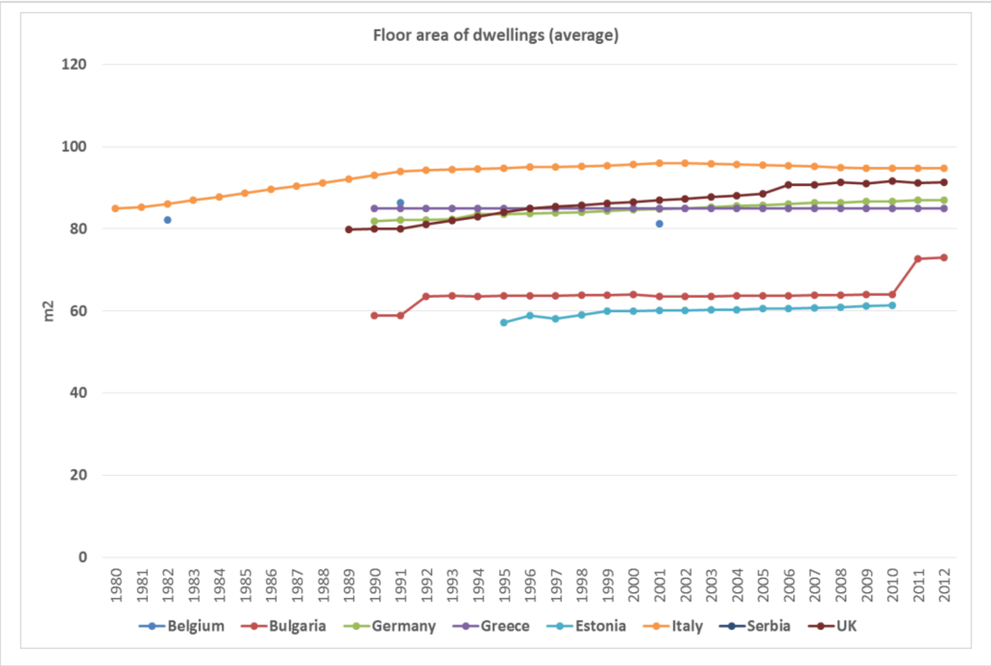

Figure 10: Evolution of the average floor area of dwellings in square meters (m^2) for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

starting from 1990, the lack of adequate energy prices time-series, lead to the need to use the Harmonized Index of Consumer Prices, for all products but also for energy and liquid fuels, as price indicators, which datasets start in 1997. The report aims at developing a general model that can be applied to different countries, different sectors (residential, tertiary, transport) and different energy products (oil, gas, electricity) under different specifications. A similar effort has been implemented in a recent study (Hirl and Bertoldi, 2013) concerning the building sector, namely the tertiary and residential sectors.

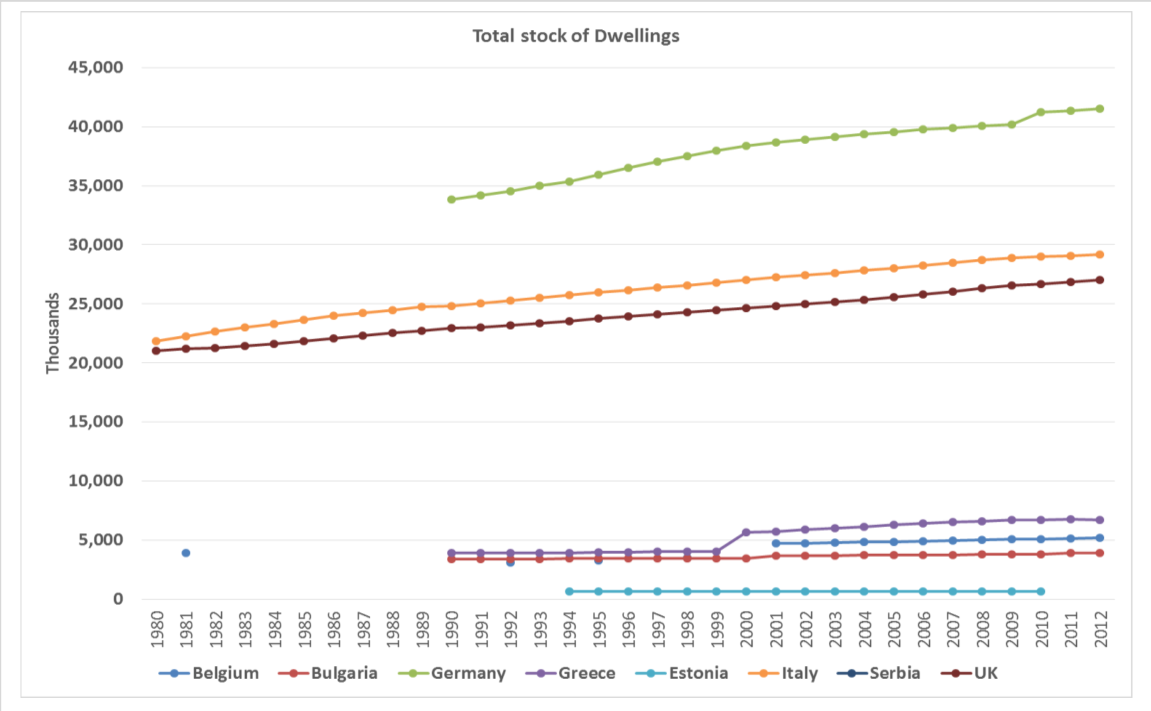

Figure 11: Evolution of the total stock of residential dwellings (households) in thousands for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

2.4 Macro variables

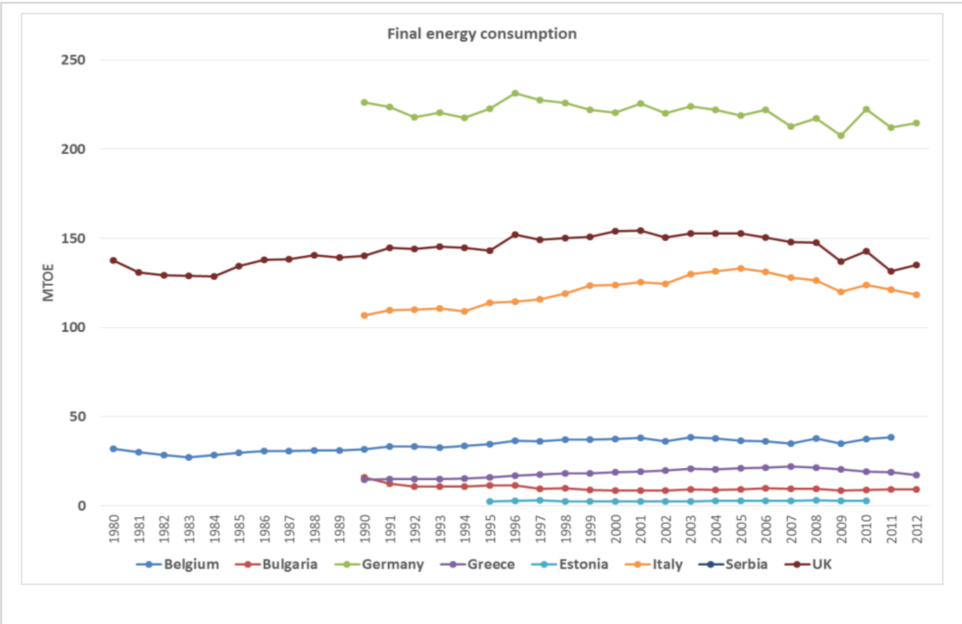

Figure 12: Evolution of the final consumption in Millions Tons of Oil Equivalent (MTOE) for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

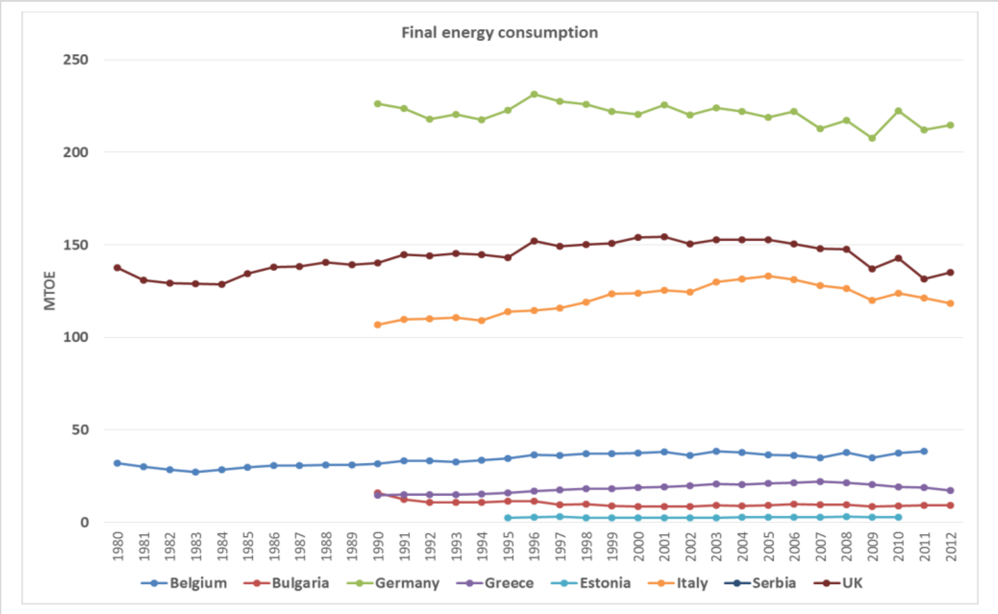

Figure13: Evolution of the Private consumption of households at 2005 Purchasing Power Parities (PPP) in Million 2005 Euros for 8 specific European countries over the period 1980-2012, source: ODYSSEE database.

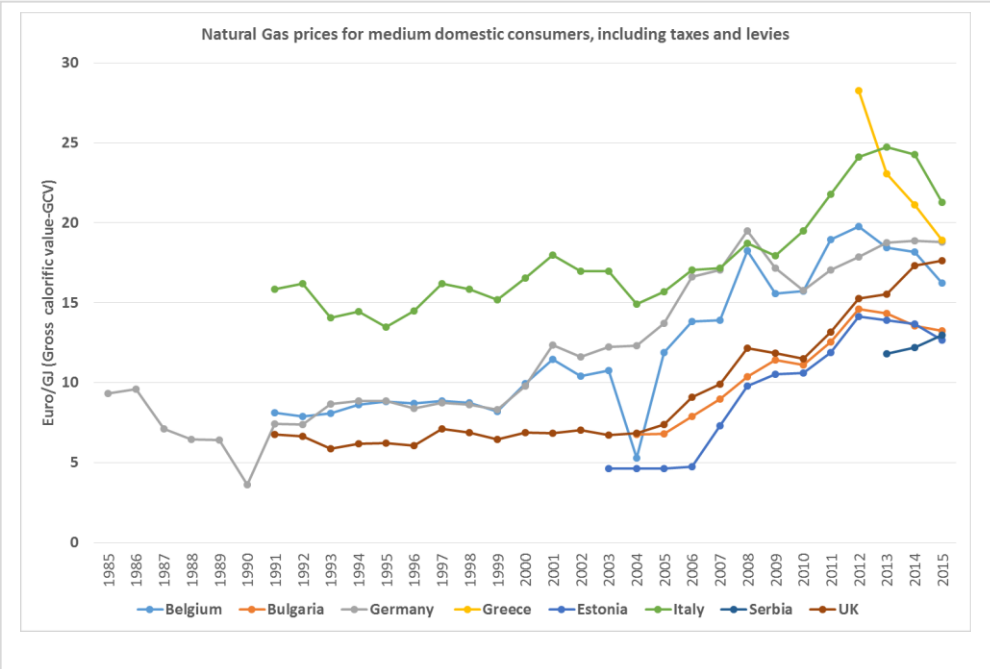

Figure 14: Evolution of Natural Gas prices for medium domestic consumers, including all taxes and levies, in Euro/GJ (for Gross Calorific Value – GCV) for 8 specific European countries over the period 1985-2015, source: EUROSTAT database.

This effort is further extended in this study, trying to incorporate further explanatory variable but as well to apply it also for the transport. There are two main forms of the econometric models: time series models and panel data models. Concerning time series models, individual models for each country has to be estimated. Concerning panel data models, aggregate models for similar countries have to be estimated e.g. one for the more developed (Germany, UK, Italy, Belgium and Greece) and one for the Eastern European countries (Bulgaria, Estonia and Serbia). Considering that the focus of this report is to provide econometric models for each country,

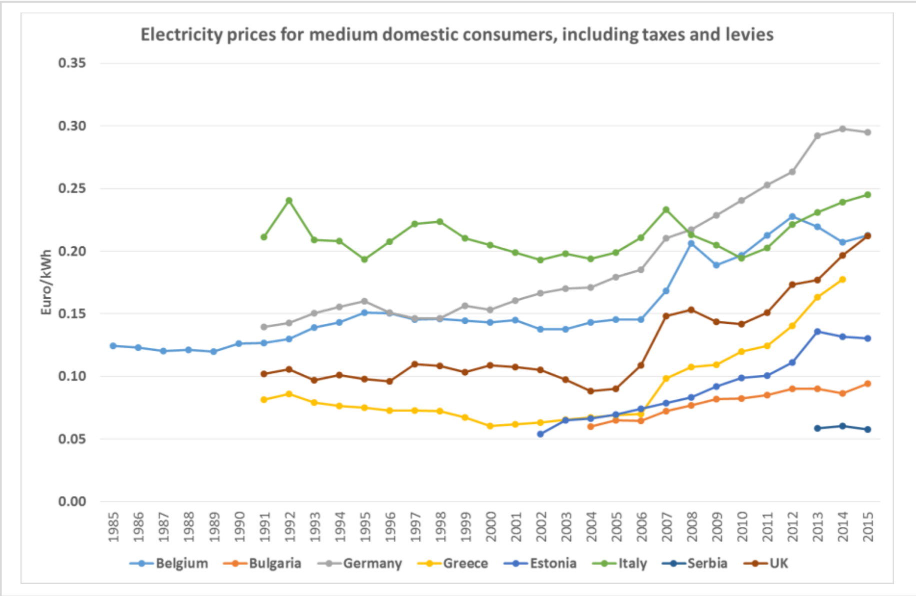

Figure 15: Evolution of electricity prices for medium domestic consumers, including all taxes and levies, in Euro/kWh for 8 specific European countries over the period 1985-2015, source: EUROSTAT database.

which will be used by national energy policy experts in forming scenarios in the LEAP model, we consider that it is more appropriate to estimate individual time series models for each country. Moreover, a recent study (Hill and Bertoldi, 2013) has shown that the results from the individual time series models are generally more precise and reliable than from the panel model.

Generally, energy demand is affected by energy prices, economic activity and weather conditions but as well as other variables related to the stock (of dwellings, appliances and cars etc), the population, the energy efficiency index in order to capture the effect of the technology or behavioural change. The incorporation of variables such as the latter is important to capture energy savings effect from the implementation of green fiscal policies (Junankar et al., 2009). Such indicators are also important towards elaborating policies that stimulate energy-efficiency improvements, as they enable the partly capturing of their rebound effects Barker et al., 2009). Other variables such as employment, Cooling Degree Days and the price of competitive fuels are also important, as shown in a recent study (Polemis and Dagoumas, 2013).

Energy demand is the dependent variable of the econometric model, while all the others are the explanatory variables. All variables, as the literature suggests for better fitting and representation of the models are expressed in log form.

The general aggregate energy demand model has the following form:

$$E_{i,t} = f\left(\mathrm{Pr}_{i,t}, EA_t, St_{i,t}, Pop_t, HDD_t\right).$$

where:

$E_{i,t}$, concerns the Energy demand for energy product i in year t

$\mathrm{Pr}_{i,t}$, concerns the Price (energy prices of product I or of competitive products, Harmonized Index for Consumer Prices) for energy product i in year t

EA_t, concerns the Economic Activity (GDP per Capita, Value Added of the sector) in year t

$St_{i,t}$, concerns the Stock (of dwellings, appliances, cars) for energy product i in year t

Pop_t, concerns the Population in year t

HDD_t, concerns the Head Degree Days (and/or Cooling DD if available) in year t

The general model provides a reliable forecast for aggregate energy demand, but it is also adequate for forecasting energy demand for some major fuels in a sector (e.g. electricity in the residential sector). However, the forecast of energy demand for each fuel is a more complicated issue, strongly related to policy measures, which could be incorporated in the model through policy variables from national energy policy experts.

Table 3: Detailed list of variables from the ODYSSEE and EUSOSTAT databases that have been elaborated towards creating the econometric models.

Residential	Tertiary	Transport
Electricity Price	Electricity Price	Electricity Price
Gas Price	Gas Price	Gas Price
HICP - All products	HICP - All products	HICP - All products
HICP - Liquid fuels	HICP - Liquid fuels	HICP - Liquid fuels
HICP - Energy	HICP - Energy	HICP - Energy
Coal consumption of residential sector	Coal consumption of tertiary	Annual distance travelled by cars
Degree-days	Degree-days	Average specific consumption (l/100 km) of cars
Electricity consumption of residential	Electricity consumption of tertiary	Car traffic
Energy efficiency gains in residential	Electricity intensity of services sector	Degree-days
Energy efficiency index of households	Electricity unit consumption in private offices	Diesel consumption of cars
Final consumption of	Employment of tertiary	Diesel consumption of transport
Floor area of dwellings (average)	Energy efficiency gains in tertiary	Electricity consumption of transport
Gas consumption of residential sector	Energy efficiency index of tertiary	Energy efficiency gains in transport
GDP per inhabitant (ppp)	Energy intensity of services sector (at purchasing power parities)	Energy efficiency index of transport
Number of households	Final consumption of tertiary	Energy intensity of transport
Oil consumption of residential sector	Floor area of tertiary	Final consumption of transport
Population	Gas consumption of tertiary	Fuel oil consumption of transport
Private consumption per households (ppp)	GDP per inhabitant (ppp)	Gas consumption of transport
Renewable consumption of residential tertiary ...	Oil consumption of tertiary	GDP per inhabitant (ppp)
Stock of dwellings (permanently occupied)	Population	Oil products consumption of transport
Total stock of dwellings	Total consumption of tertiary (with climatic corrections)	Population
	Value added of tertiary at exchange rate	Share of public transport in total land passenger traffic
		Stock of cars
		Total consumption of road transport
		Total passenger traffic

For example, the penetration of electric cars is strongly related to the existence of subsidy schemes by the governments.

Therefore, the current report provides an aggregate energy demand econometric model for the three sectors (transport, residential and tertiary) for the above-mentioned countries.

In order to estimate the short-run and long-run elasticities, we followed the two-step Engle and Granger (1987) methodology by estimating an error correction model (ECM). The main reason for using this approach instead of using a vector auto regression model (VAR) is that the latter is more sensitive to the number of lags that can be used (Kremers et al.,1992), while on the other hand the individual coefficients in a VAR are difficult to interpret, so the analysis must focus on the causal relationships of the endogenous variables. Using an ECM, short- and long-run effects can be captured by estimating the short- and long-run elasticities, respectively (Banerjee et al.,1993). However, the goodness-of-fit measure (R2), that has been used to assess the performance of the different models, has increased slightly, adding also complexity in the models. Therefore, for the needs of this report, which is to provide precise and reliable models – adequate to forecast energy demand in the building and transport sector, we don't provide estimates for the more detailed models that include both the long-run and short-run elasticities.

Moreover, in order to conclude to the suggested models for the energy demand functions, a number of different combinations from a list of variables, shown in Table 3, have been elaborated. Tables 4-6 present the latest available data for those variables. Some of those variables have been exempted because of the insufficient data, while some others because they did not strengthen the reliability and preciseness of the model. The overall criterion for approving the suitability of one model is the goodness-if-fit measured, where R-squared (R2) is unanimously used. R2 is a measure showing how much of the variance in the dependent variable is explained by the independent variables of the proposed model. The aim of the modellers is to develop a model with high R2, as much close to 100%.

Moreover, another important criterion is the sign and significance level of the coefficients. E.g. price is expected to have a negative effect on the energy demand, while economic activity a positive one. The model results are aligned with the expectations, concerning the sign of the elasticities. This concerns all main variables, namely price variables have a negative sign, while economic activity, stock, Heating Degree Days and population variables have a positive sign.

Moreover, the significance level of the estimation outputs is very important; as the modellers aim at p-values lower than the 5% significance level. However, sometimes a modeller may accept p-values at higher significance level e.g. 10% or even higher, in case his priority is on the forecasting preciseness rather than on the goodness-of –fit measure (Hirl and Bertoldi, 2013).

The following tables show the R-square, coefficients, t-statistic and p-values of the models. The models that are presented have been selected through an extended number of models, combining different parameters. The main criteria were the highest R2, the sign of the coefficients and then the significance level of the coefficients. For the needs of this study which aims at providing forecasts to be used in the LEAP model, we also consider the forecast error for a period of the last 5 years with available data e.g. 2009-2013. This period was not excluded from the dataset used for the fitting of the model, as the remaining dataset would have few years for a reliable estimation, especially in case of some countries. Therefore, we have incorporated the sample period of the last 5 years both in the fitting process but also in the forecast validation process. This technique is not misleading, but in fact it uses a broad dataset of many years for model fitting, considering that the last years are more important in minimizing the forecast error. This is a technique that is also implemented in other forecasting methodologies, such as the neural networks. The main drawback for this technique in the econometric models is that the significance level of some parameters' coefficients might be higher than the usually accepted 5% significance level. In fact there is a trade-off between the forecast error and the estimation outputs that are statistically significant.

4. Results

This section provides the results from the estimation of the econometric models for the aggregate energy demand. The models are presented by country and sector.

Two important comments:

1. The estimated models are not using direct values of the variables, but their logarithmic value, as the majority of the literature is doing on energy demand forecasting models. Therefore, al variables listed in the upcoming tables (besides the intercept) refer to their logarithmic value.
2. The criterion for selecting the variables are: a. having a general model (meaning same variables among countries); b. having a high Adjusted R square, as measure of the fitting of the model, c.

having low forecast errors in the last 5 years and d. the coefficients having the expected sign e. the coefficients are statistical significant.

a. This has led to the omission of some critical values, such as the population for residential demand, although it developed the model but provided no logical signs of coefficients for some countries e.g. Belgium.
b. Moreover, several models have coefficients that are not statistical significant, which normally would lead for judging them as not suitable.
c. Finally, some models have low Adjusted R square, e.g. 0.6 for Estonian residential demand, which means that the model is not good. However, the facts that we adopted the logic of a generic model among countries, together with the lack of longer time-series and variables cannot lead to significant improvements for those insufficient models.

This section organizes the above estimations in one chapter, in order the estimated parameters to be organized together allowing comparisons among parameters, sectors and countries. The following Tables 4, 6 & 8 present the estimated parameters, while Tables 5, 7 &9 present the initial values of the variables considered in the analysis.

5. Conclusions

This paper is an outcome of the WP4.3 of the HERON project. According to the description of the WP4.3, the task aims at providing: “The mathematical reflection of energy consumption as a function of GDP, household income and any other relevant economic factor will be defined by UoA0KEPA. The necessary functions will be used in the LEAP modeling to illustrate the future evolution of energy consumption in buildings and transport.”

This report provides the aggregate energy demand econometric functions for the 8 countries: Belgium, Bulgaria, Estonia, Germany, Hellas, Italy, Serbia, UK, for the transport and buildings sector, namely residential and tertiary sectors. The models have been designed to have the same or similar explanatory variables, in order to capture the differences among countries and sectors.

The report aims as designing a general energy demand model, applicable for many sectors, countries and energy products. In general, energy demand is affected by energy prices, economic activity and weather conditions but as well as other variables related to the stock (of dwellings, appliances and cars etc), the population, the energy efficiency index, employment, Cooling Degree Days and the price of competitive fuels.

The general energy demand model that was created has the following form:

$$E_{i,t} = f\left(\Pr_{i,t}, EA_t, St_{i,t}, Pop_t, HDD_t\right),$$

where:

$E_{i,t}$, concerns the Energy demand for energy product i in year t

$Pr_{i,t}$, concerns the Price (energy prices of product I or of competitive products, Harmonized Index for Consumer Prices) for energy product i in year t

EA_t, concerns the Economic Activity (GDP per Capita, Value Added of the sector) in year t

$St_{i,t}$, concerns the Stock (of dwellings, appliances, cars) for energy product i in year t

Pop_t, concerns the Population in year t

HDD_t, concerns the Head Degree Days (and/or Cooling DD if available) in year t

The overall criterion for approving the suitability of one model is the goodness-if-fit measured, where R-squared (R2) is unanimously used.

The aim of the modellers is to develop a model with high R2, as much close to 100%. Moreover, another important criterion is the sign and significance level of the coefficients.

These were the main criteria for approving the suitability of the models, namely the highest R2, the sign of the coefficients and then the significance level of the coefficients. For the needs of this study which aims at providing forecasts to be used in the LEAP model, we also consider the forecast error for a period of the last 5 years with available data e.g. 2009-2013.

4.1 Residential

Table 4: Estimated parameters for the residential sector for the different countries.

	Belgium	Bulgaria	Germany	Greece	Estonia*	Italy	UK
Intercept	6.644716	6.942301	-1.27007	-16.0672	-48.6965	-19.4146	4.450599
HICP - Energy	-0.02108	0.054807	-0.04524	-0.30224	-1.5315	-0.15074	-0.11411
Degree-days	0.470227	0.561068	0.654841	0.821086	0.098886	0.54168	0.806856
GDP per inhabitant (ppp)	0.428408	0.841065	-0.25323	1.220438	1.602099	0.54529	0.862163
Private consumption per households (ppp)	0.61676	-0.81246	1.760128	-0.81926	-1.21666	-0.32967	0.023787
Stock of dwellings (permanently occupied)	-1.36568	-1.29629	-0.48143	1.474649	8.460281	1.876187	-0.94882

* Variable "HCIP - All Products" instead of "HCIP Energy"

Table 5: Last available values for each variable used for the estimation of the parameters for the residential sector for the different countries.

Residential	Units	Belgium	Bulgaria	Germany	Greece	Estonia	Italy	UK
	Year	2013	2012	2013	2013	2010	2013	2012
Electricity Price	€/kWh	0.2194	0.09005	0.292	0.163	0.0987	0.23075	0.17335
Gas Price	€/GJ (GVC)	18.435	14.5823	18.74	23.05	10.6033	24.73	15.2727
HICP - All products	2005=100	119.57	144.58	115.3	121.56	126.95	119	123
HICP - Liquid fuels	2005=100	144.24	150.6	143.2	203.57	155.65	145	176.3
HICP - Energy	2005=100	171.27	169.3	155.8	262.07	131.76	140.5	201.7
Coal consumption of residential sector	MTOE	0.11	0.26	0.68	0	0.01	0	0.66
Degree-days	Degree-Days	2137.7	2610.68	3365.59	1451.37	4825.41	1828.97	3182.72
Electricity consumption of residential	MTOE	1.7	0.93	11.9	1.5	0.17	5.76	9.87
Energy efficiency gains in residential	%	30.42	15.94	21.4	4.47	10.77	7.51	23.46
Energy efficiency index of households	2000=100	69.58	84.06	78.6	95.53	89.23	92.49	76.54
Final consumption of residential	MTOE	8.97	2.4	59.54	3.76	1.03	30.05	40.49
Floor area of dwellings (average)	m^2		73.07	91.3	85	61.3	93.65	91.37
Gas consumption of residential sector	MTOE	3.72	0.05	23.07	0.23	0.06	14.03	26.7

GDP per inhabitant (ppp)	k€2005	28.21	9.88	30.53	17.04	13.87	22.42	29.51
Number of households	k	4770.26	3082.65	39933	4613.43	583.9	24997.79	26794.43
Oil consumption of residential sector	MTOE	2.81	0.03	13.31	0.99	0.01	2.57	2.56
Population	k	11150.52	7305.89	80767.5	11062.51	1340.16	60782.67	63705
Private consumption per households (ppp)	k€2005p/hh	32.96	16.35	33.96	29.31	16.14	32.59	42.43
Renewable consumption of residential-tertiary ...	MTOE	0.71	0.86	7.59	1.07	0.44	6.97	0.88
Stock of dwellings (permanently occupied)	k	4727.98	3150	37715.4	4613.43	627.03	24603.55	26184.87
Total stock of dwellings	k	5229.36	3909.35	40995	6784.45	653.6	31593.93	27008

4.2 Tertiary

Table 6: Estimated parameters for the tertiary sector for the different countries.

	Belgium	Bulgaria	Germany	Greece	Estonia*	Italy	UK
Intercept	-12.5342	-8.09318	-2.53256	-9.48986	-7.62804	-40.2479	7.900009
HICP - Energy	-0.03651	-0.04047	-0.09076	0.311446	0.492289	0.246878	0.012283
Degree-days	0.303009	0.48769	0.530791	-0.09133	0.293637	0.481809	0.284845
Value added of tertiary at exchange rate	0.513663	0.981458	0.724086	0.481483	0.793702	3.334077	0.433527
Employment of tertiary	0.692706	-0.68676	-0.81028	0.45619	-0.85352	-0.77659	-1.32425

* Variable "HCIP - All Products" instead of "HCIP Energy"

Table 7: Last available values for each variable used for the estimation of the parameters for the tertiary sector for the different countries.

Tertiary	Units	Belgium	Bulgaria	Germany	Greece	Estonia	Italy	UK
	Year	2013	2012	2013	2013	2010	2013	2012
Electricity Price	€/kWh	0.2194	0.09005	0.292	0.163	0.0987	0.23075	0.17335
Gas Price	€/GJ (GVC)	18.435	14.5823	18.74	23.05	10.6033	24.73	15.2727
HICP - All products	2005=100	119.57	144.58	115.3	121.56	126.95	119	123
HICP - Liquid fuels	2005=100	144.24	150.6	143.2	203.57	155.65	145	176.3
HICP - Energy	2005=100	171.27	169.3	155.8	262.07	131.76	140.5	201.7
Coal consumption of tertiary	MTOE	0	0	0.11	0	0	0	0.02
Degree-days	Degree-Days	2137.7	2610.68	3365.59	1451.37	4825.41	1828.97	3182.72
Electricity consumption of tertiary	MTOE	1.88	0.7	11.01	1.46	0.22	7.65	8.37
Electricity intensity of services sector	kWh/k€2005	96.33	533.91	79.57	145.09	382.96	92.78	67.85
Electricity unit consumption in private offices	kWh/emp			1517.98			2227.93	814.52
Employment of tertiary	k	3636.9	1398.67	31234	2585.15	372.7	16960.6	26486
Energy efficiency gains in tertiary	%	2.66	24.01	7.6	0	0	0	30.4
Energy efficiency index of tertiary	2000=100	97.34	75.99	92.4	100	100	100	69.6
Energy intensity of services sector (at purchasing power parities)	koe/€2005p	0.02	0.02	0.02	0.02	0.04	0.02	0.01
Final consumption of tertiary	MTOE	4.88	1	27.66	2.07	0.42	20.01	18.44
Floor area of tertiary	Mm^2			1670.63	6.47			
Gas consumption of tertiary	MTOE	1.94	0.08	9.66	0.12	0.03	11.3	8.65
GDP per inhabitant (ppp)	k€2005	28.21	9.88	30.53	17.04	13.87	22.42	29.51
Oil consumption of tertiary	MTOE	0.94	0.04	5.18	0.45	0.03	0.73	0.9
Population	k	11150.52	7305.89	80767.5	11062.51	1340.16	60782.67	63705
Total consumption of tertiary (with climatic corrections)	MTOE	4.53	1.02	29.17	2.2	0.4	20.93	19.16
Value added of tertiary at exchange rate	M€2005	226680.66	15288.74	1609570.1	117200.8	6615.71	959091.06	1433578.7

4.3 Transport

Table 8: Estimated parameters for the transport sector for the different countries.

	Belgium	Bulgaria**	Germany	Greece	Estonia*	Italy	UK
Intercept	-9.98797	-1.64209	-3.35107	-5.13737	-3.51785	-0.88684	-15.0239
HICP – Energy	-0.08566	-0.0867	-0.06149	-0.04174	-0.00031	-0.05584	-0.00635
GDP per inhabitant (ppp)	0.602727	0.614875	0.349436	0.456985	0.135699	1.200908	0.946292
Annual distance travelled by cars	0.569595	-0.21002	1.407486	0.275746	0.208329	0.090018	1.83165
Car traffic	1.133717	0.801685	-1.75556	1.043383	0.364363	-0.02138	-0.63283
Stock of cars	-0.04463	-0.54616	1.361329	-0.83029	-0.10203	0.103819	0.737281

* Variable "HCIP - All Products" instead of "HCIP Energy"

** Variable "Total Passenger Traffic" instead of "Annual distance travelled by cars"

Table 9: Last available values for each variable used for the estimation of the parameters for the transportl sector for the different countries.

Transport	Units	Belgium	Bulgaria	Germany	Greece	Estonia	Italy	UK
	Year	**2013**	**2012**	**2013**	**2013**	**2009**	**2013**	**2012**
Electricity Price	€/kWh	0.2194	0.09005	0.292	0.163	0.0921	0.23075	0.17335
Gas Price	€/GJ (GVC)	18.435	14.5823	18.74	23.05	10.5163	24.73	15.2727
HICP - All products	2005=100	119.57	144.58	115.3	121.56	123.56	119	123
HICP - Liquid fuels	2005=100	144.24	150.6	143.2	203.57	139.66	145	176.3
HICP - Energy	2005=100	171.27	169.3	155.8	262.07	97.35	140.5	201.7
Annual distance travelled by cars	km	15284		14000	13076.64	13775	9872.66	13386.04
Average specific consumption (l/100 km) of cars	l/100 km			7.18	5.7		6.03	5.61
Car traffic	Gpkm	109.84	50	916.27	86.5	10.5	620.37	642.66
Degree-days	Degree-Days	2137.7	2610.68	3365.59	1451.37	4302.37	1828.97	3182.72
Diesel consumption of cars	MTOE			13.25	0.12		8.28	7.56
Diesel consumption of transport	MTOE	6.68	1.61	31.29	2.04	0.4	21.44	22.07

Electricity consumption of transport	MTOE	0.14	0.02	1.05	0.02	0.01	0.41	0.35
Energy efficiency gains in transport	%	17.23	5	16.56	27.07	2.1	12.64	17.01
Energy efficiency index of transport	2000=100	82.77	95	83.44	72.93	97.9	87.36	82.99
Energy intensity of transport	koe/€2005	0.03	0.11	0.02	0.04	0.07	0.03	0.02
Final consumption of transport	MTOE	9.65	2.87	62.48	6.34	0.74	38.19	50.83
Fuel oil consumption of transport	MTOE	0	0	0	0.25		0.29	0.1
Gas consumption of transport	MTOE	0	0.07	0.22	0.01		1.03	
GDP per inhabitant (ppp)	k€2005	28.21	9.88	30.53	17.04	13.45	22.42	29.51
Oil products consumption of transport	MTOE	9.17	2.7	58.52	6.18	0.74	35.49	49.57
Population	k	11150.52	7305.89	80767.5	11062.51	1340.27	60782.67	63705
Share of public transport in total land passenger traffic	%	23.28	20.91	16.22	17.99	19.76	20.25	14.83
Stock of cars	M	5.49	2.81	43.43	5.12	0.55	36.96	28.72
Total consumption of road transport	MTOE	8.02	2.65	51.52	4.89	0.66	33	37.08
Total passenger Traffic	Gpkm	143.18	63.28	1103.53	107.14	13.09	794.11	762.81

This is a technique that is also implemented in other forecasting methodologies, such as the neural networks. The main drawback for this technique in the econometric models is that the significance level of some parameters' coefficients might be higher than the usually accepted 5% significance level. In fact there is a trade-off between the forecast error and the estimation outputs that are statistically significant.

The model results are aligned with the expectations, concerning the sign of the coefficients. This concerns all main variables, namely price variables have a negative sign, while economic activity, stock, Heating Degree Days variables have a positive sign. Moreover, all models that were selected showed a high R square (R2), which is a strong indicator of the reliability of those models. The models can be used from the national experts of the WP4.3 Heron project, to form their scenarios towards examining socio-economic factors at Energy efficiency policies in the EU.

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Profitable pathways to sustainable electrical systems. Conditions for Change in 3 countries

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Abstract

What are obstacles and driving forces, at the system level, for a transition to a renewable-based electricity system? In our project we have studied this question for the southern BRICS countries As a focus and simplification for this paper we will study the important sustainable technologies that are standardized and medium/small in size (like solar and wind) and therefore well fitted to a market based game-changing process and inviting significant changes to the infrastructure of energy supply. This paper is an early attempt on systematic analysis. We have done qualitative interviews and literature studies and will contrast the developments and factors in Brazil, China and South Africa, with some references to the special conditions in Norway. The general theoretical basis is the Awareness-Motivation-Pathways (AMP) model that helps explain the gap between technological possibility and a new regime, laid out in the multi-level theory. The awareness of the challenge, the needs for a shift seem to be well established. Motivation seem to be linked to how this shift goes together with more visible and short-term factors, like local pollution (China), electrical supply system breakdown danger (South Africa) and profit/production possibilities (China and Norway as positive and negative examples). This paper will focus on the third factor, the "pathways" that is a result of financial, regulative and political conditions that together may open a wave of change, much broader than projects and state supported niches, driven by state guided market forces, consumers, investments and profit possibilities. We will discuss the positive factors of state regulation and planning in China and Brazil, the role of small enterprises and investment opportunities in South Africa, Brazil and China, the role of tenders (Brazil and South Africa) and the challenges of a non-adaptive or blocking regulative setup (South Africa) and lacking willing government priorities and investment capital (Norway). The theory of path dependence and associated lock-ins are used and also turned on its head in a discussion of guiding activities in the building of new sustainable paths new path.

1. Background: State of the earth and our energy transformation problem

While pockets of dissidents persist it Is now accepted (Paris 2015; Anthropocene committee) that humans after a history of insignificance (Harari 2014) are now firmly established as significant "geological actors" (Schwägerl 2014) who, through their "make, take and waste" engagements with earth resources have, and are, fundamentally changing earth systems, including climate systems. These economic engagements have shifted the earth and its systems away from a short period of uncharacteristic stability, marked by stable "planetary boundaries" that have provided humans and many other species with a "safe operating space" (Rockstrom et al

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2009) – a geological era known as the Holocene.

Constant technologically improvements in the ability of humans to access what humans have through of as an unlimited warehouse of resources (that the classic German philosopher Heidegger termed a "standing reserve") enabled humans, over the past couple of centuries, to exponentially expand their taking, making and wasting to the point where they have not merely threatened the availability of the resources of "earth's warehouse" and its "natural capital" (Schumacher 1973) "nature's services" (Daily, G.C. 1997 but have fundamentally altered the way the workings of earth's systems. This has created what is now being termed a new geological era, the Anthropocene. These altered systems are no longer producing the stable ecosystems upon which humans, and other species, have been completely reliant. This has led some to speculate that the earth might be moving towards a 6th mass extinction. This line of argument is also placing humans and their organization in the center as actors in a new way: We, our actions and policies are relevant and directly involved in processes that destroy, save or repair our own platform. Much attention is now being given to the challenge of how human civilizations, through their economies, might shift the ways in which they engage earth systems so that they continue to support, rather than threaten and destroy, the human friendly ecosystem services associated with the Holocene era. A central conceptual thread in this thinking, and the empirical work associated with it, has been the idea that humans, through their institutional arrangements, have become locked into assemblages of people and things that have produced, and sustained the" take, make and waste" practices that have brought about the earth system shifts that have undermined, and are undermining, the production of human friendly ecosystem services. The responsibility, necessity and possibility are gradually finding its way in to political consciousness. Two relevant examples for this paper is example is how the concepts of "Circular Economy" end "Ecological Civilization" have found their way into the now ruling 12. 5-year plan in China and how South Africa made significant promises for CO_2 reduction at the Copenhagen Summit.

Energy production is at the center of these processes. Energy uses, as fulcrums that have shaped, and that have the potential to reshape, the take, make and waste paradigms that characterize our economies, and particularly the industrial economies that have come to human engagements with nature's capital. Not only does the use of fossil fuels (the contemporary dominant energy resource) directly result in the bulk of the carbon being released into the atmosphere that is bringing about global warming with all its climate and related consequences (IPCC 2015), but other uses of fossil fuels (for example, in the manufacture of plastics) and shifts in engagement practices that fossil fuels have enabled (for example, contemporary agricultural practices) are at the center of humans shift in status from insignificant animals to geological actors.

2. Narrowing our problem and the theoretical toolbox

In this paper we present the results of work that has explored shifting forms of energy production and use in Brazil, China, and South Africa (three of the four BASIC countries) as examples of developing countries that are engaged in simultaneously responding to both a global awareness of the disastrous implications of not reducing fossil fuel use for human wellbeing and who are faced with massive demands both from their local populations and their trading partners to increase their energy to produce and grant access to energy dependent goods. An important framing conception in this research has been the understanding of transitions that Geels and his colleagues have been developing. Particularly useful has been their concept of economic **"regimes"** as stable take, make and waste institutional assemblages, that are associated with sociotechnical **"landscapes"** that support and enable them, but that can, and sometimes do disrupt (unlock) regimes if they shift – an idea that fits well with the idea of geological eras as landscapes such as the Holocene. Also useful is there idea of **"niche"** developments, particularly technological developments, that can, and do, provide sources of regime change post-disruption. In the energy sector there are several niches of well functioning production and distribution systems that could develop into regimes, depending on landscape developments and political and regulative conditions. Often **path dependence** (Pierson 2000, Meyer & Schubert 2007, Berkhout 2002**)** and **institutional forces** will keep them from developing into a regime, but sometimes there can be a rapid change turning a niche into a regime, a process that may now be happing for wind and solar power, while hydrogen and nuclear phase IV is still in the niche role.

To this framing we have added insights from institutional and organizational theory on change. This dialogue was used to develop an **AMP framing** (Honig et al 2015) in the course of other empirical research. In this research we continue this processes of incorporating insights from organizational and institutional theory in both seeking to explain transition developments and to enhance understanding of them. Within the AMP framing, the **A refers to awareness** understood as a "sensibility" (Shearing and Ericson 1991) out of which engagements with natural systems emerge. Expressed differently, to use a term from Dorothy Smith sensibilities provide "ways of seeing" and "not seeing" worlds, ways of making up worlds. **The M refers to motivation**, namely to an institutional decision-making nexus. Stable regimes depend on aligned motivations that enable assemblages of actors to support each other. When these alignments are disrupted regime change becomes possible as actors might withdraw from the assemblages on which the stability of regimes depend. In understanding regimes, regime disruption and regime transitions institutional histories that have enabled motivational alignments is important. Within these developments a focus on **regulatory framings**, associated with political developments is useful. The **P stands for pathways**, that is, opportunities for action. Regimes, and the assemblages/alliance that enable them are built around pathways that enable taking, taking and wasting. Within the context of our research, with its focus on energy and particularly electrical energy, pathways are centered on energy sources and technologies for their use. We will, in this paper, focus on pathways that opens up for state-market joint forces, for the pathways that enroll market actors and mass production into energy system changes. We will take the awareness for granted, assume that several forces and interests jointly create motivation (Jensen et al 2015). One factor the especially help a new technology from niche to regime status is of course the possibility of profitable production, evoking interest and values of export, profit and workplaces. With the present status of new sustainable energy sources being well fitted for mass production and marked-consumer relations, the power of **manufacturing** possibilities come into focus (Mathews 2013, 2014). Renewable energy sources that can be mass-produced can even be at a core in a new techno-economic paradigm (Mathews 2013) with great disruptive power.

3. Energy technologies

Most industrial countries, organizes its electricity regime in ways that are fundamentally shaped by the nature of electricity itself as an "actant" (Latour 2004; Mitchell 2011). Electricity became a form of energy that can be distributed via conducting wires. This feature of electricity has enabled the development of distribution grids. The use of grids is also enabled by the fact that the principle technologies used for electricity production were established fossil fuel (coal) based technologies mainly under the classic beliefs and experiences of "economies of scale" (bigger is better) particularly those that used coal as a form of power to turn turbines a technology that can be used to produce electricity. The principal forms of electricity production across the globe, that have enabled the emergence of electricity as a dominant form of energy within what has emerged as digital civilizations have been coal fired turbines.

The change in awareness, that has prompted, and is prompting, governments and other institutional actors as well as individuals across the globe to recognize the need to engage earth systems very differently and to be far more careful about the nature of these engagements.

The impact that this awareness change on motivations has provided to be necessary but not sufficient in bringing about shifts in human engagements with earth systems. What is clear from existing explorations of the reasons why shifts in awareness is not sufficient are captured via the two other factors identified by the AMP model, namely, other motivational influences and the availability of alternative pathways that will enable shifting motivations to lead to new practices not withstanding what "path dependencies" that are such fundamental features of organizations.

What is clear is that these variables unlike awareness, that has witness a global shift, are almost entirely related to context. This means that shifts in awareness will express themselves differently in different context. The study of which the research on which this paper is a part sought to hold level of development, broadly understood, constant. It did so by comparing energy transitions in the BASIC countries. These countries while very different in the size of their economies and their histories all have developmental goals that require massive expansion in their energy requirements. What they have done in response to shifting awareness has been different and these differences. In our research we have considered the extent to which differences in social histories and resources have shaped, and are continuing to shape, their energy transitions.

The technology of the new renewable sources of energy – most important is solar and wind have some interesting properties, and are growing fast. In 2015 U.S. built more solar than natural gas. Half the solar capacity installed was outside the utility-net (Fehrenbacher, 2016). These new and sustainable technologies are the most mature representatives of a new family of energy production niches with a few important characteristics: Firstly, they are economical at small and medium scales, inviting a dramatically different structural pattern from the centralized and grid-based production pattern that has been the path since early 1900s. Medium and small size is also inviting mass-production of standard commodified goods in a traditional industrial pattern., thus inviting a different and powerful set of marked forces into the game. Secondly their running costs (wind and sun, but also rain/hydro and tidal) is "God-given" and in a sense free. No fuel burning, running costs are basically maintenance. Cost structure is so skewed in the favor of up-front building costs that modern sustainable energy can be seen as investment and installation more than a production operation. The smaller the scale, the more the marked can be seen like "commodity" activities in a consumer-market. Opening up for small-scale, distributed production and more decentralized grids is an important part of the shift to sustainable energy systems and our focus in this paper. It is of course a choice and a simplification that is not taking large-scale hydroelectrical power into the analysis and we are also skipping the important debate on nuclear, both the Phase IV (medium to large-scale) technologies that might play a part in our context and the more distant fusion possibilities. Large-scale power plants of all kinds are beyond mass production and will most likely be partly public funded, delayed and more expensive than planned. Not a tempting and safe investment opportunity that can enroll financial interests [3]. But also large hydroelectrical plants have most costs as up-front investments and a long lifespan, making pricing and competition a challenging task for market regulation. Adding the natural structural monopoly of a grid we can see some of complication and regulative needs of the sector. Central dimensions in our comparative study are capacity, institutions and forces that promote and inhibit changes – drivers and constrains. We select three dimensions: Technology and markets, regulation and regional and local political actors.

After an initial phase of distributed and mostly private generation, electricity shortly became tied to the economic argument that some public values cannot be effectively and efficiently produced in the market, both due to the heavy investments needed and the need for economies of scale. This pointed for the need to centralize generation with large integrated public utilities positioned as the strategic units with a de facto monopoly in the market. More recent technological advancements, however, have somewhat undermined the economies of scale argument for many forms of energy source generation. Some technologies are almost impossible to downscale from the size of a huge plant (Classic Nuclear phase I-III), others have significant economies of scale (hydro, coal), some seem to be best at a medium scale (wind or concentrated solar power, CSP) or very easily downscaled (PV solar).

[3] From our interviews in the financial sector in SA, 2015

Within the very competitive auction systems for renewables many emerging economies have established, the tendency is that projects have been getting bigger due to economies of scale. Smaller developers cannot compete. On the other hand the global tendency is that mega huge plants are less and less able to compete cost-efficiently with smaller ones, and increasingly also with distributed forms of electricity generation. A key advantage with distributed or embedded generation is minimalizing transmission losses. That seems to be one of the reasons that the amount of actual trades going through the Southern African power pool is only a third of the agreed trades, transition losses are huge. It's not economic. Another argument that relates to more distributed generation is now directly related to arguments for a total reorganization of the electricity grid structure, with the new ideas about smart grids, 'prosumer' power, and so on. It is argued, both in the literature, and by many of our informers, that the opening up for consumer control will have a strong disruptive effect on the current system for generating, transmission and distribution of electricity (*ESKOM interview, SA source)*. We then turn to a discussion about how decentralized forms of energy production are emerging in the global south. Many emerging economies have untapped capacities for such technologies, and for some it offers the opportunity to leapfrog directly into what most experts believe will be the future of our electricity systems; modular, 'smart' and distributed systems for generating and consuming electric power. The market for off-grid distributed solutions has recently been growing fast in many regions of the world, particularly in the less urbanized areas. Most southern countries, however, cannot jump directly into the future like this, since the majority of them have been on a trajectory for more centralized energy systems for years and have developed a regulatory environment to support this trend. For these countries attempts to develop distributed forms of energy production confronts many challenges in the form of vested interests and large sunk investments in traditional forms of electricity production. This paper will compare trends in electric power production in three emerging economies, China, South Africa and Brazil, and explore the challenges and opportunities each of them are facing. A particular emphasis will be on the role of regulation in maintaining the status quo, or facilitating change.

Security and vulnerability are also arguments. We might start with Lovins and Lovins book Brittle Power published in 1982 (Lovins and Lovins, 1982) which argued that the US electricity systems and similar centralized systems are vulnerable to major failures since they rely on large-scale power generation technologies which are primarily fueled by depletable, often imported energy sources (Cherp and Jewell, 2014). This argument is currently made more relevant by the concern for terrorist attacks for which centralized systems are particular vulnerable. In addition to the resource-dependency and terrorist arguments, there are convincing contributions on the risk of large-scale complexity in itself (Schewe, 2007). Modern electricity grid have grown through decades into a huge webs that also has vulnerabilities and unpredictable sides driven by layers of complex interdependence and system complexity problems.

We should mention at least three different forms of distribution with gradually stronger needs for coordination and grid services. The first is the small independent production, or even a small (micro-) grid that will serve an isolated island or rural community. To do this with modern technology and renewable sources is a cost effective and promising way of ensuring energy safety in many areas. Small independent distributed producers in China, as of 2009, had 45GW capacity, the largest in the world (Liu 2013) and such solutions are still the preferred solution for many areas in China (Interviews, jan 15). Secondly, local producers can make energy for their own purposes (factories, farms, shopping malls, some private houses). This may use local sources (hydro, wind, ground heat) and reduce their need for electricity from the grid. This is actually an old form (windmills, small river hydro facilities and up to huge aluminum smelters) but are now growing again with new technology. Finally, and most challenging and promising are the local production that actually delivers onto the grid, both as small standalone producers and as cogeneration with own needs. This may trigger a revolution that changes energy production and mobilizes small companies and consumers as co-producers (prosumer) and energy citizens in new ways, including the creation of full and part-time job opportunities on rural areas (important in South Africa). Challenges for the grid administration is rather serious in this third form, but progress is made and the ability to average over big numbers of small producers are becoming better (Germany is the positive example). The final large-scale success may be dependent on storage technology (like the new batteries from Elon Musk or hydrogen gas as storage (Rifklin 2002)

The last and maybe most important technological aspect is the question of supply and possibilities. Can the emerging economies of the world have their energy needs fulfilled ? And with sustainable power ? Keeping in mind that energy is, for all practical purposes, is not a finite resource, the answer is probably positive, even if we restrict the growth path to what we can observe historically (Fisher and Jensen 2016).

4. South Africa[4]

Seen from a distance South Africa has a quite clear, and in many ways successful history of electrification. From an early start around 1900 with involvement from entrepreneurs like Edison, came electricity and light to the big houses of the (white) rich, to some towns and public utilities and some mining companies. Power came from several sources: hydro, coal and waste burning. Gradually a system developed based fully on coal, regulated and/or owned by public bodies and supplying the important mining industry and most white areas. Electricity was among the absolute cheapest in the world 1930-2008. Cheap workforce in the mines, then cheap coal and more cheap workforce together with cheap electricity from the coal gave good competitive export possibilities, and coal was abundant and in stable supply. The transition from apartheid to democracy in 1994 made cracks in this system. The huge efforts by state monopolist ESKOM to connect also black poor communities to the grid under the slogan “Electricity for all” were successful, but capacity building and grid maintenance suffered. Gradually a power crises with blackouts and price hikes became visible. An expensive nuclear R&D project (Pebble technology, Nuclear phase IV) had to be shut down and a huge investment in more big coal powerplants ended with many years of delay and rising investment prices. Now; economy, energy security and sustainability are coming together in a huge pressure for change The natural resources of South Africa includes sun and wind in large quantities, making a reform in a sustainable direction look reasonable. At present (spring 2016) the most significant initiative from the government is the plans for buying a series of nuclear power plants, but it is difficult to interpret the resistance and the complexities of the international credit that is needed to get such a deal (with China and/or Russia).

At the national level the situation seem to be a institutional lock-in around the old system: the state monopoly, a high number of highly paid workers, a strong system of corporate influence, the mining trade unions that support this system and culture of “big is better” at the central government level. But there are some modifications and pressures for change that must be discussed, especially at the municipal and market level

National government has established an Independent Power Producers Procurement program (IPP and REIPPP) for phasing in energy from renewables into the national electricity grid. The electricity crisis that struck the country in 2008 and more recently, from 2014, has been a main driver behind the reform. Most observers perceive the REIPPP program as highly successful, arguing that it has been built on a well-designed regulatory structure with ongoing inputs from both private and public actors. The disruptive potential of the program is debated. While it will clearly increase the percentage of renewable energy in the grid, so far it has had less of an impact on the overall institutional structure of the South African electricity system, keeping Eskom’s monopolist position

[4] In different forms the SA material and interpretations have been made by the SA team of the project: Jan, Froestad, Melani van der Merwe and Thor Ø Jensen, they also conducted the interviews. For a more detailed description, see Froestad, Jan (2016) Managing flows of electrons and men in South Africa’s minerals energy comlplex, or Skauge/Jensen/Froestad/Bothelo (2016): Distributed electricity generation: A comparison of trends in China, South Africa and Brazil

more or less intact. The important factor that keeps this well-functioning program from being a game-changer is that the whole structure is tailored to be an adjustment and an add-on to big-grid coal power, which also make some of the (foreign) suppliers of wind energy a little nervous for their long-time participation (Interview, 2015)

In the long run, the changes have to come in one way or another. Even a senior officer we interviewed in Eskom perceived the future very differently,

'if you look at the disruptive technologies coming into the industry now, it's going to be a very, very different future. If I take a twenty year view of the power sector it's going to be completely different. I don't think anyone is prepared for it … The moment you put those supply side choices into the hands of the consumer outside of any regulatory process, you lose control of the industry … The name of the game is resilience and flexibility' (Lennon)

On the other hand, traditional framings of the baseload argument, that there has to be a huge percentage of big coal, hydro or nuclear at the bottom of the supply mix seem to continue to inform how the highest level of government in South Africa perceives the energy scenario of the future and tend to detract its interest away from small scale and distributed energy solutions. However, the reason that national government is not a major driver of distributed generation seems not only to be related to its adherence to a system for generating and distributing electric power that many experts think will become uncompetitive during the next couple of decades or so). It also seems to be a question of lack of regulatory capacity. A case in hand is when NERSA tried to incentivize Eskom to take energy efficiency more seriously. It tried to introduce the Californian model whereby the utility, if it managed to incentivize its customers to use less energy, would be compensated for the loss of its own annual revenues from so doing. But they did not figure out a way to do it, probably through a combination of not having the energy data they needed since the system lacks transparency and not having the means to enforce it, with the potential of Eskom taking the issue to court. The contrast to the energy savings that seem to be captured by new forms of distributed generation is telling. Self-generation of power tends to have a high impact factor on consumers' level of awareness of their energy consumption, every amount of energy saved is directly related to your own cost savings The conclusion reached by one of our informers, a position most of the stakeholders we met with seemed to agree to was that '*the private sector is the driver … the government don't want to decentralize even though they talk about it and put it into policy documents and so on. They are not going to do it because they want Eskom to continue…*' (Sebutosi)

The Solar Water Heater program, which has been supported by national. The Solar Water heaters save money for consumers, take load of the grid and are quite easy to integrate with the system. But the SWH market has not been scaling up due to a range of problems; the industry is fragmented, the Eskom subsidy was ill-designed and jumped prices, the banks have not been in support, and the national standardization system has been driving prices beyond requirement, backed by big manufacturers promoting an adopted model of expensive system testing as a way to captivate the marke. As one informer argued *'the solar water heating industry itself hasn't stepped up to the plate. It's still a bakkie brigade which is not sustainable'* (Vermeulen). As another our informers observed the SWH program has become 'an absolute mess, and it's a classic case of an ill-informed subsidy mechanism to stimulate the market that ends up paralyzing the market' (Rise). Obvious solutions like including SWH in building costs and loans is not happening. It should be added to the observation of "mess" that the system is not fitted for, or liked by, regulation authorities and, even more important, it will reduce municipal (tax) income that follows the electricity bill. Implementation problems of the SWH heater program was also found for the

The big cities - Cape Town and Johannesburg

It is a stated policy in South Africa that Eskom is the sole buyer of electricity. However, the legalities of private producers to produce directly to business or other buyers, are in place. As one informer pointed out, however, 'exercising that right of veto is proving to be though at the moment as I understand a number of municipalities are going ahead' (Worthington). The big metros have reached the understanding that they cannot wait any longer for national policy to sort out the issue, and have started experimenting.

A key challenge is that the big cities have traditionally had a large portion of their revenue stream ensured by the selling of electricity, up to forty percent. The problem is that high-energy users are dropping from high-energy usage to lower energy usage, which is undermining the established policy of the municipalities to use higher energy tariffs to subsidize poorer communities. Several informers argued that one needs to rethink entirely how local government is funded. As stated by one informer the challenge is currently 'a massive misalignment of incentive structures because of the way institutional arrangements have been set up' (Greyling). This is creating huge challenges for the metros on several aspects. An official at Johannesburg's City Power, pointed to how the need to subsidize poor communities under current circumstances has detrimental effects on the city's ability to attract and keep core industries, 'Our business tariffs are the highest, which is a hot plan. Big manufacturers are going to move out. We're lucky in some respect that Johannesburg survives on retail, it survives on insurance companies and financial support … but in reality we are overcharging our business customers' (Vermeulen).

With energy efficiency, the metros are phasing other problems. The more efficient the cities are the more they lose in revenue, and they are not compensated by national government. 'So what happens is that we are meeting a national objective around energy efficiency and saving Eskom money and breathing space, etc. So we achieve a national objective but at the expense of our own' (Greyling). The argument put forward by this informant was that the cities and their customers need to be incentivized to go for renewables and energy efficiency. Households ought to know that if they put up solar panels they would get paid for instance 1 Rand per KW hour by national government, which would be split 80c to them and 20c to the City. This might send a message for a massive uptake of embedded generation (ibid).

The big metros have tended to meet the challenge of distributed generation somewhat differently. City Power in Johannesburg has not been very comfortable with localized solar projects due to the revenues it stands to lose. They have tried to excuse themselves by arguing that 'we are trying to understand it better, look at the safety elements and understand the revenue implications' (Chennells) The City of Cape Town, to the contrary has tried to meet the challenge more proactively and have put in place legislation that allows reverse feed into the grid (ibid). Durban has initiated a similar program through which its customers are allowed to put excess electricity into the grid through which they will be compensated on their monthly accounts (Balmer). The Black River Park was the first commercial project in the Western Cape allowed to feed back to the grid at the same price as they would buy from Eskom. If the project overproduces at certain days, like over the weekends, they will get 60c for each kw-hour from the City. It implies that the city is buying power from the project similar to its cheapest tariff from Eskom, and it is not losing much of its revenue stream. A win-win situation is created (Chennels).

Another key concern for the big cities is how to promote themselves as good investment sites for international investors. The current energy crisis is regarded as a constraint. As the director of trade and investment in Cape Town municipal government argued:

'one of the things that has been identified as a constraint on investment is the national energy crises, so if you can't guarantee investors some form of energy security … it is making it more difficult for them to continue doing business here and its disrupting their business model' (Greyling, interview month 2015).

The city has responded by trying to shield some of their businesses and future investors from the worst impacts of the energy crisis (ibid). This has become a concern committing the city in favor of distributed generation because 'if companies are able to put in solar panels and keep their activities going through a load shedding incident, that means more to our economy than the bit of revenue that we lose' (ibid)

Cape Town has made it a requirement for most new houses to have a sustainable intervention, such as solar, heat pumps, SWH, etc. For Cape Town and other cities, the most fearful thing is grid defectors, producing their own electricity. That is the biggest risk. The tendency, however, seems to be that the cities are getting wiser and taking a more pro-active attitude to the issue of the electricity revenue stream (Worthington). One informer argued that the cities should be smart and ask their customers to put up more than they need and sell the surplus to them, 'I'm here to support you when the little cloud comes, use me as a battery', etc.

Some of the bigger cities are also looking at buying directly from IPPs. The position of NERSA, the national electricity regulator, in this regard is that 'willing buyer, willing seller' is an accepted principle. As an IPP you can sell power to another company or to a city through the grid. But you need Eskom's permission, a purchase agreement, and a license from NERSA. You will also pay a grid levy. Several informers pointed to the fact that currently to sell electricity to a third party through the grid is a cumbersome process. The South African Constitution contains prescriptions that all public procurements should be 'fair, equitable, transparent and cost effective and competitive'. A major problem for the cities is thus that they are not allowed to buy at a price higher than Eskom's, and since it is selling vendor price new IPPs are not able to compete. That makes it difficult for municipalities to contract directly with the IPPs, as

'any IPP is going to struggle to come under 60c per kw-hour. And that's what makes it very difficult for municipalities to contract with IPPs' (Greyling, interview month 2015)

Eskom's monopoly position as sole grid owner is currently the main factor preventing a larger up-take of IPPs selling directly to cities and other customers (Chennells).

However, there might be ways of coming around this, which some of the cities currently seem to be exploring. According to the Constitution if there is lack of power you cannot deny someone to generate their own power. That would be regarded as a captive power plant and there would be no wheeling charges to Eskom involved. A question arising is if this argument could be stretched to include buying electricity from other providers, 'you could for instance say if Eskom can't give me any power because of its own constraints then we should be able to procure it from another provider even at a higher price' (ibid). The problem for the cities is that the Department of Energy has not clarified its position on the topic. For the cities it is very difficult to estimate what the price structure of the future will look like and if entering into long term procurement contracts with alternative providers will be affordable (ibid).

The current tendency is that the cities differentiate their customer base into commercial and residential customers. As a representative of Cape Town city government maintained they prioritized an up-take of distributed generation by their commercial clients. The city was consciously trying to design the system for the residential sector in such a way that it is not hugely attractive for households to engage in decentralized generation, except for very high energy users. The problem is two-fold, the city is losing revenue and decentralized generation comes with new registration requirements that it is costly to fulfill. So, the stance is that households can do it if they want, but the city is not promoting it (Greyling).

Many firms are under pressure from their foreign head-offices to buy green energy. But, under the current regulations this means that the City must find a willing buyer accepting to buy electricity at a higher price from a particular producer because the customer wants to be green. That implies that the City will take all the risk, since if things get hard, green clients tend to disappear and the City will have to take the loss. Also, the current tendency is that these customers rather move to produce their own green energy putting up their own PV systems. If they connect to the grid and the City wants to buy that energy they have to pay wheeling charge to Eskom. Several informers argued that in spite of this, prices are getting more and more equal and it was assumed that investors might start exploring the possibility of setting up generation plants physically next door to city power systems and transmit power directly to customers. There are signs that the system might be reaching a tipping point were IPPs might increasingly be willing to take the chance of circumventing Eskom and start selling directly to consumers without entering the grid. A potential loophole for the cities is to count this power generation as an off-set against what Eskom requires them to load-shed. Again, it seems basically to be a question of regulation.

The commercial and domestic sectors

The market is becoming a dominant driver of distributed energy generation. Investors are increasingly willing and confident. The manufacturing and service market for distributed solutions is starting to take off and may have a large impact in the short term. As one informer observed, '*the private sector is going to be a major player in power generation, especially unregulated power is now coming in very strongly ... It is very economically now, very price competitive'* (Sebutosi). Most countries are currently moving away from feed-in tariffs, which have relied on large public subsidies. Market forces are kicking in to a much larger degree as a key development mechanism for alternative energy solutions (Campbell/Bloomberg). One emerging tendency is growth of green bond markets. It's argued to be a massive untapped market (Campbell). The City of Johannesburg has recently launched a green bond project market. If a carbon market is coming into effect it may well spur such developments as it would have a huge impact on companies' green reporting. Many of the firms are pressured, they have to be concerned with their sustainability level and none of them want to be caught with the possibility of being the dirtiest company in the sector. Thus especially applies to the tourist and consumer (wine, fruit) export industries that are dependent on their reputation

PV is the driving technology for small scale distributed generation; it's a growing 'rooftop' market. The advantage with in-house electricity generation is that it's a free market. There is no obligation to buy from or sell back to Eskom, the city or any other energy provider. As one of informers maintained, 'It is purely for self-consumption and that is really what drove the Black River Park PV system'. One of the big South African retailers, Woolworth, has also become a driver for embedded generation, and although this only covers a very small part of their overall energy consumption so far 'it's demonstrating to the market that this is possible, they are doing it, and they expect other people to follow suit' (ibid). One stumbling block seems to be that many of the office blocks that potentially are very attractable as installations sites for the new technologies are utilized by firms who are not the owners, but are renting the facilities. If government decides to subsidize such installations it increases the value of the property and who should realize the additional profit if it is sold? (Balmer).

Several of the wine farms are trying to get off the grid as much as possible. They are pressured to lower their carbon footprints by their competitors in the European wine market. The challenge that is holding wine farms off the new technology seems basically to be the huge up-front expenditures of installing PV solutions, some regulation issues as well as the insecurities related to the future costs of electricity from other sources. There are also tendencies that the mining houses are trying to change their business models to reduce their reliance on Eskom. Their long term favorable electricity contracts with Eskom are running out and they face the prospect of a carbon tax. The mining houses are looking for opportunities to go off-grid, installing solar equipment in particular.

There are also difficulties with several important aspects of regulation that applies to the interface with the grid, with the possible sell-back of surplus, with the legislation that limits the size of a system or with subcontracting to a specialist company. These problems may be seen as just teething problems or active resistance from the established system or a series of difficult technological challenges, probably a little of all. But it makes difficult and a little dangerous to go into the sustainable energy sector, both as a small supplier or a consumer at private or corporate level. Many actors said they were dependent on doing things without approval and maybe or maybe not having an under-the-table agreement with local regulation. There are some bottom-up initiatives that might solve this situation. One aspect is the standardization of a more mature PV market, where standard will be accepted gradually. Even more promising is the organized attempts for negotiating and setting standards for the small scale embedded producers in Western Cape, enrolling big industry players, national authorities (ESKOM) and local and national government, with the aim of standards that can get transaction and implanting costs down (interview 2016).

A key question with renewables in South Africa and elsewhere in the developing world is the extent to which it will create new jobs. What seems to be a critical learning that has emerged is that the employment potential does not lie for the most part in utility scale production as with the IPP procurement program, which basically offers jobs during the construction phase. But, as one informant argued *'then everything comes to an end until you come to the next phase. So when you want to create stable employment opportunities then you have to focus on distributed generation and stuff like that'* (Ntuli). This position is also defended by the special vehicle that has been set up for promoting the green economy in the Western Cape Province, the 'Green Cape'. As the head of the organization told us there are lots of employment opportunities in creating jobs for mounting solar PV, for manufacturing the components, for putting on solar water heaters and heat pumps, and *'you can train people up in three months to do it safely and well'* (Rise).

Conclusion

Currently the innovations are primarily driven by companies perceiving localized generation as enhancing their own energy security and increasingly also as a cost-efficient alternative, and by the big cities realizing that they need to look beyond a particular revenue stream drying up, and take a bigger picture and a more proactive attitude to what is happening. A more top down policy initiative is associated with the national Solar Water Heater program, but this has not been scaling up due to a range of problems. Between national and local government the Provinces are placed in a somewhat ambiguous role in relation to many environmental policies. In the Western Cape, however, the provincial government has been exploring the establishment of so-called 'special vehicles', hybrid organizations set up to facilitate developments in fields that are felt to be of particular importance. 'Green Cape' is one such organization that is active in promoting the distributed electricity generation field, assisting municipalities and nurturing relations across the public and private divide.

Several drivers for growth in small scale sustanable energy generation in South African have been identified, mostly through bottom up processes and less through policy, but there are also heavy institutional lock-in mechanisms that are maintaining the status quo. As one of our informers stated,

'we are one energy system at the moment which is leading to extremely suboptimal outcomes and it's also based in an ideology of the past which isn't going to get us the kinds of advances and dynamism where the energy system globally is moving towards. It's keeping us trapped in an old system that is not able to cope with the changes that are happening globally and the disruptive technologies like solar panels etc. are bringing in ... It's completely monopolistic, it's completely state monopoly control ... So you have got complete government failure leading to market failure. So, we need to reform the system' (Greyling).

There are many constraints that prevent bigger up-scaling of sustanbale energy production:

- There is a cap on the amount of energy that can be sold back to the grid;
- The current monopolistic grid ownership is dis-incentivizing producers who might otherwise be able to compete with Eskom;
- The Public Municipal Financing Act requires municipalities to buy power from the cheapest source, and private producers cannot compete with Eskom's average (and, in reality, subsidized) price.

All our interviews pointed towards the need for regulatory reforms. Such reforms are needed to reduce risks and incentivize investors and city governments to up-scale distributed electricity generation. The current regulatory framework in South Africa contains many elements that counter-act a more massive up-take of such technologies. A few policy options to consider that might reform the current incentive structure might be some strategic packages of reform:

*Solving the problem of taxation through the electricity bill combined with the ESKOM as monopoly provider.

*A whole train of small regulatory reforms, standards and routines must be in place to ensure the tipping point of a market driven reform. Some financial bits as well as startup infrastructure must also be in place.

*The wind producers must get a broader path that the present narrow auction-based IPP program.

A lot can be said for this positive option, but there are also hidden in the presentation above two other and at least just as likely scenarios. It might happen that the central structures will block these developments and at the same time solve most of the energy crises with the large delayed coal plants, grid maintenance and new nuclear plants to be built. The political and financial situation of South Africa is not very stable and this might press over the cliff to scenario where the existing systems breaks down in unreliability and high prices and a lot of actors build thir own bottom up systems, like in a Schumpeterian "creative destruction".

5. BRAZIL[5]

Brazil possesses one of the most centralized energy-infrastructures in the world. Around 90% of electrical generation capacity is traditionally accounted for by hydroelectric stations (Toledo et al., 2010). Brazil has huge distances between its major power generation areas – mostly hydro and its biggest consumption centers. Its national grid is as large as the whole of Europe and transmission losses is calculated to be 18% (WB, 2014). The share of renewables has declined and varied as a supply percentage between 90% (2004) and 75% (2014) and up again to 83% in 2016. High prices to consumers, economic problems in the industry and general difficulties for the country. The stable position of Brazil as a more or less totally renewable

Brazil is one of the world's leading countries on renewable energy supply. In 2007 55% of the production was renewable as compared to OECD around 7% and the world energy supply in total, aprox. 13 % (Leite, 2009: 40).

It is also endowed with a huge potential for wind and solar power. The wind potential in Brazil has been estimated to 143 GW (Pereira et al., 2012: 3792). Recent estimates suggest that Brazil's wind power potential amounts to 500 GW, considering the latest technological developments (Evwind, 2015). Installed capacity of wind after 14 auctions with a participation of wind energy has produced 561 wind energy projects. The capacity till 2019 is expected to be 14 GW (Energypedia, 2015).

Surprisingly, solar energy still plays a minor role in the Brazilian Energy mix, but installation is expanding. The Northeast region of Brazil has a solar radiation close to solar radiation in India (Pereira et al., 2012: 3790). Even though the solar capacity installed is limited both in Brazil and in the rest of the world, the technology is important as most of the solar capacity in Brazil are not connected to the electricity grid. Instead, energy from photovoltaic system powers pumping systems or solar home systems (Ibid).

The demand for electricity is increasing by 5-6% annually. For several reasons, hydro cannot be relied upon as much as in the past to generate the additional power that is needed. This should make decentralized power production a huge opportunity for the future of its electricity system.

Mllions of people in rural Brazil still lack electric power. Around 2005/2006 approx. 8 million people in Brazil were without electricity. An estimate from 2009 shows more than 4 million households without access to electricity (Zerriffi, 2011: 59).

Regulations governing the Brazilian electricity system mandate that utilities serve all customers within their territories at rates designed to lower the price for lower income consumers. The regulatory regime is characterized by exclusive service territories, subsidies by federal government to covet utilities' capital costs, and mandated low tariffs for low-income households. The regulatory framework has (Meyers, 2016, Borges and Falcao, 2006) favored centralized utilities that are the only ones which can access generous federal funding. This has led to a rapid expansion of basic household electrification at low prices, but the sustainability of the system is entirely dependent upon the continuous flow of subsidies. Alternative models for decentralized generation cannot compete, and the potential for developing niche markets through electric power is not adequately served.

[55] This part is based on earlier drafts by Anitonio Bothelo and Tom Skauge (Brazil team) as well as a study by Andreas Nesse Perssonand Tom Skauge on wind implementation in Brazil (see references).

The need for new regulatory arrangements seems paramount. A couple of options (discussed briefly in Zerriffi 2007) include a revision of the regulatory environment to incentivize alternative actors to participate in solving the rural electrification problem, for instance through a regulated concession model (the utility allowing a cooperative to operate within its territory)

In spite of these adverse conditions, Brazil's distributed generation connection has shown a remarkable strong growth trend recently. In 2015 the number of connection grew 308% (Meyers, 2016).

One explanation might be the rapid rise of power prices in Brazil. In 2014 the prices rose about 17 %. Expectation for 2015 were prices up more than 40% (Reuters, 2015).

"*Power generation, particularly solar and wind, is basically the only sector detached from the current economic crisis in Brazil," said Mario Lima, a director with consulting firm EY in Rio de Janeiro. "Solar is very quick to install so it has a huge advantage over other sources in the current situation," he said."* (ibid).

Recently the Brazilian federal government announced plans to reduce taxes for distributed solar energy generation. Solar panels is expected to reduce vulnerability for households in after a long period of draught (Edgerton and Dezem, 2015).

The need for new regulatory arrangements seems paramount. A couple of options (discussed briefly by Zerriffi 2007) might be to:

- Revise the regulatory environment to incentivize alternative actors to participate in solving the rural electrification problem, for instance through a regulated concession model (the utility allowing a cooperative to operate within its territory
- Provide and energy subsidy, rather than an electricity subsidy, directly to end-users, allowing customers a choice of how to meet their own energy demands.

The recent auction in Brazil that were organized as a separate solar auction has stimulated a growing market for companies that sell panels and inverters and has thereby also incentivized a growing market for decentralized power production. The environmentalists in Green Peace are still not satisfied:

Yes, I mean that our auction system could improve a lot; could be to when it sets the price to actually consider what socio and environmental aspect that the source brings alongside with it. Like pollution, like JAG emissions, like making lot of disrespect for human rights, or taking a whole community off the land. (Rubin, interview Nov 2014).

A key regulatory stumbling block lies with federal-state relations. The states generally want more money from federal government and under the current institutional arrangement, state governors have strong political veto powers.

This spills over to the politics of decentralized power generation. States have a tradition for taxing electricity up to 30% and with decentralized generation they demand to

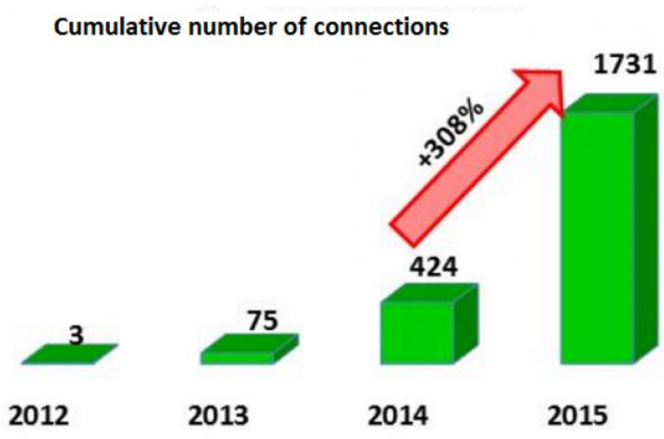

Figure 1: Cumulative number of connections in Brazil (ibid).

tax their 'prosumers' both when they consume and sell electricity back to the grid. Only one state, Minas Gerais has so far been willing to change its tax law to stimulate an up-take of decentralized power generation. Federal government is negotiating the issue with the states through their mutual tax forum, Confaz..

However, as an informer at the Ministry of Development pointed out, the federal government is exploring opportunities for improving the financial situation for customers who want to invest in decentralized power technologies. One option that is currently debated is the system in use in the US where customers only pay companies that install the equipment a small initial amount, and then a monthly revenue.

Another obstacle, however, is the distribution companies which have strong disincentives to the emergence of a more decentralized power market. The companies first tried to stop regulation for decentralized power generation to be put in place, and then they sought to create a very complex and cumbersome process for such systems to be connected to the grid, which ANNEL did not accept. The regulator has been working with the companies to change their attitude and explore opportunities with them that might prevent them from losing to too much of their revenue stream with the introduction of the new technology.

The debate on decentralized energy production in Brazil is focused on the issue of solar power. One of our informers made the point that Brazil also has a huge untapped potential for small hydro, but which is currently strongly dis-incentivized compared to both wind and solar. On our question on "why is there so little solar energy manufactured in Brazil?", our Wind-specialist answered:

"Because it just started. Because it's too much a high. They are starting with twice the price of the wind energy offering. The tariff, because it's more projects but Brazil it's too big, transmission lines costs a lot, so that they need… I think that one way they can go is to combine projects with wind." (Veiga interview, Nov 2014).

This might be related to the particular historical trajectory and path-dependence of electricity production in Brazil, where hydro has always been framed as large and federally governed investments in huge plants for power generation.

Several of the cities are experimenting with smart grid developments. A peculiarity in Brazil is how this technology is explored as a possible means to turn non-paying customers in the favellas into law-abiding citizens. The utilities is losing large amount of money due to non-payment for electricity. In the current political environment in Brazil, however, it is not possible to enforce the poor into compliance. State governments instead are trying to incentivize these customers to become 'electricity citizens' buy offering them to buy, but also having the option to sell back to the grid, by installing solar panels at their roof tops. To be able to document that you pay your electricity bill and have a registered place of residence opens new opportunities for poor users allowing them to open a bank account, etc.

To increase the up-take of decentralized generation in urban areas it thus seems necessary to find a way of solving the tax issue without dis-incentivizing customers from investing in these technologies. Smart grid solutions might be an important means to incentivize a further up-take of decentralized generation in poor communities.

Wind

In 2001, it was launched the first Atlas of Brazilian Wind Power potential which estimated at 143 GW the national potential, taking into account towers of up to 50 m tall. Nowadays, with the expansion of the sector, most of the Brazilian States are reviewing their potential now to towers of 120 m or more. There is the prediction that the potential reaches 350 GW.

Since the first wind plants in Brazil were installed in Brazil in the beginning of the last decade, the segment has experienced a formidable growth. The main driver was the Program of Incentive to Alternative Sources (Proinfa), which was the starting point of the national wind power sector, to contract in 2004 just over 1.4 GW of power (54 power plants). At the time, it was the most expensive and least developed of the three renewable sources encouraged by Proinfa, overcoming the thermal biomass and SHPs.

Over the years, other incentives were incorporated or added into Proinfa. These range from federal exemptions tax on components and equipment for solar and wind energy first issued in 1997 and rectified and extended multiple times since then to local state tax exemptions on sale of self-generated energy by the consumer so far issued by the states of São Paulo, Goiás and Pernambuco.

In 2005, the national wind generation capacity was only 24.5 MW, mainly from pilot projects of State-owned companies such as Companhia Energética de Minas Gerais (CEMIG) and Petrobras. From 2006, the wind farms contracted by the Pronfa, established in 2003, began to come into operation, and since then, they've added 904, 4MW to Brazilian generator park as shown in table below.

The catalyst was the first auction for wind, in 2009, that initiated the competitive phase, in which the most efficient and inexpensive park was the winner. Immediately prices retreated, reaching, in 2012, its lowest value. In 2013 and 2014 there was a small recovery. In 2015, due to the devaluation of the Real, the prices start to rise significantly, but keeping an almost constant path on the values in US$/MWh.

In 2010 there are in Brazil, 51 wind power plants in operation, with a total installed capacity of 928.9 MW, corresponding to 0.8% of the Brazilian generation. According to Aneel, will be added in 2011, 879.6 MW of power in the coming years by investing in 31 wind farms, which are being built. After 2011, 3 GW are planned that will be installed in 88 projects. Another highlight the complementarity of wind generation at power plants in the dry period, as there are stronger winds and constant when the tanks are with lower levels. The expansion of wind power plants should remain in the coming years, as the average selling price of this energy source in the country has decreased: in recent years, R$/MWh, 148 enterprises engaged in energy auctions, in 2009, to 99.58 R$/MWh in the energy auction-3, 2011. The ventures contracted had capacity factors between 40% and 50%, considered high for wind generation, which contributed to the discount on the price of the auction. On the other hand, projects that present capacity factor of up to 30%, closer to the reality of wind generators, hardly will be able to sell energy to negotiated prices in the current market (Pires and Holtz 2011).

By the end of November 2015, there were contracted 16.6 GW of wind power, of which 6.8 GW were in operation, 3.6 GW under construction, and 6.2 GW ready to begin construction. To reach the goal of 24 GW in 2024, provided for in the decennial plan of Expansion of energy PDE2024, it is necessary to still contract also 7.4 GW over the period 2016 to 2021.

In 2006, began to come into operation the first generators contracted in the Proinfa auction, and in 2011, the first contracted in 2009 reserve auction. Since 2006, installed capacity power roughly doubled every two years until 2012 and from that year to 2014 grew 172%.

Despite the low price of wind energy in the last auctions of energy, one must consider the risks of operation of this source, being considered seasonal and intermittent. To mitigate the uncertainty of energy production, the EPE proposed a contracting model that considers the average production over the years, and admits a margin of variation.

Another problem is the government to conduct auctions (for example, in 2012 there was no auction because of the crisis in the electric system and the misguided policy response) of transmission lines that will integrate the National Integrated System (*Sistema Integrado Nacional* SIN) to the Transmission Facilities of exclusive interest of Generation Centres (ICG). They are not part of the basic grid and have marketed energy in reserve energy and alternative sources auctions. Further, transmission lines auction in 2015 was a failure and it was rescheduled to April 2016, with the terms modifications imposed on Aneel by the Union Audit Courts (TCU).

Next, delay in granting environmental licenses delays the schedule of construction of transmission lines, thus hampering the progress of the wind projects. The ICG are required for the sale of wind energy sold in the auctions of alternative sources and energy reserves, which led to contracting of 1,206 MW of installed capacity in Bahia, Ceará and Rio Grande do Norte. Another issue that remains unclear is the issue of charging royalties for wind generation.

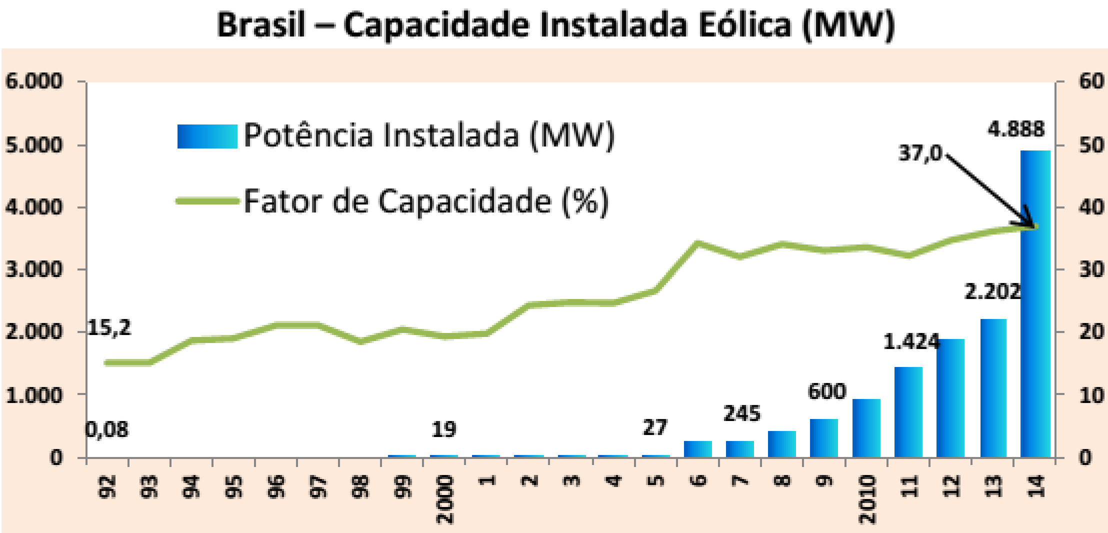

Figure 2: Source: Núcleo de Estudos Estratégicos de Energia / SPE/MME (2015). Energia Eólica no Brasil e Mundo. Ano de referência – 2014. Boletim. Edição: 11/12/2015.

Brazil currently has 9 manufacturers of wind turbines, with annual production capacity of little over 4,200 MW, distributed in the States of CE, PE, BA, SP and SC. There are 4 manufacturers of helices, with annual capacity of producing 10,400 units in the States of EC, EP and SP. In regard to the towers, there are 12 manufacturers, with production capacity of 2,430 units/year distributed in the States of CE, RN, PE, SP, PR and RS. The national average content of equipment is between 50% and 70%, with better performance targets for some components, established by the BNDES. The government has recently sought to provide responses to identified problems and barriers to the evolution of wind (N3E/SPE/MME 2015):.

Environmental licensing: the resolution 462/2014, of the National Environmental Council (CONAMA), standardized rules for licensing of power plants, eliminating disparities of requirements and criteria among the State agencies. In addition, the legislation allows the prior licensing of complex whole wind farms rather than license each park separately, as it was done until then.

Qualification of manpower: small and long-term courses are being promoted by the wind enterprises and trade associations. Partnerships with the National Industrial Apprenticeship Service (Senai) and Petrobras, have ensured the training of teachers and the maintenance of laboratories of operation and maintenance courses. The units of the Senai of Ceará and Rio Grande do Norte, linked to CTGás (Tecnológias-Center of Gas and Renewables), are considered the most ready to offer training for the wind power sector.

A critical new factor in the evolution of more decentralized energy production on Brazil is the involvement of regional governments and their collaboration with other government levels and civil society organizations. The ‘Letter of the Winds’ manifesto with ten steps to boost wind energy in Brazil was signed in Natal, Rio Grande do Norte stat, a wind-wept area, in 2009. The letter was signatured by Ministers, Governors, academics and entrepreneurs: the first two — removing the tax on industrialized products (IPI) of towers, propellers, turbines and the guarantee of an auction exclusive were implemented in that year. Since then, every auction contracted double MW of the previous auction. With the expansion of the scale, prices have dropped. In six years, the participation of wind energy in the energy matrix has quintupled. The challenges ahead are connecting wind farms to the national system and produce in the country more complex components. The ‘Sun Letter’ manifesto was signed in Rio in 2011, by State Secretaries, scientists, Ministers and ecologists. Among the 15 measures are: zero the ICMS for equipment and solar energy; ensure two-way counters — to measure the energy released into the network by generators; stimuli for the decentralized generation and distribution; use in sports stadiums, lamp posts, condos. Aneel has approved two-way meters, but the diffusion has been slow. Rio de Janeiro state in 2015 passed a law that zeros services and goods circulation tax (ICMS) for solar energy generated, promotes micro-generators, sets priorities for solar energy in condominiums and public equipment and favors research and deployment of companies in the sector. However, distribution companies still fail to comply with and law and unduly charge ICMS (Minc 2016)[6]. Solar also seem to have met admistrative and routine barriers in regulation. Also small hydro is remaining a small market and probably demand is now being replaced by wind power (Persson/Skauge 2016) . Energy needs could have been met by other sources than wind, but the policy have been clear and effective, to support wins. The installed capacity in 2015 was 96GW, a 43% increase over the previous year, and a further increase of 18,7GW is planned until 2019.

Taken together the policies and changes in regulation seem to have shifted the energy production path of Brazil away from hydro and in the direction of wind. Big hydro has both time/cost problems and political environmental problems (in the Amazon area). Wind is now (2015/16), after the series of auctions the cheapest electricity source and is establishing itself as a new path. One theoretical way of describing the situation is that deliberate push politics and problematic inner dynamics have managed to more or less stop the long standing path dependence on (big) hydroelectric power and create a new path of wind energy. The framework of the wind power market was deliberately created by government regulations. Also path-creating actions helping the future stability of the wind path have been put in place.

7. CHINA- forward in all directions, but mostly the Highway[7]

"A centralized energy supply system is the main method of supplying energy in China" Zhenya Liu, Chairman of State Grid Corpration in China, (the worlds' largest supplier of electricity) p120 in his book (2013).

Modern China started with a communist revolution in 1949 and soon was inspired and helped by the Soviet-Union, also in the area of energy. Large scale development of electrical energy, central planning and state control and ownership, linked to huge plants (coal and hydro) was a main tool for making the new industrial Soviet society and its new citizens. The same path was the advice for China. The first Chinese 5-year plan (1953 – 1958) was rather successful in the energy area (Geall et al 2014). The practical and symbolic role of the electrical grid is also easy to see in some of the revolutionary art, where electrical grid lines are painted into the skyline. The second plan represented serious problems in food supply, but still pushed big industrialization and energy. After the break-up with Soviet, the cultural revolution and the death of Mao, there was (from 1980) rapid growth again and by 2005 the GNP per capita was four times 1980-level. Environmental targets started coming into the plans from the 10th plan in 2006. The tendency grew and in the present 12th plan and other government papers, environmental values seem to play an important role. The aim is a different society that combines good living standards with environmental concerns and lower growth. Energy production is of main importance here, and the new leader Xi Jinping is associated with both a new attitude to growth and a major wish for strong changes in energy production in the direction of renewable sources, as well as the anti-corruption campaign. (Interview data, Jan 15, Jinping 2014). This focus is obviously balancing the need for energy security and ever more households connecting to the grid on one side and on the other the acute and serious pollution crisis that is present in big cities and also in the generally highly populated areas. Of importance, but with less drama, is the concern over both the general balance between humans and nature and the gradually more problematic dependence on imported oil, gas and coal. However these factors both give China the awareness and the motivation for a change (see section 1 and 2)

China is now the world's biggest producer and consumer of energy. In the energy production plans coal is to be reduced from above 70% of total electricity production to 50% in 2050, but in total numbers generation

[7] This analysis is based on a series of interviews in January 2015 as well as ordinary public written sources. List of interviews in Appendix 1. Data collection ended March 2. 2016

from coal will still grow. China is still very high in using coal as direct energy (36%, compared to India 13,8%, EU 3,9%), indicating that grid development and growth in electricity production will continue. China has also the biggest total CO_2 emission in the world, but USA is more than three times higher pr. capita. The change in composition of generating sources have been faster than most observers expected, and in 2014 the growth in CO_2 emission in China stopped, after growing 230% from 1990. Some (planned) slowdown in Chinese economy may be part of the reason, but growth in renewable sources, especially wind power, and shutdown of small dirty coal power plants, are major significant facts. In 2016 there are reports on too many new coal plants coming online, indication problems with slowing the coal path.

From 2005 China was doubling its wind capacity each year and is now doubling each 2-3 years, creating the world's largest wind power sector and the largest area of wind farms (Mathews 2015). Growth continued in 2015 with a growth of 33%. This fits with good access to finance and good innovation and coordination power, making China the strongest driver in the world wind market (Lema/Berger/Schmitz 2013) and drawing profit and manufacturing activity from the sector.

From 2005 to 2014 solar energy in China grew 400 times, but from a very low starting point. On the other hand, the capacity of 28GW (2014) is impressive and China is now both the world's biggest producer and biggest market for solar panels. In 2015 the growth in installed solar capacity was 73%. By 2013 China had the largest renewable energy industry in the world, and is also stepping up (12th 5year plan) grid investments for absorbing the more complicated and fluctuating energy from these renewables (Mathews 2015, Interviews 2015).

It is also important to note that nuclear power grew with 30% in 2015 and that China has by far the highest number of nuclear plants under construction (27 of 72 in the world) (NEA/IEA 2015, Energy Post 2016)

The Chinese position as a producer and, gradually, innovator in renewable energy manufacturing is a game changer in world energy development, but also interesting for understanding the structure of the Chinese energy system. China has a position as a major manufacturer of standardized items for the world market and both China and the fordist logic of big-scale manufacturing of standard units is rightly linked to falling prices and Chinese effiiciency and economic power. Many western countries that produce wind and solar power units are still linked to research, random state support and small niche activities/markets. Profitable large-scale manufacturing of renewable energy producing units is "capitalism" that also puts China in a position for its own supplying needs as well as profitable manufacturing for export. For solar PV the export possibilities are even more important. Both for solar and wind thsi is made possible by state involvement and planning on many levels (Mathews 2013, Mathews/Reinert 2014, Mathews 2015).

Both solar and wind are almost out of their global niche position due to this development The wind power production is relatively large units (0,7-1.5MW), but medium in a electricity-producing system. The solar panels are mostly small, and are eventually made bigger by linking huge numbers. Wind Power and even more solar power are technologies that belong to a more decentralized production system of electricity. These sources should press production in a more distributed direction.

As indicated above, this development is initiated and pushed forward by a centralized planning system and state-level tools, like direct funding, capital access, research, goal-setting, orders, planning, and arranging profit opportunities. The five-year plans, the change in values, the concept of ecological civilization, the formulated energy policy all fits in this picture of will and power from the central level (interviews 2015). In the Chinese governance system this means party authority an all sides of the table, and we got a clear impression that the top level take the energy reform quite serious and use their governing power accordingly

Chinas' need for energy, its pollution crisis and dependency of import have pushed energy planning and production in many directions: 27 of 72 planned classic (Phase II/III) nuclear power plants in 2015 are in China. After Fukushima there was a pause and some redesign, but the nuclear program seem to be on track again (Interviews 2015)

All is happening….

So far we have seen sharp growth in electricity production with a shift towards renewables enough to stop further growth in CO_2 emission (earlier than planned). We have mentioned nuclear power growth. Hydroelectric power has also grown and a long series of big projects are planned to use more of the huge reserves of hydroelectrical potential, and also the small hydropower sector is planned to grow, to 75GW in 2020 (Liu 2013).

There are research and initiatives and model plants for concentrated solar heat power (CSP). Wave power and other ocean renewable is looked into (Wang et al 2011). Offshore wind plans are discussed (Chen 2011). Geothermal resources are mapped and planned for (Zhao/Wan 2014) Big projects are dedicated to cleaner coal electricity (main activity in a research facility we visited) that many believe to among the most realistic paths.

China is also one of the few countries that have taken over and bought into research on new nuclear technology "phase IV" (smaller, standardized, cleaner, safer). China is probably leading the R & D on Thorium as nuclear fuel (Economist 2014), they are running the only functioning pebble-reactor. And China has experiments and/or working test reactors in Molten Salt, Sodium-cooled Fast Reactor, Supercritical Water Cooled, High temperature Gas Cooled (Alvin Weinberg Foundation 2012). These technologies are mainly going in the direction of smaller reactors, even container-sized and mass produced sometimes in the future. On the other hand China is also producing (and exporting) ever larger classical (gen II,III, III+) reactors.

In the grid area there are started expensive building of modern Ultra High Voltage Lines that are a priority in the 12th plan and research that looks into micro-grids (Liu 2013, Zeng et al 2014). Distributed electricity production is also "highest in the world" (45GW, 2009) but this sector is also deemed to be in "acute crises" (Liu 2013). The story is probably one of a mixed situation of old and new, private and rural utility and above all: old and new. There are companies with coproduction based on gas and there are small hydro and some solar. The crises is the mainly challenge of connecting this into the grid and make it a part of the general grid production, according to Liu (2013).

The main picture is a big push for more energy in many directions and with a lot of success, preferring energy in a form that do not pollute and do not have to use imported fuel, if realistic.

Pushing for centralization or decentralized?

Zhenya Liu is the key leader of the worlds' largest grid company. His perspective on distributed electricity production seems quite predictable, his institutional position taken into our interpretation: Distribution and decentralization only if necessary and most of the distributed production today should be integrated, reformed and standardized into the grid. Distribution of production is a problem, not a solution

There are some choices made relating to size. Distributed small size generation is usually between 10 and 50 kW (USA), but the Chinese sense of "small" is more at a MW level.

The "small" wind turbines are quite popular abroad, but mostly exported, the domestic ones and the ones with priority is the large ones, getting larger for each model series (Interview 2015). These big generators are, however, more efficient and stable, it must be admitted. The local environmental and political problems of placing the biggest windtowers was not seemed significant.

Solar power panels are mostly used as big solar farms, the biggest under construction (22,5 km2) in the Gobi desert that will supply a million households. The distributed solution with small rooftop panels that are used elsewhere in the world seem to have little priority. Solar PV has few obvious advantages from the scale in itself and could easily integrate in both urban and rural areas. Planned nuclear plants are also growing in size, reaching 1,5GW. Examples could be pluralized, the point is our impression that where there are options there is a "bigger is better" principle that grows out of the old system together with continuing reliance on the classical grid structure.

But also small rooftop has its research and reform plans in China. In a study by Liang (2014) he found that since mid-2012, seven different ministries and agencies issued at least 20 policies which focus on distributed solar generation including mid-term development strategy, subsidy programs, grid interconnection service, financial funds, and pilot demonstration projects. His study is important, one of his tables is presented as "Table1" at the end of this document and his conclusion:

In early 2014, the Chinese government laid out an ambitious goal for distributed solar generation— aiming for 14 GW of additional solar capacity over the course of the year, 60 percent of which is to be derived from distributed solar generation capacity rather than utility-scale projects. However, this aggressive goal is facing numerous economic and political difficulties, which resulted in the disappointing fact that in the first half of 2014, half of the 13 provinces in a survey received zero application for distributed solar installation (Liang 2014 p2).

This result is due to a series of implementation problems, but it is also a clue to a larger pattern. There are also some relevant grid observations. The quite dramatic imbalance that comes from the huge distance between energy consuming provinces and the energy producing ones, is mostly planned solved by a series of UHV (UltraHighVoltage) grid lines. These are under construction. The 12th plan has significantly stepped up investment plans for the Grid (Geall et al, 2014). Renewable production from smaller units (mostly wind) are gradually linked to the net. A few years ago up to 3 out of 10 wind generators were without grid connection (some built with Norwegian CDM money), but this problem is mainly solved (Zheng et al 2013, Interview 2015). The next bottleneck is the actual transport capacity of the grid and here the planned UHV lines are relevant (Yunna/Ruhang 2013), but probably not enough. It is seriously discussed to use the energy locally (making heat, use for production). This is both a classical solution and fits with in a more decentralized grid/production structure (interviews 2015). Distributed production (and micro-grids) seem to be seen as a solution only if it's the only solution, like on islands and in isolated areas (Liu 2013), but one interview stated that even the island/rural needs were not properly taken care of in the planning. "Big grid" is still the standard solution, even if there are serious research and models also for micro-grids (Zheng et al 2014).. It should be noted that this is a tendency, a footnote to a situation where new power is used and connected to the net and problems/bottlenecks are gradually solved.

The political and administrative level is of natural importance. Are the central administration (the two big grid companies), the (five) big producers, the (new) regulation bodies pressing for smaller scale and sustainable production or the opposite? The central planning system is strongly implemented and is a main tool for central government. One main goal is "energy efficiency per produced unit" which might create a skewness in the direction of the big power plants, having the best efficiency (but not taking grid, flexibility and long time cost into consideration). A natural hypothesis would be that the producers, grid representatives, regional administration and regulators favors big grid and big (coal ?) production units as they were institutionalized in the old "Big is best" times and have knowledge , culture and privileges from that form. It is difficult to be sure of the answer. Out interviews pointed to a mixed impression where there was some support for our hinting to dragging of feet from these levels, but also acknowledgement of real problems and need to use time to shift thinking pattern and solve problems. Central government was most often mentioned as an actor for modernization and shifting into more sustainable production, a governance structure aspect also observed in the literature on the energy governance structure of China (Lin/Purra 2012) Probably this is also an arena for political tension and we got some impression that the top level was pressing the middle and local level with some force in the direction of accepting new energy sources and connect them. So far, there is some indication that decisions and structure is not in favor of a dramatically more distributed or decentralized power production structure. This impression is strengthened further by a third factor that is usually emphasized in the discussion of distributed (PV) power production: The role of the consumer.

With China's past mobilization of "the masses" (another word for consumers and workers and farmers?) in several campaigns, on could predict ideological infused mobilization for energy saving, for co-production, for decentralized local production and prosumer roles. Not so. Quite the opposite. At the general level of attitudes there is a significant concern over environment and pollution, but this is not connected to energy usage and production in people's minds (Andrew-Speed, 2012,+ interviews). Local solar water heaters (SWH) have a long history and is cheap, popular and proven technology in China (and exported to South Africa), but the actual usage seem to be random (we counted around 1 out of 10 houses in the countryside, none in cities) and not linked to significant central plans and campaigns (Interview). These are simple means to take load of the grid and save money for the consumer and supporting energy policy at the same time, but these dots are not clearly connected. The same applies to the maybe 150 million small electrical vehicles (motorcycles and small cargo trikes) that must have a positive role in city pollution calculations. Few of our informants saw something positive with them, and policies and support ware not mentioned. And finally, as mentioned above: there were few successful systematic efforts to implement small-scale solar panels, small wind generators and other local supportive solution with the consumer as producer.

Energy in China is produced with all means necessary and with special priority and success for renewables. These renewables are significantly more decentralized than the old technology from the revolutionary/industrial years. The main success factor is the manufacturing power of Chinas economic system and the capacity for governing from the state level. Decentralization seem to happen only if it is necessary and the main attitude is still one of integrated grid connection of relatively large units. So far it is a fairly successful shift to more energy with better sustainability with not so strong impact on the basic structure.

8. Conclusion

There are two kinds of findings we hope to make from this comparison. The first is to single out some important factors that may help or block motivations for energy change. The blocking factors are most easily seen in South Africa:

- An established system of strong political and institutional force, linked to centralized and coal based energy
- A structure that links energy production to special schemes of taxation, favoring status quo
- A regulative setup that is unfitted and only slowly and partly reformed

The factors that seem to help change is of course inverse of the above, but also a little more:

- Economic actors and interests that can profitable align with the production of power , its equipment and infrastructure
- A supportive and adaptive regulative reform program, also respecting the special needs of sustainable power production
- A political willingness to support a process that will meet problems and readjustment

The second attempt to conclude is the more general characterization of energy change in the three countries:

Brazil seem to be a country that gradually have succeeded braking the power of its hydro path dependence and more or less getting a new robust path of wind power started. This is both due to build-up of problems for hydro and a deliberate political and regulative work.

China has the advantage of economic strength and rapid growth and has used these advantages to build manufacturing power of the two main new sustainable energy sources. Market success guided by strong planning and priorities. Including R & D and capital access. The size and general growth has so far made China able to have several paths of energy production at the same time, but brakes that are put on coal seem to be at least partially working. These developments are taking place inside a classic big grid system.

South Africa is difficult to describe, with many tendencies. Conflicts and unbalanced processes. They have the strongest path dependence of the old system and very good possibilities for sun and wind energy of many sizes including a huge reservoir of workforce and entrepreneurship. Regulation and lock-ins are many and with only small tendencies to being solved, The whole power regime of South Africa may even continue without structural changes until it dissolves, a creative destruction. It may also survive with state power and foreign help to get more big coal and big nuclear. But on the other hand, the path to a very different and sustainable energy system has its positive tipping point only a few reform packages away, mostly in regulation.

Table 1: Q1 2014 Completion Rate of Distributed Solar Generation in China.

Province	2014 planned amount of distributed solar power application for permits (MW)	The amount of application by Q1 2014 (MW)	Completion Rate
Beijing	200	0.0	0.00%
Jilin	100	0.0	0.00%
Guangxi	100	0.0	0.00%
Chongqing	10	0.0	0.00%
Guizhou	30	0.0	0.00%
Henan	550	0.0	0.00%
Yunan	10	0.0	0.00%
Shangdong	1000	4.2	0.42%
Hunan	200	5.0	2.50%
Fujian	300	10.0	3.33%
Zhejiang	1000	44.8	4.48%
Heilongjiang	50	5.0	10.00%
Guangdong	900	130.0	14.44%

Source: Xiupei Liang (2014)

Appendix 1 :

China: List over interviews, January 2015, 9 informant interviews with 11 persons

Hong Kong Electric (TC Yee, Raymond Choi, Alex Lee)
Shanghai Jiao Tong University (Yi-Wen Yu)
Inter China Consulting (Simon Zhang)
China National Renewable Energy Centre (Wang Wei)
Goldwind (Alfred Zhaojinzhuo, Tristan Evans)
Energy and Climate Policy /Intasave (Gørild Heggelund)
BP Clean Energy Research and Education Centre (Ma Linwei)
Carnegie-Tsinghua Center for Climate Policy (Tao Wang)
Greenpeace, Climate and Energy Campaign (Li Yan)

Brazil: List over interviews, November – December 2014: 9

Roberto Veiga, Presidente, Conselho de Energia Eolica, ABIMAQ.
Antonio Claret, Elisa Astronelli, Movimento de Atingidos por Barragens, MAB
Leonardo Bauer, MAB Brasil
Barbara Rubim, Campanha de Clima e Energia, Greenpeace Brasil
Dr. Rui Guilherme Altieri Silva, suoerintendante, ANEEL - AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA
Donald Sawyer, Research Associate. Institute for Society, Population and Nature, ISPN.
Alberto Lourenço - MCTI - Ministério da Ciência, Tecnologia e Inovação - Gabinete
Celso Knijnik - Ministério do Planejamento - Ministério do Planejamento.
Adriana Ramos, Adjunct Executive Secretary, ISA
Fausto de Paula Menezes Bandeira, Consultor legislative,
Francisco Jose Rocha de Sousa, Consultor legislative, Mines and Energy Area Congress
Caetano Glavam Ulharuzo, ABDI. Project Specialist - Biocombustível SBN Quadra
Otavio Silva Camargo, Director, ABDI
Miguel Antonio Cedraz Nery, Assessor Especial – Projetos. Project Advisor
Luciano Cunha Ministerio do Desenvolvimento Esplanada dos Ministérios,
Moara Giassoni, IBAMA - SCEN
Ricardo Gorini de Olivera, D.Sc., Head of the Energy and Economic Department, EPE –
Mauuricio Perez Botelho, Vice Presidente Financeiro e Relacao com investidores/CFO & Investor
Roberto Schaeffer COPPE Centro de Tecnologia, Sala C-211, C.P. 68565, Cidade Universitária
Fernando Pintas Dias Perrone. Head of Energy Efficiency Projects Department .
Marcio Drummond, Head of Department. Energy Trading Department,
Roberto Schaeffer , Associate professor. Alberto Liuz Coimbra Institute for Research and Post-graduate Studies of Engeering. Federal University of Rio de Janeiro Energy Planning Program. PPE/COPPE/UFRJ. rberto@ppe.ufrj.br
Andre Mendes - BNDES - Manager of Gas and Oil department -
Alexandre Esposito and Paulo Fuchs - BNDES - Manage Energy Studies

<u>South Africa Interviews (19 different, 2014-2016)</u>

- Derek Campbell/Bloomerg
- Steve Lennon /ESKOM
- Karen Surridge-Talbot /Ren En Center /SAWEA, RES SA
- Evan Rice/ Green Cape

Ntombifuthi Ntuli / DTI
Anton Eberhardt/UCT
Ben Sebitosi/Dep of Mech & Duncan Ailing
Richard Worthington/WWF
Nicolas Rolland/G7 ren en

- Peter Atkins/ Green Cape Marlett Balmer /SAGEN-GI
- Johan van den Berg/ SAWEA, SA Ren Energy Council
- Karin Breytenbach/IPP Center
- NERSA
- 4 Small Entrepreneurs and company consumers (with Melanie van der Merwe)

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Assessment of the acceptance of energy systems transformation

by

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Abstract

The transformation of existing energy systems into sustainable energy systems with low carbon emissions is an important challenge facing climate change. However, in modern democratic societies, transformation strategies, even if they are technically and economically feasible, may become politically unfeasible, if they are not accepted by the public. Therefore, the reliable assessment of public acceptance is essential for the successful management of transforming an energy system. The aim of the paper is to explain and illustrate how a tool called technology monitoring is used in order to assess the acceptance of Germany's energy system transformation. Firstly, the research questions examined by technology monitoring will be described as well as the tool's elements and methods. Subsequently, by using the examples of CO_2 capture and storage (CCS) and the extraction of shale gas it will be illustrated how technology monitoring can be used for the assessment of public acceptance. This will include a comparison of the public acceptance of CCS and shale gas extraction in Germany along the indicators risk perceptions, benefit perceptions and general attitudes by applying descriptive statistical analyses. Furthermore, the determinants of attitudes towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas will be identified by applying regression analyses. Against this background the contributions of technology monitoring for the assessment of the acceptance of energy systems transformation in general as well as possible contributions to energy scenarios in particular will be discussed.

1. Introduction

Energy systems transformation, also called energy transition[8], means fundamental structural changes in energy systems, which have occurred in the past and still occur worldwide [1]. However, energy transitions differ in terms of motivation, objectives, drivers and governance [ibid.]. The main objectives of the energy transition in Germany, the so-called "Energiewende", are to decarbonize energy supply by switching to renewable sources and to reduce energy demand by using energy more and more efficiently [2]. Thereby, Germany aims to make a significant contribution towards combating climate change.[9]

The transformation of the existing energy system in Germany into a more sustainable energy system requires long-term fundamental changes, which includes changes in the energy mix, the application of new energy technologies and possibly the exploitation of new energy sources, but also changes in the demand behavior of the citizens. However, such transformation strategies, even if they are technically and economically feasible, may become politically unfeasible, if they are not accepted by the public. Therefore, the reliable assessment of public acceptance is essential for the successful management of transforming the energy system.

The aim of this paper is to explain and illustrate how a tool called technology monitoring is used in order to assess the acceptance of Germany's energy system transformation. Firstly, the research questions and the aim of technology monitoring will be described as well as the tool's elements and methods. Subsequently, by using the examples of CO_2 capture and storage (CCS) and the

8 The terms "energy systems transformation" and "energy transition" are used synonymously in this paper.

9 The goals and measures of the energy transition in Germany are described in detail in the German government's Energy Concept [3] and the 10-Point energy agenda of the Federal Ministry for Economic Affairs and Energy [4].

extraction of shale gas it will be illustrated how technology monitoring can be used for the assessment of public acceptance. This will include a comparison of the public acceptance of CCS and shale gas extraction in Germany along the indicators risk perceptions, benefit perceptions and general attitudes by applying descriptive statistical analyses. Furthermore, the determinants of attitudes towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas will be identified by applying regression analyses. Against this background the contributions of technology monitoring for the assessment of the acceptance of energy systems transformation in general as well as possible contributions to energy scenarios in particular will be explained.

2. Technology monitoring

Technology monitoring is part of the integrated assessment of energy systems, which is the main focus of the interdisciplinary work of the group "Systems Analysis and Technology Evaluation" at the Institute of Energy and Climate Research at Forschungszentrum Juelich (Research Centre Juelich). The integrated assessment of the transformation of energy systems includes technical, economic, environmental and social assessment. The social assessment of energy systems transformation comprises the organization and realisation of stakeholder dialogues, the investigation of mentalities and patterns of behaviour related to energy consumption, life cycle sustainability assessment and technology monitoring. Technology monitoring is the main approach for assessing the public perception of energy systems transformation and will be described in more detail in the following chapters.

2.1 Research questions and aim of technology monitoring

In order to assess the public perception of energy transition in Germany, technology monitoring investigates three general research questions: (1) What is the status quo? (2) Which dynamics does it have? and (3) What are the determinants?

Investigating the first question includes assessing how aware the general public is of energy transition and which knowledge and attitudes the public has. Examining the second question comprises measuring how the public awareness, knowledge and attitudes develop and change over time. Exploring the third question means to reveal the relevant factors which determine public perceptions and general attitudes.

Thus, the aim of technology monitoring is to contribute to the assessment of the acceptance of the German energy system's transformation by surveying the awareness, knowledge and attitudes among the German public regarding technologies, instruments and impacts of the energy transition.

2.2 Methods of technology monitoring

Core element of technology monitoring is a representative survey of the public in order to measure the acceptance of the energy system's transformation in Germany. The survey is carried out annually since 2011/12 (= IEK-STE Panel Survey). Population of the IEK-STE Panel Survey are all German citizens from the age of 18 with landline connection (cf. Table 1). Participants for the survey are recruited using multi-stage systematic random sampling. For the selection of the respondent the last birthday selection method is used, i.e. the person from the age of 18 who had the last birthday in the household will be interviewed.

Every year (= panel wave) at least 1000 interviews are realized. The reproduction accuracy of the survey sample is examined by comparing the distributions of the characteristics gender, age, professional qualification, income and household size with the data of the Microcensus, which is a representative household survey of the official statistics in Germany.

Every wave of the panel survey comprises questions which are asked every year (= core questions; e.g. questions regarding attitudes towards energy sources) as well as questions on specific up-to-date topics (e.g. questions regarding attitudes towards CCS, shale gas or expansion of the electricity grid) which vary every year or which are repeated in larger temporal intervals (e.g. every second year).

Table 1: Parameters of the IEK-STE Panel Survey.

Parameter	Specification
Population	All German citizens from the age of 18 with landline connection
Sampling procedure	Multi-stage systematic random selection from the existing landline numbers in Germany
Selection of the respondent	Last-Birthday Selection: Person from the age of 18 who had the last birthday in the household
Realised sample size	At least 1000 persons
Criteria for the representativeness of the sample	▪ Gender ▪ Age ▪ Professional qualification ▪ Income ▪ Household size
Data base for verifying the representativeness of the sample	Data of the Federal Statistical Office (Microcensus)
Survey method	Computer-assisted telephone interviews (CATI)

Source: authors' own.

Further essential elements of technology monitoring are specific representative surveys of the German public performed only once in order to investigate research questions related to research projects focussing on specific energy technologies; e.g. CO_2 storage, energy storage, vehicle to grid [5-11] or other aspects of the energy system's transformation, e.g. energy consumption or energy security.

In the following, the examples of CO_2 capture and storage (CCS) and the extraction of shale gas will be used in order to illustrate how technology monitoring can contribute to the assessment of public acceptance of energy transition.

3. Assessment of public perception of CCS and shale gas in Germany

CO_2 capture and storage (CCS) is perceived worldwide and in the European Union (EU) as a key technology for greenhouse gas (GHG) emissions mitigation [12, 13], whereas the extraction of shale gas is seen as strategy for enhancing energy security [14]. In Germany, the transportation and storage of CO_2 [cf. 15] as well as the shale gas extraction[10] is controversially discussed in scientific and political debates. The perceptions of CCS and shale gas among the German public were surveyed for the first time 2011/12 in the first wave of the IEK-STE Panel Survey and for the second time 2015 in the fourth panel wave. Furthermore, the public perception of CO_2 offshore storage, CO_2 onshore storage and CO_2 pipelines was surveyed in more detail in three representative surveys (a nationwide survey and two regional surveys) of the German public which was carried out in 2013 within the framework of a project called "CCS-Chances" [7].[11] In this paper, the data of the two panel waves as well as the data of the national "CCS Chances survey" were used to compare the public perception of CCS and shale gas in Germany along the indicators risk perceptions, benefit perceptions and general attitudes by applying descriptive statistical analyses. Additionally, linear regression analyses were performed in order to identify the factors that determine the general attitudes towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas.

3.1 Risk perceptions of CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas

Previous studies on the acceptance of risks and technologies verified that the acceptance of technologies by the general public is greatly influenced by the intuitive perception of risks, as well as by the perception of benefits and trust [e.g. 16, 17, 18]. In our studies, we generally differentiate between the perception of the personal risk, this means how risky the

[10] http://www.shale-gas-information-platform.org/areas/the-debate/shale-gas-in-germany-the-current-status.html.

[11] https://www.tib.eu/suchen/download/?tx_tibsearch_search%5Bdocid%5D=TIBKAT%3A835363600&cHash=bfea90dc8a82276cf056479593a0fb61#download-mark (webpage in German).

respondent think an energy technology would be to him and his family and the perception of the societal risk, this means how risky the respondent think an energy technology would be to society in general [10, 19]. The risk perceptions are specified on a seven-level Likert scale, ranging from 1 (= very low) to 7 (= very high).

In our "CCS Chances survey" we collected data on the perceptions of the personal and societal risk of CO_2 transport via pipeline, CO_2 onshore storage and CO_2 offshore storage, but not of CCS in general. This was due to the research focus of the project "CCS chances" which was the investigation of the perception of CO_2 offshore storage among the German public in comparison to the perception of CO_2 onshore storage and CO_2 transport via pipeline. Thus, in this paper we compared the risk perceptions of CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas (cf. Table 2).

With regard to the assessment of personal and societal risks of CO_2 transport via pipeline, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas, a comparison of the means shows that the personal and societal risks of CO_2 onshore storage and shale gas are perceived as higher than the personal and societal risks of CO_2 pipelines and CO_2 offshore storage. However, in all cases the societal risks are deemed higher than the personal risks.

3.2 Benefit perceptions of CCS and the extraction of shale gas

With regard to the assessment of benefits, we also differentiate between the perception of the personal benefit and the perception of the societal benefit [19]. Benefit perceptions are also specified on a seven-level Likert scale, ranging from 1 (= very low) to 7 (= very high).

Due to the limited number of questions which we can pose in our surveys, it was not possible to include questions on the perceptions of personal and societal benefit of CO_2 pipelines, CO_2 onshore storage and CO_2 offshore storage, but only questions on the perceptions of personal and societal benefit of CCS (cf. Table 3).

Concerning the assessment of the benefits of CCS and shale gas, a comparison of means shows that the personal and societal benefits of shale gas are considered to be markedly lower than the personal and societal benefit of CCS. However, in both cases the societal benefit is perceived as higher than the personal benefit.

Table 2: Risk perceptions of CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas.

	Personal risk		**Societal risk**	
	Mean[1]	SD[2]	Mean[1]	SD[2]
CO_2 transport via pipeline	3.7	1.8	4.1	1.6
CO_2 onshore storage	4.3	1.6	4.5	1.6
CO_2 offshore storage	3.9	1.8	4.2	1.7
Shale gas	4.2	1.7	4.7	1.6

[1] Scale from 1 (= very low) to 7 (= very high). [2] SD = Standard deviation. Data sources: Survey "CCS Chances" 2013 (n= 1000); IEK-STE Panel Survey 2015 (n=1000). Question: "How risky do you think CO_2 transport via pipeline/CO_2 onshore storage/CO_2 offshore storage/the extraction of shale gas would be to you and your family/to society in general?"

Table 3: Benefit perceptions of CCS and the extraction of shale gas.

	Personal risk		**Societal risk**	
	Mean[1]	SD[2]	Mean[1]	SD[2]
CCS	3.4	1.6	3.9	1.7
Shale gas	2.8	1.4	3.4	1.5

[1] Scale from 1 (= very low) to 7 (= very high). [2] SD = Standard deviation. Data sources: Survey "CCS Chances" 2013 (n= 1000); IEK-STE Panel Survey 2015 (n=1000). Question: "To what extent do you think CCS/the extraction of shale gas would benefit you and your family/society in general?"

Table 4: General attitudes regarding CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage, CCS and the extraction of shale gas.

	General attitude	
	Mean[1]	SD[2]
CO_2 transport via pipeline	3.9	1.6
CO_2 onshore storage	3.3	1.7
CO_2 offshore storage	3.6	1.8
CCS	3.8	1.7
Shale gas	2.9	1.6

[1] Scale from 1 (= very negative) to 7 (= very positive). [2] SD = Standard deviation. Data sources: Survey "CCS Chances" 2013 (n= 1000); IEK-STE Panel Survey 2015 (n=1000). Question: "Overall, how do you assess the idea of CO_2 transport via pipeline/CO_2 onshore storage/CO_2 offshore storage/CCS/the extraction of shale gas?"

3.3 General attitudes regarding CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage, CCS and the extraction of shale gas

The general attitude regarding CO_2 transport via pipeline, CO_2 onshore storage, CO_2 offshore storage, CCS and the extraction of shale gas was measured in our surveys by asking the question "Overall, how do you assess the idea of CO_2 transport via pipeline/CO_2 onshore storage/CO_2 offshore storage/CCS/the extraction of shale gas?" The respondents specified their general attitude on a seven-level Likert scale, ranging from 1 (= very negative) to 7 (= very positive).

A comparison of means illustrate, that the general attitude of the German public is considerably more negative towards shale gas than towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and CCS (cf. Table 4). Furthermore, the general attitude is more negative towards CO_2 storage, especially CO_2 offshore storage, than towards CO_2 transport via pipeline and CCS in general.

3.4 Determinants of general attitudes towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas

In the previous sections the risk perceptions, benefit perceptions and general attitudes regarding CCS, CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas were compared by applying descriptive statistical analyses. In addition, the question as to which factors determine the general attitudes towards CO_2 transport, CO_2 storage and the extraction of shale gas is relevant. In order to answer this question, four linear regressions were performed.[12]

The results of our regression analyses showed that the most important direct determinants of general attitudes towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage and the extraction of shale gas are the perceptions of personal and societal risks.[13] The perception of the societal risk has the highest estimated parameter in every regression model, followed by the perception of personal risk. Furthermore, the perceptions of societal and personal risk revealed negative correlations with the general attitude in every regression model, i.e. the higher the perceived personal or societal risk, the more negative the general attitude towards CO_2 pipelines, CO_2 onshore storage, CO_2 offshore storage or the extraction of shale gas.

The perception of societal benefit is an important positive determinant of the general attitude in all regression models: the higher the assessed societal benefit, the more positive the general attitude towards CO_2 transport via pipeline, CO_2 onshore storage, CO_2 offshore storage or the extraction of shale gas.

The perception of personal benefit is an important positive determinant of the general attitudes towards CO_2 onshore storage, CO_2 offshore storage and shale gas extraction, i.e. the higher the assessed personal benefit, the

[12] Readers who are interested in the detailed regressions' results will be provided with them if they send an email to the author (d.schumann@fz-juelich.de).

[13] This confirms results of other empirical studies on public perception of CCS [16].

more positive the general attitude. For the general attitude regarding CO_2 pipelines, the perception of the personal benefit is not a statistically significant influence factor.

The general attitudes towards CO_2 transport via pipeline, CO_2 onshore storage and CO_2 offshore storage are also weakly positive influenced by the perception of nature as tolerant[14], whereas the perception of nature as benign is a positive determinant of the general attitudes towards CO_2 onshore storage and CO_2 offshore storage. The perception of nature as capricious determines the general attitude towards shale gas extraction weakly positive. In contrast, the general attitude of CO_2 offshore storage is weakly negative influenced by the perception of nature as ephemeral.

The perception that both the environment and the economy are important, but the economy should come first, determines the general attitudes towards CO_2 transport via pipeline, CO_2 onshore storage and CO_2 offshore storage weakly positive, whereas the influence of this factor is a bit stronger on the general attitude of CO_2 pipelines. A weak positive determinant of the general attitude towards shale gas extraction is the perception that decisions of policy and economy regarding technology are often made above citizens' heads.

4. Conclusions

Using the examples of CCS and the extraction of shale gas, this study has illustrated that technology monitoring contributes to the assessment of the acceptance of energy systems transformation with three different functions: (1) a descriptive, (2) a comparative, and (3) an explanatory function.

The descriptive function of technology monitoring is to provide information about public acceptance of technologies, instruments and impacts of energy transition. This includes information about the status quo within the survey period as well as about the development over time.

The comparative function of technology monitoring enables for identifying similarities and differences between the perceptions of different technologies, instruments and impacts of energy transition. This makes possible to ascertain which characteristics are specific for the respective technology or instrument and which not and to derive generalizable conclusions. However, such a systematic comparison requires that the perceptions of different technologies, instruments and impacts are measured with the same indicators, such risk perceptions, benefit perceptions and attitudes.

Furthermore, technology monitoring has an explanatory function, which was shown in this study by identifying important determinants of general attitudes regarding energy technologies.

All three functions of technology monitoring provide information which can be used for assessing public acceptance of different energy transition paths. This can be done for example by integrating indicators of public perception either ex-ante as input parameters or ex-post as output parameters in energy scenario construction processes [20]. Integrating acceptance factors as input parameters would be helpful for generating holistic scenarios, whereas integrating acceptance factors as output parameters would be useful for generating normative scenarios [ibid.]. Both ways of integrating acceptance factors in energy scenarios would be valuable in order to assess the societal feasibility of future energy systems and delivering information which could facilitate the management of energy transition.

[14] For the explanation of the attitudes towards the vulnerability of nature see [10].

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Investigating controversies between coexisting building and environmental regulations in Greece

by

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Abstract

Building activity is currently responsible for almost 1/3 global of global greenhouse emissions and according to the latest report of the Intergovernmental Panel on Climate Change (IPCC) for the environmental performance of buildings, 32% of the world's annual energy consumption comes from buildings, while at the same time they are considered as one of the most promising areas for reaching the decarbonization goals agreed in the COP 21.

The Greek state has updated its building regulations and introduced new laws concerning the energy performance of buildings. At the same time, several laws were - and still are - introduced in order to regulate structures built without formal permission. Inevitably, there is currently a debate about the environmental impact of the latter and some broader concerns about whether these two legislative initiatives comply with one another.

Object of this paper, due to the relative lack of research regarding the environmental impact of the regulation of spaces built illegally, is to contribute to the current discourse by providing results about the effect that some of these structures have on the thermal performance of the national building stock. The research methodology is a quantitative approach using simulation, thermal and lighting, conducted at three stages; fist the careful selection of data to be used as input for the simulations, then the specification and encoding of the typology of spaces to be used in simulations and finally the comparative examination of all selected types.

1. Introduction

In several studies (Ibrahim, et al., 2003; IPCC, 2014; Lucon, et al. 2014; Martinez, et al., 2010; Samar and Salman, 2011) the building sector is considered the main reason for the constant increase of energy demand globally. The rise in energy consumption of buildings is caused by many factors, such as climate change, population increase and living standards among others. In warm climates, like the Greek, one of the causes of this rise is the expansion of air conditioning systems (A/C) (Chen, et al., 2010; Giabaklou, 1996). According to research made for Athens (capital of Greece) on air conditioning loads during the 1990s, more than half of households installed A/C systems, and the percentage is constantly rising (Hassid, et al., 2000). This challenges utilities that sometimes find it hard to deal with the increased air conditioning energy demand, especially during the frequent summer heat waves. So, a buffer space or a fixed shading device, like the semi-outdoor spaces, under certain conditions could have positive effects on the energy consumption of buildings.

Although research in the scientific field related to semi-outdoor spaces has been conducted in the past, lately, scientific research in this area has grown substantially. Since, as mentioned above, semi-outdoor spaces represent a form of fixed shading devices, the research relating to semi-outdoor spaces has benefitted substantially from this renewed interest. According to relevant literature, this renewed interest can be attributed to the increased scientific interest regarding thermal comfort in open-air spaces.

More specifically, several scientists (Tan and Fan, 1992; Pagliarini and Rainieri, 2011; Beazley 1991) have acknowledged the benefits that these semi-outdoor spaces can yield in improving the thermal performance of the building. Research has mainly focused on issues such as thermal comfort, assessing the potential energy savings as well as suggestions for enhancing the role of these spaces in providing a thermally stable and comfortable environment.

In identifying the impact of semi-outdoor spaces on energy consumption of the adjacent inner spaces, several different (and often contradicting) approaches have been explored. For example, Pitts and Saleh, (2007) suggested that the PMV (predicted mean vote) and PPD (predicted percentage dissatisfied) parameters emerging from the Fanger model were appropriate for assessing the thermal comfort in these semi-outdoor spaces, while Toudert and Mayer (2007) as well as Boyer et al (2007) experimented with the physiological equivalent temperature (PET) in order to evaluate thermal comfort on semi-outdoor settings.

However, apart from the thermal comfort, research concerning these particular spaces is also concentrating on the impact of these spaces (in terms of cooling, heating and total thermal loads) on the thermal behavior of the buildings. According to Pitts and Saleh (2007), significant benefits (rising up to 13% reduction in energy required for heating/cooling) can be derived from the use of these transitional spaces. However, as Pitts and Saleh (2007) admit, more building types should be investigated in order to be able to draw more general conclusions regarding the benefits of semi-outdoor spaces on thermal performance, a limitation which is addressed in paper. In addition to this gap in scientific research, it is important to note that the effect of these semi open-air spaces on the adjoining spaces is not explicitly taken into account.

2. Research Goal

Semi-outdoor spaces were introduced in Greece by law, in 1985. This regulation defined this kind of space as a covered space of a building with at least one open side, whose use was either for circulation or temporary accommodation. According to the regulation this space could have different proportions (within some limitations) and a specific area that depended on the area of the building. In addition, the area of this space - room was considered as an additional area of the building, so it was in a way a motive for the construction of more buildings suitable to Greek climate. However, the intentions of the law were in most cases misinterpreted by owners and constructors, as it was considered an opportunity for higher profit. In most cases the open side of the space was replaced by glazing, or other poor insulated materials, because this kind of building features can be easily removed in case of the report of this illegal enclosure.

The 1985 law (often referred to in this paper as former regulation) was firstly replaced with the introduction of a new law concerning semi-outdoor spaces in 2009 and later on, in 2012, with the introduction of a new national building regulation (often referred to in this paper as current regulation). The new laws coincided with a vast effort by the relevant ministry to decrease the energy consumption of buildings. So, almost at the same time a new environmental regulation for buildings (KENAK) (Ministry of Environment, 2010/D), a new measure concerning semi-outdoor spaces dimensions in 2012 and also new measures for the legalization of illegally closed semi-outdoor spaces were introduced in 2009, 2011 and 2013. These regulations aim at the construction of buildings with smaller semi-outdoor spaces, in order for illegal enclosures to stop (at least that is the ministry's belief), and at the same time through certain procedures to legalize the illegally arranged spaces and keep them as they are.

These legislative changes have created a huge discussion in the academic and architectural community. The former regulation was widely accepted as it gave city residents the opportunity to have in their homes this space which is well-suited to the Greek climate (Papaioannou, 2005). The current regulation is under strong criticism because the decrease of semi-outdoor space dimensions raises questions about the ability of the reviewed semi-outdoor spaces to fulfill their functional and bioclimatic purpose. At the same time questions have also been raised about the effect of preserving illegally arranged spaces and whether it is right only with the payment of a fee to keep a space that is illegal, has not been designed and will coexist with buildings built according to new environmental regulations.

The main goal of this study is to investigate the effect of different types of these spaces on the energy concumption of multi-storey residential buildings in Greece. In other words, to investigate how and to what extent the diverse types of the semi-outdoor spaces affect the thermal performance (heating and cooling loads) of adjacent inner spaces. It focuses on numerous types of semi-outdoor spaces that appeared in the past twenty five years in the Greek urban context and gives answers to the following questions:

- How is the energy load of an apartment changed from former – 1985 - case without semi-outdoor space by adding one legally?
- How is the energy load of an apartment changed from former – 1985 - case with semi-outdoor space by illegally enclosing it?
- How is the energy load of an apartment changed from current – 2012 - case without semi-outdoor space by adding one following the current regulation?
- How is the energy load of an apartment changed from current – 2012 - case without semi-outdoor space by adding one without taking into account the dimensions limitations of the current regulation?

3. Research methodology

The research concentrates on the main floors of a typical, semi-detached, multi-storey residential building in Athens and Thessaloniki. It refers to the types of semi-outdoor spaces, formed by the national building regulations and the effect of this feature on the energy performance of buildings.

The research methodology of this particular study is a quantitative approach using simulation. The tool used for the calculations regarding thermal analysis is the Autodesk Ecotect Analysis software package. The use of one simulation tool has encouraged the direct comparison of the several outcomes and as a result the tracking of possible percentage alterations of the outcomes in the diverse case studies. In parallel, the results, as numbers, are being checked and analyzed in every stage of the research with the help of the appropriate case literature.

The first stage of the research includes the collection and careful selection of data that was used as input for the simulations. The appropriate computational models formed the base for making the required measurements and obtaining the required results. The main endeavoring element and leading principal for the shaping of the models was the notion of "realism", though the research's main target is the "arithmetic" analysis of a real problem that is taking place in a very specific site with very specific characteristics. The first category of selected data refers to the description of the Greek modern urban space, which is the host environment for the research. The detailed descriptions of its geometrical, climatic and constructional characteristics, contributed to a great extent to the selection of representative examples that were used as hostage sites for the measurements. The main source for the collection of those data was the existing building regulations. Additionally, the study was enriched with data from official statistical authorities and from relevant studies.

The second stage of the research was the specification and encoding of the typology of semi-outdoor spaces used in simulations. The selected types are representative examples that refer to a broader spectrum of case studies. In the first part, the models of semi-outdoor spaces are designed according to the former building legislation geometrical guidelines (the illegal reformations-arrangements produced by the inhabitants of the buildings were also studied and taken into consideration), and in the second part the models are designed according to current building legislation and a further analysis take place regarding the correlation between the former and the current regulations.

In the end, all different types are examined after being located on different floors of the building and measured for diverse orientations. In total, there have been thermal simulations of one hundred and sixty two different cases and a complementary insolation level analysis on seventy two of them.

4. Energy performance of the Greek building stock

The Greek building environment has undergone several changes in the past twenty five years. Table (1) displays the Greek building stock through different construction periods (Hellenic Statistical Authority, 2011/A). In the years from 1985 till recently, 20% of the present Greek building stock has been built. Almost 1/5 of Greek buildings have been built following the former regulation about semi-outdoor spaces. Moreover, the vast majority (74.6%) of those buildings are dwellings, the case that we are interested in.

While the number of buildings was constantly increasing, the population as well as the size of the cities was growing too. The major thing about the national building stock that interests this particular study is that Greek household energy demands increased in the same period. During the 1990's Greek household energy demands increased by 27,4% (European Commission, 2004), while during the same period the respective percentage in other European cities was lower due to the improved building design materials and construction methods as well as because of the implementation of more efficient building methods. As a result, the electrical energy consumption of Greek buildings was increased to a great extent represented by 40% of the total CO_2 emissions in the whole country Ministry of Development (2004) as cited in (Balaras, et. Al, 2007) and by 30% of the total energy consumption in national level (Ministry of Environment, 2010/C).

The increase of the numbers, mentioned above, can be attributed to several different reasons, the main one being the non-enforcement of the regulations regarding the energy consumption of buildings. For example, the regulation issued on building thermal insulation in 1979 has been implemented only in very few buildings (Droutsa and Balaras, 2005) and the regulation for semi-outdoor spaces (Ministry of Environment, 1985), as mentioned above, has not been implemented correctly. The result of this sporadic and problematic implementation of the regulations is the wide range of values regarding the energy consumption in Greek buildings. In a research regarding building heating loads, undertaken by the European Union, it was shown that in the climate zone of Athens, which is the capital of Greece, the consumption for buildings of similar age ranges between 42.1kWh/m² to 284.6 kWh/m² with an average value of 111.6 kWh/m² (Droutsa and Balaras, 2005).

In the literature, there is no mention of the exact impact those illegalities have on the shaping of that range, a topic which is examined in the current research. The absence of data related to energy consumption is officially stated by the Greek Ministry, in papers regarding energy saving in dwelling buildings, as the main problem in the implementation of the laws (Ministry of Environment, 2010/A and 2010/C). However, a few years ago, the new environmental regulation for buildings (KENAK) was enacted (Ministry of Environment, 2010/D1), and aimed to modulate new constructions in Greece. That new regulation also tried to control the existing situation by forcing the owners of buildings to acquire an "Environmental Building Certificate", while at the same time provided them with information on how to improve existing constructions. The main target of that regulation, apart from bringing Greek legislation into conformity with the corresponding European Directive [EU11, 04.01.2003], is to decrease the energy demand of the building sector, which is essentially needed.

The current status of the Greek building sector as well as the future arrangements for both existing and new buildings, play an important role for the current research. They are presented in more detail in the next "Research Design chapter", since the general building regulations have a great part in shaping the simulation process.

Table 1: Greek buildings by chronological period of construction.

	Until 1919	1919 - 1945	1946-1960	1961-1970	1971-1980	1981-1985	1986-1990	1991-1995	After 1996
Greece	**199,510**	**406,633**	**665,315**	**761,182**	**737,575**	**404,303**	**297,348**	**241,615**	**191,739**
Urban Areas	**47,501**	**133,370**	**290,615**	**389,483**	**413,144**	**221,852**	**165,187**	**133,170**	**107,084**
Athens	**1,516**	**7,552**	**14,312**	**17,204**	**12,232**	**3,286**	**1,944**	**1,578**	**1,624**
Thessaloniki	**780**	**1.,780**	**3,097**	**5,755**	**6,043**	**1,752**	**1,733**	**1,381**	**1,005**

Research Design

Typical examples of big cities in Greece are Athens (37°N, 25°E), Thessaloniki (40°N, 22°E), Larisa (39°N, 22°E), Heraklion (35°N, 25°E) and Patras (38°N, 21°E), with the first two gathering in total approximately 50% and 80% of the national and national urban population (World Bank, 2016). Greece, located in Southwest Europe has an area of approximately 132,000 km^2, with geographic coordinates 39°N, 22°E (Central Intelligence Agency, 2016), and with a population, according to the last census, of 10,760,136 residents (General Secretariat of National Statistical Service of Greece, 2011). Greek climate is considered Mediterranean and according to the relevant climatic data the annual cycle can be divided into a cold and rainy season (October to March) and a warm and dry season (April to September).

The simulations were conducted for Athens and Thessaloniki. The choice of two cities/sites, instead of one was made in order to gain a complete image of the function/performance of semi-outdoor spaces, for the total of cases. The population concentrations that are observed in these two cities are already mentioned, but they are not the only criteria for choosing these particular sites for studying. The cities of Athens and Thessaloniki are the main "areas" where the phenomenon/problem, which this paper examines, takes place. First of all, they are the cities with the largest number and largest percentage of multi-storey buildings. As can be seen in table (2), over half of their buildings have more than one floor, (Hellenic Statistical Authority, 2011/B). Thus, while the total of multi-storey buildings in Greece does not exceed 12.2% of the national built environment and 22.5% of all buildings in Greek cities, in the cases of Athens and Thessaloniki it exceeds 61% and 75% respectively. The typical Greek urban environment, which represents the subject of this study, is characterized by such buildings.

The vast majority of buildings is constructed from concrete, with brick walls and has a flat concrete roof (Hellenic Statistical Authority, 2011/C and 2011/D). The proportion rises in the cities of Athens and Thessaloniki, where almost 100% of buildings have concrete frame and approximately 80 to 90% have brick walls and a flat concrete roof. Therefore, as table (3) demonstrates, the main materials used in the simulation models are concrete and bricks. Windows were also designed, according to the relevant regulations, to be of an area equivalent to 10% of the surface of the floor (Ministry of Environment, 2010/B). As for the material for street construction asphalt was used, since it is encountered in the majority of Greek urban streets (Doulos, Santamouris and Livada, 2004).

The models designed for the simulations could be theoretically divided into two parts. The first is the body of the building and the second is the semi-outdoor spaces considered as additional features of the building. The simulations aim to understand what happens firstly in the interior of the building (thermal analysis) and secondly to its external surfaces (insolation levels analysis). The element that distinguishes the results between the various simulations is the different types of semi-outdoor spaces that are tested.

Table 2: Buildings in Greece (number of floors).

	Ground floor		1 Floor		Multi-Storey	
	Number	Percentage	Number	Percentage	Number	Percentage
Greece	**2,310,021**	**57.8%**	**1,194,088**	**29.9%**	**486,861**	**12.2%**
Urban Areas in Greece	**910,527**	**46.7%**	**600,849**	**30.8%**	**438,675**	**22.5%**
Municipality of Athens	**11,075**	**17.8%**	**13,005**	**20.9%**	**38,197**	61.3%
Municipality of Thessaloniki	**3,420**	**14.5%**	**2,601**	**11.0%**	**17,542**	74.5%

Table 3: Settings and materials used in simulation models.

General Settings								
Comfort Range	Clothing		Humidity %		Occupants		Sensible Gains	Air Ch. Rate
	Winter	Summer	Winter	Summer	8:00-18:00	18:00-8:00		
22-26 ºC	1.0 clo	0.6 clo	55%	65%	2p-50%	4p-100%	45 W/m^2	2 ac/h

Former Regulation, Materials			
U-values (W/m^{2}K)	Walls	Floor	Windows
Athens	1.40	2.25	6.00
Thessaloniki	1.40	2.25	6.00

Current regulation, Materials				
U-values (W/m^{2}K)	Walls	Roof	Floor	Window
Athens	0.60	0.50	1.41	2.70
Thessaloniki	0.48	0.38	0.66	2.70

Thus the building can be considered as the stable element/part of this correlation and the semi-outdoor space as the dynamic one.

For both cities IWEC weather files were used, that consist of data generated from a recorded period of thirty years and as there is no specific regulation or research on the representative values for Greece, clothing was assumed to be 1.0 (clo) and 0.6 (clo) during cool and warm periods of the year respectively**.** The occupants are assumed to have sedentary activity (70W) and the air movement slight (0.1 m/s). The temperature comfort range was estimated to be between 22°C and 26°C. According to the data for typical Greek households, collected from relevant literature (Hassid, et al., 2000; Papadopoulos, Oxizidis and Papandritsas, 2008; Nikolaidis, et al., 2009), the internal sensible gains (both lighting and other power loads) where considered to be 45 W/m^2. The number of occupants was defined by the relevant regulation for the calculation of the population for residential buildings and the air change rate from the regulation concerning natural.

Research Results

Testing the former regulation refers to successive phases of absence (*No S-O*), presence (*With S-O*) and illegal transformation (*Glazed S-O*), of semi-outdoor spaces. In the case of "*Glazed S-O*", the semi open-air space has been converted into an inner space of the building and thus obtains the same settings as the thermal zone to which it belongs, which are the same settings as the rest of the floor to which it belongs.

Similarly, for the current regulation, the successive phases of calculation refer to the absence (*No S-O*), presence (*Shallow S-O*) and augmentation (*Deep S-O*) of semi-outdoor spaces. The "*S-O*" stands for semi-outdoor space and the results (average for all orientations), are presented below, in table (4), for each city and type separately.

The results reveal that the effect of the semi-outdoor space is beneficial for the energy consumption of a building in both cities, since the ratio of cooling to heating loads results in the decrease of total thermal loads on all floors and orientations. In the case of the former regulation (1985), the decrease of total thermal loads per square meter, is ranging between 0.04% (Thessaloniki/1985/deep/1st floor/north) and 0.33% (Athens/1985/shallow/3rd floor/east).

Table 4: Simulation Results.

	Av. Change in Heating Loads (kWh/m^2)	Av. Change in Cooling Loads (kWh/m^2)	Av. Change in Total Loads (kWh/m^2)
Former regulation (1985), From (No S-O) to (With S-O)			
Athens/1985/shallow	+0.12%	-0.51%	-0.22%
Athens/1985/deep	+0.04%	-0.29%	-0.13%
Thessaloniki/1985/shallow	+0.18%	-0.87%	-0.19%
Thessaloniki/1985/deep	+0.07%	-0.44%	-0.10%
Former regulation (1985), From (With S-O) to (Glazed S-O)			
Athens/1985/shallow	+55.88%	+11.82%	+31.17%
Athens/1985/deep	+22.22%	+4.65%	+13.13%
Thessaloniki/1985/shallow	+28.73%	+12.41%	+23.14%
Thessaloniki/1985/deep	+13.16%	+4.58%	+10.31%
Current regulation (2012), From (No S-O) to (Shallow S-O)			
Athens/2012/shallow	+0.04%	-0.36%	-0.26%
Thessaloniki/2012/shallow	+0.15%	- 0.50%	-0.15%
Current regulation (2012), From (No S-O) to (Deep S-O)			
Athens/2012/deep	+0.10%	-0.51%	-0.35%
Thessaloniki/2012/deep	+0.25%	-0.97%	-0.28%

As for the current regulation (2012), the decrease is ranging between 0.04% (Thessaloniki/2009/shallow/1st floor/North) and 1.1% (Athens/2009/deep/3rd floor/East).

Eastern oriented buildings have the higher numbers (in absolute value and numerical variations) in all of cases. In other words, the presence of a semi-outdoor space, “shallow” or “deep”, has a greater impact on east oriented buildings, which are at the same time and in all cases the most energy demanding.

Regarding the former regulation (1985), it was shown that both types have positive impact, with the “shallow” one to be more effective than the “deep”. However, due to the misinterpretation of the regulation as well as due to the illegal transformations, the slight beneficial effect of the semi-outdoor spaces was replaced by a highly negative one. In that case, the increase of the total thermal loads per square meter is ranging between 8.6% (Thessaloniki / 1985 / deep / 1st floor / South) and 37.6% (Athens / 1985 / shallow / 1st floor / East). If the 20% increase of the floor area is also calculated [120m^2(floor area) + 24m^2(S-O area) = 144m^2 (total area after the illegal transformation)] then these percentages rise to 30.3% and 65% respectively (increase of floor’s total thermal loads).

Regarding the current regulation (2012), it was proved that semi-outdoor spaces help in reducing the buildings thermal load. Nevertheless, depth augmentation (research hypothesis), achieves even higher decrease. So we could claim that, in newly built buildings in particular, which are constructed in compliance to the current environmental regulation (better thermal insulation), a deeper semi-outdoor space can have positive impact.

5. Concluding remarks

The simulation models of semi-outdoor spaces were designed according to the former and current regulation directives. Furthermore, the reformations performed illegally by the inhabitants of the building were taken into account. In order to provide a more general conclusion, parameters such as floor height and orientation were taken into consideration. The conclusions of this particular study were drawn from thermal simulation of one hundred and sixty-two different cases as well as from insolation level analyses for seventy-two of them.

The analyses performed proved conclusively that semi-outdoor spaces, which were constructed according to the former regulation (1985), had a positive impact on the buildings performance by marginally decreasing their total thermal loads (0.33% maximum reduction achieved). However, this positive effect is negated when the open (not covered) side is glazed (semi-outdoor spaces illegally reformed to inner spaces). For this reason, even though the former regulation (1985) can be considered a positive measure in terms of energy consumption, the extensive illegal reformations mentioned before, transformed this regulation into a negative one (58.4% possible increase in total thermal loads), due to the fact that not only the area/volume of the buildings increased but also the consumption per square meter.

Regarding the current regulation (2012), the results of this study suggested that semi-outdoor spaces will continue to have this positive effect mentioned above despite the fact that their size/depth is reduced. This positive effect is enhanced even more (0.96% maximum decrease in total thermal loads), due to the higher levels of thermal insulation achieved by the new buildings in order to conform to the standards set by the recently introduced environmental regulation. However, according to the findings of this study, if the former regulations concerning dimensions of the semi-outdoor spaces had not been revoked, the positive impact would be even greater (decrease in total thermal loads up to 1.1%).

The Greek state has updated its building regulations and introduced new laws concerning the energy performance of buildings. At the same time, several laws were - and still are - introduced in order to regulate structures built without formal permission. Inevitably, there is currently a debate about the environmental impact of the latter and some broader concerns about whether these two legislative initiatives comply with one another. As mentioned above, object of this paper is to contribute to the current discourse by providing results about the effect that some of these structures have on the thermal performance of the national building stock.

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Session 4: Energy – Climate Change

Effective Forest Finance to Enhance Climate Change Mitigation, Adaptation and Biodiversity: Lessons from Global Environment Facility Finance

by

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Abstract

This research shows that although the GEF has been able to mobilize finance from multiple donors and to engage diverse actors in implementing forest-related projects, it is important to establish institutions that not only mobilize finance from multilateral and bilateral public funds but also mobilize more private funds for the forest sector. Further, the analysis demonstrated the diversity of forest-related projects under the GEF as well as the need to create indicators to maximize the benefits of different forest conservation and management measures, such as those focusing on sustainable forest management, biodiversity conservation, and emissions reduction from deforestation and forest degradation, and to integrate different programs and initiatives relating to forest conservation and management.

This research focuses on financing systems for the forest sector, which are key to enhancing the multiple benefits of forest conservation and management in developing countries. Currently, forest finance is fragmented, and there is a growing need to understand the big picture in forest finance (UNFF, 2016; Singer, 2016). By drawing lessons from the Global Environment Facility (GEF), we explore in this research effective finance systems in developing countries for forest conservation and management measures that enhance benefits in climate change mitigation, adaptation and biodiversity. The GEF is serving as a financial mechanism for the UNFCCC and the CBD, and it is actively cooperating with the UNFF (GEF, 2010). To discuss the effective allocation of funds to maximize these benefits, and to explore the effective ways of mobilizing finance for forests, we use two approaches: analyses of 1) trends in focal areas and implementing and executing agencies in GEF forest-related projects and 2) co-funders' trends in GEF forest-related projects.

1. Introduction

Forest conservation and management are an important agenda item not only within the United Nations Forum on Forests (UNFF) but also within the major international environmental conventions such as the UN Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). Forest conservation and management can generate multiple benefits, including in relation to climate change mitigation, adaptation, and biodiversity conservation. Effective institutions for forests are thus necessary to enhance those benefits.

The problems of deforestation and forest degradation have been escalating in many developing countries. However, these countries lack the financial and technical capacity to prevent such problems. One of the keys to enhancing forest conservation and management in developing countries is finance for forest-related activities.

This research focuses on financing systems for forest-related activities, which are key to enhancing the multiple benefits of forest conservation and management in developing countries. Forest finance is currently fragmented, and there is a growing need to understand the big picture in the field (UNFF, 2016; Singer, 2016). By drawing on lessons from the Global Environment Facility (GEF), this research explores effective finance systems in developing countries for forest conservation and management measures that enhance benefits toward climate change mitigation, adaptation, and biodiversity.

Figure 1 shows the diverse levels of finance that contribute to sustainable forest management (SFM). Diverse finance for forest includes not only forest sector financing but also climate change and energy sector financing. Although effective forest financing is increasingly becoming an important agenda item within UNFF[15] and UNFCCC,[16] there is limited research in this area (Singer, 2016).

2. Research Approaches

Various multilateral and bilateral funding sources finance forest conservation and management in developing countries, however, the GEF is the only agency serving as a financial mechanism for the UNFCCC and the CBD. It also actively cooperates with UNFF (GEF, 2010).

This research focuses on the GEF, and in order to discuss the effective allocation of funds to maximize these benefits, and to explore the effective ways of mobilizing finance for forests, we use two approaches: analyses of 1) trends in focal areas and implementing and executing agencies in GEF forest-related projects and 2) co-funders' trends in GEF forest-related projects. We use the data from the GEF project database.[17]

2-1 Global Environment Facility

The GEF was established in 1992 at the Rio Earth Summit. It is a financial mechanism for five major international environmental conventions: the UNFCCC, the CBD, the Minamata Convention on Mercury, the Stockholm Convention on Persistent Organic Pollutants (POPs), and the United Nations Convention to Combat Desertification (UNCCD). As Figure 2 shows, the GEF has partnerships among agencies, including United Nations agencies, multilateral development banks, national entities, and international non-governmental organizations (NGOs). The GEF has provided $14.5 billion in grants and mobilized $75.4 billion in additional financing for almost 4,000 projects.[18]

The GEF is the only multilateral funding institution with mandates deriving from all the three principal international accords on forests: the UNFCCC, the CBD, and the UNCCD, and actively cooperates with UNFF on a range of fronts (GEF, 2010). To date, the GEF has supported over 380 forest-related projects, with $2.1 billion in grants that leveraged an additional $9.5 billion.[19] The fifth GEF replenishment (GEF-5) from 2010 to 2014 funded 69 projects in 80 countries, with over $700 million in grants (GEF, 2014).

The GEF has launched forest-related programs, and from GEF-1 to GEF-3 (until June 2006), early efforts mainly dealt with single focal areas, such as focusing on biodiversity. In GEF-4 (July 2006 to June 2010), the GEF launched a pilot incentive scheme, a tropical forest account, and implemented multi-focal area projects, yielding benefits of reducing emissions from deforestation and forest degradation in developing countries (REDD+). In GEF-5 (July 2010 to June 2014), the GEF launched the SFM/REDD+ incentive mechanism and implemented multiple environmental benefits from the improved management of all types of forests. In GEF-6 (July 2014 to June 2018), the GEF launched the SFM Program and strengthened support to maintain, manage, and restore forests.[20] The goal of the new

[15] UNFF Forest Financing http://www.un.org/esa/forests/forum/capacity-development/forest-financing/index.html

[16] UNFCCC documents in relation to reducing emissions from deforestation and forest degradation in developing countries http://unfccc.int/land_use_and_climate_change/lulucf/items/6917.php

[17] GEF project database http://www.thegef.org/projects

[18] GEF What is GEF? http://archive.thegef.org/gef/whatisgef

[19] GEF Sustainable Forest Management https://www.thegef.org/topics/sustainable-forest-management

[20] GEF Financing for forests: an overview of approaches and funding priorities under UNFCCC, CBD, and UNFF. 2015 https://unfccc.int/files/cooperation_support/financial_mechanism/review/application/pdf/gef_finance_for_scf_sept15.pdf

GEF-6 SFM strategy is to achieve multiple environmental benefits from the improved management of all types of forests (GEF, 2014), and the GEF-6 SFM Strategy advocates an integrated approach at the landscape level, embracing ecosystem principles and including livelihood objectives in the management of forest ecosystems (GEF, 2015).

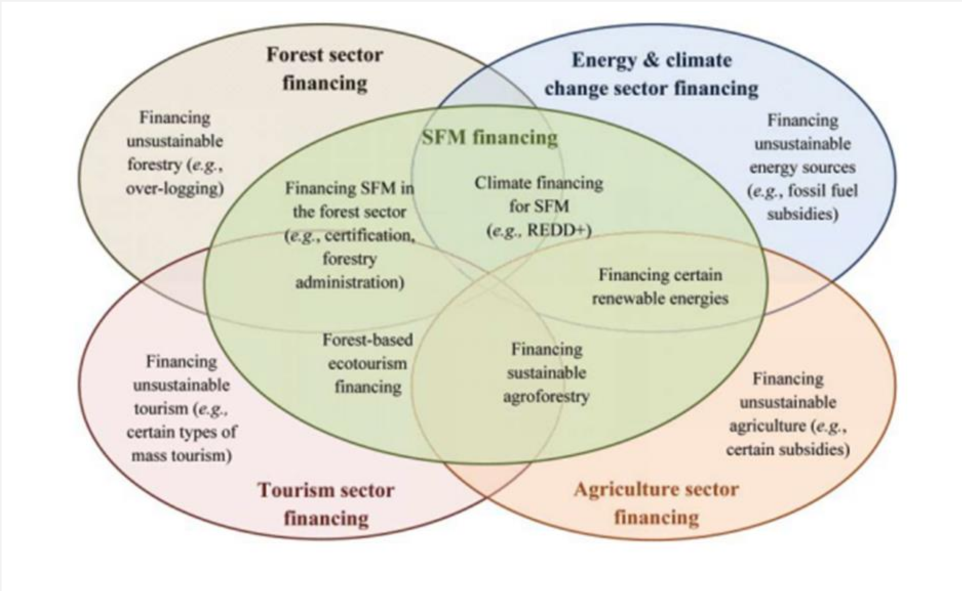

Figure 1: Sustainable Forest Management Financing (Singer, 2016).

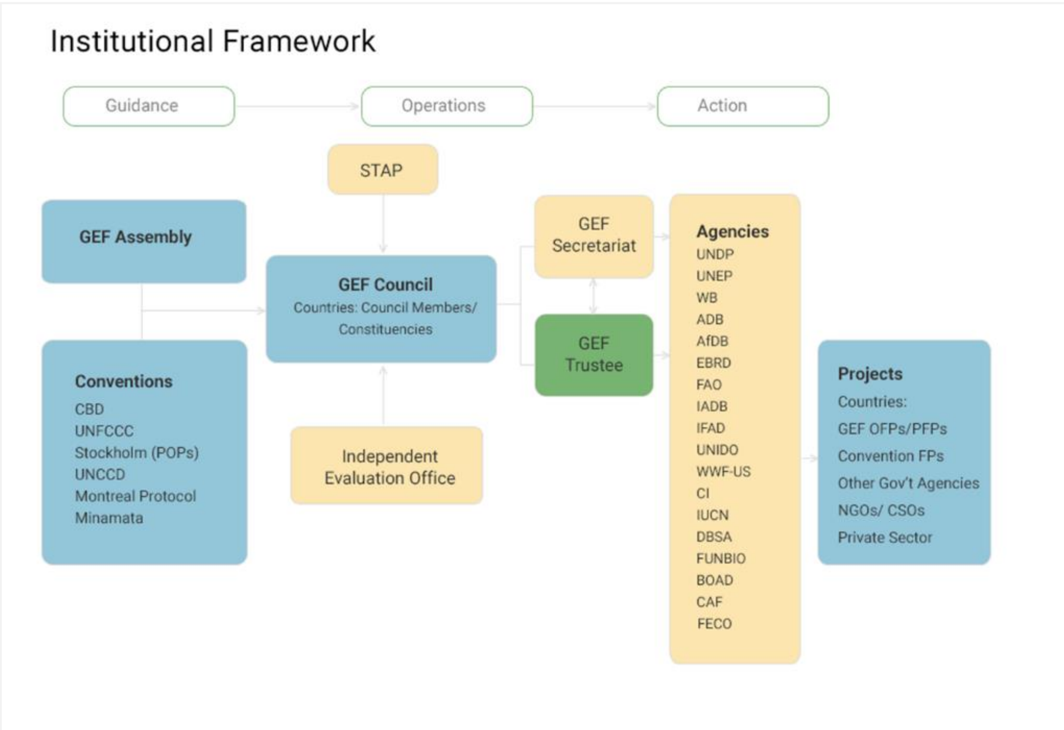

Figure 2: The GEF Institutional Framework[21].

[21] GEF Organizations
https://www.thegef.org/about/organization

2-2 Data

In this research, we analyze the following two items by using the information available from the GEF projects database and project reports.

1) Analysis of trends in focal areas as well as of implementing and executing agencies in GEF forest-related projects;

2) Analysis of co-funders as well as the amount of co-funding in GEF forest-related projects.

As Table 1 shows, we use forest-related project data from the GEF projects database (accessed 11 July, 2016). We extracted the forest-related project data by sorting the data from the GEF projects database and typing the word "Forest." Using the term "Forest" to sort the data, we extracted 149 approved national forest-related projects and 29 approved global and regional forest-related projects. We organized the data in relation to the number, focal area, implementing agencies, executing agencies, and co-funding of each project. We also classified the project information according to the replenishment period, GEF-1 to GEF-6 (e.g., projects starting in the period between July 1994 and June 1998 were categorized in GEF-1). Since not all projects provided all of this information, we excluded projects that lacked information.

3. Results of Analysis

The analysis shows that the GEF is increasing its support for national forest-related projects, especially multi-focal area projects that produce multiple benefits, including in relation to climate change and biodiversity. In analyzing the trends relating to funding and the actors (funders and implementing and executing agencies) engaged in the GEF's forest-related projects, it becomes evident that although the GEF has been able to mobilize finance from multiple donors and to engage diverse actors in implementing forest-related projects, private funds contributions are limited. Further, since there is a wide range of forest-related projects under the GEF, the analysis shows the importance of integrating different programs and initiatives relating to forest conservation and management in order to achieve more effective and efficient forest management and conservation.

Table 1: Examples of Forest-related Projects in the GEF Projects Database[22].

GEF_ID	Country	Project Name	Focal Area	Agency	Project Type	GEF Grant	Cofinancing	Status
2	Philippines	Samar Island Biodiversity Project: Conservation and Sustainable Use of the Biodiversity of a Forested Protected Area	Biodiversity	UNDP	FP	5,759,470	7,198,420	Project Completion
218	Central African Republic	A Highly Decentralized Approach to Biodiversity Protection and Use: The Bangassou Dense Forest.	Biodiversity	UNDP	FP	2,500,000	1,000,000	Project Closure
356	Mauritius	Restoration of Highly Degraded and Threatened Native Forests in Mauritius	Biodiversity	UNDP	FP	200,000	0	Project Completion
368	Guyana	Programme for Sustainable Forestry (Iwokrama Rain Forest Programme)	Biodiversity	UNDP	FP	3,000,000	780,000	Project Completion
490	Uganda	Kibale Forest Wild Coffee Project	Biodiversity	World Bank	MSP	750,000	3,400,000	Project Closure
539	Poland	Forest Biodiversity Protection	Biodiversity	World Bank	FP	4,500,000	1,700,000	Project Closure
642	Malaysia	Conservation and Sustainable Use of Tropical Peat Swamp Forests and Associated Wetland Ecosystems	Biodiversity	UNDP	FP	5,990,000	6,670,000	Project Completion
661	Suriname	Conservation of Globally Significant Forest Ecosystems in SurinameÃ¢â¬â¢s Guayana Shield	Biodiversity	UNDP	FP	9,240,000	8,800,000	Project Closure
793	Benin	Program for the Management of Forests and Adjacent Lands	Multi Focal Area	World Bank	FP	6,000,000	22,000,000	Project Completion
815	Grenada	Dry Forest Biodiversity Conservation	Biodiversity	World Bank	MSP	723,000	404,580	Project Closure
818	Sri Lanka	Conservation of Globally Threatened Species in the Rainforests of Southwest Sri Lanka	Biodiversity	UNDP	MSP	724,713	226,000	Under Implementation

[22] GEF project database http://www.thegef.org/projects

3-1 Analysis of Results: Approved Forest-related National Projects

As Figure 3 shows, the number of forest-related national projects is on the rise, from three projects in GEF-1 to 54 projects in GEF-6. Up to GEF-3 (until 2006), the primary focal area of forest-related national projects was biodiversity; however, for the current GEF-6, the focal areas of the projects include biodiversity, climate change, and multi-focal area.

Up to GEF-4 (until 2010), the main implementing agencies of forest-related projects were United Nations Development Programme (UNDP) and the World Bank. Currently, however, the main agencies of projects are UNDP and the Food and Agricultural Organization (FAO), as shown in Figure 3.

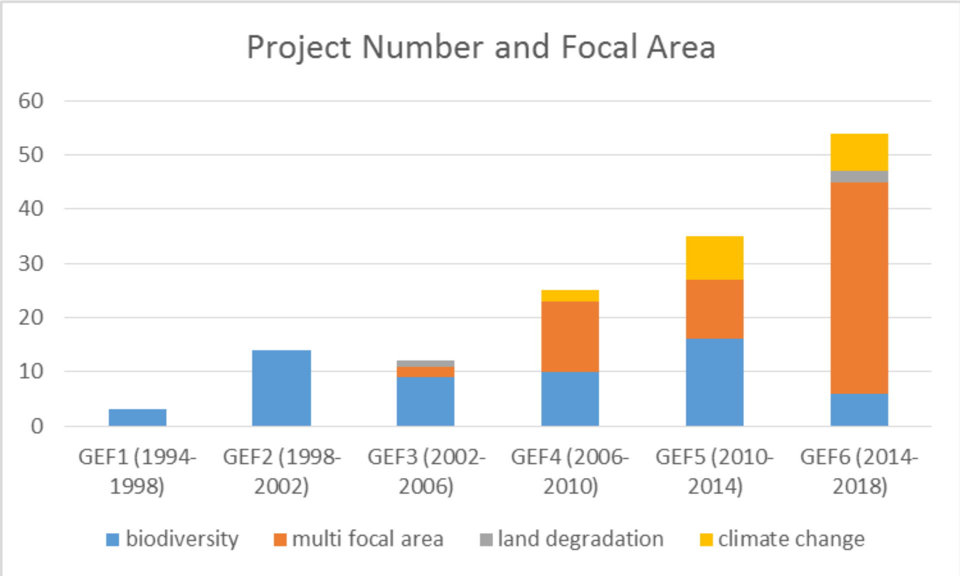

Figure 3: Project Number and Focal Area of the GEF's Forest-related National Projects.

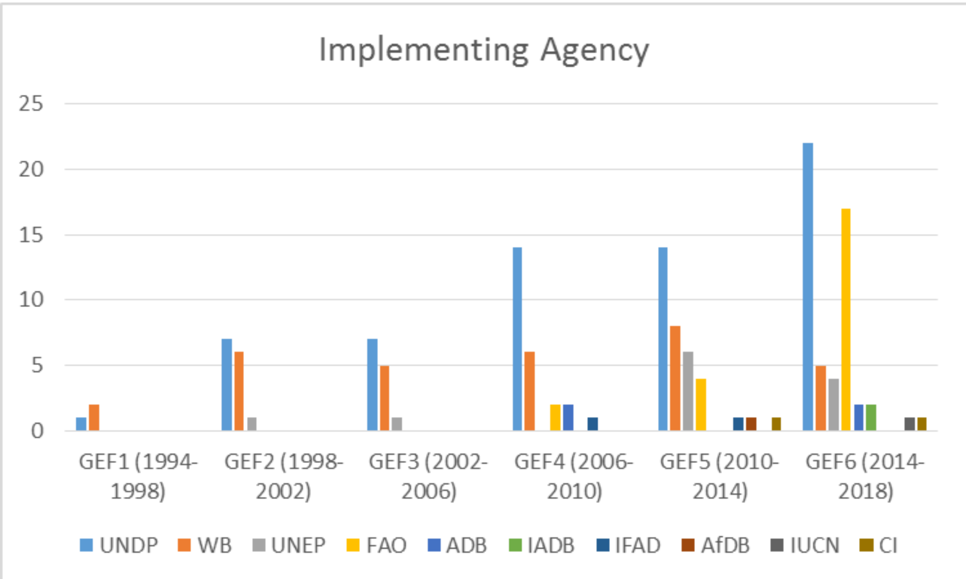

Figure 4: Implementing Agencies of the GEF's Forest-related National Projects.

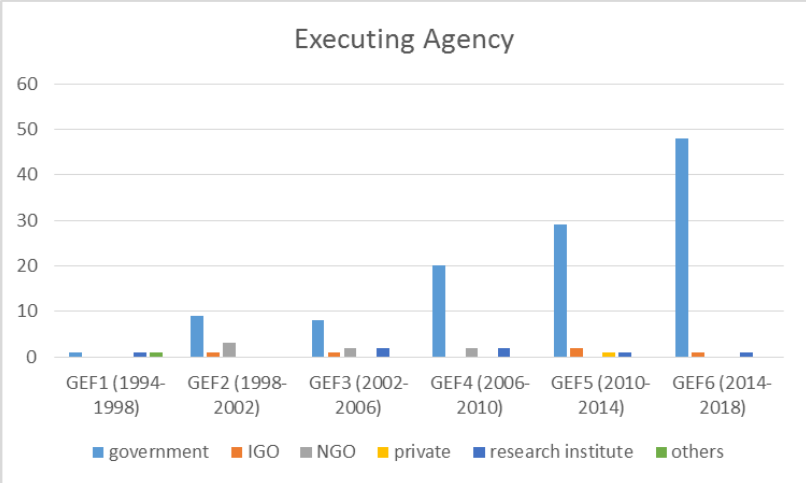

Figure 5: Excuting Agencies of the GEF's Forest-related National Projects.

Table 2: Co-financing of the GEF's Forest-related National Projects.

	Average amount of GEF funding for each project (USD)	Average amount of co-funding for each project (USD)	Average share of co-funding for each project
GEF1 (1994–1998)	807,333	1,455,333	60.8%
GEF2 (1998–2002)	3,379,009	18,307,903	63.5 %
GEF3 (2002–2006)	3,229,565	13,921,929	63.7%
GEF4 (2006–2010)	3,551,287	25,651,887	72.6%
GEF5 (2010–2014)	4,989,884	17,433,485	64.0%
GEF6 (2014–2018)	6,517,805	37,228,938	80.8%

Most of the executing agencies of the projects are national governments of host countries, as per Figure 5Table 2 shows the average amount of GEF funding and co-funding of each project and the average share of co-funding for each project. As shown in Table 2, the share of co-funding for each forest-related project has increased from 60.8% to 80.8%. Co-funders include multilateral aid agencies (e.g., UNDP, FAO, the World Bank, and Asian Development Bank [ADB]), bilateral aid agencies (e.g., Germany, the European Union [EU], the United States [US], and Australia), governments in developing countries (e.g., ministries addressing the environment and forestry), which provide mostly in-kind assistance, NGOs (e.g., World Wildlife Fund for Nature [WWF], Wildlife Conservation Society [WCS], Conservation International [CI], Birdlife International, and International Union for Conservation of Nature [IUCN]), and the private sector (e.g. national forestry company).

3-2 Analysis of Results: Approved Forest-related Global and Regional Projects

With regard to the forest-related global and regional projects shown in Figure 6, unlike national projects, the number of projects is limited, and the focal areas of global and regional projects include biodiversity, land degradation, climate change, and multi-focal areas. As per Figure 7, United Nations Environment Programme [UNEP] is the main implementing agency for global and regional projects. With regard to the executing agencies, projects are executed by diverse actors, not only the national government of host countries, but also research institutes and NGOs (see Figure 8).

As shown in Table 3, similar to the forest-related national projects, the share of co-funding for each global and regional project has been increasing from an average of 21.8% of the share of co-funding in GEF-1 to 76.9% in GEF-6.

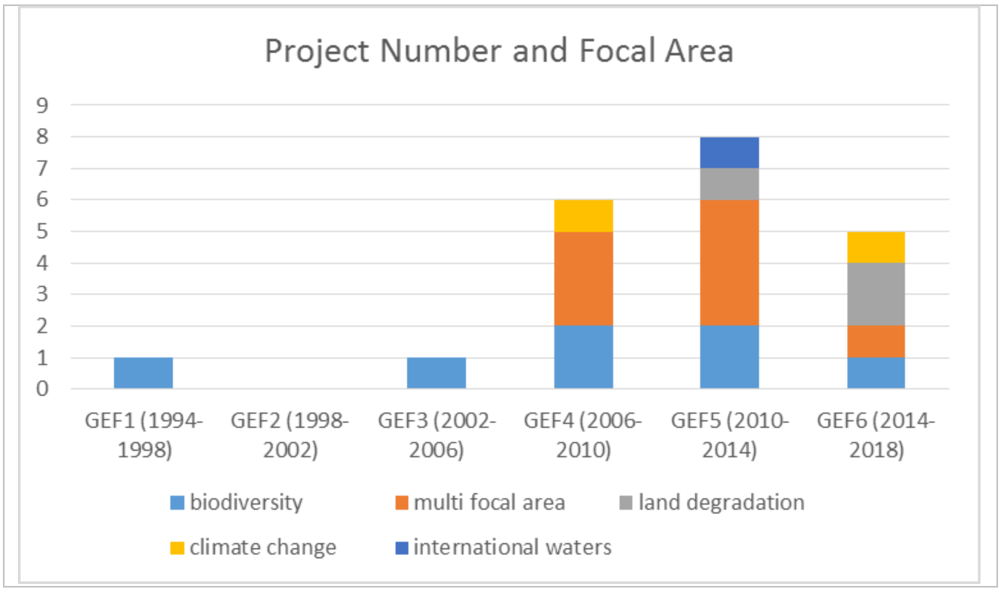

Figure 6: Project Number and Focal Area of the GEF's Forest-related Global and Regional Project.

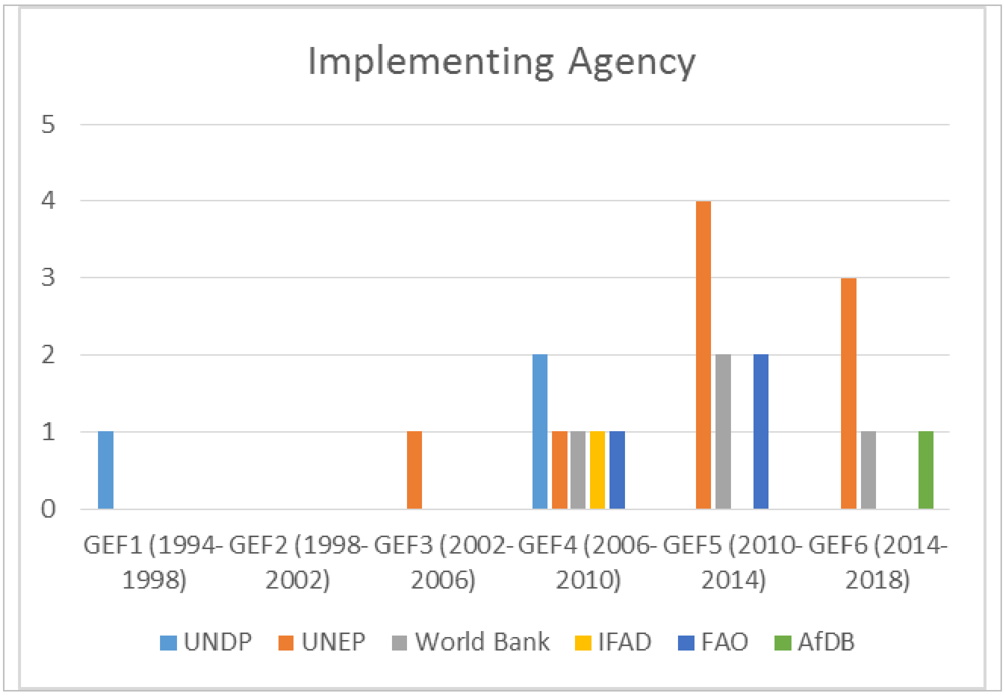

Figure 7: Implementing Agencies of the GEF's Forest-related Global and Regional Projects.

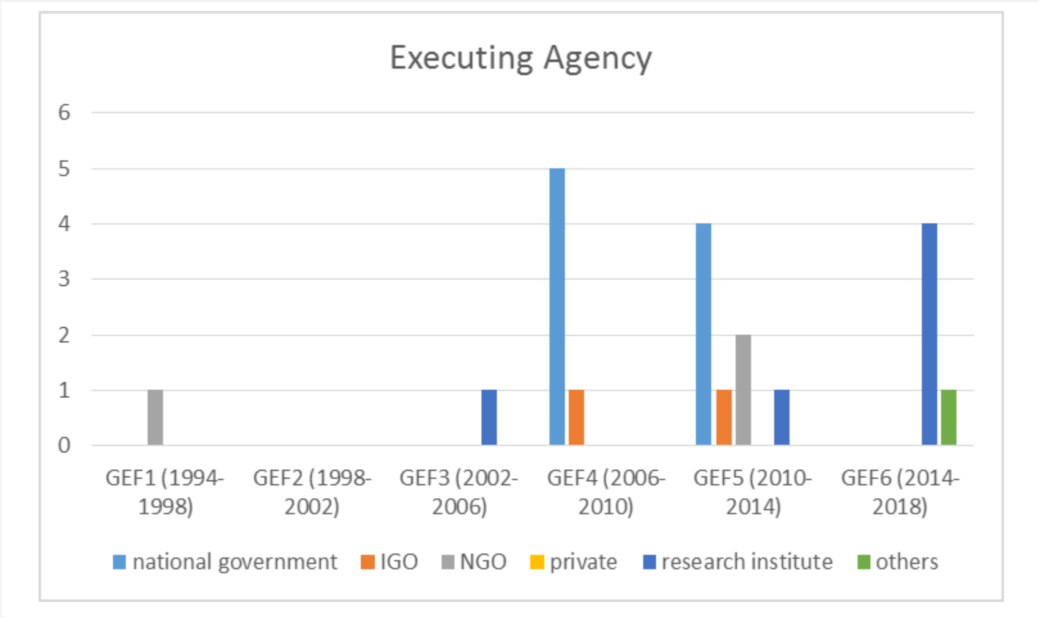

Figure 8: Excuting Agencies of the GEF's Forest-related Global and Regional Projects.

Table 3: Co-financing of the GEF's Forest-related Global and Regional Projects.

	Average amount of GEF funding for each project (USD)	Average amont of co-funding for each project (USD)	Average share of co-funding for each project
GEF1 (1994–1998)	742,000	207,000	21.8%
GEF2 (1998–2002)	-	-	-
GEF3 (2002–2006)	962,000	467,000	32.7%
GEF4 (2006–2010)	3,622,584	8,659,528	70.2%
GEF5 (2010–2014)	3,275,642	5,557,163	62.8%
GEF6 2014–2018)	4,628,493	27,116,000	76.9%

Co-funders include multilateral aid agencies (e.g., UNDP, FAO, and the World Bank), bilateral aid agencies (e.g., Germany, Norway, and the EU), governments in developing countries, NGOs (e.g., WWF), and the private sector (e.g., Moore Foundation).

The follwing summarizes the analysis of the results.

Approved GEF Forest-related National Projects

- The number of forest-related national projects is increasing.
- Up to GEF-3 (until 2006), the main focal area of forest-related national projects was biodiversity. Currently, however, the main focal areas of these projects are multi-focal areas, climate change, and biodiversity.
- Up to GEF-4 (until 2010), the main implementing agencies of the projects were UNDP and the World Bank. Currently, the main agencies are UNDP and FAO.
- Most of the executing agencies of the projects are the national governments of host countries
- The share of co-funding for each forest-related project is increasing.
- Co-funders include multilateral aid agencies (e.g., UNDP, FAO, the World Bank, and ADB), bilateral aid agencies (e.g., Germany, the EU, the US, and Australia), governments in developing countries (e.g., ministries addressing the environment and forestry), which provide mostly in-kind assistance, NGOs (e.g., WWF, WCS, CI, Birdlife International, and IUCN), and the private sector (e.g., national forestry company).

Approved GEF Forest-related Global and Regional Projects:

- The number of forest-related global and regional projects is limited.

- The focal areas of global and regional projects are diverse. UNEP is the main implementing agency.
- There is a diversity of executing agencies, not only national governments of host countries, but also NGOs and research institutes.
- The share of co-funding for each forest-related project is increasing. Co-funders include multilateral aid agencies (e.g., UNDP, FAO, and the World Bank), bilateral aid agencies (e.g., Germany, Norway, and the EU), governments in developing countries, NGOs (e.g., WWF), and the private sector (e.g., Moore Foundation).

4. Conclusion

This research explored effective finance systems in developing countries for forest conservation and management measures that enhance benefits toward climate change mitigation, adaptation, and biodiversity by drawing on lessons from GEF funding. We used two approaches: analyses of 1) trends in focal areas and of the implementing and executing agencies of GEF's forest-related projects; and 2) co-funders' trends in GEF's forest-related projects. This research showed that the GEF is increasing support for forest-related projects, especially multi-focal area projects that generate multiple benefits, including in relation to climate change and biodiversity. By analyzing the trends in funding and actors (funders and implementing and executing agencies) that engage in GEF's forest-related projects, although the GEF has been able to mobilize finance from multiple donors and to engage diverse actors in implementing forest-related projects, it is important to establish institutions that not only mobilize finance from multilateral and bilateral public funds but also mobilize more private funds for the forest sector.

Further, the analysis demonstrated the diversity of forest-related projects under the GEF as well as the need to create indicators to maximize the benefits of different forest conservation and management measures, such as those focusing on sustainable forest management, biodiversity conservation, and emissions reduction from deforestation and forest degradation, and to integrate different programs and initiatives relating to forest conservation and management.

Acknowledgement

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Gaining Insight on Climate Policy Transfer: Opportunities and Challenges

by

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Abstract

The 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) marked a milestone in the course of international efforts on global climate action. In order to implement the Paris Agreement and reach its overall objective to limit global temperature increase to well below 2ºC significant effort is needed at the international level and more so at country level. The Intended Nationally Determined Contributions (INDCs) submitted by 188 Parties ahead of COP21 are very different and, thus, a key challenge is to better understand the specific policies and measures adopted to achieve these varying pledges.

In order to harmonize the efforts towards tackling climate change, it is highly probable that climate policies within different regions interact in many ways. International bilateral and multilateral cooperation towards policy transfer are crucial in supporting the different activities related to INDC. Beyond direct country support, knowledge sharing activities, peer to peer learning, as well as policy experiences exchange could be helpful. Europe, as a frontrunner in climate policy, can therefore share its experience gained, while stakeholders and policy-makers can extract lessons from climate policy insights from non-European frameworks in different climate policy fields. In the above framework, the aim of this paper is to build a conceptual framework on how the climate policy transfer could be implemented among regions and in different climate policy fields. This approach is implemented within the framework of the just completed "POLIMP – Mobilizing and Transferring Knowledge on Post-2012 Climate Policy" project, funded by the European Commission 7th Framework Programme for Research.

The paper proposes concrete steps, based on the policy transfer theory, starting from the region's needs identification and the policy selection to the policy evaluation, providing answers in questions, such as who transfers policy, what elements of policy are transferred and through which channels, what factors enable and constrain transfer, etc. This conceptual framework is applied in the case of industry sector examining several policy options, in order to prevent carbon leakage, within the frame of the emissions trading system (ETS). Finally, this study could serve as a channel for policy transfer between European and non- European frameworks, and therewith assisting in identifying and overcoming the barriers that exist for mutual interaction.

1. Introduction

Climate change is a global concern, and thus climate policies are developed worldwide in various countries with a final global impact. The 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) in Paris marked a milestone in the course of international efforts on global climate action. The emission reduction pathways needed to implement the Paris Agreement, aiming to reduce global temperature increase to well below 2ºC, are ambitious but not impossible as many of the needed technological solutions are known and innovative policies and measures are already adopted mainly in countries' national perspective.

The story started at the 19th Conference of Parties (COP 19) in 2013 in Warsaw, where Parties agreed that they would initiate or intensify domestic preparation for their so called "intended nationally determined contributions" (INDC) towards that agreement, and to communicate these well before the COP21 in Paris in December 2015. These INDCs set out the mitigation pledges, countries are willing to propose for the period post-2020. This decision can be seen as a big step for developing countries, many of which are for the first time designing mitigation plans or targets, or communicating them at the international level. It also explains why Parties were hesitant to agree on a common format in which these INDCs should be presented, or what type of targets or actions they should contain (Karakosta, 2016b). The INDCs submitted by 188 Parties ahead of COP21 are very different and, thus, a key challenge is to better understand the specific policies and measures adopted to achieve these varying pledges (UNFCCC, 2015). In order to achieve the priorities of The Paris Agreement, COP22 will take over the reins from COP21 and focus on action items, especially related to adaptation, transparency, technology transfer, mitigation, capacity building and loss and damages (UN, 2016).

Given the emerging landscape of climate policy worldwide, it is highly probable that climate policies within different regions can interact in many ways that cannot be always foreseen (Sathaye, 2007; UN, 2012). As a result, there are ample opportunities for mutual learning from the design and implementation of climate policies globally, and all relevant policies that fall under the umbrella of climate change, such as renewable energy, energy efficiency, adaptation and climate financing (EU, 2011). Europe, as a frontrunner in climate policy, can therefore share its experience gained. This enables the European Union (EU) to support developing countries with making more systematic economic and social changes that are needed for a global low emission development (EC, 2016). Likewise, European stakeholders and policy-makers can also extract lessons from climate policy insights from non- European frameworks in all these climate policy fields (World Bank, 2016). However, what makes it difficult to draw policy recommendations in regions worldwide is the severe dearth of empirical research on climate policy interaction (WTO, 2010).

Policy transfer is most frequently cited as a process in which knowledge about policies, administrative arrangements, institutions, etc. in one time and/or place is used in the development of policies, administrative arrangements and institutions in another time and/or place (Dolowitz & Marsh, 1996). It is considered to be an effective way for cities, municipalities or countries to learn from one another, and is documented by many Evans, 2009; Common, 2001; Marsden & Stead, 2011) as a process that is being used with increasing frequency.

Learning towards policy transfer about opportunities and pathways, and about scientific insights and warnings is important to help creating positive dynamics and provides stakeholders with better insights on implications of possible international climate policy directions (European Communities, 2007; UN, 2008). Policy makers need access to improved knowledge transfer and uptake, so as to understand the consequences of current and future international climate regimes, being better able to extract key policy conclusions (Karakosta & Flamos, 2016c). Understanding the aspects of an existing policy through trans-national cooperation provides digestible information to further design good policies that will ensure a more sustainable management of the environment and its resources (OECD, 2012). Policy transfer supports policy and decision makers in taking well informed decisions, thereby reducing uncertainties and mitigating the risk that decisions are taken against poorly-understood climate policy contexts, and build awareness among the society as a whole of costs and opportunities of future climate policies (The new climate economy, 2014).

This report serves as a channel for policy transfer (inspiration) between EU and non-EU frameworks, and therewith it aims to overcome the barriers that exist for mutual interaction between these groups. Specifically, the aim of this paper is to provide a concrete-steps methodology on how the climate policy transfer could be implemented in different climate policy fields. The paper proposes concrete steps, based on the policy transfer theory, starting from the region's needs identification and the policy selection to the policy evaluation, providing answers in questions, such as who transfers policy, what elements of policy are transferred and through which channels, what factors enable and constrain transfer, etc. The proposed methodology is applied in the case of industry sector examining several policy options in order to prevent carbon leakage, within the frame of the emissions trading system (ETS).

The paper proceeds as follows: Chapter 1 summarizes the general theoretical debate on policy transfer offering an introduction to policy transfer as an approach to cross national policy development. After defining the central term of "policy transfer", mechanisms of policy transfer and mediating variables influencing transfer processes are discussed, as well as normative implications explored in Chapter 2. Chapter 3 provides a summary of the approached being followed in the present paper while Chapter 4 presents the application of the proposed policy transfer approach in the case of industry. Finally, Chapter 5 concludes by assessing lesson learnt and highlighting knowledge gaps and further research needs/ concludes with some research and methodological recommendations.

2. The Policy Transfer Concept

Policy transfer was coined by Dolowitz & Marsh and is defined as the process by which knowledge of policies, administrative arrangements, institutions and ideas in a political system are used for the development of similar features in another political system (Dolowitz & Marsh, 1996). Since then various definitions of policy transfer were developed (Marsden & Stead, 2011; Phelps, et al 2013; French et al., 2014; Aritenang, 2015; Bunnell, 2015).

The literature of policy transfer emerged in 1990s from the political and urban studies (James and Lodge, 2003; Aritenang, 2015), when the analysis of international influences on policy change gained momentum with "Policy transfer studies" or "Policy diffusion studies" representing the two major research programs in the field (Bender et al., 2014). Today, there are several theories on policy transfer, as many countries share similar problems across various policy fields, with a distinction on transfer and diffusion, where the first refers to cases where one country imports knowledge of policies that exist abroad, while the latter explains how innovations, policies or programs spread from one country to another (Levi-Faur & Vigoda-Gadot, 2006).

Policy transfer allows cities, municipalities or countries to learn from one another and solve their problems. As mentioned above, although policy transfer was originally developed with the aim of explaining the adoption of policy and the spread of diffusion in the U.S. (Walker 1969; Gray 1973), the framework of transfer has been recently refined to consider the role of learning in policy diffusion (Dobbin, Simmons, & Garrett, 2007; Elkins & Simmons, 2005; Gilardi, 2010), policy convergence (Drezner, 2005; Holzinger & Knill, 2005), the social embeddedness of transfer institutions (Locke & Jacoby 1997; .Radaelli, 2000) and the policy networks (King, 2010; Blanco, Lowndes, & Pratchett, 2011; Benson & Jordan, 2011; Cao, 2012; Grossmann, 2013; Jarvis, 2014).

Policy transfer can involve a number of processes. The objects of transfer can include (i) policies, (ii) institutions, (iii) ideologies or justifications, (iv) attitudes and ideas, and (v) negative lessons (Dolowitz, 1997). Transfer can take place across time, within countries and across countries (Bennett, 1991; Dolowitz & Marsh, 1996; Dolowitz, 1997; Marsden & Stead, 2011). It must be added that transfers can also take place across policy fields. The logic of privatisation, for example, has been applied from public industries (steel or automobile production) to public services (user-pays in health and education). Similarly, transfer occurs between the private and public sectors. However, the agents of policy transfer are a much broader category of individuals, networks and organisations (Stone, 2001).

There is a growing interest in policy transfer in the climate policy world (Evans, 2009; Common, 2001). No single country can insulate its economy from global pressures, and therefore public policy takes place not only in national political system but also in a world system. However, global economic forces are not the only pressure toward policy transfer. Many authors (e.g. Evans 2009, Common, 2001) believe that the rapid growth in communications of all types, networking, events of bilateral and multilateral meeting between policy-makers and politicians on economic, politic, and law subjects, makes exchange of ideas and knowledge much easier (Borras and Jacobsson, 2004; O'Dolan and Rye, 2012; Rose, 1991; Marsden & Stead, 2011). Moreover, international organisations such as the European Union and the World Bank, but also climate-related bodies and frameworks such as the UNFCCC, advocate similar policies across diverse countries. Policy-makers therefore "increasingly look to other political systems for knowledge and ideas about institutions, programs and policies" (Dolowitz & Marsh, 2000; Stone, 2000).

Researchers have applied the theoretical arguments of policy transfer to ever more empirical venues (Benson & Jordan, 2011; Bewley-Taylor, 2014; Jarvis, 2014). The following Table gives an overview of the most popular sectors identified in the literature, where policy transfer has been applied so far.

Possible constraints to policy transfer may include previous policy directions, policy complexity and local or national contextual factors. There is a wide literature which demonstrates how the transfer of information and knowledge between these domains can be problematic (Crilly et al., 2010; French et al., 2014). These obstacles are cognitive decisions in the pre-decision phase, in other words decisions made prior to the policy model being transferred. These issues include the process by which the policy problem was recognised and defined, the nature of the search for a solution and the receptivity of policy actors to the alternative.

Secondly, environmental obstacles, which include the need to ensure effective implementation and the institutional and political constraints can affect the success of the model, these are often separated into policy compatibility and feasibility of implementation.

A further variable identified as constraint to policy transfer relates to public opinion, including bureaucratic, political, media and importantly, the attitudes and resources of constituency groups. Additionally, Dolowitz & Marsh, 2000, analyse three additional factors that have a significant effect on policy failure. The first factor is the so- called "uninformed transfer" where the borrowing country may have insufficient information about the policy/institution and how it operates in the country from which it is transferred.

Table 1: Sectors of policy transfer application.

Sectors of policy transfer applications	**Literature**
Social and welfare policy	Dolowitz et al., 2000; Pierson, 2003; Collier & Messick 1975; Skocpol & Ikenberry 1995; Waltman 1980; Morais, 2005; Sugiyama, 2008; Bender et al., 2014
Crime	Jones & Newburn, 2006
Public education	Bache & Taylor, 2003; Jarvis, 2014
Finance	Waltman 1980; Lana & Evans, 2004;
Development assistance	Greener, 2002; Stone, 2004; Dunlop, 2009; Dussauge-Laguna, 2013
Health	Ogden et al., 2003; Tambulasi, 2013; French et al., 2014; Bewley-Taylor D.R, 2014
Spatial and/or urban planning	Wolman & Page, 2002; De Jong & Edelenbos, 2007; Dolowitz & Medearis, 2009; Pojani & Stead, 2015; Shih & Chang, 2016
Transport and planning	Marsden & Stead, 2011; O'Dolan & Rye, 2012; Oslen & Fearnley, 2014
Utilities regulation	Bulmer et al., 2007; Padgett, 2003
Environmental issues	Jordan et al., 2001; Betsill & Bulkeley, 2004; Smith, 2004; Bulmer & Padgett, 2004; Holzinger & Knill, 2005; Hermawati et al., 2016
Creative industries	Prince, 2010; Aritenang, 2015; Pratt, 2009

Second there is incomplete transfer in cases when although transfer has occurred, crucial elements of what made the policy or institutional structure a success in the originating country may not be transferred, leading to failure. Third, insufficient attention may be paid to the differences between the economic, social, political and ideological contexts in the transferring and the borrowing country describing inappropriate transfer.

Policy Transfer in Climate

Smith (2004) states that especially when confronted with a new problem, policy-makers will tend to search for ready-made solutions in other jurisdictions, i.e. look for policy transfer. Therefore, policy transfer in the area of climate change is common, as climate change policy interventions have only started as recently as the 1990s. Since it is such a developing policy area, climate policy transfer is less likely to be hampered by contextual constraints such as path dependency.

According to Feng (2012) in the UN climate change framework of the UNFCCC, during the meeting high-level policy inspiration can take place. In this case, a country (a Party to the UNFCCC) poses its own national climate policy as an example for the rest of the world, and after this is included into a written conference agreement, other countries will adapt a similar policy. High-level policy inspiration is mainly based on developed country policies. Within this setting, policy transfer competition takes place as countries, but also NGOs, aim to push for the transfer of their own preferred policies.

Exporting EU and adopting non-EU climate policies

Considering the history of climate policies in the EU, which is relatively extensive compared to the history of climate policy-making in other countries, there is wide array of experiences and knowledge on climate change topics within the EU. It is common ground therefore that policies, measures and general experiences of the EU and its Member States should be shared with other jurisdictions, so that possibly policy transfer can take place. The European Commissioner for climate action and energy, Cañete, stated in 2014 that it is important that the EU remains a global leader on climate action, and therefore not only domestic policies need to be drafted and refined, but also policy transfer has to take place in order to expand the impact of the EU's climate knowledge (Cañete, 2014). Taking the frontrunner position of the EU in designing and implementing such policies addressing climate issues (originating from various fields, such as technology transfer, renewable energy, energy efficiency, adaptation and others), lessons can be drawn and could be useful for other countries globally.

Considering that similar climate policy issues are also relevant in non-EU frameworks, EU stakeholders can learn from those frameworks, and enable an effective policy transfer (Tuerk et al., 2015). Knowledge needs with possible 'lessons learned' from non-EU policy frameworks have been identified in eight different categories: (1) climate policy interaction; (2) renewable energy; (3) emissions trading; (4) financing; (5) industry, including issues such as carbon leakage; (6) energy efficiency; (7) adaptation; and (8) transport. Lessons may be learned on these issues from foreign domestic policy frameworks, but also from international programmes such as low-emission development strategies (LEDS), nationally appropriate mitigation actions (NAMAs), and technology needs assessments (TNA).

3. The Approach

In order to analyse the process of policy transfer, Dolowitz and Marsh (2000), provided the conceptual framework for policy transfer by posing and answering six questions. It is worth noting that several authors have used this framework, elaborated to it, and adapted it to specific situations in different fields of policy making (Martinez, 2005; Benson & Jordan, 2011; Smith, 2004; Stone, 2001; French et al., 2014; Aritenang, 2015).

Taking into account the policy transfer theory and its benefits, in order to analyse the process of policy transfer in the climate sector, this paper builds upon four concrete steps. First, the analysis of the sector and the identification of sector's need are conducted (Step 1). Consequently, an overview of the policies that are in pace in the examined country/ region are is elaborated (Step 2) and the lessons learn from other case studies are examined (Step 3). Finally (Step 4), some policies are presented as recommendations for transfer between two regions.

The above steps have been applied in the industry sector in order to prevent carbon leakage. The EU policies on this direction are presented, while lessons learnt from non-EU countries are further investigated in order to be implemented within EU.

Policy Transfer: The case of industry sector

After defining the conceptual framework that could facilitate the process of policy transfer in the climate sector the concrete steps are applied in the industry sector and more particularly in the policies preventing carbon leakage.

An extended literature review took place both in EC regulation, as well as related documentation in non-EU regions.

Key aspects of this paper were implemented within the framework of the just completed "POLIMP – Mobilizing and Transferring Knowledge on Post-2012 Climate Policy" project, funded by the European Commission 7th Framework Programme for Research. POLIMP in essence coordinated and facilitated the information exchange and outcomes of existing research on climate policy and climate agreements in order to broaden the knowledge in the field and enable associated stakeholders to extract key policy conclusions.

Step 1: Identification of the sector

Carbon leakage is the term used to describe the situation where businesses transfer their production to other countries with laxer greenhouse gas (GHG) constraints, because of the high environmental costs (EC, 2015).

This leads to an increase of GHG emissions outside the EU and other Annex I countries as a result of their climate policies, because they affect industries, and especially the energy intensive ones.

Carbon leakage can occur via either one of the following paths (Karakosta, 2016a):

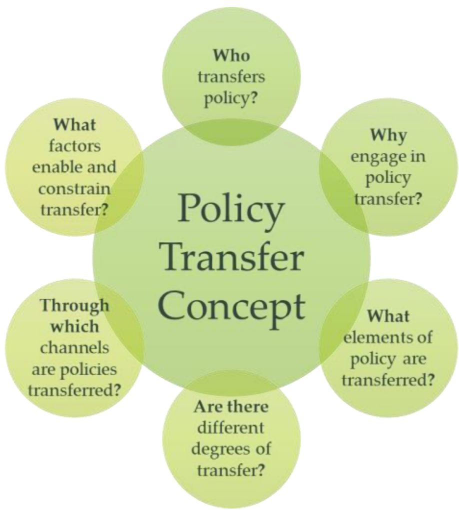

Figure 1: The policy transfer concept.

Figure 2: The 4-step approach for policy transfer.

- Carbon reduction commitments decrease the demand for fossil fuels in Annex 1 countries, which may lead to a decrease in international fossil fuel prices. Consequently, the demand for fossil fuel and the corresponding emissions may follow an upward trend in non-Annex countries.
- Carbon reduction may increase the cost of energy intensive products resulting in a loss of competitiveness for Annex 1 countries against non-Annex 1 countries. Thus, a shift of production to non- Annex 1 countries can be the result.

The costs for the industrial sector in Annex I countries can be direct or indirect. Direct costs are the costs that occur from the procurement of more efficient instruments that are needed to reduce GHG emissions. The indirect costs come from the electricity production costs for the utilities, which are passed through to the industrial customers, further increasing their production costs (Marcu, et al., 2013).

Step 2: Policies taken so far in the region

The nature of the problem is that there is no global agreement for GHG emission regulation. This results in increased costs related to GHG emissions in the EU, constituting the main cause for carbon leakage. Another cause that has a significant impact on carbon leakage is the reduction of the fossil fuels' usage in Annex I countries, which leads to a decrease in their international prices, further encouraging industries to move to non-Annex I countries, in order to be able to use fossil fuels and, also, decrease their production costs.

The EU has implemented several policies so far in order to prevent carbon leakage. Specific sectors that are considered to be at risk are included in five-year exclusion lists, with special provisions for both direct and indirect costs. These lists (EC, 2014) are renewed by the Commission every five years, in order to include the industries that are more prone to carbon leakage. The first list was adopted in late-2009 and additions were made to it during the following years. The second list is already active, with an envisaged duration from 2015 to 2019. In parallel, industries in the EU are motivated to transform their technology and improve their production processes in order to reduce their emissions and comply with the EU regulations (Karakosta, 2015). This provides sufficient incentives for research in break-through technologies and innovation, which is necessary for the achievement of radical changes in energy use and CO_2 emissions reduction in the industrial sector. These incentives include public funding and practical support in order to help industries move to low-carbon production methods.

Step3: Lessons learned from other cases

Non-EU countries that belong to Annex I are facing the same problem of carbon leakage. A policy that is used in the United States to prevent carbon leakage is the "Allowances under the Cap-and-Trade Regime" (Parker & Blodgett, 2008). This policy is based on the hypothesis that a set amount of GHGs emitted by human activities can be assimilated by the ecological system without undue harm, while the rest of GHGs beyond the cap are put in an emissions trading system, similar to EU ETS, between industries and other polluters. Another policy that is used in the US is the tax credit approach, where industries have a decrease in the carbon taxes they have to pay for their emissions, in order to be encouraged to keep their production in the country.

Additionally, in the US, straightforward financial assistance from the governments is provided to the GHG emitting industries, with focus on specific issues, such as research, development and demonstration of technologies.

Another direct policy, proposed by the Australian Government in its Green Paper, is to penalise foreign industries whose emissions are high, with import taxes to their products, which affect producers and prevent carbon leakage from countries with high demand on each industry's products. However, this option is identified as being difficult to be applied (Australian Department of Climate Change, 2008).

Apart from the Emissions Trading Systems and the straightforward financial assistance, the International Energy Agency (IEA) proposes another set of direct policies, which are focused on border adjustment measures. Whereas the Australian Government proposes to penalise foreign industries whose emissions are high, with import taxes to their products (Australian Department of Climate Change, 2008), the IEA focuses on the option of purchasing of special offsets or allowances on the Carbon market of a country. Two proposals are mentioned by the IEA to be existing (IEA, 2008). The Lieberman-Warner bill proposes that "allowances originate from a separate pool of allowances", where importers either have to buy allowances from an international reserve, or obtain credits from the US GHG regulatory program. On the other hand, the French proposal includes allowances that come from the European Allowance (EUA) and are auctioned the following year.

The border adjustment measures, however, are difficult to be applied, while they have to be compatible with the World Trade Organization (WTO) rules. Article III of the General Agreement on Tariffs and Trade (WTO, 1994) mentions the principle of "national treatment". According to this Article, the imported foreign products have to be treated equally to the domestically produced goods and services, which means that border adjustment measures must not exceed the internal taxes that are applied to the carbon intensive products and companies.

Step 4: Policy Transfer Recommendation

European policies, such as the EU ETS and the industry specific lists can be expanded and completed with other policy measures, while encouraging and motivating industrial innovation can have a positive impact in carbon leakage. Emission taxes application to products imported in the EU at the same levels of taxation that exist in the EU Countries, would discourage EU industries from moving to other countries and consequently export their products back to the EU countries. Moreover, another policy that could be adopted, in parallel with the five-year lists, is the establishment of a list of sectors with less taxes and emission costs than others and a longer duration, in order to encourage them to keep their production in the EU.

Not only the EU concerns about industrial competitiveness due to the existence of climate policies, but also other Annex I countries with climate targets. Some examples in non-EU countries may be interesting also for the EU. A policy that is used in the US is the tax credit approach, where industries have a decrease in the carbon taxes they have to pay for their emissions, in order to be encouraged to keep their production in the country. Additionally, in the US, straightforward financial assistance from the governments is provided to the GHG emitting industries, with focus on specific issues, such as research, development and demonstration of technologies.

4. Conclusion

Climate change is a harsh reality, posing one of the most pressing challenges to humanity. The most recent results presented by climate scientists are alarming. Only a joint global response will ensure that this threat is countered effectively.

Policy transfer in the area of climate change is common, since policy intervention in this field is quite recent and policy-makers search for ready-made solutions in other jurisdictions. The EU continues to lead by working towards the success of international climate negotiations, and by taking strong action within the borders of the Union. Hence, the EU is increasingly mainstreaming adaptation and mitigation in partnerships at national, regional and continental level. There are many synergies to exploit and full benefit should be taken thereof, and as it was highlighted from this paper the EU is playing a catalysing role on many levels. Considering that similar policy issues are also relevant in non-EU frameworks, EU stakeholders can learn from those networks and enable an effective policy transfer.

The approached followed in this paper is based on extended literature review on the policy transfer theory, as well as the outcomes of POLIMP project and the four concrete steps proposed aim at supporting policy makers in apply policy transfer in the field of climate between countries or regions. This conceptual framework could serve as a basis for further establishment of a roadmap with analytical guidelines on how policies could be transferred among two regions, what are the prerequisites and what the mutual benefits that occur. Knowledge needs with possible lessons learned from non-EU policy frameworks have been identified in the industry sectors. Through the four-step process, this paper provides an overview of these frameworks in the case of carbon leakage to support EU towards climate change mitigation and adaptation. The examination of policy transfer from non-EU to EU countries through the proposed approach indicates that EU could benefit from several policies worldwide in order to prevent carbon leakage, such as tax credit approach and emission taxes application that encourage production to be kept in the country.

Finally, the study has been also validated through research and stakeholder workshops conducted during the European project POLIMP, where an important number of key policy and decision makers participated. The stakeholder workshops investigated different option for the EU transition to a low-carbon economy taking advantage from the important input of the attendees.

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Day-Ahead Economic Dispatch for Oil Shale Power Plants in Deregulated Electricity Market

by

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Abstract

The Estonian electricity sector development has been very rapid during the last years - from the domination of the power monopolies in the regulated market to the electricity trading over the borders in the deregulated market. The deregulated market brings new challenges for power producers that are facing the economic power dispatch problem in the competitive conditions. The traditional economic power dispatch problem considers the minimizing of total thermal cost rate, where only the electric constraints are satisfied in the electric power system under the regulated electricity prices. Deregulation of the electricity market makes it necessary to perform the changes in classical algorithm and develop the new model for finding a good solution in a reasonable period of time. The objectives of this paper is to elaborate day-ahead economic dispatch model for oil-shale-based power plants; implement the proposed algorithm by using different optimization techniques, and estimate the effectiveness of used optimization techniques for solving the economic dispatch problem.

The day-ahead economic dispatch optimization is formulated as a mixed-integer linear programming problem. The proposed algorithm has been implemented in the modeling language GAMS using Cplex mathematical programming solver. The test cases with different properties were carried out for oil shale generating units using by primal simplex, dual simplex and interior-point optimization techniques. The electricity and thermal power production, generation costs by the components, CPU time, results of the start-up costs calculation, primary energy consumption and emissions amounts are calculated. The outcomes are presented as the calculations of one typical week in winter and summer.

Keywords: economic dispatch, unit commitment, primal simplex, dual simplex, interior-point, GAMS, Cplex, day-ahead market.

Nomenclature

Indices and sets

D_{max}	Set of maximum days in the model $D_{max} = \{1 \dots n\}$
D_t	Set of days with elements $t \in D: D \subset D_{max}$
H	Set of time per day, where $h \in H: H = \{1 \dots 24\}$
U	Power generating units $u \in U: U = \{Unit1 \dots 10\}$
U_e	Power generating unit for electricity production $U_e \in U_e: U_e \subset U$
U_h	Power generating unit for heat production $u_h \in U_h: U_h \subset U_e$
E	Production technology set $e \in E: E = \{CP, CHP, CFBC\}$
B	Primary energy $b \in B: B = \{OS, SO, RG\}$
W_u^e	Power generation units emissions for power $w_e \in W_e: W_e = \{SO_x \dots HM\}$
W_u^h	Power generation units emissions for heat $w_h \in W_h: W_h = \{SO_x \dots HM\}$

Variables

Variable	Unit	Description
$\eta_u(t)$	%	Power generating unit's u efficiency for the time period t
$B_u(t)$	MWh	Power unit's u primary energy consumption for the time period t
$P_u(t)$	MWh	Power unit's u electricity production for the time period t
$Q_u(t)$	MWh	Power unit's u heat production for the time period t

$C_u^B(t)$	€	Power unit's u primary energy costs for the time period t
$C_u^{SU}(t)$	€	Power unit's u start-up costs for the time period t
$W_{u,e}(t)$	t	Emission amount of type e for power unit u for the time period t
$C_u^w(t)$	€	Power unit's u environmental impact costs for the time period t
$C_u^{VC}(t)$	€	Total manufacturing variable costs of power units
$C_u^{FC}(t)$	€	Total manufacturing fixed costs of power units
$C_u^{GC}(t)$	€	Total generation costs of power units
$\alpha_{i,t}$	0/1	Controllable variables: $\alpha_{i,t} = 1$ boiler i is in operation, $\alpha_{i,t} = 0$ boiler is off
$\beta_{j,t}$	0/1	$\beta_{j,t} = 1$ turbine j is in operation, $\beta_{j,t} = 0$ turbine is off
$\gamma_{u,t}$	0/1	$\gamma_{u,t} = 1$ power unit u is in operation, otherwise $\gamma_{u,t} = 0$.

1. Introduction

In 2003, when Estonia's treaty of accession to the European Union (EU) was signed, it was agreed that Estonia would open its electricity market partially in 2009, and completely in 2013. The partial opening of the electricity market in Estonia took place in April 2010 for large-scale consumers, who consumed more than 2 GWh of electricity per year. At the beginning of 2013, Estonian electricity market was opened for small and household consumers (Elering, 2012). Estonia is a member of NordPoolSpot (NPS) power market and mainly operates in Elspot and Elbas power markets.

Deregulation of the electricity market in Estonia has brought favorable possibilities to encourage competition among power producres by improving the efficiency and operational management. However, at the same time, it has also created new challenges and uncertainties in this sector (Carraretto, 2006).

The Estonian area oil shale power plants generate revenues depending on electricity prices and traded volumes in deregulated market. In the competitive conditions of the deregulated electricity market the power plant faces the problem of finding effective supply offers. Moreover, when hourly prices are announced to the market and trades are settled, another problem arises: how to operate power plants in order to fulfil the power contracts, meet the emissions limit and maximize profits by producing the electricity as much as possible during high-priced peak hours and reducing the electrical load during off-peak hours.

The objectives of this paper is to elaborate day-ahead economic dispatch model for oil-shale-based power plants; implement the proposed algorithm by using different optimization techniques, and estimate the effectiveness of the used optimization techniques for solving the economic dispatch problem.

The problem of economic dispatch requires the following tasks:

- oil-shale-based power units input characteristics and determination of
- optimality conditions for day-ahead economic load dispatch model;
- comparison of economic load dispatch and unit commitment;
- analysis and evaluation of the existing optimization techniques;
- practical testing of the economic load dispatch algorithm by using optimization techniques;
- evaluation and summing up the research results.

The benefits of day-ahead economic dispatch are as follows (US Department of Energy, 2005):

- reduction in total electricity generation costs;
- better fuel utilization and air emission reduction by using more efficient;
- generation units;
- increasing operational reliability without increasing costs.

The day-ahead economic dispatch optimization is formulated as a mixed-integer linear programming problem. The proposed algorithm has been implemented in the modeling language GAMS using Cplex mathematical programming solver. The test cases with different properties were carried out for oil shale generating units using by primal simplex, dual simplex and interior-point optimization techniques.

The proposed algorithm has practical value and used in the creation of real day-ahead optimization model for oil shale power plants for estimation the generation costs and maximization of power plant profit.

2. Economic dispatch using optimization techniques

The previous solutions to economic load dispatch (ELD) problems have applied various mathematical programming methods and optimization techniques. Wood and Wollenberg (1984) used many optimization techniques for solving ELD problem, such as genetic algorithm (GA), fuzzy, hybrid techniques. The type of modern optimization techniques called Particle Swarm Optimization (PSO) was introduced by J. Kenedy and R. Eberhart in 1995 (Aravindhababu P, Nayar K., 2002). Sheble (1989) proposed a real-time economic dispatch algorithm known as Merit Order Loading (MOL) based on the theory of linear programming, but with impossibility to solve combined cycle (CC) generation dispatch problem. Ongsakul (1999) has made a modification for MOL and sorted CC units based on the unit incremental cost at the highest outputs, but an example with only CC units was provided. Sheble and Brittig (1995) proposed a refined genetic algorithm (RGA) method to solve ELD problem with non-convex cost curve, taking into account the valve point effect. Yang H., Yang P. and Huang (1996) have used non-smoothing fuel cost functions for solving ELD problem. The evolutionary programming based algorithm for ELD with environmental constraints was first time implemented by Wong and Yuryerich in 1998.

The classical economic load dispatch problem has been solved by using classical mathematical optimization methods, such as the Lambda-iteration method, the Newton method or the gradient method (Smallwood, 2002; Hernandez-Aramburo, Green, 2005). Unfortunately, these techniques rely on the essential assumption of the incremental costs' monotonically increasing function, and they do not take into account the constraints imposed by the generators. In addition, the presence of restrictions, such as ramp rate limits, valve points and prohibited operation zones, introduces discontinuities that add additional complexity to the ELD problem (Victoire, Sugnathan, 2008). Therefore, dynamic programming, genetic algorithms, nonlinear programming, artificial intelligence, practical swarm optimization and their modification techniques for solving ELD issues have been presented in Park, Lee and Shin (2005), Sinha, Lai (2009) and Bhattacharya, Chattopadhyay (2009).

The Estonian researchers presented the estimation of input-output characteristics and the principles of optimal dispatch of condensing units in a power plant under incomplete information in 1976 and 1977 (Valdma et al., 1976; Valdma, 1977). Keel, Shuvalova, Tammoja and Valdma introduced the economic dispatch and unit commitment solution for cogeneration power plant with combined cycle in 2001. The principles of min-max optimal load dispatch in condensing thermal power plant were proposed by Valdma, Keel, Liik and Tammoja in 2003. Several papers were provided on the topic of optimal load dispatch solution for the generating units in the power system under probabilistic and uncertain information with the presentation of min-max models (Liik et al., 2004; Keel et al., 2005; Tammoja, Valdma, Keel, 2006; Valdma, et al., 2007). The book "Optimization of Thermal Power Plants Operation" was published in 2009 in Estonian and English, and it introduces the theory and methods of operational optimization for different kinds of thermal power plants (Valdma et al., 2009). The evaluation of optimization efficiency in the power systems for two classic optimization problems - economic dispatch and unit commitment problems of thermal power units - was carried out in paper "On Efficiency of Optimization in Power Systems". The authors have shown that the maximum efficiency of optimization in load distribution and unit commitment problems in thermal power plants can decrease the fuel cost and economic impacts of thermal units approximately by 10–20%. Moreover, they stated that the optimization is the cheapest possibility of economizing on energy resources, thermal power plants and power systems by minimizing the operation and investment costs and reducing environmental impact (Keel et al., 2011). However, efficiency of optimization in both load distribution and unit commitment was introduced based on the conditions of regulated electricity market, where the electricity prices are relatively stable and under the control of the government. Deregulation of the electricity market makes it necessary to perform the changes in classical algorithm and develop the new model for finding a good solution in a reasonable period of time.

This economic dispatch and unit commitment problem in conditions of the deregulated market for oil-shale-based power units is formulated as a mixed-integer linear programming problem (MILP). The mathematical programming formulation is implemented in the modeling language called the General Algebraic Modeling System (GAMS). GAMS is described in a number of publications including Brooke et al. (1998), Jensen (2006), Kalvelagen (2001, 2002, 2003), Markusen (2005), McCarl (1998), McCarks et al. (2013), McKinney and Savitsky (2003), Robichaud (2010), Andrei (2011) and Rosenthal (2011) (Neculai, 2013).

It includes the following mathematical algorithms:

- primal and dual simplex algorithm,
- barrier or interior-point algorithm,
- network algorithm,
- sifting algorithm,
- concurrent algorithm.

The paper focuses on the primal, dual simplex and interior-point algorithm. The simplex algorithm is generally attributed to George Dantzig (1914-2005), who is known as the father of linear programming. In 1984, Narendra Karmarkar published a paper describing a new approach to solving linear programs that was both numerically efficient and had polynomial complexity. This new class of methods is called interior-point methods. These new methods have revolutionized the optimization field over the last 30 years, and they have led to efficient numerical methods for a wide variety of optimization problems well beyond the confines of linear programming (Burke, 2013).

3. Primal and dual simplex algorithm

Linear programming is constrained minimization of a linear objective over a solution space defined by linear constraints:

$$\min cx \tag{1}$$

$$Ax \leq b \tag{2}$$

$$l \leq x \leq u \tag{3}$$

A is an $m\times n$ matrix, c is a $1\times n$ vector, and x, b, l, u are $n\times 1$ vectors.

A dual problem could be constructed for every LP problem, where c and $y = [y_1, y_2, \dots y_m]$ are row vectors and b and x are column vectors. The standard form for the primal and dual problem is given in Figure 1.

The dual problem uses exactly the same parameters as the primal problem, but in different locations. The primal problem on the left is stated as a maximization problem, to match the standard presentation of duality, recognizing that $\max cx \equiv \min(-c)\, x$.

Primal Problem				*Dual Problem*	
Maximize	$Z = cx$			*Minimize*	$y_0 = yb$,
subject to				*subject to*	
	$Ax \leq b$	$\Leftrightarrow$			$yA \leq c$
and				*and*	
	$x \geq 0$				$y \geq 0$

Figure 1: The primal and dual problem in matrix notation. Source: (Hillier, Lieberman, 2001).

For a primal maximization problem and a dual minimization problem, the primal objective cx starts low and increases, while the dual objective yb starts high and decreases. This gives an upper and lower bound on the optimum value of the solution (Hafer, 1998).

Both the primal and dual simplex algorithms will reach the same solution, but arrive there from different directions. The dual simplex algorithm suits the best for problems for which an initial dual feasible solution is easily available. It is particularly useful for reoptimizing a problem after a constraint has been added or some parameters have been changed, so that the previously optimal basis is no longer feasible. In practice, the simplex algorithm is quite efficient and it can be guaranteed that the global optimum is found if certain precautions against cycling are taken (Jensen, Bard, 2003).

4. The interior-point method

Interior-point method was initially proposed by Frisch in 1955. Fiacco and McCormick proved global convergence for general interior-point methods for problem by reformulating this problem as an unconstrained optimization problem. Classical log-barrier methods, one type of interior-point algorithm, were used extensively in the 1960s and 1970s (Doyle, 2003). The basic approach for interior-point method was proposed in 1967 by a Russian mathematician Dikin I. (Hillier, Liebermal, 2001). In 1984, Karmarkar presented an algorithm that solved linear optimization problems in polynomial time. This was a significant improvement over current algorithms (notably the simplex method), which solved worst-case problems in exponential time. It was soon shown that Karmarkar's algorithm was equivalent to the log-barrier method and interest in interior-point methods resurged (Doyle, 2003). After the appearance of Karmarkar's work, it was rediscovered by a number of researchers, including Barns, Cavalier and Soyster. Vanderbei, Meketon and Freedman who presented a modification of Karmarkar's linear programming algorithm in 1986 (Hillier, Liebermal, 2001).

Karmarkar's algorithm falls within the class of interior point methods: the current guess for the solution does not follow the boundary of the feasible set as in the simplex method, but it moves through the interior of the feasible region, improving the approximation of the optimal solution by a definite fraction with every iteration, and converging to an optimal solution with rational data (Strang, 1987). The term interior-point method implies that the solution process maintains strict inequality for constraints that are expressed as inequalities (Doyle, 2003).

The primal, dual and interior-point method example solution is given in Figure 2. The example considers and variables and 11 constraints that are shown as blue lines. Each iteration of the algorithm is marked as red circle points.

5. Case study

The case study is based on the solving the economic load dispatch problem for 10 power generation units with total capacity ca 2 000 MW in oil shale power plants, which minimizes the total generation costs of power plant under the technological and environmental constraints. As it is a day-ahead planning, the author assumed that all data are reasonably well known. The day-ahead load demand and electricity prices are determined by supply and demand curves, and they do not consider the intra-day adjustment supplies.

The total generation costs of the power units, including power units manufacturing fixed and variable costs, have been determined. The manufacturing fixed costs are not dependent on the electricity produced, and therefore are not included in the objective function. Besides the costs, the following detailed results are expected: the number of power units required and the number of start-ups, the load of each generating units, heat and electricity production unbalance with respect to the demand, power plant's electricity and heat output, power units' emissions amount and primary energy consumption.

Input data

Input-output characteristics are the most important initial data for solving the economic dispatch task. Input-output characteristics would be defined from the following parts:

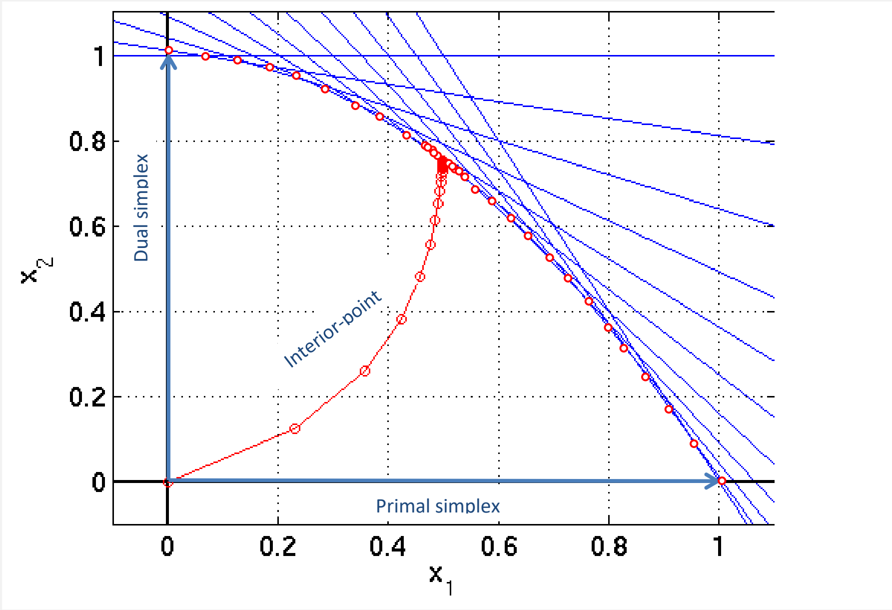

Figure 2: The primal, dual and interior-point method example solution. Source: (Hillier, Lieberman, 2001).

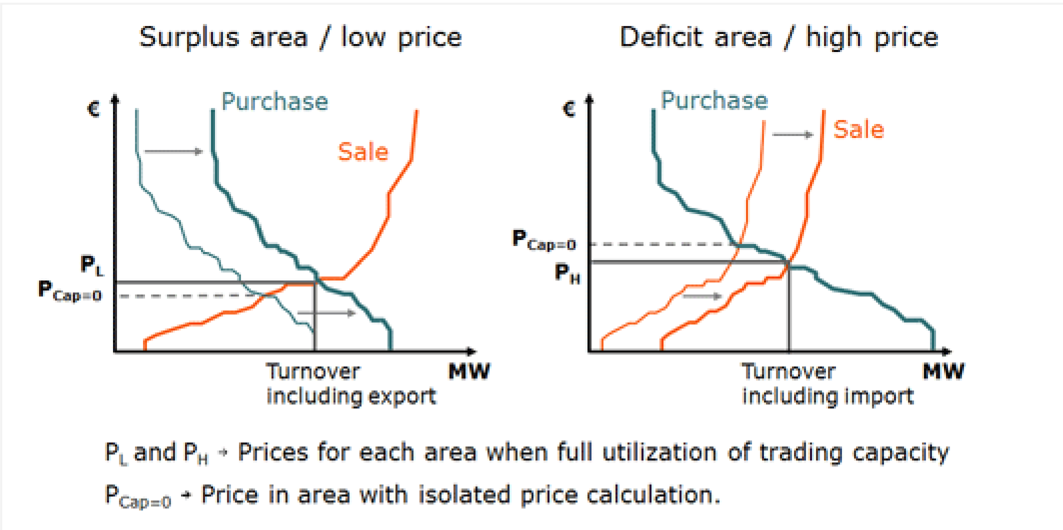

Figure 3: Market price and market balance principle. Source: NordPoolSpot.

- input and output characteristics from deregulated market;
- input and output characteristics from power plant units;
- limitations related to technological and environmental requirements;
- optimality conditions of power units operation.

Input and output characteristics from deregulated market are electricity prices and volumes. The electricity price for each hour is determined by intersection of the aggregate supply and demand curves, which represent all bids and offers from the participants of the market (NordPoolSpot). The price is relatively lower in the surplus area and relatively higher in the deficit area (Figure 3).

Electricity power produced from power plants is changing and has day and week cyclic recurrence. During the night hours the electric power generation could be two times less than in daytime and the same for working days and weekends.

The fluctuations of NPS prices and electrical power generation in a typical winter week are shown in Figure 4.

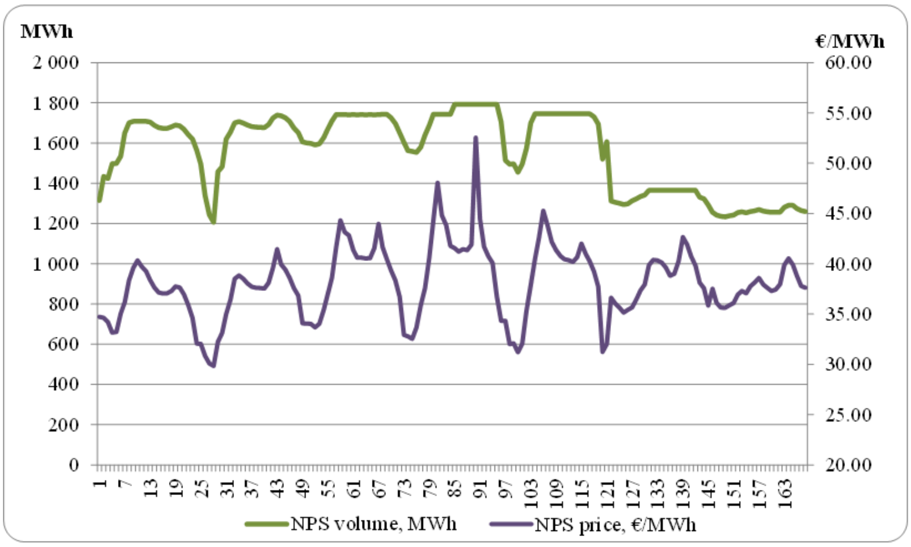

Figure 4: Electrical power price and volume fluctuations of a typical winter week. Source: NordPoolSpot.

Initial information used for day-ahead economic dispatch of the power plant operation is the set of input-output characteristics of the boilers, turbines and power units. The paper focuses on several types of thermal power plant units:

- Condensing power plant units (CP)
- Combined cycle power plant unit (CHP)
- Circulated fluidized bed combustion (CFBC) technology

The following characteristics are used as the static model of the power units (Valdma et al., 2009):

Input-output characteristics:

$X = X[Y,U,V(Y)] = G_{U,V(Y)}(Y)$ (4);

Environmental impact characteristics:

$W = W[Y,U,V(Y)] = W_{U,V(Y)}(Y)$ (5);

Auxiliary characteristics:

$P^{aux} = P^{aux}[Y,U,V(Y)] = P^{aux}_{U,V(Y)}(Y)$ (6);

where

X – input vector,
Y – output vector,
U – vector of state parameters,
$V(Y)$ – state vector function,
W – compounds affecting the environment,
P^{aux} - auxiliary power.

The following generating unit characteristics in economic load dispatch (ELD) are considered in this paper:

- electrical and thermal power unit output, auxiliary power;
- generation costs, which depend on:
- power generating unit capacity,
- manufacturing fixed costs,
- power generating unit efficiency and variable manufacturing costs (fuel, environmental and CO_2 emission costs); start-up costs.

The constraints and optimality conditions of the power units' operation that affect power units (Wood,Wollenberg, 2006):

- availability of power units;
- minimum and maximum electrical and heat generation capacity;
- ramp rate (how quickly the unit's output can be changed);
- minimum amount of time the generator must run;
- minimum amount of time the generator must stay off once turned off.

Emission constraints have also impact on the operation of the power units. The European Union has issued standards for SO_2, fly ash, CO and NO_x emissions for large combustion plants in its LCP Directive. The standards apply to all power plants with a thermal input of energy more than 50 MW.

Model formulation

The optimization problem is the following: to find permitted cross active loads of the power units $P_1, \ldots P_m$, which would guarantee the given NordPoolSpot electricity production volume $P_e^{NPS}(t)$ from overall power plant with minimal manufacturing variable costs $C_{tot}^{VC}(t)$ while meeting the constraints listed below. Objective Function:

$$minimize \quad C_{tot}^{VC}(t) = \sum_{u=1}^{m} C_u^B(t) + \sum_{u=1}^{m} C_u^W(t) + \sum_{u=1}^{m} C_u^{SU}(t) \tag{7}$$

Subject to the following constraints:

NordPoolSpot electricity production volume: $P_e^{NPS}(t) - \sum_{u=1}^{m} P_u(t) = 0$ (8)

Active power limits to the power units: $P_u^{min} \leq P_u(t) \leq P_u^{max}, u = 1, \ldots m$ (9)

Thermal load for cogeneration unit:

$$Q^D(t) - \sum_{u=1}^{m} Q_u(t) = 0 \tag{10}$$

Heat power limits to the power units:

$$Q_u^{min} \leq Q_u(t) \leq Q_u^{max}, u = 1, \ldots m \tag{11}$$

Ramp rate requirements:

$$P_{u,\tau+1} - P_{u,\tau} \leq R_u \tag{12}$$

where

$C_{tot}^{VC}(t)$- total manufacturing variable costs in time interval t,

$C_u^B(t)$- power units' primary energy costs in time interval t,

$C_u^W(t)$ - power units' environmental impact costs in time interval t,

$C_u^{SU}(t)$ - power units' start-up costs in time interval t,

P_u^{max}- maximum power units' electrical capacity,

P_u^{min}- minimum power units' electrical capacity,

u- power units (double-blocks), $u = 1, \ldots m$,

$Q^D(t)$- district heating thermal load,

$Q_u(t)$- power units' thermal load,

Q_u^{max}- power unit's u maximum thermal load,

Q_u^{min}- power unit's u minimum thermal load,

$P_{u,\tau}$- active power of unit u in time interval τ $(t \geq \tau)$,

$P_{u,\tau+1}$- active power of unit u in time interval τ $(t \geq \tau)$,

R_u- ramp rate.

In addition, the following constraints are considered:

Emission limit values:

$$W_{u,e}(t) \leq W_{u,e}^{max} \tag{13}$$

Retort gas usage limitation:

$$B_{u,RG}(t) \leq B_{u,RG}^{max} \tag{14}$$

where

$W_{u,e}(t)$- emission type e of power unit u,

$W_{u,e}^{max}$- maximum permitted emission type e of power unit u,

$B_{u,RG}(t)$- retort gas usage of power unit u of time interval t,

$B_{u,RG}^{max}$- maximum retort gas usage of the power unit u.

Minimum down-time:

$$T_{u,t}^{down-time} \geq T_{stay-off}^{min} \tag{25}$$

Minimum up-time:

$$T_{u,t} \geq T_{must-run}^{min} \tag{16}$$

where

$T_{u,t}^{down-time}$- down-time of the unit u at the beginning of time interval t,

$T_{stay-off}^{min}$- minimum amount of time the generator must run,

$T_{u,t}$ - time period of the power unit running,

$T_{must-run}^{min}$ - minimum amount of time the generator must stay off once turned off.

Restriction for number of start-ups:

$$m_u(t) \leq m_u^{max} \tag{17}$$

where

$m_u(t)$ - planned number of start-ups of the time interval t,

m_u^{max} - maximum number of start-ups during the planned period.

Power units' primary energy costs could be found as:

$$C_u^B(t) = \sum_{u=1}^{m} B_u(P_u) = \sum_{u=1}^{m} \frac{C_f}{\eta_u(P_u)} \tag{18}$$

where

$B_u(P_u)$ - fuel costs characteristics of the power unit u,

C_f - fuel type f price,

$\eta_u(P_u)$- efficiency of the power unit u.

Power units' environmental impact costs are calculated as follows:

$$C_u^W(t) = \sum_{u=1}^{m} W_{u,w} \cdot C_w = \sum_{u=1}^{m} (w_{e,w}^f + w_{h,w}^f) \cdot B_u^f \cdot C_w \tag{193}$$

where

$W_{u,w}$ - amount of the power units' emission type w for the power unit u,

C_w - emissions tariffs for emission type w,

$w_{e,w}^f$, $w_{h,w}^f$- specific emission type w for electricity and heat production for fuel type f,

B_u^f- power unit's primary energy consumption for fuel type f,

Power units' start-up costs could be defined as follows:

$$C_u^{SU}(t) = \sum_{u=1}^{m} C_f \cdot (\gamma_{u,t} \cdot B_u^{SU}(T_{u,t}^{down-time})) \quad (20)$$

where

C_f - fuel type f price,

$\gamma_{u,t}$- parameter considering the start-up of unit u in time interval t,

B_u^{SU}- start-up fuel consumption of the power unit u,

$T_{u,t}^{down-time}$- down-time of unit u at the beginning of time interval t.

Total generation costs could be calculated as:

$$C_{tot}^{GC}(t) = C_{tot}^{VC}(t) + C_{tot}^{FC}(t) \quad (41)$$

where

$C_{tot}^{GC}(t)$ - total generation costs of the power units,

$C_{tot}^{VC}(t)$- total manufacturing variable costs of the power units,

$C_{tot}^{FC}(t)$- total manufacturing fixed costs of the power units.

The day-ahead economic dispatch optimization is formulated as a mixed-integer linear programming problem. The proposed algorithm has been implemented in the GAMS/Cplex. The computational tests are carried out in an Intel(R) Xeon(R) CPU X5570 with 8 logical processors and 40.0 GB of RAM memory. The basic structure of a mathematical model coded in GAMS has the following components: sets, data, variable, equation, model and output.

Algorithm of the power unit's optimization

Step 1. Calculate unbalance of the active power (Eq. 8), check the active power limits of the power units (Eq. 9).

Step 2. Find the thermal load demand (Eq. 10) and check the heat power limits of the power units (Eq. 11).

Step 3. Calculate the primary energy costs (Eq. 18), check the retort gas usage limitation (Eq. 14).

Step 4. Calculate power units' environmental impact cost (Eq.19), check the emission limits (Eq. 13).

Step 5. Check the start-up parameter $\gamma_{u,t}$, if the $\gamma_{u,t} = 1$, check the ramp rate of the power unit (Eq. 12) and minimum up-time (Eq. 16).

Step 6. If $\gamma_{u,t} = 0$, then check the minimum-down time (Eq. 15).

Step 7. Check the restriction of the number of start-ups (Eq. 17).

Step 8. Find power units' start-up costs (Eq. 20).

Step 9. End, delivering the results.

The proposed day-ahead economic dispatch algorithm includes several simplifications:

- the spinning reserve requirements considered to be without limitations;
- the start-up costs of the turbine and boiler are not considered separately in calculation of the start-up costs;
- only one type of oil shale with heat value 8.4 MJ/kg is used;
- the shale oil usage is considered only for start-ups;
- the transmission losses and fuel stocks are eliminated.

The listed simplifications could be used for the improvement of the model formulation, when the initial information is collected, the impact of these assumptions is fully assessed and designed. For example, for using fuel mixes in algorithm, the initial information based on the real tests should be fully described and the influence of fuel composition on the emission amount should be estimated.

Implementation of the case study is based on real data of the year 2013. The results are represented in the next chapter as the calculations of one typical week in winter and one typical week in summer.

For the implementation and testing of day-ahead economic dispatch algorithm, the primal simplex, dual simplex and interior-point methods are selected and used as the most suitable for these types of practical cases.

Results and discussions

In order to estimate the effectiveness of the primal simplex, dual simplex and interior-point optimization techniques, 42 test cases having different properties for 10 generating units were considered.

The results of the calculation concerning the electrical and thermal power production that are the same for all cases are provided in Tables 1,2. The electricity market volume is 30% more in winter week than in summer. It is caused by the climate conditions, such as outdoor temperature, humidity, atmospheric pressure, wind, precipitation, etc. The unbalance of electricity is 5,4 GWh, which shows that power plants could not be able to meet the requirements concerning the NPS volume during winter week. The main reason of electricity unbalance is unavailability of power units due to repair, emergency or cleaning needs. As the NPS prices and volumes are usually lower in summer than in winter, the repairs and overhauls are planned mostly for this period. The average NPS price in Estonia decreased by 4% (-1,4 €/MWh) in the summer week as compared to the winter week in 2013.

There is no unbalance of thermal power, and power plants meet the requirements concerning thermal demand during the winter and summer week. The heat power price approved by the Competition Authority is stable during the winter and summer week. The difference of heat power production in the winter and summer week is 86%, which is caused by the climate conditions (Table 2). The average outdoor temperature was -1,0 ºC in winter week and +18,9 ºC during the given summer week (Ilmategija Internetis, 2014). Using the real data, the computational results of manufacturing variable, fixed, total generation costs and CPU time are given in Table 3.

As seen from the results, the minimum variable costs achieved by interior-point algorithm were 9,93 million euros and generation costs are 11,6 million euros for the test cases of winter week. The results of generation costs of primal and dual simplex algorithm are very close to interior-point algorithm. The difference is marginal: 0,6% for primal simplex algorithm and 0,3% for dual simplex algorithm as compared to interior-point algorithm.

The generation costs are the same in all three cases and they are considered to be 8,07 million euros for the given summer week. The difference of generation costs between the winter and summer week is 19%, which is caused by the smaller number of power units required. The number of units required to cover the NPS demand during the winter week is 10 and during the summer week it is 8. CPU time or process time shows the amount of time that a central processing unit (CPU) uses for processing a computer program. The optimal solution of economic dispatch was to be within CPU time 509 seconds summing for winter and 528 seconds for summer week using interior-point algorithm.

Table 1: Electrical power production. Source: Compiled by the author.

Period	NPS volume, MWh	NPS electricity price, MWh	NEJ electricity output, MWh	Electricity unbalance, MWh
Winter week	262 349	39,45	256 935	5 414
Summer week	182 493	38,01	182 493	0

Table 2: Thermal power production. Source: Compiled by the author.

Period	Thermal demand, MWh	Heat power price, MWh	NEJ heat output, MWh	Heat power unbalance, MWh
Winter week	14 389	21,03	14 389	0
Summer week	2 032	21,03	2 032	0

Table 3: Generation costs and CPU time for the winter and summer week. Source: Compiled by the author.

Algorithm	Manufacturing variable costs, m €	Manufacturing fixed costs, m €	Generation costs, m €	CPU, sec
Winter week				
Interior-point	9,93	1,67	11,60	509
Dual simplex	9,96	1,67	11,63	515
Primal simplex	9,99	1,67	11,66	576
Summer week				
Interior-point	6,88	1,67	8,07	528
Dual simplex	6,88	1,67	8,07	529
Primal simplex	6,88	1,67	8,07	544

Table 4: Number of the required units, number of start-ups and costs in the winter and summer week. Source: Compiled according to the author's calculations.

Algorithm	Number of required units	Number of start-ups	Start-up costs, m €
Winter week			
Interior-point	10	0	0,00
Dual simplex	10	1	0,02
Primal simplex	10	2	0,06
Summer week			
Interior-point	8	1	0,04
Dual simplex	8	1	0,04
Primal simplex	8	1	0,04

Table 5: Emissions amount based on the interior-point algorithm. Source: Compiled by the author according to calculations.

Period	SO_x, t	NO_x, t	CO_2 for heat production, t	CO_2 emission allowance, t	Fly ash, t	Bottom ash, t
Winter week	2 903	701	37	1 074	954	366
Summer week	1 454	447	5	723	224	244

The CPU time using primal and dual simplex method is 13% and 1% more respectively during the winter week, and 3% and 0,2% more during the summer week. It shows that the results of the interior-point algorithm provide the best performance as compared to primal and dual simplex optimization methods.

The manufacturing fixed costs are constant through the whole power range. The manufacturing fixed costs apply irrespective of the fact whether the power plant units were used during this day or not. The fixed costs have been defined as O&M and personnel costs. The manufacturing fixed costs composed approximately 17% of the total generation costs during the winter time and 24% of the total generation costs during summer.

The manufacturing variable costs are not constant through the whole power range and consist of fuel costs, emissions and CO_2 emission allowance costs. The difference in variable costs is marginal and is considered to be 0,3% using primal simplex algorithm and 0,1% using dual simplex algorithm compared to interior-point algorithm. The manufacturing variable costs composed 83% of the total generation costs during the winter time and 76% of the total generation costs during summer. The main component of the manufacturing variable costs is fuel cost that makes up 77% of the total generation costs. The emission costs are 23%, where CO_2 emissions allowance costs are 17%.

Table 4 presents the results of the start-up number and costs calculation. Those costs are typically fuel-costs for warming up. The number of start-ups is different for the given algorithms, and as a consequence, the start-up costs are also different during the winter week. The primal simplex method during the winter week shows the worst result from three algorithms, and the start-up costs are ca 70% higher when using dual simplex method. The interior-point algorithm has no start-ups during the winter week. The results of the start-up costs during the summer week are the same for all three algorithms.

The main fuel used in power plants for heat and electricity production is oil shale and it amounts to around 94% of total primary energy consumption in both winter and summer weeks. Total primary energy consumption is 813 MWh for winter week and 565 MWh for summer week.

The primary energy consumption results using other algorithms are close to the presented interior-point method's results and are not presented separately. The retort gas is used as auxiliary fuel and it makes up around 6% of the total primary energy consumption during the winter and summer week. As the shale oil is used only for start-ups, its consumption is very small and amounts only to 0,2% during the winter and summer weeks.

The environmental issues in power generation play an important role. Minimizing the cost associated with those emissions could be considered in detail as a separate task due to the complexity of modelling. This problem is called an environmental dispatch problem and it includes emission concentration limit values as well as annual limits that are declared in the integrated environmental permits of the power plants. The emissions amounts of SO_x, NO_x, CO_2, fly ash and bottom ash are presented in Table 5.

In order to prove the possibility for minimization of the generation costs in a power plant by using the proposed ELD algorithm the units' optimal electrical power output after using the algorithm is provided. The optimal electrical power output for the winter week is presented in Figure 5. The optimal electrical power output for the summer week is presented in Figure 6.

As the results of the optimal electrical power outputs using other algorithms are close to the results of the interior-point method, therefore they are not presented separately.

In order to estimate the effectiveness of optimization techniques and compare the difference in generation costs of the power plants before and after the implementation of the economic dispatch and unit commitment, the hourly manufacturing variable costs are calculated.

The variable costs of power plants in the winter week are presented hour by hour in Figure 7. The efficiency of optimization in load distribution and unit commitment problems in the power plants decrease the manufacturing variable costs on average by 1 million euros or 9% during the week in winter.

The decrease the manufacturing variable costs is based mainly on the savings due to the smaller number of start-ups and more economic distribution of the load between the power units.

The number of required units is 10 for the winter week and the number of start-ups decreased from 4 to 0 number. It brings the significant reduction of start-up costs after the implementation of ELD algorithm. The impact of implementation of economic load dispatch during the summer week in power plant is presented in Figure 8.

During the summer week, the impact of economic dispatch in power plants is around 0,4 million euros or 6% due to more economic distribution of the load between the power units. The major impact on the economic distribution of the load between the power units in power plant. The number of required units is 8 for the summer week and the number of start-ups is 1 for all cases.

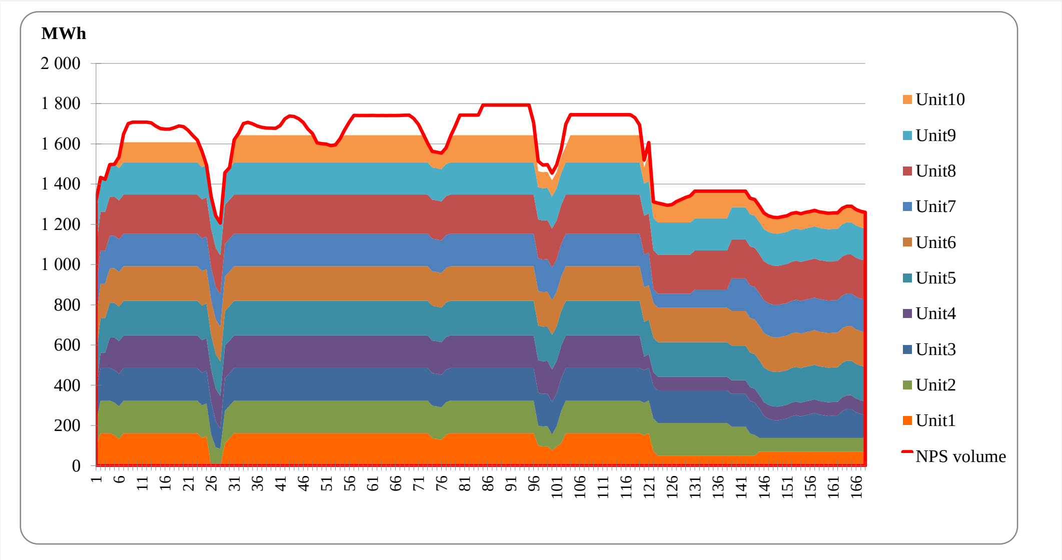

Figure 5: The optimal electrical power output of the power units in the winter week. Source: Compiled according to the author's calculations.

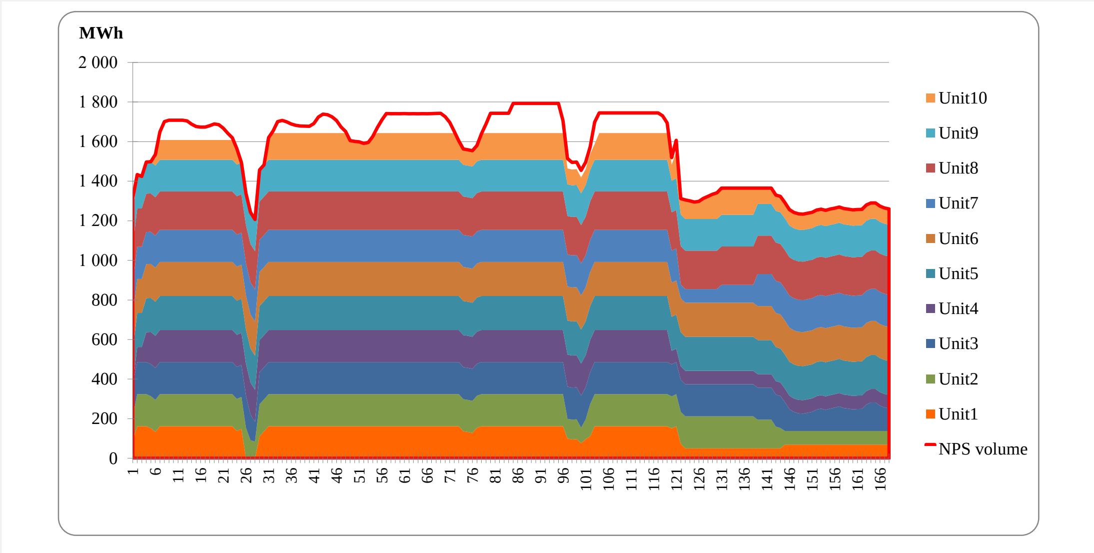

Figure 6: The optimal electrical power output of the power units in the summer week. Source: Compiled according to the author's calculations.

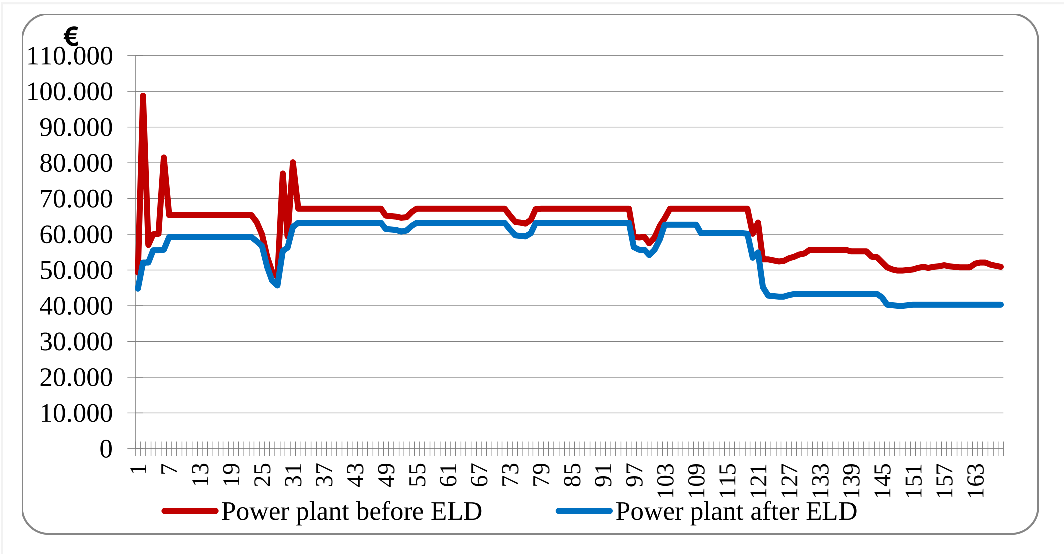

Figure 7: Manufacturing variable costs of the power plant in the winter week. Source: Compiled according to the author's calculations.

6. Conclusions

The economic load dispatch and the unit commitment are both essential problems to be solved in order to supply high-quality electric power to the customers in a secured and economic manner. These two problems have been widely studied in case of the regulated electricity market. Nevertheless, deregulation of the electricity market, strict technological and environmental requirements must be taken into account.

There are several techniques used for optimizing the economic dispatch and unit commitment schedules. Solving the economic dispatch problem by using primal simplex, dual simplex and interior-point method are discussed in the thesis. The algorithm of economic dispatch for the oil shale power generating units is proposed. A number of important factors, such as minimum and maximum available capacity, the electricity market price and volume, technical requirements, emission limitations and optimality conditions are determined. The day-ahead economic dispatch optimization has been formulated and implemented in the mathematical programming solver GAMS/Cplex.

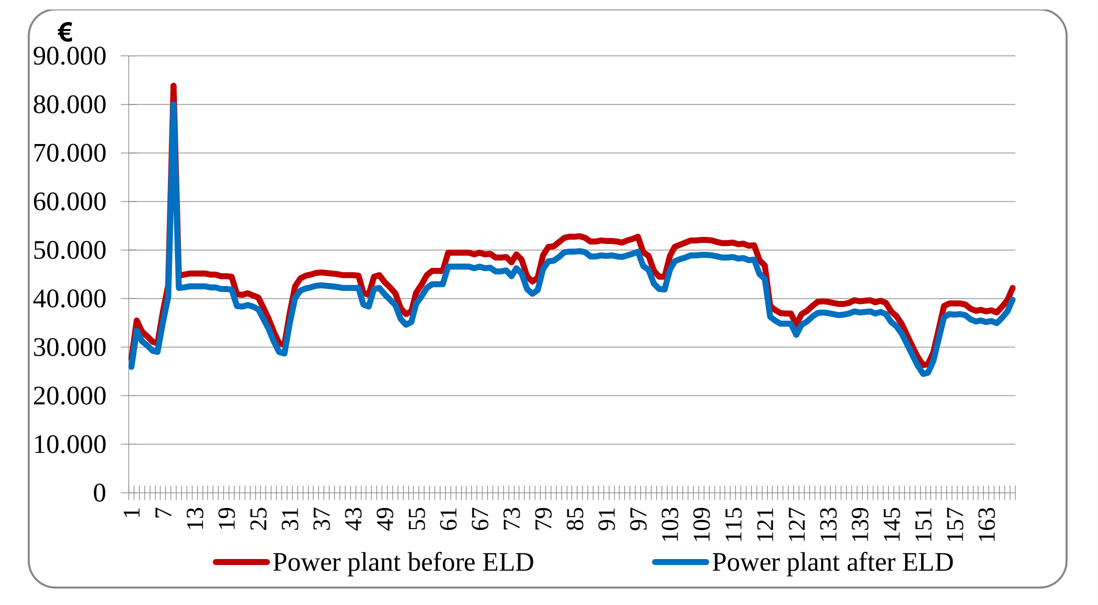

Figure 8: Manufacturing variable costs of the power plant in the summer week. Source: Compiled according to the author's calculations.

42 tests have been carried out with different properties for determining the minimum generation costs of the generating power units over a time period. The electricity and thermal power production, unbalance of energy, generation costs by the components, CPU time, results of the start-up costs calculation, primary energy consumption and emissions amounts are calculated. The outcomes are presented as the calculations of one typical week in winter and summer.

The results of used optimization techniques have a marginal difference; the optimization techniques are indicative for day-ahead economic dispatch development and could be useful for a precise performance evaluation of the power plant's operation. The outcomes show that the results of interior-point algorithm provide the best performance as compared to the optimization methods of primal and dual simplex. The optimal solution of day-ahead economic dispatch was within 75 seconds for one day, when using interior-point algorithm. The using interior-point algorithm is on average 4% faster than primal and dual simplex optimization. The advantage of using these algorithms is that they allow getting reliable results by using comparatively low input data within a reasonable period of time.

The optimal electrical power outputs for the winter and summer week are presented. The difference between manufacturing variable costs before and after using economic dispatch algorithm to prove the possibility for minimization of the generation costs in the power plants is provided. The efficiency of optimization in load distribution and unit commitment problems in power plant could decrease the manufacturing variable costs up to 9% to the power producer in a week time period. The main reasons are more economical distribution of load between the power units and savings in start-up costs.

The proposed algorithm may serve as a basis for more accurate economic dispatch and unit commitment model of power plant. The improved economic dispatch model, where the simplifications have been taken into account, could generate short-term as well as long-term business value to the company without any additional investments and costs.

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Appendices

Appendix 1. Input data

Symbol	Unit	Description
C_e^{NPS}	€/MWh	NordPoolSpot electricity price
P_e^{NPS}	MWh	NordPoolSpot electricity production volume
C_{CO2}	€/t	CO_2 allowance price
C_h	€/MWh	Heat sell price
H_f	MJ/kg (1000 m^3)	Heat value of fuel type f
C_f	€/t(1000 m^3)	Price for fuel type f
C_w	€ /t	Emissions tariffs for emission type w
C_u^{SU}	€	Power units start-up costs
P_u^{max}	MW	Power unit's maximum generation electrical capacity
P_u^{min}	MW	Power unit's minimum generation electrical capacity
P_u^{aux}	%	Power unit's auxiliary power
Q_u^{max}	MW	Power unit's maximum generation thermal load
Q_u^{min}	MW	Power unit's minimum generation thermal load
Q_u^{tot}	MW	Cogeneration power unit's total heat and electricity capacity
B_u^f	MWh	Fuel consumption characteristics of fuel type
$B_u^{RG,lim}$	%	Retort gas usage limit (constant 7% for power units)
$w_{e,w}^f, w_{h,w}^f$	t/MWh_f	Specific emissions type for power and heat production
R_u	MW/min	Ramp rate (constant 2,0 MW/min)
$T_{must-run}^{min}$	h	Minimum amount of time the unit must run (48h)
$T_{stay-off}^{min}$	h	Minimum time the unit must stay off once turned off (48h)
m_u^{max}	number	Maximum number of start-ups during the period (60n/year)
$C_u^{O\&M}$	€/MWh	Power unit's O&M costs
C_u^P	€/MWh	Personnel costs

Manufacturing fixed costs of the power plants

Unit	O&M costs, €/MWh-yr	Personnel costs, €/MWh-yr	Manufacturing fixed costs, €/MWh-yr
Power Plants	5,7	0,8	6,5

Source: author's estimation

Actual fuel prices in 2013

Fuel	2013 price, €/t
Oil shale	13,97
Shale oil	513,2
Retort gas	82,7

Source: Statistics Estonia

Emissions' tariffs and other environmental characteristics

Emissions and ohter characteristics	Unit	2013
Carbon dioxide for electricity production (CO_2)	€/t	0,0
Carbon dioxide for heat production (CO_2)	€/t	2,0
Sulphur dioxide (SO_2)	€/t	86,1
Nitrogen oxides (NO_x)	€/t	101,1
Carbon monoxide (CO)	€/t	6,4
Fly ash	€/t	86,5
Bottom ash	€/t	2,1

Source: Environmental Charges Act

Start-up costs of the power units

Technology	Hot start-up, th €	Warm start-up, th €	Cold start-up, th €
CP	20	30	40
CHP	30	50	80
CFBC	25	45	70

Source: author's estimation

Appendix 2. Output data

Symbol	Unit	Description
$P_{e,tot}$	MWh	Power plant electricity output total
P_u^e	MWh	Power plant electricity output of each power unit
n_u	nr	Number of power units required
$P_{e,S-D}$	MWh	Unbalance of electricity production
Q_{tot}	MWh	Power plant heat output total
$W_{u,w}$	t	Power units emission's type w amount for power unit u
B_{tot}	MWh	Primary energy consumption total
m_u	nr	Planned number of start-ups during the planned period t
C_u^B	€	Power units primary energy costs
C_u^w	€	Power units environmental impact costs
C_u^{FC}	€	Power units manufacturing fixed costs
C_u^{VC}	€	Power units manufacturing variable costs
C_u^{GC}	€	Power units generation costs
C_{tot}^{FC}	€	Total units manufacturing fixed costs
C_{tot}^{VC}	€	Total units manufacturing variable costs
C_{tot}^{GC}	€	Total units generation costs
CPU	sec	Central processor unit time

Snow Cover Digital Elevation Models Using Unmanned Aerial Vehicle and Total Station

by

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Abstract

Impact of climatic changes and human activities on water resource is a global major socio-economic concern. Middle East is expected to face severe water challenges both in terms of quantity and quality. In Lebanon specifically, water uses has increased over recent decades, due to population and economic growth. The country is expected to reach water scarcity level in the coming years. Therefore, long term assessment to address deteriorating water resources is becoming crucial.

Snowfalls on Lebanon and Anti-Lebanon mountains are known to be the major input source for underground water. Snowpack act as natural water storage in winter, and supply fresh water during spring and summer. Estimation of water provided by snow requires accurate snow cover volume quantification. However, this evaluation is difficult because of the relief heterogeneity and its impact on snow cover thickness distribution. It is therefore most important to investigate new methodologies enabling these quantifications at low cost, both in terms of human resources and sensors for data collection. For the last five years, we monitored volumes evolution for a witness sinkhole at "Ouyoun el Simane". The region has been studied with very precise topographic approach using Total Station. This approach is now correlated to aerial digital photogrammetric images captured by UAV (SFM[23]: structure from motion). It will enable extrapolation of these evaluations to larger scales, with high accuracy, for snow cover monitoring. Our objectives are to combine and compare topographic and photogrammetric results prior to snow cover volume assessment, in order to validate the low cost photogrammetric method for both methods.

Keywords: Snow cover, Volume, Digital Elevation Model, low cost, topography, UAV, sinkhole

1. Introduction

Climate changes has an important negative impact on water resources at an international scale due to the cumulative effect of temperature rise as well as decreasing snowfall and rainfall (Abou chakra et al., 2015; Drapeau et al., 2013; Somma et al., 2006). Middle East countries were impacted by these changes as most of the region is an arid area (Mhawej et al., 2014; Abou Chakra, 2013). Although Lebanon has one of the richest snow cover in the Middle East area (Shaban, 2011; Shaban et al., 2004), it is importantly affected by climate change and has decreasing water resources.

In addition of its decreasing water resources, Lebanon is facing an important growth of its population especially after hosting a large number of refugees due to regional wars. Water needs supply is crucial for majority of Lebanese people especially during the dry summer season, caused by the above reason and due to lack of water resources legal control (Telesca et al., 2014; Shaban et al., 2011; Fawaz, 2009; El-Fadel et al., 2000). Consequently, continuous and systematic water supply observation is needed for water management planning within current climate change framework (Somma et al., 2014; Somma, 2006; Luxey et al., 2005).

[23] SFM (structure from motion): is a technic to obtain 3D modeling from to sequences images

The high Lebanese mountains play an important role for snowfall and rainfall precipitation distribution (Telesca et al. 2014; Mhawej et al., 2014; Shaban, 2011; Jonas et al., 2009). The Lebanese snow covers contribute around 30% of water resources, and account for about 31 % of rivers and spring discharges (Telesca et al., 2014; Mhawej et al., 2014). In addition, snow covers could cover around 25% of the Lebanese territory (Shaban et al., 2004).

Based on the above, continuous monitoring of snow cover is one of the most important component of water resources investigation (Somma et al., 2014). From 2000 until now, few studies were done for the Lebanese snow cover and in progress on the monitoring of snow covers by terrestrial and spatial methodology (Abou chakra et al., 2015; Abou Chakra, 2013). From 2011, we started a systematic and continuous observation of a snow melt by estimating the decreasing of snow volumes on a witness sinkhole located at “Ouyoun el Simane” (Kfardebiane) (figure 1). This observation can helps us to predict complete snow cover melting date and consequently to predict low water flow date. With this achievement we could supply water manager with essential key information to prepare suitable plan for water resources management. Our measurements were taken with very detailed topographic approach using Total Station. Whereas this method is very accurate both in planimetry and altimetry (Milles et al. 1999), it is impossible to use for a large territory (Abou Chakra, 2013). For such scales, high cost topographic equipment and important human resources deployment**s** are required (Somma et al., 2014), in order to survey simultaneously the area involved. Snow cover is dynamic relatively to meteorological conditions and the areas of investigation are uneasy to reach by vehicles. Hence, we planned to experiment an unmanned aerial vehicle “UAV” to monitor the area and compare the results with the survey of total station for several dates to be able to use stereoscopic approach for larges territory using low cost methodology and instruments. The digital photogrammetric DEM computed from UAV gave an acceptable result on the bare lands (Arango et al., 2015) nevertheless we aim to test it on the snow cover.

The focus of this paper is the monitoring of snow cover by comparing measurement using total station tool and the UAV to validate efficiency of low cost digital photogrammetric method.

2. Study area

Lebanon, a country with of 10452 km^2, has large and high mountain chains with karstification geomorphological phenomena (Somma et al., 2014; Mhawej et al., 2014; Shaban, 2011; Shaban et al., 2004). Those high mountains play an important role by governing the distribution of snowfall and rainfall (Mhawej et al., 2014; Telesca et al., 2014; Qiu, 2012). The high plateaus are characterized by sinkholes with different geometric aspects (Somma et al., 2014). They constrain snow covers to melt inside the sinkholes then the melt water penetrates the subsurface and feeds the underground water resources (Somma, 2014; Elali, 2014; Shaban, 2011; Somma al., 2005).

The witness sinkhole is approximately about 20000 m^2 (figure 1), located at Oyoun el Siman (Kfardebiane) at 2300m above sea level and equipped by: meteorological station, geodetic point, and cameras for daily observation for many Scientifics targets.

3. Methodology

Extraction of Digital Elevation Model “DEM” is the most important element to estimate snow cover volume (Arango et al. 2015; Elali, 2014; Abou Chakra 2013; Milles et al., 1999). Thus, the accuracy of measurements play**s** an important role by defining calculated volume precision. Our objective is to evaluate errors and validity of using UAV instead of total station for creating digital elevation model for snow cover. We could then estimate snow cover volumes by comparing bare lands DEM with snow covers DEM. Therefore, the bare land was surveyed as well as the snow cover for two different dates (10 May 2016 and 3 June 2016) using total station and UAV for this witness sinkhole.

3.1. Data acquisition

3.1.1. Total Station

To create the digital elevation models for the bare land and the snow cover we used the total station Leica TS06 (figure 2). This total station is an electronic/optical instrument used usually to model the topography of land by taking many points with their coordinate x, y, z in order to represent the digital elevation model by interpolation method, based on the measured points (Doumit, 2009; Milles et al., 1999).

Using total station, we surveyed the bare land before the snow fall. For the three dates we set temporary many ground control points (figure 3) regularly distributed over the study area. The observed points by total station were distributed relatively to terrain relief. It was mainly an approximated grid of 5 by 10m. Using total station, we also surveyed the limit of the firn.

3.1.2. Unmanned Aerial Vehicle, UAV

For data acquisition with UAV, we used a "Phantom 3 Advanced" (figure 4). This aircraft is equipped with a built-in camera of 12 Megapixels, with a 17 minutes fly autonomy. The fly plan defined for the UAV was to capture pictures every 5 seconds in order to obtain 80% of overlapping by flying at 13 km/h. The fly was at an altitude of 100m above ground in order to cover the whole study area minimizing the number of pictures but keeping high resolution quality picture. We selected this option because it achieves the lowest possible cost comparing with other aircrafts. Moreover, this aircraft is not basically created for making digital elevation model. Nevertheless, it has a CA code GPS and autopilot system. We tried to use and test it. Those criteria allow us got the global tridimensional coordinate of each taken pictures and prepare a systematic mission using a tablet Samsung and Litchi Application (figure 5, and we managed the requested overlap in photogrammetric approach (60 % to 80 % according to Agisoft tutorial) for the stereoscopic procedures. Often, the flight missions were aborted because of strong wind at these altitudes precluding the UAV to fly safely. As mentioned, we surveyed the snow cover for two dates 3 June 2016 and 10 May 2016. For the 3 June 2016 we captured pictures with and 90 degrees, and we also captured three pictures with an inclined angle (figure 7) to test the interest of taking photos by several angles in addition to the horizontal images.

3.2 Data processing

3.2.1 Bare Land

The bare land is modeled using total station data only with 620 points distributed according to the land relief around 5m between each two consecutive points. This survey will act as the reference to calculate the volume for the further snow cover models. Using ArcMap we transformed the points shape to tin surface then to raster.

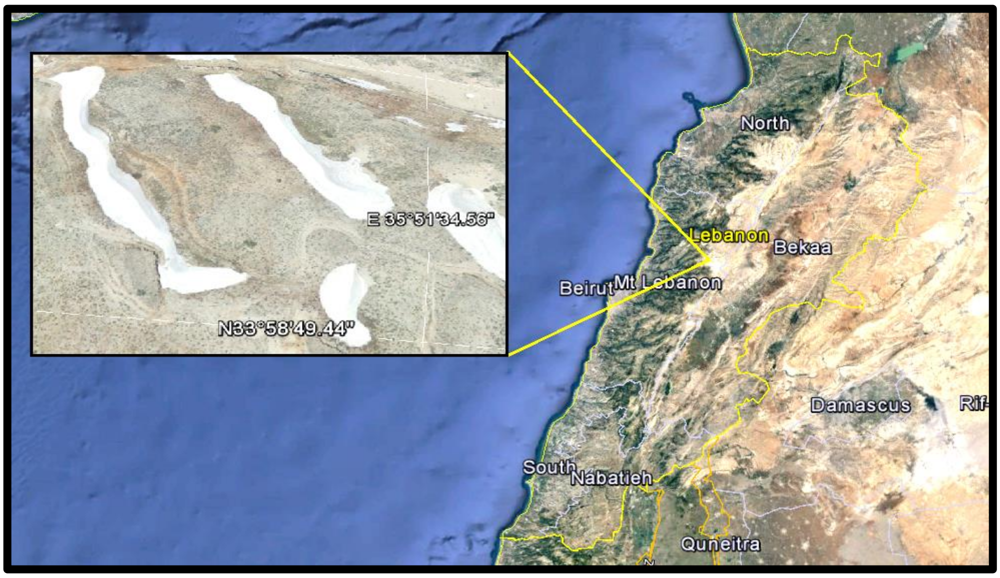

Figure 1: Location of the study area.

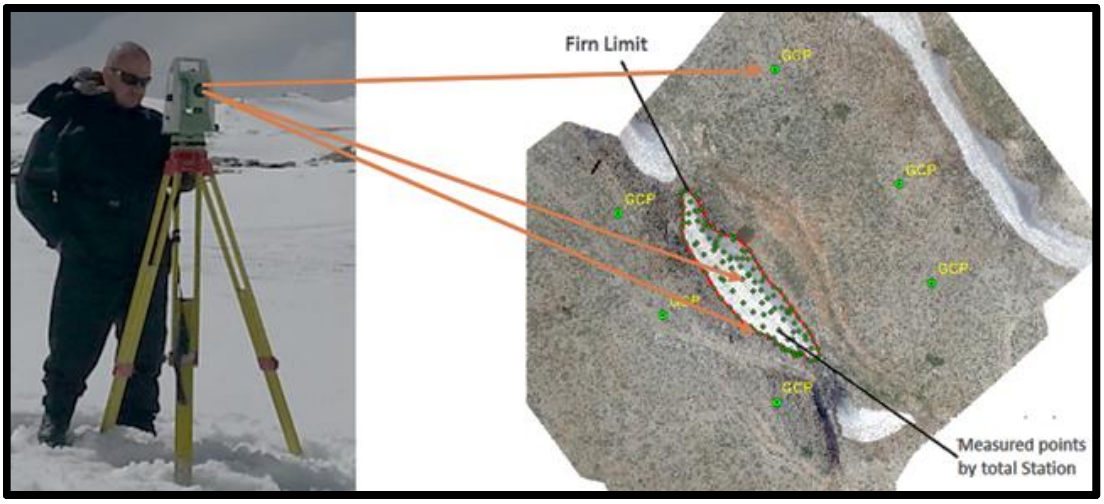

Figure 2: From left to right, Total station (Leica Ts06) during modeling then, the observed points (firn polygon, snow cover and the GCPs).

Figure 3: One of the ground control points (GCP) measured by total station and observed by UAV in order relocate and calibrate the Model created by Agisoft Photoscan.

Figure 4: Phantom 3 Advanced.

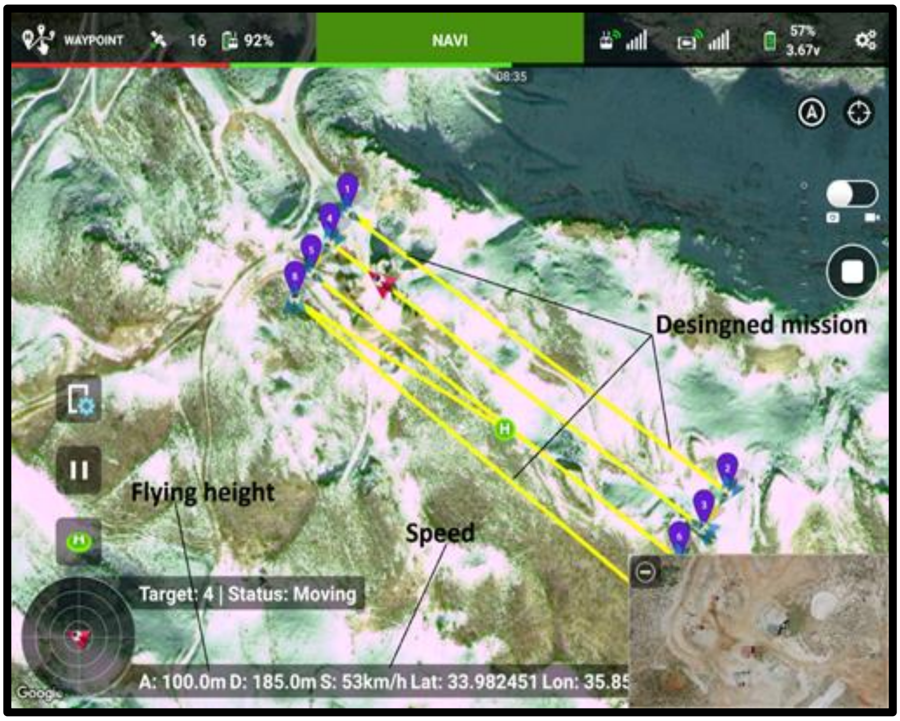

Figure 5: Litchi application, show the flight mission with the height of UAV and its speed.

3.2.2 Snow cover

Data acquisition for the snow cover was achieved with total station and UAV at the same time the 3 June 2016 and the 10 May 2016. With the total station we proceeded with the same procedure as the one used for bare land, but the data were collected just for the snowed area with measurement of the firn limit in order to obtain a closed polygon to crop the snow cover raster for the two dates (figure 6).

The 10/05/16 DEM created with UAV, was based on captured pictures with classical stereoscopic approach. The pictures were captured horizontally in order to cover the entire area of interest. The same procedure was applied for the 03/06/16 (Figure 7).

The 03/06/16 we captured 3 additional inclined pictures (figure 8) to test the interest of these to support the classical horizontal pictures. We obtained one model based on horizontal pictures on 10 May 2016, and two model**s** on 3 June 2016. We selected Agisoft Photoscan for the UAV data processing in line with our "low cost approach". For the three model**s** we used separately the following procedure: Add photos, align photos, build dense cloud, build mesh, build texture, build tiled model, create marker, update, import GCPs, Build DEM, Build orthomosaic, export DEM and export orthophoto (figure 9).

We added the DEMs and the orthophotos on ArcMap to start the georeferencing process for the computed models according to GCPs. However, the obtained models are not only for the snow cover. The UAV covered the whole area. Therefore we have to slip the snow cover from the DEM by clipping the DEM according to the firm limit measured by total station (see 4.1 first method).

4. Results and discussions

4.1. Comparing the DEMs accuracy

The Digital Elevation Model is an important reference factor to estimate volumes. And its precision has a great influence in computing accurate volumes. It is assumed that the value measured with the total station is the reference therefore called the "true value". Consequently, with ArcMap software, we use raster calculator to obtain the difference between the UAV's DEM and the other obtain by Total station.

For the model computed with the total station we obtained the raster DEM based on the measured points and its tin[24] surface.

[24] TIN: Triangulated Irregular Network

While, for the UAV's DEM we assess two methods:

- **First method**: We used the whole clipped DEM obtained from Agisoft Photoscan (figure 10)

- **Second method:** We created a new DEM by modification of the points taken by total station, therefore we use add functional surface under ArcMap by adding the pixel value of UAV with the total station (figure 11). Consequently, we could see the exact error on each point to remove the interpolation impact for this stage.

Under ArcMap we used raster calculator to carry out the difference between total station and UAV's DEM.

$$DEM_{UAV} – DEM_{Total\ Station} = Difference$$

The maximum difference for the standard deviation and mean between the first and the second method is 6 cm. Therefore, it is acceptable according to our topographic experience.

Consequently, we could use the unmanned aerial vehicle phantom 3 Advanced, with 100 m as flying altitude to achieve an error of standard deviation between 22 and 33 cm, according to above table. Furthermore, if we compare the resulting image taken horizontally with the image taken with additional inclined photo, the DEM is better and closer to the points of total station because the inclined photos support the horizontal photo to increase the overlapping area on SFM (figure 13). As we observed on the (figure 13), the model of 3 June 2016 taken by horizontal and inclined photos has the most overlapping percentage.

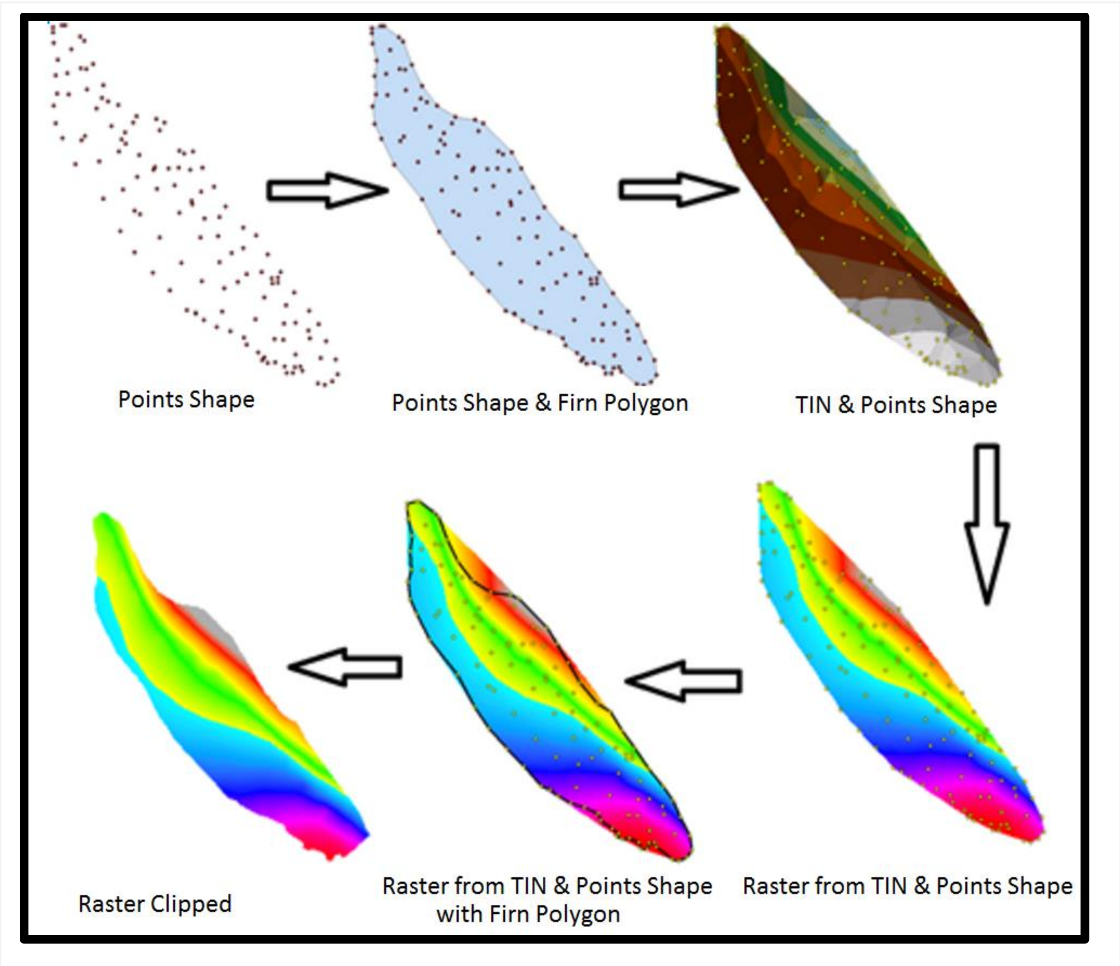

Figure 6: The steps to obtain raster DEM from shape points.

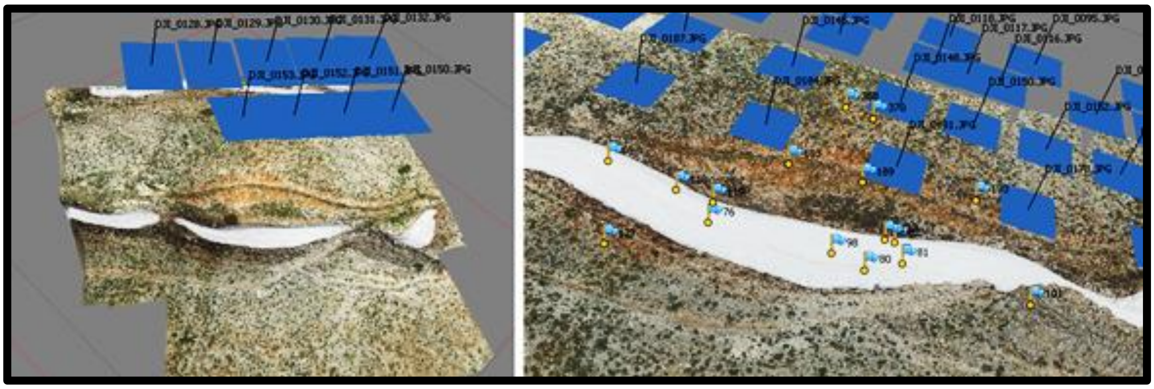

Figure 7: From left to right, the horizontal photos taken for 3 June and 10 May 2016.

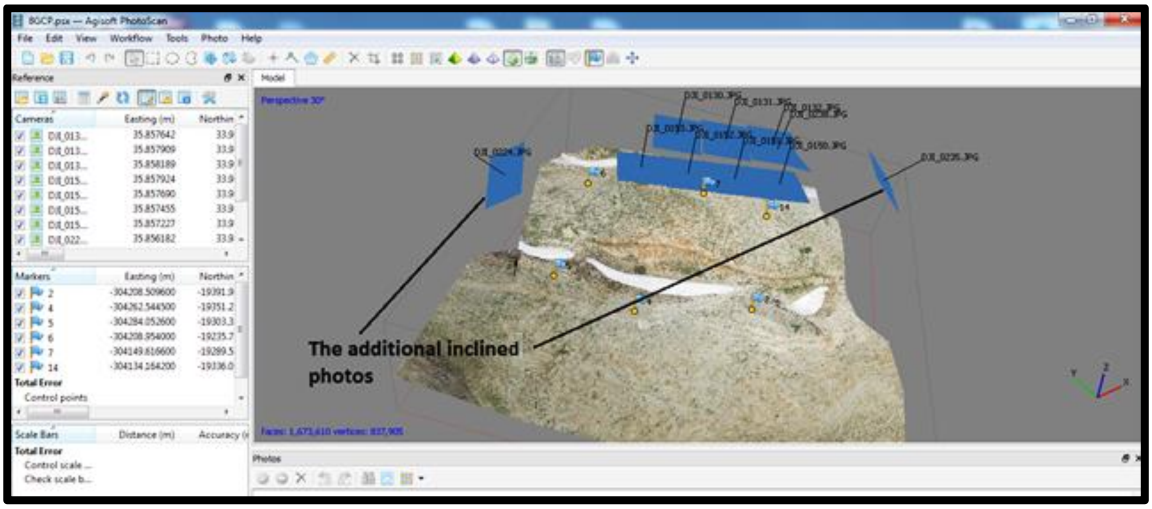

Figure 8: Additional inclined photos taken on 3 June 2016.

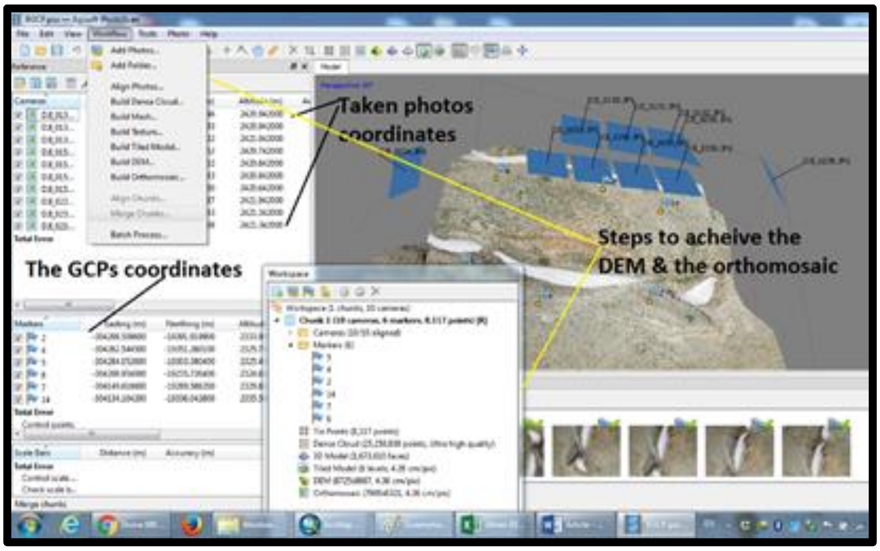

Figure 9: Different steps to obtain the DEM and rectified photo from taken image by UAV.

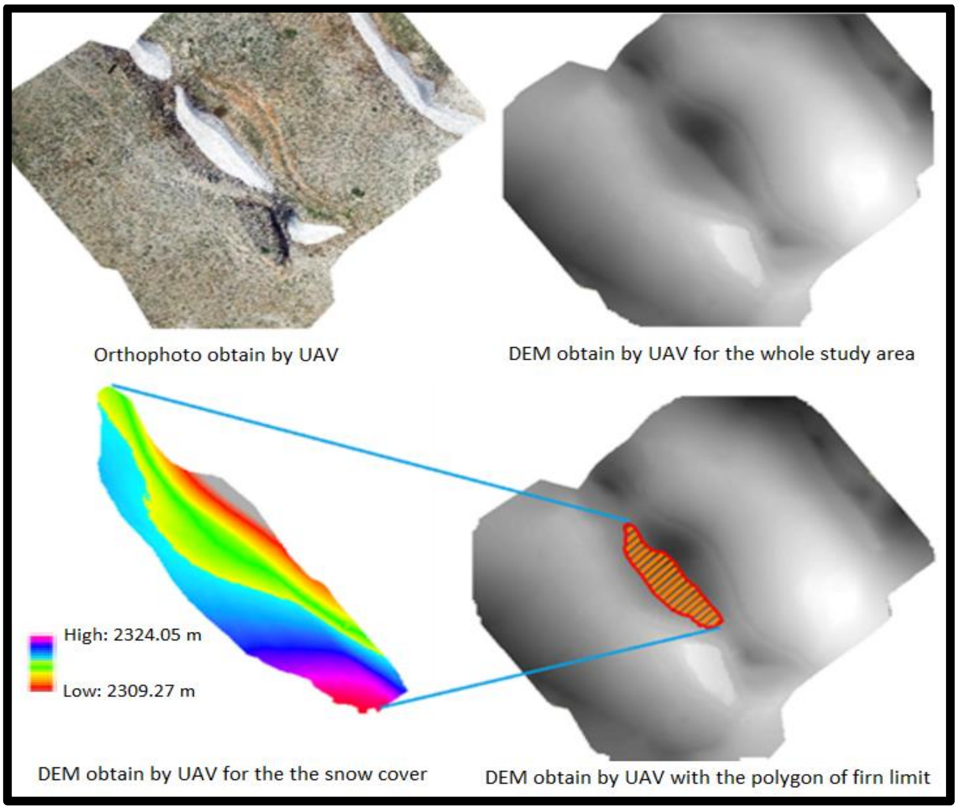

Figure 10: Realizing the clipped DEM of only the snow cover.

Snow3June2016

Point	Easting	Northing	Elevation Total Station	Code	Elevation Drone
24	-304189.6336	-19371.9464	2323.2354	L	2322.9654
25	-304191.3138	-19372.8412	2323.7512	L	2323.4560
26	-304192.9492	-19372.4591	2323.8241	L	2323.6149
27	-304196.4561	-19369.5698	2323.9423	L	2323.6899
28	-304197.0199	-19368.7457	2323.8737	L	2323.5728
29	-304198.3056	-19368.9147	2324.0035	L	2323.5381
30	-304198.6784	-19370.1141	2324.1499	L	2323.7684
31	-304200.0985	-19370.1503	2324.2576	L	2324.0239

Figure 11: DEM's elevation of total station and UAV.

4.2. Volume estimation

After analyzing the DEMs and its accuracy, we proceeded toward the snow volume estimation, using the Cut and Fill 3D analyst tools available in ArcMap. In (table 2), we used the bare land's DEM created by total station with the snow cover made by total station and UAV using the first and second methods obtained above (see 4.1).

Thus, we considered the volume obtain by the DEMs (bare land and snow cover) obtained by total station as reference, because each point of DEM was taken absolutely. In the volume result we got errors range from 0.89% to 11%, and errors range from 3.2 to 6.1% for the second method. The results obtained (table 1) are acceptable with as means and standards deviations values. The increasing errors on volume are due to some outlier values for minimum and maximum in (table 1). The majority of DEM's UAV fit around ninety percent of the total station's DEM. So it is rational to get such error for volume estimation. Furthermore, it is important to compare first and second method volumes estimation. The DEM computed with the second method is based on located points acquired with total station. Nevertheless, a large number of points, from the points cloud obtain by UAV and Agisoft are lost because we just used the points taken by total station. In addition, the DEM taken by total station is measured by an approximate grid of points distribution and for each slope changing, beside, it is not taken by a laser scanner. That is why the result was better on the first method. With the inclined photos we computed more accurate DEM. However, we arrived to bigger error for volume caused by some outlier. Using ArcMap we classified the raster images obtained by difference between Total station's DEM and UAV's DEM (figure 14). As per our analysis of error distribution between the three models in the figure, we did not notice any general rule of errors distribution.

Thus, we can deduce that Agisoft collect the common pixels randomly to build the 3D model. Therefore, we think on the next studies to repeat the processing for the same model many times in order to clarify the distribution of error and deduce the impact of the random algorithm in the Agisoft program.

So that we could predict the date of final snow melt and extend other hydrological factors to support the water manager in addition information regarding the volume and its equivalent in water.

5. Conclusion and recommendation

The similarity test between UAV and total station justified the ability of using the digital photogrammetric method and its efficiency to estimate snow cover volume.

First of all, the use of this new approach has a lot of advantages: the survey by UAV take less time than the survey with total station and it is not compulsory to have access to area for each observation.

The captured pictures with UAV provide points clouds, whereas the total station provided only the captured points taken manually by the human operator. In addition we could get an orthorectified photo which allows us to draw the firn limit and define the snow cover area. Eventually we are able to evaluate a larger area with ease and gain of time.

This experience has some weak points. Although we got ideals means and standard deviations for the similarities test between total station and UAV, some large value for minimum and maximum errors are present and influenced the volume estimation.

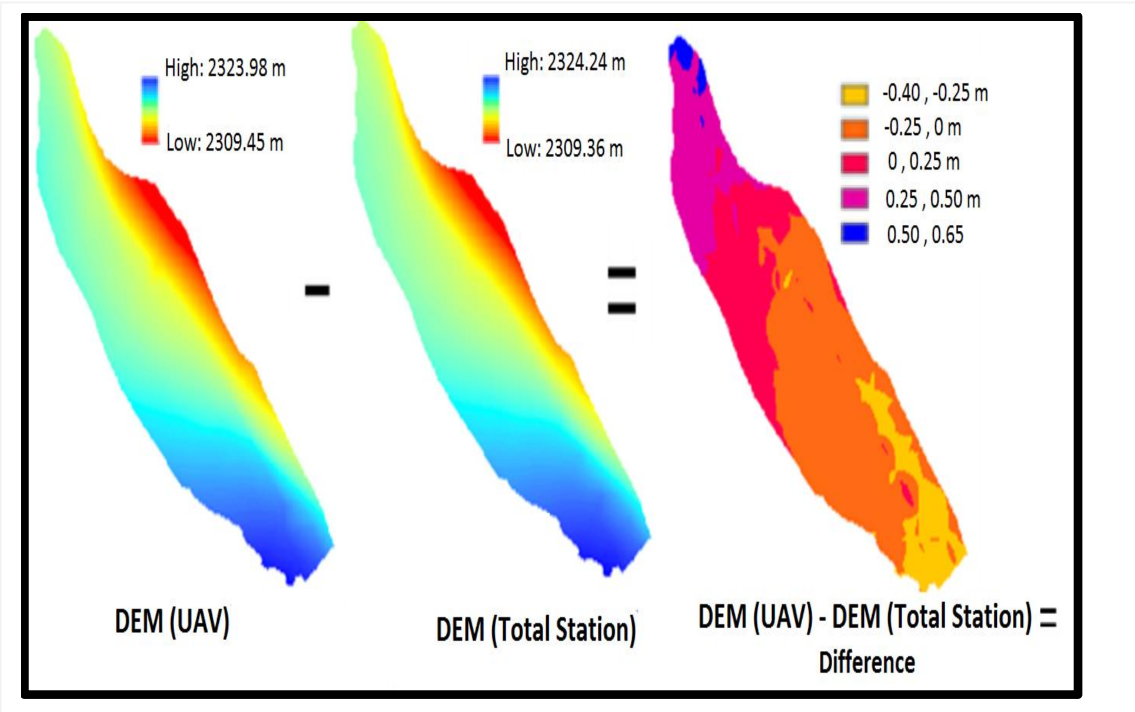

Figure 12: Obtained raster by subtracting UAV's DEM from Total Station's DEM for the same firn in the same time.

Table 1: difference between the first and second method to carry out the accuracy of obtained models.

Dates	10 May 2016 (Horizontal images)				3 June 2016 (Horizontal images)				3 June 2016 (horizontal & incline images)			
According to ArcMap Classification raster (meter)	**Minimum**	**Maximum**	**Mean**	**standard deviation**	**Minimum**	**Maximum**	**Mean**	**standard deviation**	**Minimum**	**Maximum**	**Mean**	**standard deviation**
First Method	**-0.57**	**0.86**	**0.1**	**0.22**	**-1.93**	**0.5**	**-0.21**	**0.33**	**-1.27**	**0.7**	**0.005**	**0.252**
Second Method	**-0.3**	**0.5**	**0.08**	**0.17**	**-0.79**	**0.4**	**-0.19**	**0.27**	**-0.45**	**0.6**	**0.007**	**0.22**

Table 2: The snow cover volume estimated from different data and its error percentage by assuming that the volume obtained by DEM's total station as reference.

Data		Volume			Volume error percentage %		
Bare land	**Snow Cover**	**10 May 2016 Horizontal photo**	**3 June 2016 Horizontal Photos**	**3 June 2016 Horizontal & inclined Photos**	**10 May 2016 Horizontal photo**	**3 June 2016 Horizontal Photos**	**3 June 2016 Horizontal & inclined Photos**
Total Station	**Total Station**	**9165**	**2676**	**2676**			
Total Station	**UAV first method**	**9381**	**2700**	**2975**	**-2.30%**	**-0.80%**	**-11.20%**
Total Station	**UAV second method**	**9960**	**2563**	**2879**	**-6.17%**	**5.07%**	**3.20%**

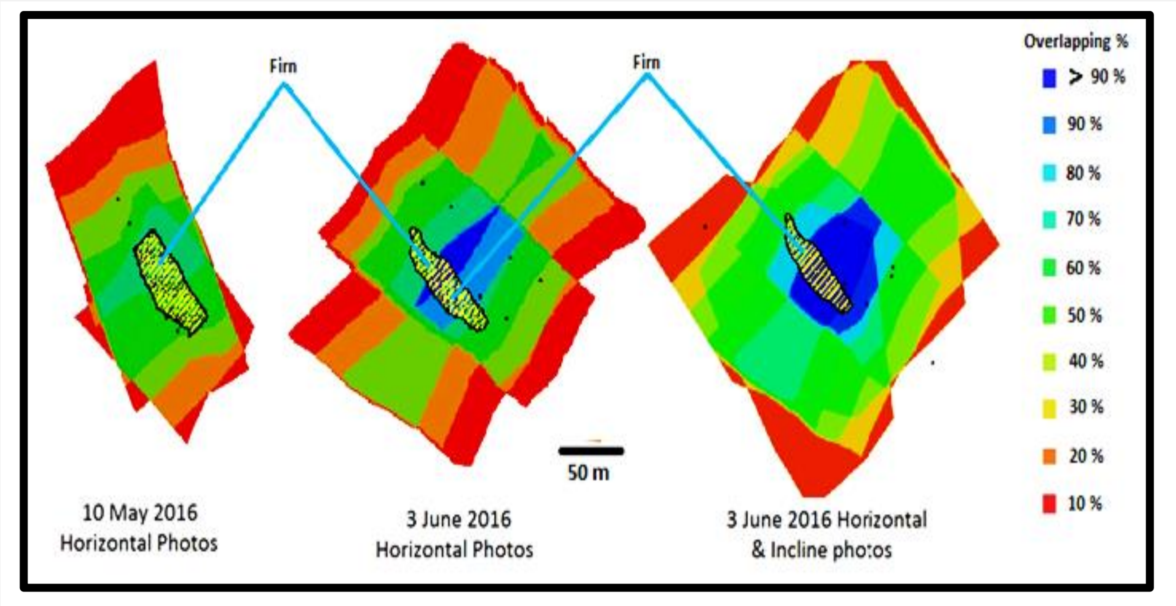

Figure 13: Overlapping percentage of each model extracted from Agisoft repor.

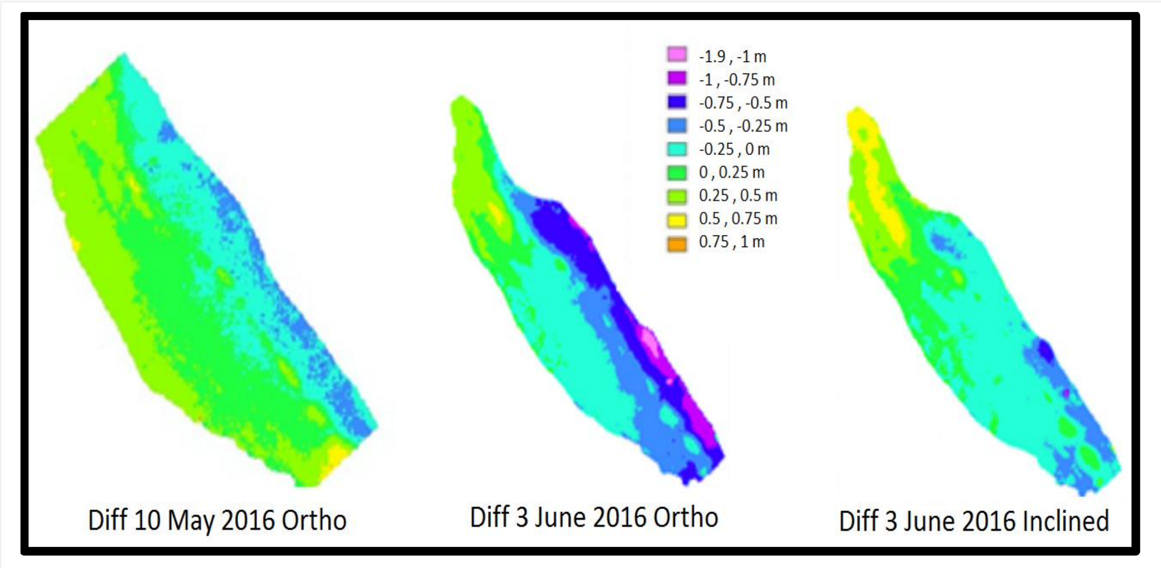

Figure 14: Distribution errors for each model.

We recommend test the same model on several dates to evaluate furthermore the efficiency of Agisoft and/or to test other softwares. We plan to investigate the same procedure using Lidar and a more efficient camera allowing an increased flying altitude for the UAV while saving the accuracy. In addition, it will be interesting to test a UAV equipped with a differential GPS (RTK) on the snow cover, avoiding the total station uses to measure the GCPs (ground control points). Eventually, we planned to change the flight altitude to estimate its exact impact, we could estimate the best altitude in order to cover an even larger territory with the lowest possible cost.

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Inserting end-users behaviour into forward looking energy efficiency modelling

by

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Abstract

Energy Efficiency (EE) consists one of the main pillars of efforts to mitigate climate change. Although there is plethora of relevant policy instruments, different types of barriers affect negatively the achievement of targets set under scenarios. Among these types of barriers, those related to end-users behaviour play a significant role and need to be incorporated in forward looking energy efficiency modelling after being identified and analysed (McCollum L. David et al., 2016; EC, 2015 a,b; EEA, 2013). This paper concerns the development of a methodology for inserting end-users behaviour into forward looking EE modelling. With the use of the Analytical Hierarchical Process (AHP), comparative analysis is conducted among barriers created by the end users' behavior towards EE targets. Based on qualitative information for the barriers, the user compares, reveals and quantifies the negative impact of each barrier on the set of the assumed targets, in EE modeling. Mathematical expressions using the calculated impact of barriers provide numerical inputs needed to energy modelling for reflecting the end-user behavior towards the assumed EE targets. Once the procedure is completed, the policy maker can modify accordingly the available inputs so as to achieve the set targets. Conclusions about the use of the methodology in energy modelling, its outcomes, advantages and disadvantages are discussed.

1. Introduction

Energy consumers exhibit different types of behavior towards the implementation of EE measures and policy instruments. Those types of end-users behavior that affect negatively the achievement of EE targets are characterized as barriers and each one has a different impact/contribution in limiting the efforts of achieving energy savings. The quantification of the barrier impact allows to have numerical inputs for incorporating end-users behavior in the forward-looking energy efficiency modelling. Additionally, the quantification allows policy makers to understand the different importance of each barrier and be able to work with the modelling outcomes for designing effective EE policies and measures.

This paper concerns the methodology for inserting end-users behaviour into forward looking EE modelling. With the use of the Analytical Hierarchical Process (AHP), comparative analysis is conducted among barriers created by the end users' behavior towards measures and policy instruments for achieving EE targets. Based on qualitative information for the barriers, the user compares, reveals and quantifies the negative impact of each barrier on the set of the assumed targets, in EE modeling. Mathematical expressions using the calculated impact of barriers provide numerical inputs needed to energy modelling for reflecting the end-user behavior towards the assumed EE targets. Once the procedure is completed, the policy maker can modify accordingly the available inputs so as to achieve the set targets.

2. Methodology

The proposed methodology is developed in nine (9) steps – procedures that facilitate its understanding.

Step 1: Selection of multi-criteria decision analysis method

The Analytical Hierarchy Process (AHP) is used for quantifying the impact of barriers. The advantages that allow its use for the needs of the concept are the following:

- *AHP is justified mathematically* (Eakin H., Bojorquez-Tapia L.A., 2008; Kablan M.M., 2004).
- *AHP presents better the problem.* Its main advantage is the decomposition of the problem into elements (Ishizaka A., Labib A., 2011; Berrittella et al., 2008).
- *AHP offers guidelines in defining the weight coefficients and has a consistency index for verifying their consistency* (Kablan M.M, 2004).
- *AHP is suitable for incorporating the preferences of relevant stakeholders regarding the importance of criteria/sub-criteria* (Fikret K.T., et al., 2016).
- The usage of pairwise comparisons does not require the explicit definition of a measurement scale for each attribute (Bozdura F.T. et al., 2007).
- Comparative analysis of Multi Criteria Decision Aanalysis (MCDA) approaches has indicated AHP to be the most popular compared to other methods due to its simplicity, easiness 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).

Step 2: Categorization of barriers per groups/sub-groups

All identified barriers linked with the end-users behavior are categorized into main groups. Each group is divided into subgroups. Due to the possible large number of identified barriers per country (or region or municipality), it is necessary to check if barriers are to be grouped into smaller groups under the main ones. Each group or sub-group contains the barriers that have the same basic characteristic. Based on literature research (UNEP, 2014; IEA, 2014; EEA, 2013) three main groups are foreseen for barriers linked with end-users behavior: "Social-Cultural-Educational", "Economic" and "Institutional". The first group can be divided into three sub-groups "Social", "Cultural" and "Educational". This step is applied for any economic sector (buildings, transport etc).

Step 3: Merging the same/similar barriers

Due to the possible large number of identified barriers per country (or region or municipality), it is also necessary to check if some barriers finally have the same content; refer to the same behavior or need to be handled by the same manner. Then they are merged into one barrier with a common title (with all similar ones included under this common title). This action is necessary so that the set of barriers is complete, non-redundant, minimalistic, with non-overlapping barriers, decomposable (Makropoulos C.K. and Butler D., 2006).

Another restriction is that: the preferable maximum number for each AHP matrix, that can be examined for its consistency, is 8x8. So, all identified barriers are either grouped or merged so as to form the respective groups and sub-groups with up to 8 barriers the most.

Step 4: Formation of AHP tree and matrixes

The previous two steps form the AHP tree, but apart from the groups and sub-groups, the goal (zero level of AHP tree) needs to be determined. The goal reflects the aim of the tree. The goal in this AHP tree is the "limiting efforts for achieving energy savings" due to the impact of each barrier that is part of the AHP tree. So, the first level of the AHP tree has the following three main groups of barriers: i) "Social-Cultural-Educational"; ii) "Economic" and iii) "Institutional". The first group has three sub-groups: "Social", "Cultural" and "Institutional". The other two groups do not have any sub-groups (Figure 1). Under each group and sub-group the identified and merged barriers are classified.

Step 5: Conducting pair-wise comparisons

Step 5.1: First level pair-wise comparisons

First, the three groups are compared using the AHP matrix and scale (Tables 1 and 2). Each cell of the AHP matrix is filled after:

i) comparing the object (in this first level, the group of barriers) of each row with the respective object of the column;
ii) assigning the appropriate - according to judgement - intensity from Table 2;

iii) the assignment of the intensity (judgement) is based on the following conditions:
   a. more important if the number of identified barriers of the first object is higher compared to those of the second one;
   b. more important depending on the level of difficulty with which it can be confronted (the more difficult, the more important);
   c. more important if it is divided in more different sub-groups; and
   d. more important if the available preferences of experts on EE issues clearly quote this importance.

iv) Depending on how important overally the first group is, compared to the second one, the intensity is assigned. The selected intensity is quoted in the respective cell. If during any comparison, the second object is more important than the first one, then the quoted intensity is 1/intensity.

Table 1 shows a filled AHP matrix.

Step 5.2: Calculation of indexes for the first level of the AHP tree

The necessary calculations of the AHP method are conducted for the determination of the weight coefficients for each group of barriers.

Each weight coefficient (or index) expresses the contribution of the category in the limitation of efforts for energy efficiency.

Step 5.3: Calculation of the consistency test

Before accepting these values (step 5.2), a consistency test is performed. The Saaty approach is used for calculating the random ratio of consistency of the respective AHP matrix.

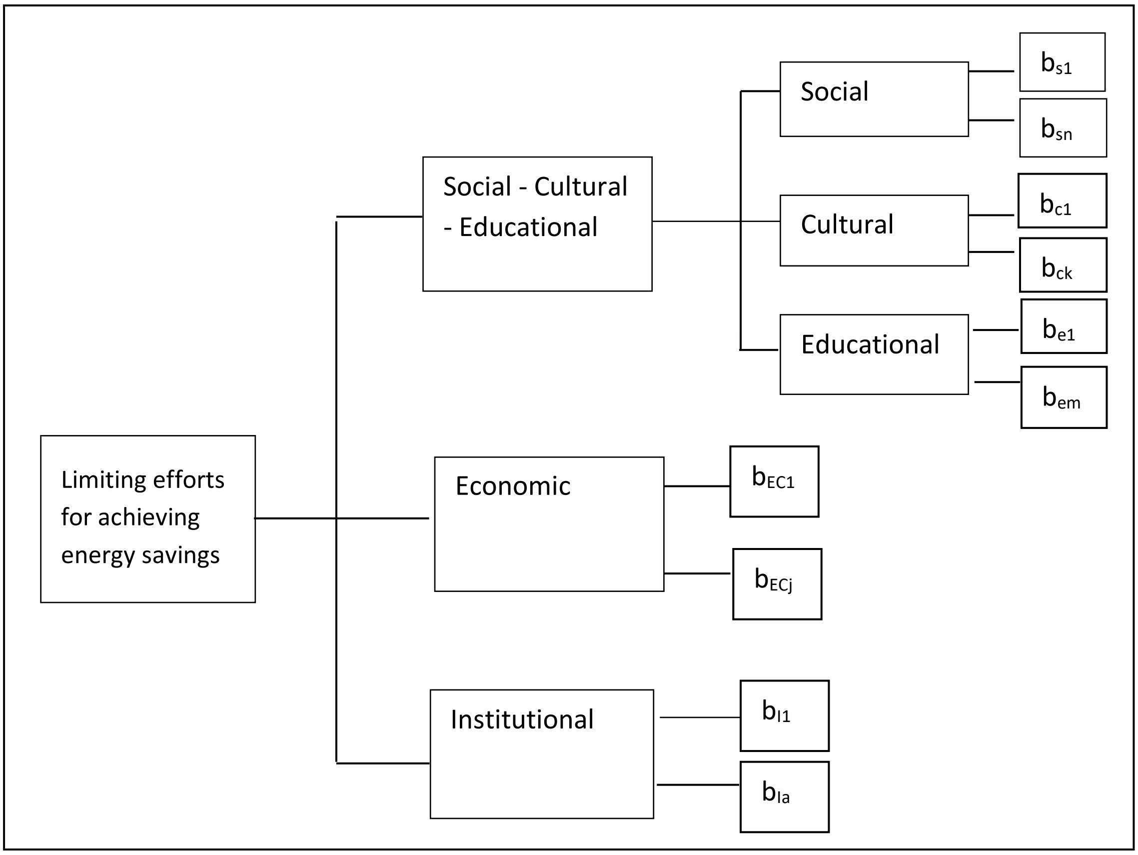

Figure 1: AHP tree of the barriers.

Table 1: AHP matrix for pair-wise comparisons.

Barriers linked with end-users behaviour	Social-Cultural-Educational	Economic	Institutional
Social-Cultural-Educational	1	A_{12}	A_{13}
Economic	$A_{21} = 1/A_{12}$	1	A_{23}
Institutional	$A_{31} = 1/A_{13}$	$A_{32} = 1/A_{23}$	1

Table 2: Relative importance between comparisons of AHP method.

Intensity	**Definition**	**Explanation**
1	Equal importance	Two barriers contribute equally to the goal
3	Moderate importance	Experience and judgement slightly favours the one over the other
5	Essential or strong importance	Experience and judgement strongly favours the one over the other
7	Demonstrated importance	Dominance of the demonstrated in practice
9	Extreme importance	Evidence favouring the one over the other of highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

Table 3: AHP matrix for the third level of barriers.

Social barriers	b_{s1}	b_{s2}	b_{s3}	……	b_{sn}	**Weight coefficients**
b_{s1}	1	A_{12}	A_{13}	……	A_{1n}	$\mathbf{W_{s1}}$
b_{s2}	$A_{21} = 1/A_{12}$	1	A_{23}	…..	A_{2n}	$\mathbf{W_{s2}}$
b_{s3}	$A_{31} = 1/A_{13}$	$A_{32} = 1/A_{23}$	1	…..	A_{3n}	$\mathbf{W_{s3}}$
……….	……	…..	…….	1	….	**…..**
b_{sn}	$A_{n1} = 1/ A_{1n}$	$A_{n2} = 1/ A_{12}$	$A_{n3} = 1/ A_{13}$	$A_{n\ n-1} = 1/ A_{n-1\ n}$	1	$\mathbf{W_{sn}}$

Initially, the consistency index is calculated as

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where

CI is the consistency index,

λ_{max} is the maximum eigenvalue of the matrix and

n is the rank value of the matrix.

The random ratio of consistency is obtained using the equation CR*=CI/CR where CR is the corresponding mean random index of consistency. CR receives the following values; 0 for a 2x2 matrix, 0.58 for 3x3, 0.90 for 4x4, 1.12 for 5x5, 1.24 for 6x6, 1.32 for 7x7, 1.41 for 8x8 and 1.45 for 9x9. A matrix is consistent if CR* < 0.10. Otherwise, the matrix is not consistent and its value should be adjusted.

Step 5.4: Calculation of indexes for the second level of the AHP tree

Weight coefficients are defined also for each one of the sub-groups "Social", "Cultural" and "Educational" to which the wider group "Social-Cultural-Educational" is divided to. The previous steps (5.1 – 5.3) are repeated. The conditions of step 5.1 are used for this level also.

Once the weight coefficients of this level are calculated then the contribution of each sub-group of the barriers to goal "limiting the efforts of achieving energy savings" is determined as

"Social barriers" impact = Index $_{social-cultural-educational}$ * index $_{social}$ = W $_{S-C-E}$ * W_S

"Cultural barriers" impact = Index $_{social-cultural-educational}$ * index $_{cultural}$ = W $_{S-C-E}$ * W_C

"Educational barriers" impact = Index $_{social-cultural-educational}$ * index $_{educational}$ = W $_{S-C-E}$ * W_E

"Economic" and "Institutional" barriers are not divided into sub-groups.

Step 5.5: Calculation of indexes for the third level of barriers

The previous steps (5.1 – 5.3) are repeated. Under each sub-group there is a number of identified barriers. For the sub-group of "Social" barriers there are b_{s1}, $b_{s2}…b_{sn}$ barriers. Following the same procedure, the AHP matrix is that of Table 3.

The AHP matrix is filled by taking into consideration the following conditions for the importance of a barrier compared to another:

- the *number of different sources* that refer to it;
- the *number of sub-sectors* that were linked with it;
- the *difficulties to confront it* (the easier to be confronted the less important it is;
- the *longer duration of one over another* (longer recorded duration);
- the *number of different policy instruments that were linked with*;
- *its situation as a cross-cutting barrier* (common among two or more different sectors (ie buildings and transport));
- the available *expressed preferences of stakeholders for it*.

Again, the calculated weight coefficients are checked for their consistency (step 5.3).

The procedure of this step (5.5) is repeated for the “Economic” and the “Institutional” barriers.

Step 6: Calculation of Total Impact per barrier

The Total Impact of each barrier is calculated based on the outcomes (impact/weight coefficient of the barriers) of the previous steps as follows:

b_{1s} impact = $\text{Index}_{\text{social-cultural-educational}} * \text{index}_{\text{social}} * \text{Index}_{\text{social 1}} = W_{\text{S-C-E}} * W_s * w_{s1}$

b_{2s} impact = $\text{Index}_{\text{social-cultural-educational}} * \text{index}_{\text{social}} * \text{Index}_{\text{social 2}} = W_{\text{S-C-E}} * W_s * w_{s2}$

……..

etc and the same procedure and mathematical expression is applied for all barriers of the third level.

For the “Economic” barriers, the impact is calculated as

$b_{EC1} = \text{Index}_{\text{Economic}} * w_{EC1}$

$b_{EC1} = \text{Index}_{\text{Economic}} * w_{EC2}$

etc

same for the “Institutional” barriers.

All calculated indexes do not have measurement units as they express the contribution of the barrier that is linked with the end-user behavior ie the ratio scale in limiting efforts for energy savings. Table 4 shows these calculated indexes for the building sector. The values of these indexes range from 0 to 1, ie TI∈(0,1), where TI means Total Impact.

Step 7: Repetition of procedure for another sector (ie the transport sector)

The steps 2-6 are followed for any other sector that is to be examined. The **transport sector** was used as the second sector.

The total impact of each identified barrier for the transport sector is calculated as presented in Table 5. The groups and the sub-groups of barriers are the same with the previous sector. The barriers themselves differ in their titles and numbers per group or sub-group.

Step 8: Linkage of Barriers Impact and technologies

Each one of the barriers (and consequently their weight coefficients in Tables 4 and 5), is linked with the technologies or practices that are promoted based on national needs and priorities through the implemented policy instruments.

The Total Impact for a technology is calculated as:

$TI_{\text{technology}}$ = sum of Total Impacts of barriers linked with the EE technology

$= TI_{\text{s1, linked with technology}} + \ldots + TI_{\text{Ia, linked with technology}}$

For a set of technologies, the same rationality is applied, but common barriers are inserted only once in the calculations.

Step 9: Incorporation of barriers impact in forward looking EE modelling

A. ***Impact of barriers on energy intensity or penetration share of an EE technology***

Once the TI of the barriers, that are linked with the specific EE technology or practice, is calculated, the next step is to calculate in terms of energy intensity or penetration share their numerical impact. Two cases are examined (buildings and transport sectors).

1. **Energy intensity per housing type (existing single family housing type 1, etc.) in kWh/m^2 (building sector)**

Function

The Initial Final Energy Consumption with the use of a technology (such as space heating technology) for the reference year (which is denoted as 0) is expressed as a function

$F_o(k,a,c,d,e,h)$ where

Table 4: Total Impact of barriers for the building sector.

Type	Name of barrier	Function
Social	Social group interactions and status considerations	$TI_{s1} = W_{S-C-E} * W_s * W_{s1}$
Social	Socio-economic status of building users	$TI_{s1} = W_{S-C-E} * W_s * W_{s1}$
Social	Strong dependency on the neighbors in multi-family housing	$TI_{s1} = W_{S-C-E} * W_s * W_{s1}$
Social	Inertia	$TI_{s1} = W_{S-C-E} * W_s * W_{s1}$
Social	Commitment and motivation of public social support	$TI_{s1} = W_{S-C-E} * W_s * W_{s1}$
Social	Rebound effect	$TI_{s1} = W_{S-C-E} * W_s * W_{s1}$
Cultural	Lack of interest/low priority/Undervaluing energy efficiency	$TI_{c1} = W_{S-C-E} * W_c * W_{c1}$
Cultural	Customs, habits and relevant behavioural aspects	$TI_{c1} = W_{S-C-E} * W_c * W_{c2}$
Cultural	Bounded rationality/Visibility of energy efficiency	$TI_{c3} = W_{S-C-E} * W_c * W_{c3}$
Cultural	Missing credibility/mistrust of technologies and contractors	$TI_{c4} = W_{S-C-E} * W_c * W_{c4}$
Educational	Lack of trained and skilled professionals/ trusted information, knowledge and experience	$TI_{E1} = W_{S-C-E} * W_E * W_{E1}$
Educational	Lack of awareness/knowledge on savings potential/information gap on technologies	$TI_{E2} = W_{S-C-E} * W_E * W_{E2}$
Economic	Lack of any type of financial support (lack of financial incentive (Public and Private sector)/ Lack of funds or access to finance)	$TI_{EC1} = W_{EC} * W_{EC1}$
Economic	High capital costs/Financial risk/ Uncertainty on investment/ High cost of innovative technologies for end-users	$TI_{EC2} = W_{EC} * W_{EC2}$
Economic	Payback expectations/investment horizons	$TI_{EC3} = W_{EC} * W_{EC3}$
Economic	Relatively cheap energy and fuel prices/ misleading Tariff system not reflecting correct prices for energy use/EE	$TI_{EC4} = W_{EC} * W_{EC3}$
Economic	Unexpected costs (Hidden costs/ Costs vary regionally (Fragmented ability))	$TI_{EC5} = W_{EC} * W_{EC5}$
Economic	Financial crisis/Economic stagnation	$TI_{EC6} = W_{EC} * W_{EC6}$
Economic	Embryonic markets	$TI_{EC7} = W_{EC} * W_{EC7}$
Institutional	Split Incentive	$TI_{I1} = W_I * w_{I1}$
Institutional	Legislation issues (Lack of relevant legislation/Lack of regulatory provision /Change of legislation for local/regional administrative division/ Complex/inadequate regulatory procedures)	$TI_{I2} = W_I * w_{I2}$
Institutional	Building stock characteristics/aging stock/ Historical preservation	$TI_{I3} = W_I * w_{I3}$
Institutional	Poor compliance with efficiency standards or construction standards/ Technical problems/ Performance gap/mismatch	$TI_{I4} = W_I * w_{I4}$
Institutional	Lack of data/information-diversion of management	$TI_{I5} = W_I * w_{I5}$
Institutional	Barrier to behavior change due to problematic Implementation Network (IN)/governance framework (Inadequate IN/governance framework /Inadequate implementation of policy measures / poor Policy coordination across different levels/cooperation of municipalities)	$TI_{I6} = W_I * w_{I6}$
Institutional	Disruption/Hassie factor	$TI_{I7} = W_I * w_{I7}$
Institutional	Security of fuel supply	$TI_{I8} = W_I * w_{I8}$

Table 5: Total impact of barriers for the transport sector.

Type	Name of barrier	Function
Social	Low satisfaction with public transport/lack of trust	$TI_{s1} = W_{S\text{-}C\text{-}E} * W_s * W_{s1}$
Social	Concerns of vehicle reliability/Hesitation to trust new technologies	$TI_{s1} = W_{S\text{-}C\text{-}E} * W_s * W_{s1}$
Social	Heterogeneity of consumers	$TI_{s1} = W_{S\text{-}C\text{-}E} * W_s * W_{s1}$
Social	Suburbanisation trends/Low density	$TI_{s1} = W_{S\text{-}C\text{-}E} * W_s * W_{s1}$
Social	Mobility problems (Vulnerability of pedestrians / Lack of adequate space for walking/ Cruising traffic/ Parking problems)	$TI_{s1} = W_{S\text{-}C\text{-}E} * W_s * W_{s1}$
Social	Inertia	$TI_{s1} = W_{S\text{-}C\text{-}E} * W_s * W_{s1}$
Cultural	Car as a symbol status and group influence	$TI_{c1} = W_{S\text{-}C\text{-}E} * W_c * W_{c1}$
Cultural	Habit and social norm of driving, car ownership and use	$TI_{c1} = W_{S\text{-}C\text{-}E} * W_c * W_{c2}$
Cultural	Cycling is marginalized	$TI_{c3} = W_{S\text{-}C\text{-}E} * W_c * W_{c3}$
Cultural	Attitude (Attitude-action gap /Bounded rationality/Buyer attitude)	$TI_{c4} = W_{S\text{-}C\text{-}E} * W_c * W_{c4}$
Educational	Lack of knowledge/information (on green transport/ULEVs/EVs - fuel economy)	$TI_{E1} = W_{S\text{-}C\text{-}E} * W_E * W_{E1}$
Educational	Low/Limited awareness (of impact of EE in transport /towards eco-driving/benefits-environmental impacts)	$TI_{E2} = W_{S\text{-}C\text{-}E} * W_E * W_{E2}$
Educational	Confusion about car and fuel costs (conventional vs ULEVs/Evs) – *Negative perception*	$TI_{E2} = W_{S\text{-}C\text{-}E} * W_E * W_{E2}$
Educational	Lack of certified instructors/examiners/technicians/professionals for eco-driving /integrated transport/mobility/ ULEVs/Evs	$TI_{E2} = W_{S\text{-}C\text{-}E} * W_E * W_{E2}$
Economic	Lack of finance/Limited financial incentives for new vehicles/ULEVs/public transport/ - Inefficient or absent fiscal measures for supporting EE	$TI_{EC1} = W_{EC} * W_{EC1}$
Economic	Limited infrastructure investment (road/train/cycling) – for public transport	$TI_{EC2} = W_{EC} * W_{EC2}$
Economic	Low purchasing power of citizens/Financial crisis	$TI_{EC3} = W_{EC} * W_{EC3}$
Economic	High cost/Low cost competitiveness of electric vehicles - High cost of batteries for electric vehicles	$TI_{EC4} = W_{EC} * W_{EC3}$
Economic	Payback period of fuel efficient vehicles	$TI_{EC5} = W_{EC} * W_{EC5}$
Economic	Negative role of Investment schemes/employee benefits encourage transport EE	$TI_{EC6} = W_{EC} * W_{EC6}$
Institutional	Administrative fragmentation and lack of integrated governance	$TI_{I1} = W_I * w_{I1}$
Institutional	Transport EE on the Government Agenda/priorities	$TI_{I2} = W_I * w_{I2}$
Institutional	Barriers to behavior change due to problems with infrastructure/public transport services (Inefficient urban/public transport infrastructure and planning/ Undeveloped cycling/walking infrastructure/ Lack of support for rail transportation/Limited rail infrastructure/ Undeveloped infrastructure for recharging of EV)	$TI_{I3} = W_I * w_{I3}$
Institutional	Lack or limited policies to support behavior change on specific transport issues (Lack of national strategy for bike and pedestrian mobility/ Limited policy on freight efficiency/city logistics	$TI_{I4} = W_I * w_{I4}$
Institutional	Limited/complex funding in urban public transport	$TI_{I5} = W_I * w_{I5}$
Institutional	Barriers to behavior change due to no policy support to technological issues/research needs (Immature status of developing technologies for EVs/ULEVs - Range of distance travelled between charges for EVs)	$TI_{I6} = W_I * w_{I6}$
Institutional	Contradicting policy goals (particularly road/car-oriented planning)	$TI_{I7} = W_I * w_{I7}$

k, a, c, d, e are factors from which the final energy consumption depends; such as population (k), income (a), space (c) that is heated or cooled, climatic conditions (d), already existing technology (e) and energy prices (h) (Department of Energy & Climate Change, 2015; Weibin Lin et al., 2014). The selection of the final number of these factors and their importance for the final energy consumption depends on scenario assumptions. A similar function is used for other types of technologies as well.

The expected/needed energy savings for target year t - ***when barriers are considered*** - are

$ES_{t,\ barriers} = F_o(k,a,c,d,e,\ h)*(p\%) * (1- TI_{barriers\ linked\ with\ target})$

Where $TI_{barriers\ linked\ with\ target}$ is defined in previous step. The value of $TI_{barriers\ linked\ with\ target}$ depends also on the scenario and on whether it concerns the whole sector or a specific sub-sector (residential or tertiary for the building sector). The latter defines the barriers linked with the technology. So, the final energy consumption for the target year t will be

$F_t\ (k,a,c,d,e,\ h,\ TI_{barriers\ linked\ with\ target}) = F_o(k,a,c,d,e,\ h) - ES_{t,\ barriers} = F_o(k,a,c,d,e,\ h) - Fo(k,a,c,d,e,\ h)*p\%*(1- TI_{barriers\ linked\ with\ target})$

Mathematical expressions for forward-looking EE modelling

The following mathematical expressions use the calculated impact of barriers and provide the numerical inputs needed to energy modelling for reflecting the end-user behavior towards the assumed EE targets.

First approach

The software LEAP is one of the tools used for the forward-looking EE modelling. In LEAP, the incorporation of the numerical outcomes that reflect the barriers impact is expressed as

BaselineValue - Interp(reference year; 0; target year; $F_o(k,a,c,d,e,h)*(p\%)*(1- TI_{barriers\ linked\ with\ target})$

where $TI_{barriers\ linked\ with\ target}$ is calculated within LEAP, by using all the calculated TIs that will be placed under a branch of the "Key assumptions" of the LEAP tree.

Another option is to have the TI values in an Excel file and link LEAP with that file. Similar mathematical expressions or functions are used.

Second approach

Calculations for $TI_{barriers\ linked\ with\ target}$ are performed in the developed Decision Support Tool (DST) software and the final outcome is inserted in LEAP (through an Excel file) or in any other forward looking EE model.

2. **Penetration shares for EE technologies or fuels (such as heating oil, natural gas, electric, heat pumps, biomass, LPG, etc.) per housing type (percentages)**

Function

The initial share (in %) of a technology (such as heat pumps) is denoted for the reference year, 0, as

$S_o(k,a,c,d,e,\ h)$ where

k, a, c, d, e are factors from which the share depends; such as population (k), income (a), space (c) that is heated or cooled, climatic conditions (d), already existing technology (e), energy prices (h). Again, the selection of the factors depends on the scenario assumptions.

The targeted increase of the penetration of the technology (such as heat pumps) is assumed to be A%. So, the share of the technology for target year t is

$S_{t,\ barriers} = S_o(k,a,c,d,e,h) + A\%*(1- TI_{barriers\ related\ with\ the\ penetration\ of\ the\ technology})$

Mathematical expressions for forward-looking EE modelling

First approach

In LEAP this is expressed as

BaselineValue - Interp(reference year; $S_o(k,a,c,d,e,h)$ *or 0;target year;* $S_o(k,a,c,d,e,h) + A\%*(1- TI_{barriers\ related\ with\ the\ penetration\ of\ the\ technology}))$

where $TI_{barriers\ related\ with\ the\ penetration\ of\ the\ technology}$ is calculated within LEAP (using all calculated TIs under a branch of the "Key assumptions" of the LEAP tree (as in previous case).

For any other forward-looking EE model the approach follows the already aforementioned rationality.

Second approach

Calculations for $TI_{barriers\ related\ with\ the\ penetration\ of\ the\ technology}$ are performed in the DST and the outcome is inserted in LEAP or in any other forward-looking EE model.

3. **Setting a general target**

In some cases, due to the limitation of detailed data, a general target is set for the sub-sector that is studied. So, the following options are adopted.

All available technologies

The achievement of any of these general targets is assumed to be accomplished by the use of all the available technologies such as BEMs, LEDS, energy efficient appliances etc.

The concept is that followed in the previously described case. The final energy consumption for the target year t will be

F_t (k,a,c,d,e, h, $TI_{\text{barriers linked with target}}$) = F_o(k,a,c,d,e, h) – $ES_{\text{t, barriers}}$ = F_o(k,a,c,d,e, h)- Fo(k,a,c,d,e, h)*p%*(1-$TI_{\text{barriers for available technologies}}$)

Combination of technologies

This option refers to the intention of exploring which technologies to use and which is the best combination to use.

For the first case, all available technologies are to be used or based on official documents (such as National Energy Efficiency Action Plans) a specific set of technologies is selected and used in forward looking EE modelling. Then the calculations follow the previous rationality.

For the second case, the possible selection of specific technologies out of a set of available ones is not possible due to the large number of combinations. Therefore, the combinations with the potential to overcome their barriers successfully and achieve the set target are those that need to be preferred and explored. For concluding with the more efficient ones the following procedure is followed:

Step 1: the available technologies form possible combinations. The combination with the **maximum number of common barriers** is more preferable than the others, because the efforts for minimizing these barriers will affect the penetration of all involved technologies.

Step 2: Additionally, if there are combinations with the same set of common barriers, the more preferable are those with **the lowest Total Impact**, since: i) the overcoming of the set of their barriers as a group requires less efforts compared to other combinations. ii) as a group these technologies will be more manageable towards the barriers and will more likely reach easier the set target compared to others.

The TI of the combination is calculated and used as described in the previous cases.

B. ***Incorporation of minimized impact of barriers in EE modelling***

Another use of the barriers impact is by developing scenarios under which barriers are confronted and their impact is reduced so that the set target is achieved. Reduced impact reflects the behavior change of end-users.

The function that describes the reduction rate of a barrier needs to follow the same rationality with that of the change rate (increase or reduction) of the final energy consumption or of energy savings. Between the different types of functions, most suitable is the linear function[25], which provides compatible results with the LEAP functionality and the structure of the scenarios.

The Total Impact of barriers is assumed to follow a reduction rate described through the form of a linear function, ie

$Q = Q_o$ (1 – (0,2/15)*t where

Q_o is the Total impact of barrier i in year t=0,

Q is the Total impact of barrier i in year t after the implementation of a policy instrument (or instruments) that addresses the barrier. The initial conditions that defined this final form, starting from the general one Q = a*t + b, were the following:

For year t=0, the Total Impact of barrier i, is that already calculated following the steps of the methodology, ie $Q = Q_o$.

For year t = 15 (in 2030), the assumption is that the Total impact of the barrier is reduced by 20%. This reduction means that barrier i, has a lower contribution in preventing energy savings (better situation for achieving energy savings or facilitating better the penetration of an EE technology). The 20% reduction was selected as an indicative value and because the mapping of the barriers showed that the majority of them remain important for several years despite the implementation of policy instruments. Whether the assumed 20% captures sufficiently the reduction of a barrier or not, this requires further research.

In the case of the best combination of technologies the minimization of the common barrier impact is divided equally among the

[25] The outcomes from the use of an exponential function are not compatible.

involved technologies. The outcomes are inserted in the forward-looking EE model as described previously.

3. Conclusions

The developed methodology leads to: i) the quantification of the barrier impact based on qualitative information; ii) the incorporation of end-users behaviour in forward looking EE modelling. It allows the understanding of: i) which barriers are more important compared to others, ii) the deviation from the expected EE targets (final energy consumption or share of a technology) due to barriers linked with end-users bahaviour.

The reliability of the outcomes of the methodology depends on the inputs. The Saaty consistency index is used for securing the consistency of the judgements across all pairwise comparisons. A second consistency index – such as that of Pelaez-Lamata (2003) - may be used additionally, leading to higher level of consistency and reliability of the results. Its inclusion as part of the methodology depends on the user requirements.

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Session 5: Renewable Energy Sources

Balancing Intermittent Renewables - The Potential of Pumped Hydropower Storage

by

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Abstract

As the share of intermittent renewable energy generation rises within the German grid, solutions are required to deal with temporary overproduction of electricity as well as shortfalls. Pumped hydropower storage systems are natural partners of wind and solar power, using excess power to pump water uphill into storage basins and releasing it at times of low renewables output or peak demand. This is a well-proven, reliable technology. However, suitable sites are limited in most countries and where they exist, opposition towards new plants is often high, due to the disruption to landscape and bio-habitats. There are recent developments in battery storage technology in particular, which may be better suited to a largely decentralised energy system. Battery stores could potentially be integrated into the built environment, sparing virgin landscape. Nevertheless, battery stores cause also environmental impacts, albeit in different impact categories (e.g. use of scarce natural resources). The proposed contribution will outline consequences of increasing renewables on the grid as contextual information, taking Germany as an example. The resulting changes to the energy market and policy implications will also be covered. Based on a scientific study for a site in Germany, the contribution explores advantages and disadvantages of pumped hydropower storage and battery stores over their entire life cycle, drawing primarily on Life-Cycle-Assessment-data. Scientific results so far suggest that pumped hydropower storage still holds environmental advantages and should continue to play a role in the German energy system.

1. Introduction

In the wake of the Fukushima disaster the German federal government decided on an accelerated energy transition, entailing a shut-down of all nuclear power stations by 2022 at the latest and generating at least 80% of power from renewables by 2050 (German Cabinet, 2011). Conventional power stations currently cover most of the balancing service requirements of the Transmission Systems Operators (TSOs) involved. However, with their share in the electricity market diminishing, they will no longer be available to cover these requirements to the current degree. At the same time the need for balancing in the widest sense will increase due to the intermittent nature of much of the prospective 80% renewables making up the energy mix, i.e. wind and solar energy. (Völker et al., 2013, p. 91).

Pumped hydropower storage systems complement wind and solar power well. They use excess power to pump water uphill into storage basins and release it at times of low renewables output or peak demand. Where new plants are being planned, locals often oppose these fiercely, due to the disruption to landscape and bio-habitats.

At the same time battery technologies are developing at a fast pace. Utility-scale batteries have recently emerged, now able to provide a range of balancing services. These can be sited on brownfield sites, thus not impacting on the local landscape to the same degree. However, they have particular requirements as to the materials they are made from, how they can be operated and how they are decommissioned at their end of life.

Hence the question arises, how the two storage technologies compare, if considering important environmental impacts over the entire life-cycle.

2. Research Question and Methodology

The question to be addressed in this paper is which technology performs better, if important environmental impacts are considered over the entire life cycle?

As point of departure, the paper examines the need for storage in the energy system of the evolving German energy transition.

This is followed by the analysis environmental impacts over the whole life cycle, which are calculated using a simplified life cycle assessment (LCA) based on the ecoinvent database version 3 (Werner et al., 2016), but also incorporating real-life data as and where available.

3. The German Energy Landscape and its Balancing Requirements

A share of 32,5% of renewable electricity could be achieved within the German electricity mix in 2015. At times of peak renewable electricity output, such as a sunny day around mid-day, over 80% of energy demand can be met by renewables, while at times of low irradiation and low wind there can be next to none. (Agora Energiewende, 2016b). The influx of high levels of solar energy in particular into the grid have led to a drop in energy wholesale prices, even leading to negative prices, when total energy supply surpasses demand. Due to this drop in prices and an ill-functioning EU-ETS (Agora Energiewende, 2016a), other conventional energy technologies, namely flexible gas turbines can no longer compete, even though they would complement renewables well, due to their ability to modulate (Beck et al., 2013). The only fuels able to compete are CO_2-intensive coal and lignite. This has led to an altogether unsatisfactory development of CO_2 factors rising between 2011 and 2013 to 622g CO_2/kWh (Icha), though this is now expected to level off. Furthermore, due to the inflexibility of lignite power stations and intermittent renewables, excess electricity has to be exported into neighbouring grids, such as that of the Netherlands, where gas-generation is now also being displaced, as a result of the low, even negative prices for excess electricity (Agora Energiewende, 2016b), (BDEW 2013).

There are therefore many reasons for finding a lower carbon solution for balancing out fluctuations in supply as well as demand, such as storage technologies. Balancing is required at different levels and temporal scales of the energy system i.e. for frequency containment processes, frequency restoration processes and reserve replacement processes. Other ancillary services relate to voltage control and emergency and restoration. Storage technologies are playing an increasing role in providing these services, in particular pumped hydropower storage and large scale batteries.

4. Technologies and Data to be Compared

Two electricity storage options shall be compared – a pumped hydropower store and a large-scale lithium-ion store. The pumped hydropower store will provide 1 GW of power and a capacity of 9,6 GWH. The sizing of the battery has to be comparable – see section “Definition of Functional Unit and Time Frame“. Pumped hydropower storage has been in use since the early 20th century. It is a technically well understood, well proven and reliable technology that can be built at large scale, often having several GWh of storage capacity. Total word wide capacity is estimated at 127 GW (7 GW in Germany. Völker et al., 2013), making it the largest scale technology for electricity storage· It can provide large amounts of balancing energy services (Fuchs et al., 2012). Pumped hydropower storage stores mechanical energy and is being used for load balancing within electric power systems. Energy is being stored in the form of the gravitational energy potential of water, which is pumped from a reservoir at lower level to another reservoir at higher altitude, when there is abundant and or cheap energy in the system. At times of high electricity demand, the stored water is released through turbines which produce electric power. Some losses occur in the pumping process making the plant a net consumer of energy (Fuchs et al., 2012).

With emerging battery needs for a vast range of applications, including electric mobility, research and development of batteries development is currently a dynamic, swiftly evolving field (TESLA, 2015), (ingenieur.de). With efficiencies of over 90% (e.g. Hiremath et al. 2015, Korthauer, 2013), low memory effect and slow aging charging cycles (Stenzel et al., 2015), lithium-ion batteries are the technology of choice for large scale stationary applications (Korthauer, 2013; Younicos AG, 2016). The particular type of lithium-ion technology considered here are lithium-manganese batteries. Utility-scale batteries have only emerged recently. They consist of a large number of battery units on racks filling large halls (Koj et al., 2014). Large scale battery stores are operated similarly to pumped hydropower energy storage, storing energy at times of high availability and feeding it back into the grid at times of high demand (Sterner et al., 2015a).

The WEMAG utility-scale battery in Schwerin is currently Germany's largest utility-scale battery with a capacity of 5 MW and able to store 5 MWh. It went online in September 2014.

It mainly provides short term balancing energy and has been subject to a number of studies (Koj et al., 2015), (Koj et al., 2014), (Stenzel et al., 2015).

With the use of utility-scale battery being an emerging field, developments can only partially be anticipated. The assumptions of this study should therefore have to be checked carefully.

5. LCA-Analysis

Initially, an assessment was made of the ability of the two technologies to provide a range of balancing and ancillary services such frequency control, voltage control and emergency restoration, based on (Beck et al., 2013, p. 112), (Sterner et al. 2015b), (Ulbig, 2015), (Höflich et al., 2010). Despite some differences on their typical use, both technologies are largely able to provide similar services. Having thus established basic comparability, their global life-cycle impacts will be examined. A simplified life cycle assessment (LCA) has been undertaken using the Umberto NXT software, which accesses the database ecoinvent. An LCA calculates environmental and human health impacts that result from inputs into the necessary processes (materials, energy) and outputs (emissions, waste…) over the whole life cycle of a product, including manufacturing with upstream processes, operation and disposal at end of life. The LCA-Method used complies with ISO14040 and ISO14044. The impact categories have been selected based on the following considerations:

- The technologies concerned consume a substantial amount of electricity in their operation, as reflected in the indicators "Global Warming Potential" and "Cumulated Energy Demand" (Goedkoop et al., 2013), (Hischier et al., 2010).
- Both technologies require large amounts of minerals and metals in their production and construction, as reflected in the indicators "Cumulated Exergy Demand of Minerals and Metals" (Bösch, Hellweg, Huijbregts, & Frischknecht, 2006).
- Pumped hydropower stores constitute substantial interventions into the landscape, as reflected in the indicator "Natural Land Transformation" (Goedkoop et al., 2013).
- The indicators "Eutrophication Potential" and "Human Toxicity (carcinogenic)" have been added in order to reflect impacts on human, animal and plant life (Goedkoop et al., 2013).

The definitions of the impact categories will not be given in detail here – the references given for each should be consulted for further information.

6. Definition of Functional Unit and Time Frame

For the purpose of this study it was decided to size both systems to have the same storage capacity (MWh). Therefore, both can provide the same amount of work, thus allowing for longer term balancing services. Consequently, the functional unit for the comparison will be defined as the provision of 9,6 GWh stored energy, that is able to provide frequency and voltage control as well as emergency and restoration services.

Therefore the 5 MWh WEMAG-Battery-store in Schwerin has to be scaled up initially by a factor of 1'920. It is assumed that the battery may lose 20% of its storage capacity within 20 years (e.g. ÖAMTC, 2014) due to aging and degradation processes (reflecting its 20-year warrantee Struck & Broichmann, (n.d.), p. 6). It therefore has to be over-dimensioned by 10%, over-producing in the beginning by 10% and under-producing towards the end of life time by 10%, also bearing in mind that the individual battery cells would be replaced gradually, as and when necessary. Hence in order to provide comparable output on average over the course of its life span, the scaling factor is 2’133. It is unlikely that a utility scale battery 2‘133 times the size of the installation in Schwerin would be installed in a single location. More likely it would be spread over a number of locations, each installation of comparable size to the original installation in Schwerin. This allows for the scaling up of a suitable building using the same factor as for battery components. Nevertheless, the battery option will be referred to in the singular in the following.

The life-span of pumped hydropower storage ranges in literature from 50-150 years (Bauer et. al, 2007), (VISPIRON, 2015). A life-span of 80 years was chosen which is also the time frame over which the two technologies were compared. There is no long-term evidence yet for life spans of utility scale batteries, as this is a recent and continuously evolving technology. However, a life span of 20 years can be found in literature, e.g. (Hiremath et al., 2015) and is in line with the warranty for the WEMAG-Battery in Schwerin. Hence replacement of the battery units every 20 years has been assumed.

7. System Boundaries

Table 1 shows the components that are included for each technology, reflecting data-availability. Items in brackets will only be accounted for in the LCA up to the point of grid connection.

8. Life Cycle Stages

A cradle to grave analysis will be undertaken. It accounts for impacts in upstream processes resulting from raw material extraction, production and all energy requirements throughout the life cycle. Hence the following aspects will be considered:

- Productions stage: Manufacturing and construction including extraction and all processing of raw materials, transportation processes, construction processes, all energy and water requirements, resulting emissions, wastes and waste disposal.
- Use stage: Operation including management, maintenance and replacement measures, in particular replacement of battery units, difference between stored and generated energy due to efficiency losses and internal electricity requirements, assuming current German electricity mix with current direct emissions and upstream processes of power stations, other generating technologies and infrastructure; for the pumped hydropower storage: lubricating oil consumption and Methane developing in reservoirs (Bauer et al., 2007).

Table 1: System boundaries.

	Utility-Scale Battery	Pumped Hydropower Storage
Storage Medium	battery cells and case	reservoir and water
Built Structures	industrial hall [(building services (heating, cooling ventilation)] racks und trays	tunnel penstock, subterranean turbine hall services for turbine hall surge tank, [services for turbine hall: lighting, ventilation etc.]
Technical Components:	inverter cabling [partial] battery management system [partial] [switchgear]	pump turbine, cabling [management system] [switchgear]
Point of Hand-Over to Grid	[transformers]	[transformers]

- End-of Life phase: Decommissioning and disposal including dismantling, separation, processing and recycling, treatment and safe disposal of hazardous wastes, final disposal of non-recyclables, related transportation processes, energy consumption and emissions.

9. Input Data Including Critical Data

For the pumped hydropower store data could be obtained from a pumped hydro-power operator in aggregated form. This data is being complemented by data from ecoinvent and from literature. Technical and operating characteristics will be based on real-life data from the operator.

For the utility-scale battery data is being used from the WEMAG-store in Schwerin, as found in literature (Stenzel et al., 2015), (Younicos AG, 2016). Data is being checked against ecoinvent data for lithium–manganese batteries. Quantities in particular stem from ecoinvent. The actual efficiency including all operational losses is based on Schwerin.

Upstream processes and their impacts, such as for example those relating to the construction of powerstations that provide the electricity for the use stage of the two storage options are based on ecoinvent-data. Based on the available data and previously discussed considerations the following input data is to be used for the Life-Cycle Assessment in table 2.

Environmental Impacts

In Figure 1 the impacts of both technologies are juxtaposed (utility scale battery = 100%). The different colours indicate shares of the different life-cycle stages in the over-all impacts.

For the pumped hydropower store impacts of the end-of-life stage are barely visible. For the utility scale battery, impacts of the end-of-life stage are discernible and impacts from the production stage are larger. This is largely due to the replacement cycles for the battery units every 20 years, which is shown in red.

Impacts of the operational stage (“use stage”) generally dominate those of the production stage in all categories except cumulated exergy demand. Especially the categories, GWP, eutrophication and impacts on human health show only a small contribution of the production stage to over-all impacts. The use stage is largely made up of the impacts of operational energy losses, i.e. the difference of stored energy and released energy. These losses depend on efficiency losses and internal energy demands of the installations. The impacts of this lost energy in turn depend on the impacts of the current German energy mix, its direct emissions from combustion plants and upstream processes (i.e. impacts from constructing power stations and renewables installations and infrastructure).

The comparison shows that the impacts resulting from the use stage are of similar order of magnitude for both options in most categories, which in turn has an equalizing effect on over-all results. This however does not apply to the categories Cumulated Exergy Demand Metals and Cumulated Exergy Demand Minerals. This impact in the use stage is comparatively small. The reason for this is that impacts of the use stage are mainly due to energy generation, as previously explained. Metals and minerals do not play a major role in energy generation (except for in upstream impacts).

The category natural land transformation is the only category in which impacts of the pumped hydropower store exceed those of the utility scale battery slightly, based on the assumptions stated previously. The short lines on the bars for natural land transformation indicate how much of these impacts relate to the direct land use of the technologies and how much relates to transformation in upstream processes.

Since impacts from electricity losses in the use stage of both technologies outweighs in most categories those in other stages by far and is similar for both technologies, an analysis was undertaken that excludes these (see Figure 2). The remaining operational impacts result from construction, battery unit replacements, end-of-life and for the pumped hydropower store lubricating oil and methane development in the reservoirs.

The remaining impacts show higher impacts for the utility scale battery in all categories except natural land transformation, even though direct land-use does not differ much. This is a result of the different types of land assumed for the sites – the pumped hydropower store would be built entirely on greenfield land, while utility scale batteries are more likely to be sited on brownfield sites, such as industrial areas and wastelands.

Table 2: Data and Assumptions.

	Pumped Hydropower Storage	Utility-Scale Battery
Storage capacity	9,6 GWh	9,6 GWh
Power rating	1 GW	9,6 GW
Efficiency	74,96 %	72,5 %
Total losses per MWH generated	0,350 MWh/MWh$_{generated}$	0,379 MWh/MWh$_{generated}$
Life span	80 years	20 years (= current best practice)
Maintenance and replacement cycles	continuous use of lubricating oil major overhaul of pumps, turbines and generators every 25 years	Replacement of battery units every 20 years (no replacements cycles assumed for the building)
Electricity generated per year	1’855 GWh/a (based on an existing installation)	1’855 GWh/a
Deterioration of performance	n/a	20 % in 20 years
Main raw materials	steel: 43,6 Mt concrete: 2966 Mt copper: 0,5 Mt	ecoinvent – data for factory building ecoinvent-Data for lithium-manganese battery
Direct use of land	98 ha	400 m^2 (estimated) x scaling factor
Type of land use	greenfield site	ecoinvent-option for „unspecified land“, which assumes 40% greenfield and 60% brownfield
Other Data	electricity use for building services, control and management systems, methane generation in basins as per eco-invent data for hydro-power	electricity use for building services, control and management systems, Energy density of 114 Wh/kg, Low self-discharge rate
Electricity mix	current German electricity mix used over the whole life cycle (in line with common LCA methodology)	

Though in some cases they may be sited near large renewables installations such as wind farms or PV-farms on greenfield land.

Discussion of Results

The pumped hydropower store shows lower environmental impacts than the utility scale battery in almost all impact categories, the exception being “natural land transformation”. Environmental impacts during the use stage dominate the overall result. These depend on the impacts of electricity, which is not fed back due to efficiency losses and internal energy requirements.

This means that the system efficiency and internal energy requirement of the examined technologies are crucial for the overall result, as they define electricity ‘lost’ in the 80-year use stage.

Real-life figures for losses resulting from efficiency losses and internal energy demand have been used and are similar for both technologies. This leads to similar impact in the use stage for both technologies, which in turn equalises the over-all results of the two technologies. If actual losses of one of the technologies was to change considerably, be it due to technical developments or optimised deployment, this could sway the over-all result in favour of one technology or the other.

Another important parameter to consider is the electricity mix to be used in the LCA-models.

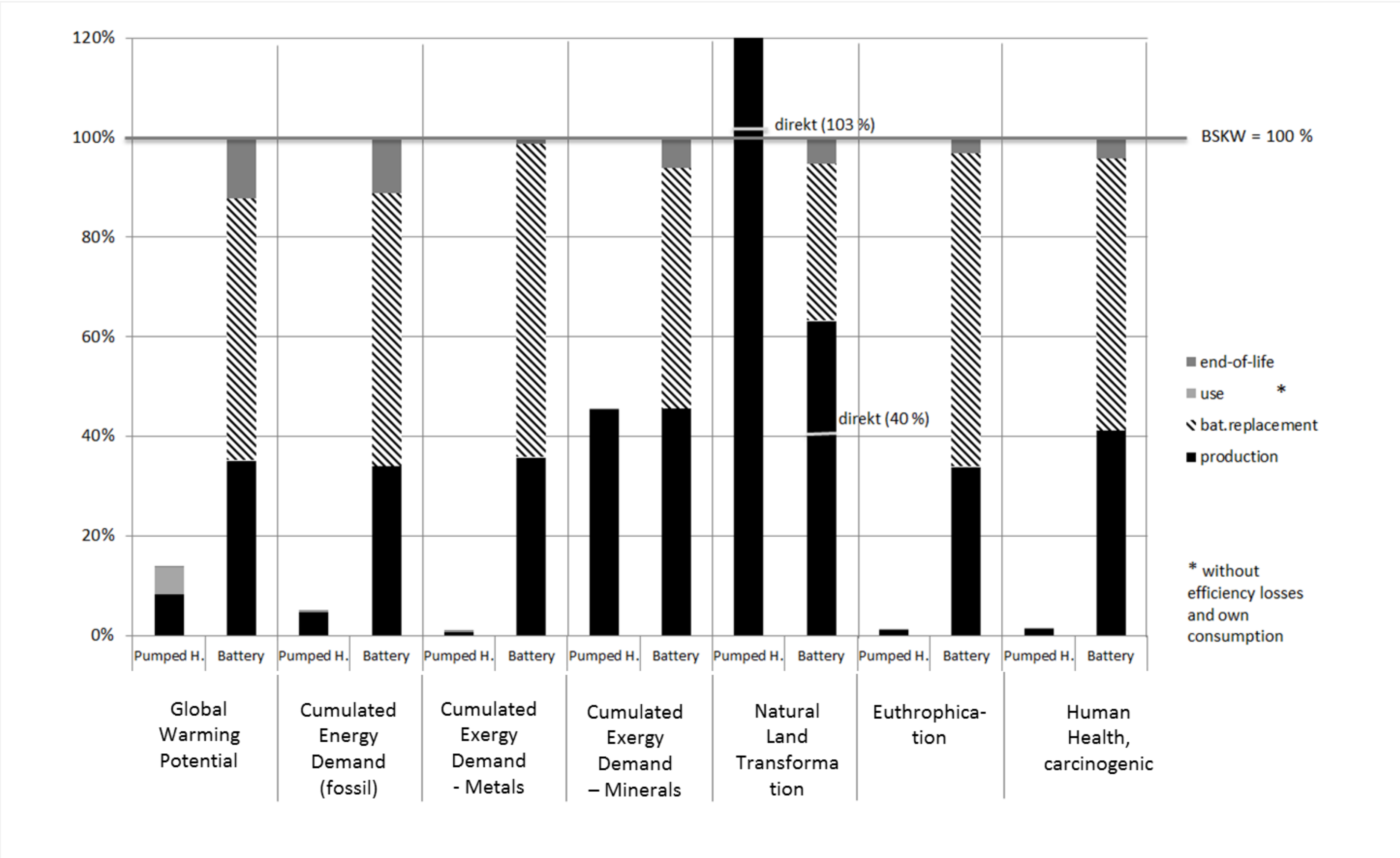

Figure 1: Comparison of environmental impacts according to life-cycle stage.

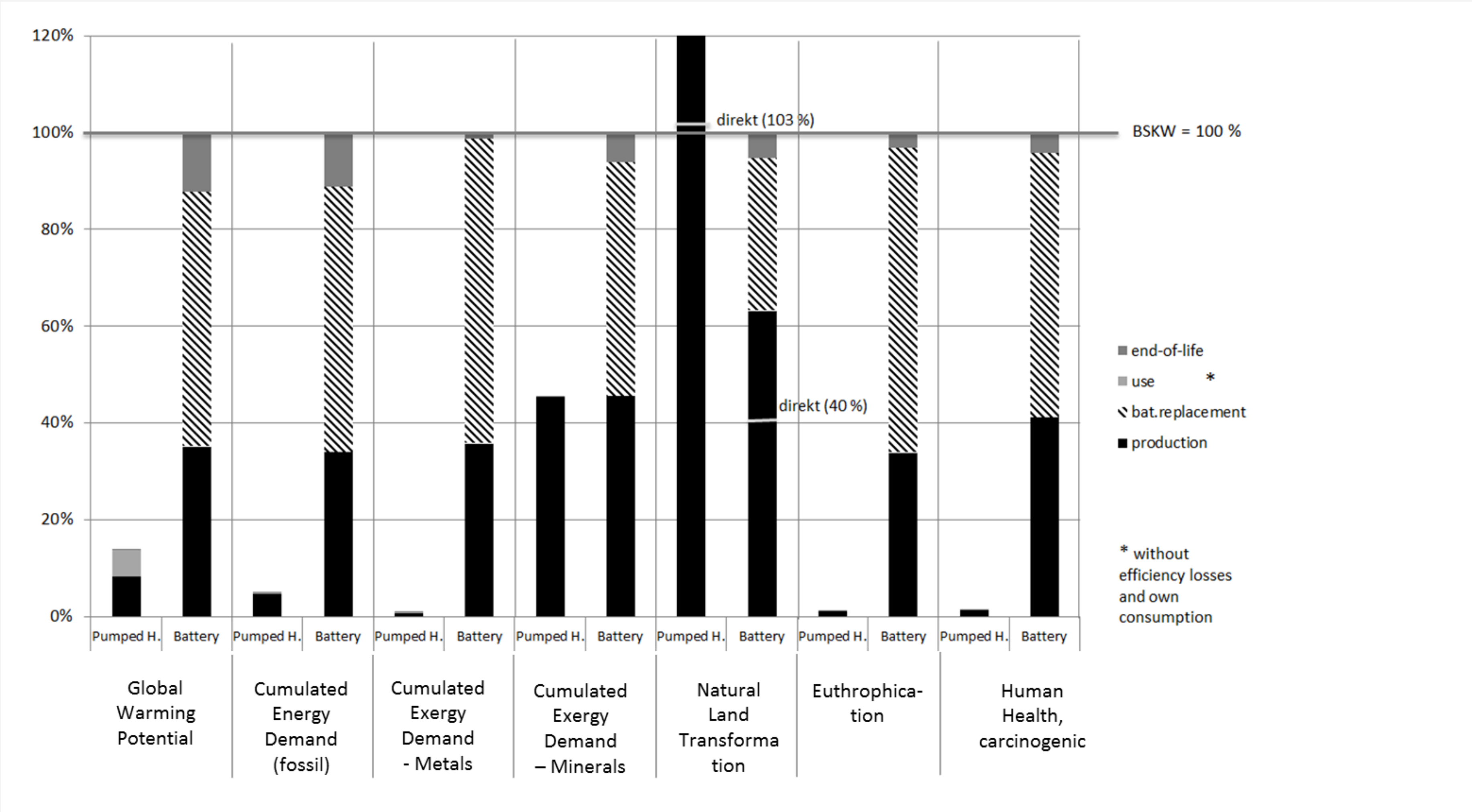

Figure 2: Comparison of environmental impacts according to life-cycle stage without efficiency losses and internal energy requirement.

It can be treated as a given that the electricity mix will substantially change over the course of the next 80 years, as there are EU-targets and national targets in place, largely relating to emissions reduction leading up to 2050. In an extreme scenario, all electricity would come from zero-emission sources and all generating technologies would be produced from recycled materials using zero-emission production energy. In this case emissions arising in the use stage would be negligible. Consequently, the overall result would be similar to that shown in the variation „without efficiency losses and internal energy demand" (Figure 2). Consequently, the equalising effect of the use stage would no longer be there and the percentage of difference between the options over the whole life cycle would no longer be just a few percentage points but be largely amplified. For example, it would be more than ten times larger for the utility scale battery in the category "cumulated energy demand" and around 100 times larger in the category cumulated exergy demand for metals.

However, the energy generation technologies for this extreme scenario do not yet exist. Even current zero-emission electricity generation technologies carry many uncertainties regarding their upstream processes. Modelling these would be an extensive LCA-exercise in itself. Therefore, the current German electricity mix with its currently high emissions and its upstream processes has been assumed for the whole life cycle (as in Figure 1). This approach is in line with common LCA-conventions.

10. Summary and Conclusions

The demand for balancing and ancillary services is expected to increase. Both the pumped hydropower storage and the utility scale battery can provide a wide range of such services. A simplified LCA has been calculated in order to assess all global impacts along the entire life-cycle, calculating the following impacts: Global Warming Potential, Cumulated Exergy Demand Minerals and Metals, Natural Land Transformation, Eutrophication, Human Health (carcinogenic).

The analysis shows lower impacts for the pumped hydropower store in all impact categories except transformation of natural land.

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A Decision Support Model for Site Selection of Offshore Wind Farms

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Abstract

The environmental problems that developed around the production of energy from fossil fuels have forced the whole planet to take thoroughly in consideration the renewable energy sources. The wind energy this time ranks in the first row of exploitation due to economic attractiveness and technological maturity. However, (offshore) wind farms may as well cause various socio-economic and environmental problems, which are mostly related with the geographic locations of these facilities. The topic of proper location of wind farms is considered a very complex process, in which a number of criteria must be analysed often hardly comparable with each other and even contradictory.

This paper presents a theoretical framework of selecting an (offshore) wind farm location based on a spatial cost-revenue optimization which combines multi-criteria analysis (MCA) with geographic information system (GIS). The proposed framework consists of three stages. The first stages excludes sites that are infeasible for wind farms based on criteria were defined by responsible authorities. The second stage identifies the best suitable sites based on social environmental and economic criteria. The economic criteria are based on the expected Net Present Value (NPV), Internal Rate of Return (IRR), Debt Service Cover Ratio (DSCR) and Loan Life Cover Ratio (LLCR), from three major cost and revenue categories that are spatially dependent: revenue from generated electricity, and costs that are generated due to distance of wind farm from the electricity grid and coastal facilities (e.g. port, shipyard). The third stage includes the sensitivity analysis, as a means of checking the stability of the results against the subjectivity of the expert judgments.

1. Introduction

The exploitation of renewable energy sources has gained enormous interest during recent years. A rising awareness of environmental issues, due to the increase in negative effects of fossil fuels on the environment, the precarious nature of dependency on fossil fuels imports and the advent of renewable energy alternatives has forced many countries, especially the developed ones, to use renewable energy sources (Cristobal, 2010). These are environment-friendly and capable of replacing conventional sources in a variety of applications at competitive prices (Aras et al., 2004; Haralambopoulos and Polatidis, 2003). Among renewable energy sources this time, wind energy is the fastest growing energy resource worldwide (Balat, 2010; Ogulata, 2003), due to economic attractiveness, technological maturity and environmental safety.

In recent years, the installation of wind farms in offshore areas has gained popularity. Offshore wind farms are the most technologically advanced form of wind energy exploitation. The force of the wind in sea areas is stable, lasting, permanent and faster than on land (Antonopoulou and Tsoukala, 2012).

Even though (offshore) wind power project developers have to complete an environmental impact assessment, few wind energy projects are finally constructed without debates. The planning and permitting of (offshore) wind turbine farms is a multi-faceted process that aims to balance the opinions of all stakeholders.

The locations with the highest wind resources are not always feasible sites for wind farms. (Haaren and Fthenakis, 2011). A variety of factors play a role in the site selection of wind turbine farms. They can be categorized into social, economic, technological and environmental. As all of these factors are spatially dependent, it seems evident that the use of geographic information systems (GIS) poses benefits for site selection.

GIS are not only computer systems designed to produced maps, but also powerful tools of geographic analysis. A GIS is a system of a hardware, software and procedures to facilitate the acquisition management, manipulation, analysis, modelling, representation and output of spatially referenced data to solve complex planning and management problems (Carrion et al., 2008). Today, there are many GIS applications which deal with studies concerning wind energy implementation (Ramachandra and Shruthi, 2007; Aydin et al., 2010; Sliz-Szkliniarz and Vogt, 2011). One of the most common GIS based technique that have been designed to facilitate decision making in site selection, land suitability analysis and resource evaluation is Multi-Criteria Analysis (MCA) (Malczewski,1999). The Analytic Hierarchy Process (AHP) method, originally developed by Saaty (1980) is a flexible and easily implemented MCA technique and its use has been largely explored in the literature with many examples in locating facilities (Kontos et al., 2005; Ramcharan and Dey, 2008; Tuzkaya et al., 2008; Wang et al., 2009) and in land suitability analysis (Yang et al., 2008).

In the current paper we present a theoretical framework of selecting an (offshore) wind farm location based on a spatial cost-revenue optimization which combines multi-criteria analysis (MCA) with geographic information system (GIS). The proposed framework consists of three stages. The first stages excludes sites that are infeasible for wind farms based on criteria were defined by responsible authorities. The second stage identifies the best suitable sites that derived from the first stage, based on social environmental and economic criteria. The economic criteria are based on the expected cash-flows of the investment, which are estimated by Discounted Cash-Flows Method (DCF) and are evaluated from the perspective of the lenders and investors, with the use of financial key figures, in order to meet the different requirements of all stakeholders This is achieved by the use of criteria from three major cost and revenue categories that are spatially dependent: revenue from generated electricity, and costs that are generated due to distance of wind farm from the electricity grid and coastal facilities (e.g. port, shipyard). The third stage includes the sensitivity analysis, as a means of checking the stability of the results against the subjectivity of the expert judgments.

The paper continues as follows: Section 2 presents the literature review, section 3 describes the software and data used. Finally, in section 4 a detailed description of the methodology is presented.

2. Literature Review

The number of studies aiming at evaluation of location suitability or the optimization of sites for (offshore) wind power development, and which additionally apply appropriate MCA and GIS methods, is still low. Even though there are studies available that address the issue of selecting suitable wind farm sites, these differ substantially from a methodological point of view. In the following, we review some related literature.

Noteworthy applications of GIS-based analyses in wind farm selection evaluations include studies by Baban and Parry, 2001; Hansen, 2005; Rodman and Meentemeyer (2006) Tegou et al., 2010; Haaren and Fthenakis, 20011; Kasbadji Merzouk and Djamai 2011; Vagiona and Karanikolas, 2012; Aras et al.,2004; Bennui et al., 2007;Synowiec and Luc, 2013; Szurek et al., 2014. Baban and Parry (2001) proposed wind farm location criteria for UK based on a questionnaire of public and private sectors and GIS-based raster operations to produce a composite suitability map for a test area on 14 identified criteria represented by single factor maps. The study by Hansen (2005) aimed at developing a multi-criteria evaluation method for analysing the trade-offs between choice alternatives with different environmental and socio-economic impacts with fuzzy logic approach in GIS. Rodman and Meentemeyer (2006) use a rule-based GIS model to predict suitable sites for large and small scale wind turbines in the Greater San Francisco Bay Area, USA. Three models are created individually: a physical model, an environmental model and a human impact model. All models are combined by ascribing the same weight to all layers. Each layer is subdivided into multiple classes, where each class gets value scores according to its suitability.

Tegou et al., (2010) combine AHP with GIS to find suitable areas for wind energy development on the Greek island of Lesvos, based on a five stages procedure. A set of environmental, economic, social and technical constraints based on Greek legislation identifies the potential sites for wind power installation. The pair-wise comparison method in the context of the AHP is applied to estimate the criteria weights in order to establish their relative importance in site evaluation. Szurek et al., (2014) also present a GIS-based methodology for optimum location of wind farm in Poland. They adopt the multi-criteria approach utilizing the AHP and the weighted linear combination method in order to determine weights of siting criteria and to develop a composite suitability map from single-factor maps representing these criteria. Haaren and Fthenakis (2011) proposed a novel GIS-based multi-criteria methodology for cost revenue optimization of wind farm site selection. The method applied to the State of New York consisted of three stages. The first one excluded unsuitable sites based on land use and geological constraints, the second one identified the best sites based on the expected net present value and the last stage assessed potential ecological impact of wind farm project. Kasbadji Merzouk and Djamai, 2011 have use GIS for wind resource mapping.Vagiona and Karanikolas (2012) applied a GIS-based AHP model to select feasible sites for offshore wind farms in Greece. The framework of this study is comparable to the procedure applied in the study by Tegou et al., (2010), where restricted areas are excluded, the AHP is performed in the evaluation phase and pair-wise comparisons provide the most appropriate sites to locate offshore wind farms, using criteria such as average wind velocity, distance to protected areas, distance to ship routes, distance to the shore and distance to the existing electricity network. Same procedures are followed by Aras et al., (2004) and Bennui et al., (2007). GIS with multi-criteria analysis for the evaluation of wind farms locations in Poland were also used by Synowiec and Luc (2013). This study employed GIS tools to assess land suitability for siting a wind farm project on the example of the Rynamow commune is SE Poland. Based on MCA analysis of anemometric, environmental, technical and spatial factors, a suitability map for this area had been developed.

In the previous paragraphs the most important GIS-based multi-criteria methods for (offshore) wind farms siting were presented. As can be observed through literature review the studies aiming at evaluation of location suitability for offshore wind power development are still very low. Also, the literature is presented incomplete as regards a multi-criteria decision framework for floating wind farms siting, which will take into consideration the particular features of this innovative application and will use the appropriate criteria in the techno-economic, social and environmental level. The proposed multi-criteria decision framework provides a reliable methodology for floating offshore wind farms siting in the presence of appropriate constraint and evaluation factors. Also, the objectification of the evaluation process and the use of appropriate tools against the subjectivity of the expert judgments enhance the reliability of this approach.

3. Software and Data

The proposed methodological framework can be implemented using any GIS system with overlay capabilities. The overlay techniques (Nath et al., 2000) allow the EL to be aggregated to determine the composite map layer (output maps). The method can be implemented in both raster and vector GIS environments. In the proposed framework a raster GIS was selected. The GIS software will be used is ArcGIS 10.4.1.

GIS data sets of marine protected areas, Greek territorial waters and boundaries, sea depth, wind potential, electricity grids, ports, residential areas, ship routes, underwater cables and digital terrain models (DTMs) were collected for the Aegean sea from the database of EuroGeographics, Open Geodata.gov, Hellenic Navy Hydrographic Service, Hellenic Centre for Marine Research and Hellenic Electricity Distribution Network Operator. For the implementation of the current study the Vestas V80-2MW wind turbine was selected. The floating platform, which was chosen to host the wind turbine is a submerge construction which consists of four peripheral cylinders and one central shaft connected by a metal mesh-grid of such geometry in order to minimize the impacts of waves.

4. Description of the Methodology

4.1 Decision Making Process

The siting process is a MCA problem requiring consideration of a comprehensive set of alternatives in determining the suitability of a particular area for a defined use. These attributes involve bounding constraints that comprise of physical, technical, economic, environmental and cultural issues and criteria that represent a yard-stick or means by which a particular alternative can be evaluated as more desirable that another (Tegou et al., 2010).These constraints and evaluation criteria determine the selection of potential sites. The constraints are based on the Boolean Logic (true/false) and limit the study area to particular sites. The evaluation criteria define a degree of continuous measure of suitability for all feasible alternatives. The AHP is used to assign weights of relative importance to each evaluation criterion. An overall suitability index for each potential site for the study area is calculated using the weighted overlay technique (Nath et al., 2000). Finally, the Sensitivity Analysis is used as a means of checking the stability of the results, which is achieved by modification of weights of evaluation criteria. Particularly, the proposed methodological framework consists of 3 stages: a) Exclusion phase, b) Evaluation phase and c) Sensitivity Analysis phase.

4.2 Exclusion phase

4.2.1 Exclusion criteria

The first stage of the methodology addresses the issue of defining the bounding constraints. These constraints are based on four basic criteria, which are set by responsible authorities and analysed as follows (MEECC, 2010):

1. Development of offshore wind farms within 6 nautical miles from shore.
2. Ensure the technical possibility of installing wind turbines at specific sites. That means that the maximum installation depth will be 50 m.
3. Avoid areas with any significant impact on the environment. This approach excluded all areas included in the network NATURA 2000 from the areas concerned.
4. Minimize the visual impact of the facilities. This criterion applies only for observation points where there is or it is expected to be significant anthropogenic activity. The criteria used were maximum visible height and maximum visible surface of wind turbines.

The criteria for visual impact are based on an international practice, where technical experience allows the construction of offshore wind farms at long distances from shore and not within 6 nautical miles. This limitation leads to the location of farms at a closer proximity from shore than the distances that farms are located abroad. It is therefore expected that in Greece, almost none of possible sites for offshore wind farms, meets this criteria. Also, in Greece there are few areas with relatively shallow waters far from the coast. Thus, the criterion four is not considered to be an exclusion criterion of possible sites, which are evaluated in the next paragraphs using multi-criteria decision analysis.

4.2.2 Spatial Analysis (Boolean Overlay)

The Spatial analysis at this phase is based on the Boolean Overlay. The Boolean Overlay is used to scan the study area in order to find suitable areas according to above constraints. The result of this process it the clear separation of areas to *appropriate* and *inappropriate* areas for installation of offshore floating wind farm. Three constraint layers (CLs) will be produced according to the above constraints. A binary GIS grid is expected to be created for each constraint, with cells falling within a constraint area assigned (0) and the rest of them assigned (1). By multiplying all constraint layers, the final Exclusion map is calculated. Only the cells with value (1) in each input layer will have non zero value in the Exclusion map, meaning these cells meet all constraints and are eligible for further consideration.

The method of Boolean Logic is indicated where there is a need for easy and quick finding widely suitable areas. The criteria that take into account in the process are simply and usually come from the constraints defined by the legal framework and the study needs. The methodological framework of Exclusion phase can be formed to figure 1.

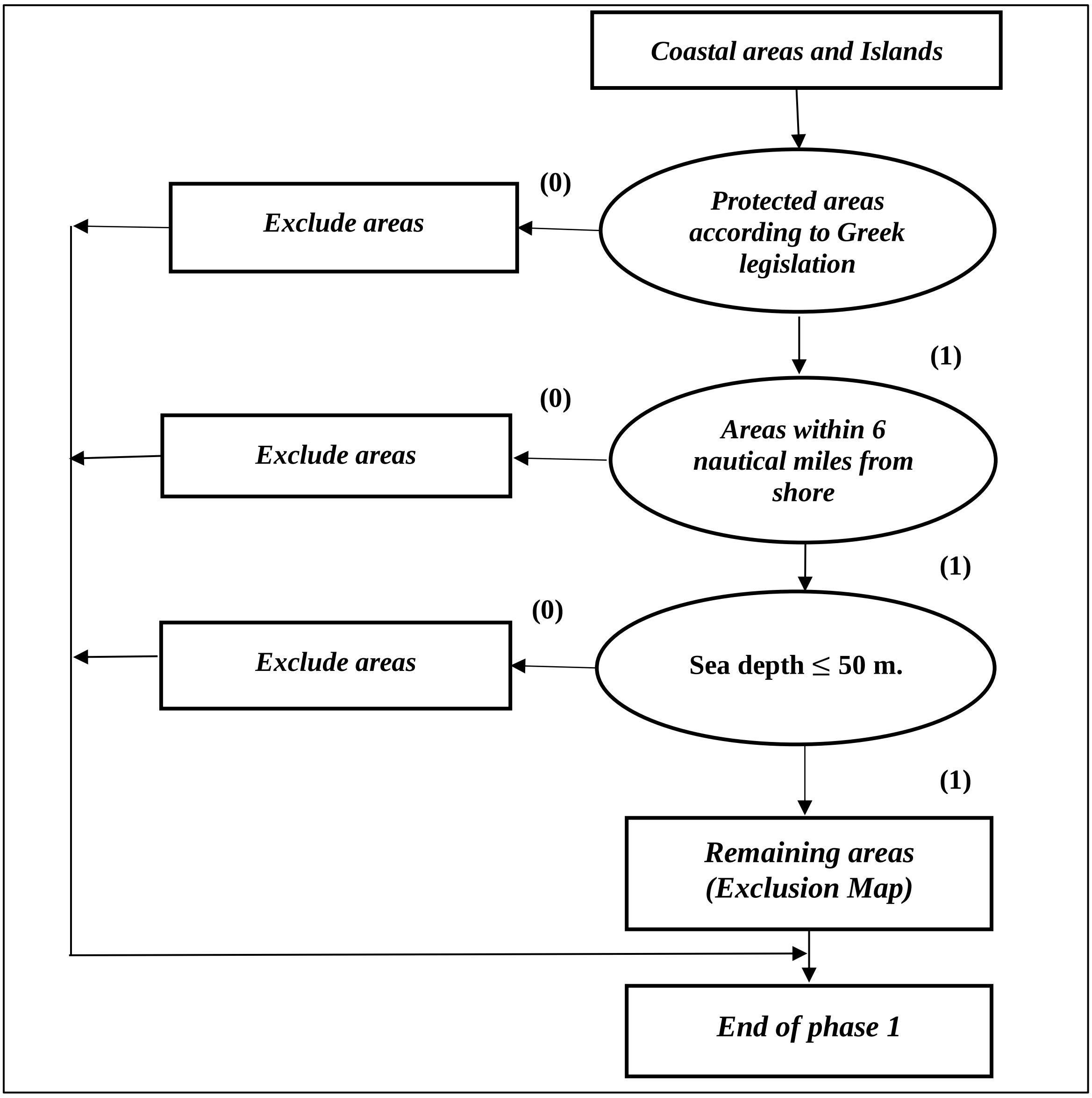

Figure 1: Methodological framework stage 1.

4.3 Evaluation Phase

4.3.1 Evaluation Criteria

Wind energy developers aim for the highest economic return of their project to satisfy the investor interests and make profits. But, because the most of the projects today are conducted in the context of project finance, means that should take into account the different concerns of all involved participants. Here, the lenders are of major importance as project depend to a great part on the debt capital. The latter is only provided against the background of expected future cash-flows of the project (Koukal and Breitner, 2013).

The stage 2 of the methodological framework identifies the best suitable sites that derived from the first stage, based on economic criteria. The economic criteria are based on the expected cash-flows of the investment, which are estimated by Discounted Cash-Flows Method (DCF) and are evaluated from the perspective of the lenders and investors, with the use of financial key figures, like Internal Rate of Return (IRR), Debt Service Cover Ratio (DSCR) and Loan Life Cover Ratio (LLCR), in order to meet the different requirements of all stakeholders. This is achieved by the use of criteria from three major cost and revenue categories that are spatially dependent: revenue from generated electricity, and costs that are generated due to distance of wind farm from the electricity grid and coastal facilities (e.g. port, shipyard).

According to Haaren and Fthenakis (2011) and Blanco (2009) the spatially dependent costs are estimated to be approximately 15-20% of the total costs. Even though the major cost component of wind power is not spatially dependent (the wind turbines), other components like distance of wind farm from the electricity grid and coastal facilities vary considerably with location.

Of course, social, environmental and spatial criteria included, in order to minimize the effects that can cause a wind farm on local communities, environment, and other sea users. The evaluation criteria are based on literature review, experts' judgments and personal experience, and analyzed as follows:

Wind resource: The most important factor that plays a role in economic feasibility is the local wind resource. It is obvious that possible sites should be characterized by high wind potential in order to ensure high energy efficiency *Distance from electricity grid*: Grid connection costs are calculated in this model as a function of distance to the nearest electricity line or substation. Distance to the nearest grid is important for feeder line costs, as well as power loss. Based on Green et al., 2007 and Haaren and Fthenakis (2011), it is estimated that the spatially variable grid connection costs are a function of the required building or upgrading of a substation ($C_{new,}$ resp, $C_{upgrade}$) and the distance to an existing transmission line or substation ($x_{w\to l}$ resp $X_{w\to s}$) in Km. The cost of connecting to an existing substation is given by:

$$C_s = C_{upgrade} + (C_{line}\, X_{w\to s}) \quad (1)$$

The cost of adding a substation and connecting to an existing line is given by:

$$C_I = C_{new} + (C_{line} X_{w\to i}) \quad (2)$$

The minimum the C_s and C_I is integrated into the proposed methodological framework.

Distance from coastal facilities: The proximity to the coastal facilities is an equally important criterion. The easy accessibility to coastal facilities indicates fewer installation, maintenance and decommissioning costs of a wind farm. And at this criterion, the installation, maintenance and decommissioning costs are calculated as a function of distance to the nearest coastal facilities.

Distance from residential areas: The distance of a wind farm from residential and large urban areas is considered one of the most influential factors that can negatively influence the public opinion (Kempton et al., 2005; Ladenburg, 2008). The adoption of long distances from residential and urban areas, it ensures limited visual and noise disturbances and thus it minimizes possible reactions from local communities.

Distance from ship routes: The adoption of adequate distances from ship routes is an extremely important factor for an offshore wind farm due to the risk of collision that may arise. In Greece, due to limitations of offshore wind farms within 6 nautical miles and 50 meters sea depth, the impacts of them to maritime transports are expected to be significantly reduced.

Distances from underwater cables: A possible interaction of an offshore wind farm to the existing underwater cables could result in significant adverse effects on the telecommunication and electricity network.

Distance from protected areas: As the development of wind farms at sea, is considered more expensive than on the land, it makes sense only when additional benefits secured. In this regard, there is no reason an offshore wind farm to be sited near to NATURA areas. Keeping sufficient distances from protected areas we ensure their preservation.

4.3.2 Spatial Analysis (Weighted Overlay)

The Weighted Overlay tool applies one of the most used approaches for overlay analysis to solve multi criteria problems, such as site selection and suitability models. In Weighted Overlay Analysis the seven steps of Overlay Analysis are followed (i.e. define the problem, break the problem into submodels, determine significant layers, reclassify or transform the data within a layer, weight the input layers, add or combine the layers, and analyze). (ArcGIS Resource Center, 2016). Next, the hierarchical structure of the problem is presented, indicating the incoming levels, the number of alternative locations derived from the first stage of exclusion phase, the evaluation criteria and the final goal.

Given that the 7 input levels correspond to different numbering systems with different scales, should be set to a common preference scale. Common scales can be predetermined, such as 1 to 9, or a 1 to 10 scale, with the higher value being more favorable. In this study, all layers, except of wind potential, identify distances while the wind potential classes. For this reason, the initial seven layers should be reclassified to a common preference scale, so then go to weighted overlay. It is important that the preference values not only should be assigned relative to each other within the layer but should have the same meaning among the layers.

The criteria of accessibility to the electricity grid and the proximity of coastal facilities will have degrees of suitability, which will reduce as we move away from them, until they reach the limit in which the degree is zero (economically inappropriate). On the other hand, for the other four criteria (i.e. distances from residential areas, ship routes, undersea cables and protected areas) the degrees of suitability will increase as we move away from them. Finally, for the criterion of wind potential, the class with the highest degree of suitability will correspond to highest average annual wind speed.

Also, not all evaluation criteria are equally important. So, the most important criteria should be heavier weighted than the others.

The AHP method is used to assign weights to the criteria. The AHP method is based on the pair-wise comparison method in order to determine the weight for every unique criterion. In the pair-wise comparison method, the importance of two criteria at a time is asked and the relative importance is scored, based on a fundamental nine point's measurement scale (Saaty, 1980). The basic question applied has the form "which one of these criteria is more important and how much more or less important; and thus a matrix of pair-wise comparisons is created. The scale of suitability for each criterion remains the same as is described above. The rationale behind the particular criteria weighting used here, based on the on literature review, experts' judgments and personal experience, is shortly presented in the following:

- The wind potential is considered to be the most important criterion since it determines the output of the wind turbine.
- The ship routes and the underwater cables criteria are comes next, since the already use of the sea by other users might hinder the wind farm installation and/or licensing.

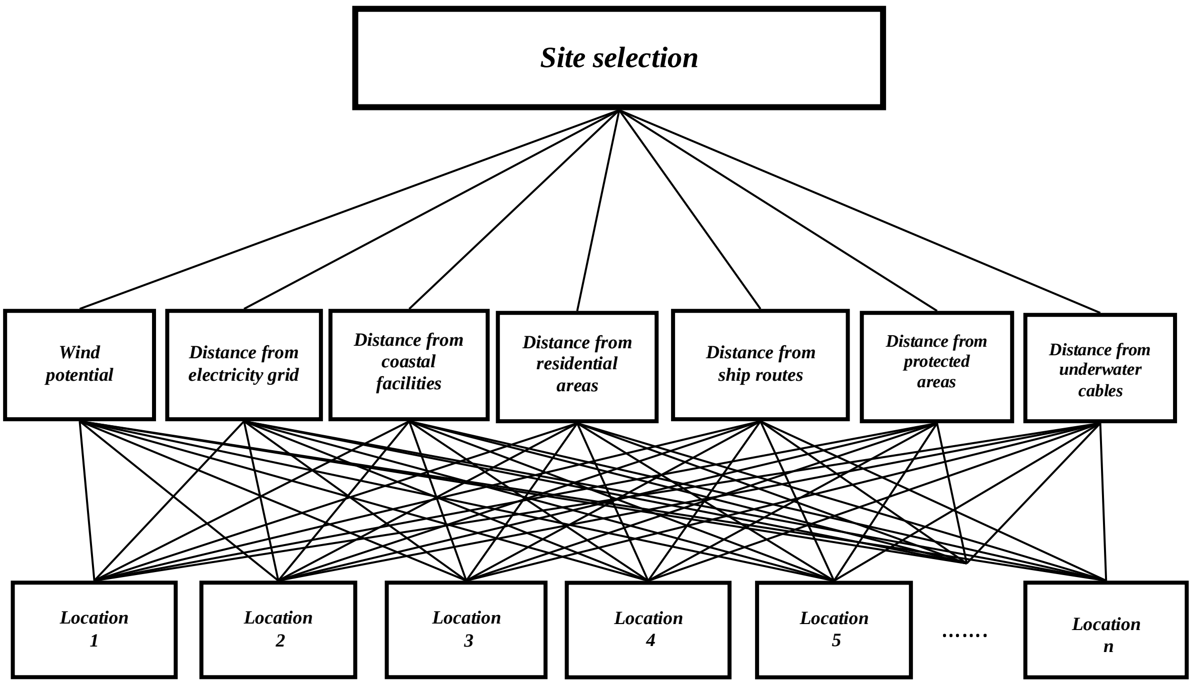

Figure 2: Hierarchical structure of the problem.

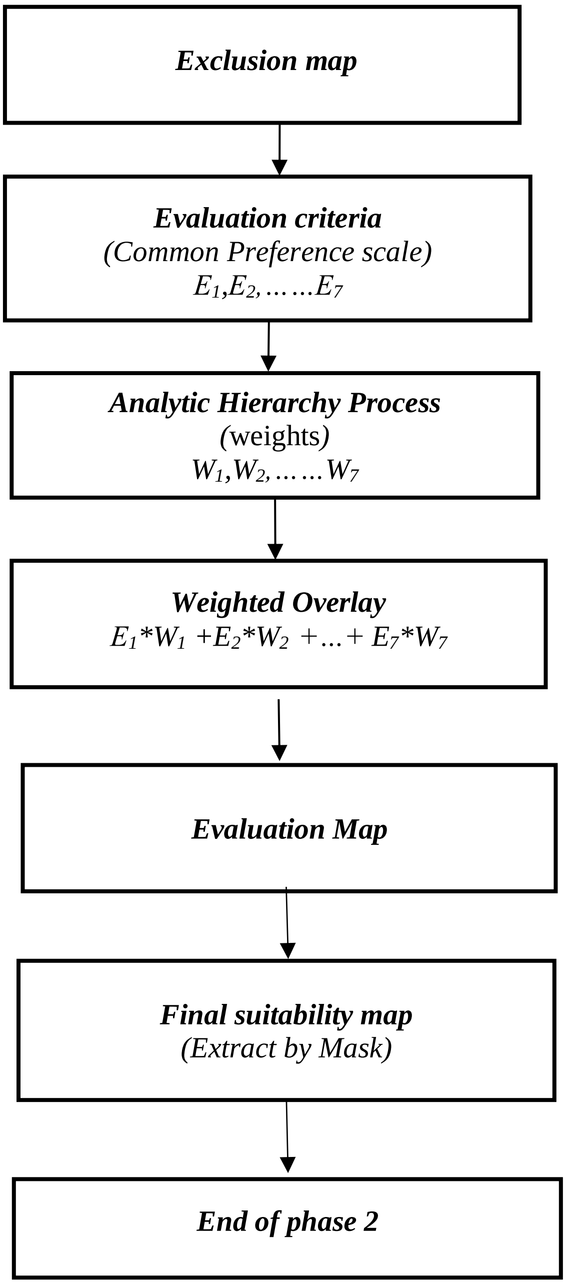

Figure 3: Methodological framework stage 2.

- The distance from the electricity grid and coastal facilities are thought to be less important as they affect mainly the final cost of installation, maintenance and decommission and the grid losses.
- Sixth in the order of priorities is the distance from residential areas. This criterion is closely linked to visual impact and final acceptance of a wind farm by local communities. According to Eurobarometer survey, the Greek public appears to favour strongly the development of wind power (EC, 2006). In any case, the adoption of sufficient distances from residential areas can minimize possible reactions from local communities. Thus this criterion is deemed less important than the previous ones.

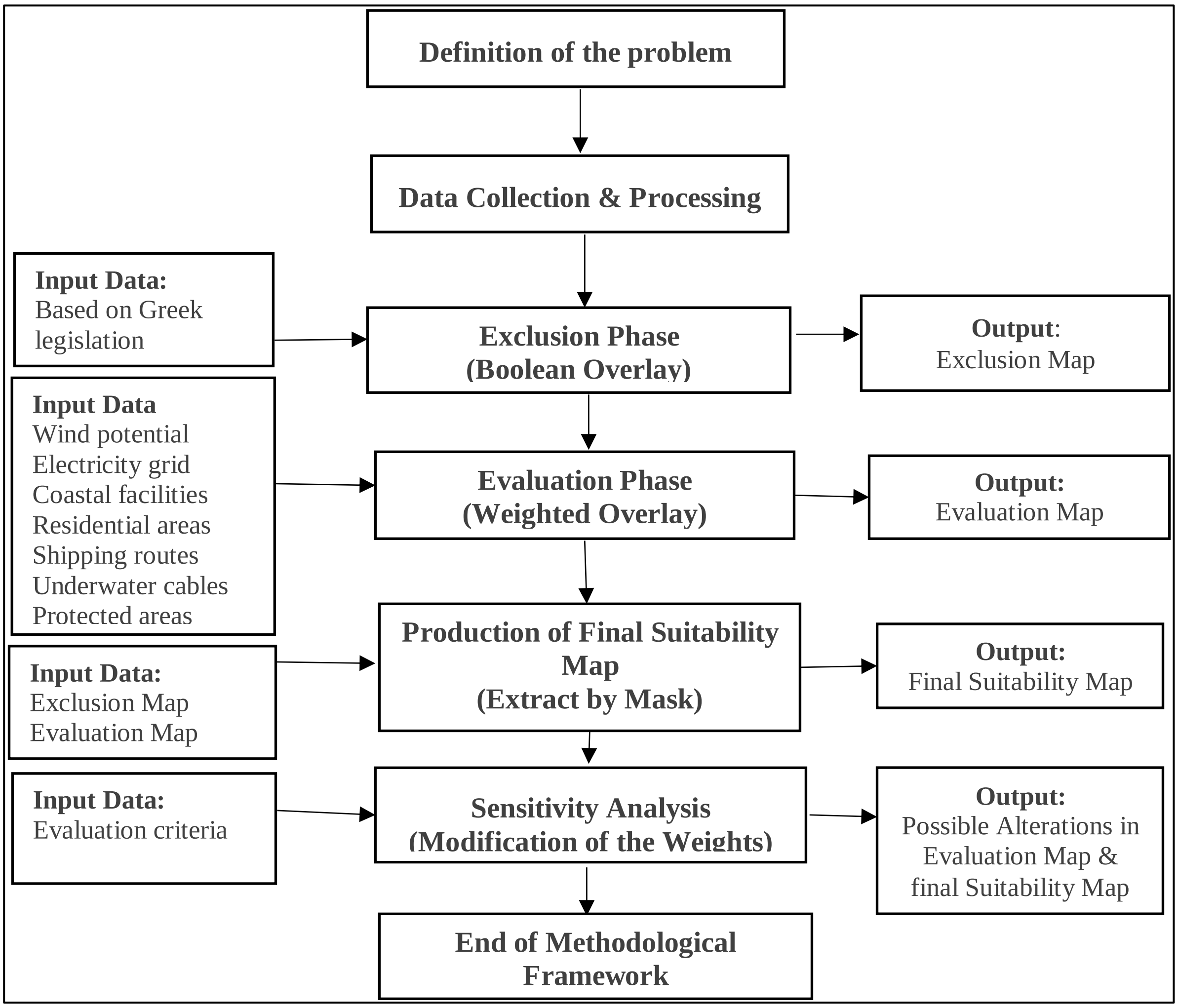

Figure 4: Integrated multi-criteria decision support framework.

- Finally, the distance from protected areas is placed last in order of importance, since the protected areas have already been excluded from the first stage. Similarly here, with the previous criterion, the further away the better for an installation of a wind farm.

After the criteria weights have been estimated, a weighted sum aggregation function is used in order to compute an overall suitability index for each cell of the study area. More specifically, the cell values of each input layer are multiplied by the raster's (criterion) weight (or percent influence). The resulting cell values are added to produce an overall suitability index for each cell. The map cells are ranked from the highest to the lowest score. In GIS, this technique results in an overall evaluation map.

With the application of weighted overlay, the areas derived from first stage of exclusion phase, are finally evaluated. Given that the areas of interest are considered only those, which resulted from the first stage, the exclusion map is used like a "mask" so the final results to be attributed only to interest areas. The results of overlay, except of interest areas, are not taken into account. To be achieved this, the tool extract by mask of spatial analyst will be used. This tool has the ability to extract the cells of the incoming layer (raster), which correspond to the areas that define the mask (ArcGIS Resource Center, 2016).Product of this process is the final suitability map. In the final suitability map the suitable locations will be presented and ranked based on NPV, IRR, DSCR and LLCR, which were described above.

4.4 Sensitivity Analysis

In multi-criteria exercises a "what if" sensitivity analysis is recommended as a means of checking the stability of the results against the subjectivity of the experts judgments (Tegou et al., 2010). The most common method is to modify the weightings obtained from the experts. The assumption of equal weightings is also used for this purpose (Nekhay et al., 2009). In this paper, the sensitivity analysis considers the effect of criteria weights changes upon the overall suitability index. To that aim, the following two cases are examined:

- All criteria have the same weights
- The weights of the criteria "distance from residential areas" and "distance from protected areas" are zero. This is to explore the actual wind potential, without taking into account the particular social and environmental dimension of wind energy.

The integrated multi-criteria decision support framework can be formed in figure 4.

5. Conclusions

This paper presents a theoretical methodological framework for offshore floating wind turbine site selection based on the combination of the multi-criteria analysis and GIS techniques. The objective of the study was to develop an integrated multi-criteria decision support framework for offshore floating wind farm installation, which takes into account the particular features of this innovative application, use the appropriate criteria in the techno-economic, social and environmental level and assess its economic value. The economic value of such a projects is calculated with a discounted cash-flow model. But, due to the different requirements of project developers and lenders additional key figures like the IIR, DSCR and LLCR are taken into account to meet the requirements of all stakeholders.

The pair-wise comparison method in the context of the AHP is used to assign the relative weights to the evaluation criteria, while the GIS establishes the spatial dimension of constraints and evaluation criteria in order to produce the overall suitability map. Also, a sensitivity analysis on the weights of the evaluation criteria is used in order to examine the influence of each criterion in the evaluation of the suitability of site. This paper proves the reliability and the strength of multi-criteria analysis as a means to serve energy planners a clear tool for decision making. Energy planners and scholars may use this methodological framework to determine locations for feasible offshore floating wind farm installation or to use this as a useful guidance.

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Creating Jobs in the Solar Cell Industry - Learning from Developments in Norway and Germany 2001-2015

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Abstract

Several papers have addressed the subject of the development of the solar cell industry, also known as the photovoltaic (PV) industry, in Norway, but they lack discussion of recent developments, other PV technologies, and job creation (Hanson, 2006, Klitkou and Godoe, 2013, Koesah, 2013). With a mixed method approach of text analysis and supplementary interviews, our contribution to this field is to discuss the PV industry's contribution in generating jobs in Norway, by comparing it with the situation of Germany. Mirroring with a country of similar governance, while dissimilar size and energy mix, may uncover learning that has not previously been considered.

Three patterns in the development in the number of PV jobs in Norway are uncovered: a growth (2001-2010), a rapid decline (2010/2011), followed by a new growth (2011-2015). The strategy tripod (Peng et al., 2009) reveals a complex explanation for these patterns. The first pattern shows to, primarily, be a result of prior competence built on the expertise developed historically in the Norwegian metallurgical industry, and contracts with foreign suppliers. The second pattern reflects the Chinese government's incentives, resulting in a price war in the PV market, as the main reason for the decline. The third pattern, which is unlike the German development, reveals, mainly, to be a result of focus on a different technology, in addition to experience from a concentrated part of the value chain supplemented with enthusiasm and community spirit. These explanations go to show that all of the three parts of the strategy tripod, in addition to its combined effects, are necessary for an adequate conclusion of the development of PV jobs in Norway. At the end, the results show several implications for future job creation in the PV industry in Norway.

1. Introduction

Jobs in the solar cell industry, also known as the photovoltaic (PV) industry, might qualify for all the three dimensions in the Triple bottom line: Economic, social and environmental (Carson et al., 2015:191), which is outlined in the debate on corporate social responsibility. The environmental part of PVs should be clear, and reading from the recent developments in the jointly set goals of zero net emissions by the midcentury in COP21 in Paris in 2015 (UNEP and Bloomberg, 2016), there is a social and economic commitment to climate change. This leads to new opportunities for generating jobs in Norway, where the social and economic dimensions of the Triple bottom line would be applied, again, resulting in a strategy for environmental change. This measure should be considered, bearing in mind the decline in the number of jobs in Norway the last couple of years, due to the changes in the oil and gas industry.

Since the current unemployment rate, per 1000 citizens, in Norway is at its highest level since 1993 (SSB, 2016), there is a strong desire to decrease this figure. A number of industries may facilitate this situation, and one strategy would be to learn from the market. The major group making up the high unemployment today, originates from the oil and gas industry, which has seen a declining tendency in both investment and production the last few years compared in percentage against renewables (UNEP and Bloomberg, 2016), while wind and solar have shown the opposite development. In 2015, renewables were the most invested energy sources, growing past oil and gas for the first time. And of these, solar was the greatest.

At one point Norway was one of the leading producers of silicon wafers (IEA PVPS Norway, 2006), which is a part of the PV production value chain, and several PV companies are still in operation. The latter is in contrast with many other European countries, including Germany, making the PV industry in Norway a rare, and even unusual, case. Investigating the explanations for this, in addition to finding possible improvements, may lead to a better understanding of a further growth in the number of jobs in Norway.

In both Norway and Germany, the PV industry has experienced unstable and fluctuating progress. Based on the recent numbers on PV investment, where PVs are most invested among the renewables (UNEP and Bloomberg, 2016), in addition to the historical shift in production shares, it is not expected that it will stabilize yet. The research questions in this paper try to uncover this fluctuation, and find possible explanations and understandings:

How has the number of jobs in the PV industry in Norway developed from 2001-2015? How can we explain this development? What can we learn from the past and from mirroring the Norwegian development with that of Germany?

2. Methodology

The focus in this paper is on the development of number of jobs in the PV industry in Norway, ranging from feedstock, ingot and wafer production, to cell and module production, and the aim is to uncover improvements and lessons for future development. This is in other words, the dependent variable, and is therefore the focus of the study.

Germany is only used as a comparison to the Norwegian development. The reason for this was a wish to find the explanations that may be difficult to uncover when only one case is studied. Using Germany as a mirror to find (unexpected) factors that may have contributed to the development, could be informative. Germany is similar to Norway when it comes to governance and the degree of being an industrialized country. But Germany show differences in size and energy mix. Germany's development in the number of jobs are by that, also subject for research to some extent.

To research these factors, we conducted a testing case study, both qualitative and quantitative, with emphasis on a longitudinal timeline, with the focus on the national level, and with statistical gathering, text analysis, meta-analysis and with supplementary interviews, as research methods. This made up a mixed method, where we conducted the research through triangulation.

The reports used as the main data source in this paper are presented by IEA PVPS, almost annually (IEA PVPS, n.a.). One for each of the 29 member countries, and one report where the data are gathered into one entity. The former is called the National Survey Report of PV Power Applications for Norway/Germany, in this case, and the latter reports are called Annual Reports. For the purpose of the paper and easy recognition, the report authors' names are not used, and are henceforth termed "IEA PVPS Annual" + the applicable year, or "IEA PVPS" + Norway/Germany + the applicable year. As a supplementary source, expert interviews with two persons with extensive insight in the companies' point of view, and in the research and formal institution point of view, were conducted. Referred to as: "Bjørseth, 2016" and "Marstein, 2016". In addition, several papers with similar topics were reviewed.

3. Theory

3.1 Jobs

The main case, and the dependent variable, of the paper is the development in the number of jobs in the PV industry in Norway. The more people that have jobs, the more people are able to pay for products and services from other people that are working. This is known as division of labor, where some workers specialize in particular products or services, while other workers specialize in other products or services (Arntzen, 2009). This is what the economy is built on, and it shows a virtuous circle where the whole system benefits from a growing work force (Reich, 2014).

Gary Higgins has claimed that the right manufacturing industries contribute more to the economy than other sectors are able to do in a developed economy (Heskett, 2012). However, these jobs are normally easier to "steal" by other companies or countries, and they can be termed tradable jobs. The jobs in the defined PV industry in this study, are examples of tradable jobs. The tradeable jobs may add more value per employee (Spence and Hlatshwayo, 2011), and by being closer to the product, strategies towards research and innovation may be easier to implement, adding even more value to the industry. This makes it an important task for the national economy to keep manufacturing jobs within the country.

Jobs in the PV industry can range from manufacturing of materials to operation and maintenance of the main grid. As mentioned, this paper focuses on jobs from manufacturing of materials, cells and modules, namely the upper part of the value chain, which will be addressed with the relative term of the upstream part of the value chain. The focus is on the production part, because this is the part that is, to some extent, independent of whether or not the sales and market grow in the specific country that is studied.

3.2 Strategy tripod

It is a belief that the strategy a firm, an industry or a government conducts will affect the development of the job creation in an industry. That is why Peng et al. (2009) strategy tripod, which includes three aspects of strategies (see figure 1), was chosen. The strategy tripod includes the resource-based view of Barney (1995), the industry-based view of Porter (1980) and the institution-based view of either North (1990) or Scott (2008).

The three theories of the strategy tripod are defined and confined from the time and economic restriction of this study. From the resource-based view, the first three of four parts, which deals with the value, rareness and imitability of a resource of a firm is included. Barney (1995) states that value is closely linked to a firm's use of resources to exploit opportunities and threats, where the competitive environment is of great importance. If the resource can not be said to exploit an environmental opportunity and/or neutralize a threat, thus being valuable, no competitive advantage exists for the firm.

The question of value is the first consideration, and emphasizes that a resource needs to be valuable to even be considered by the next parts of the tool. The next part deals with the rareness of the resources. In this context, rareness means that only a few firms hold control of the resource. The last part deals with the imitability. According to Barney (1995), imitation happens when a competing company produces the same resource or a resource with the same strategic implications. If a company's resource has value and rareness, but is easily imitable, it possesses a competitive parity, but if it is also hard to imitate, it possesses a temporarily competitive advantage.

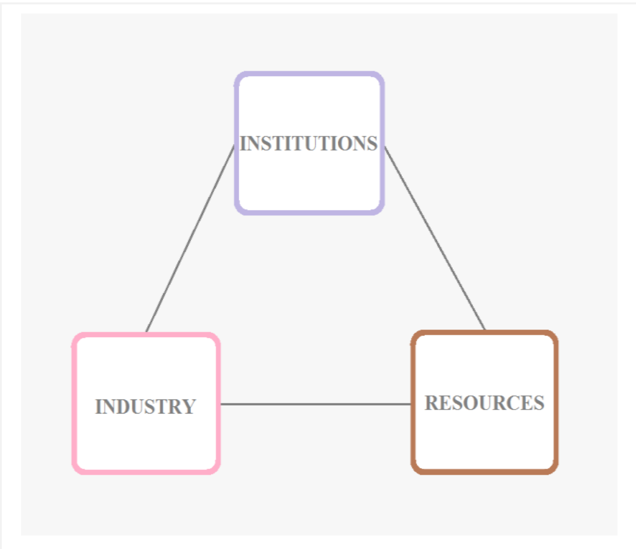


Figure 1: Edited version of Peng et al.'s (2009) strategy tripod.

The industry-based view is an extension of the competitive forces of Porter (1980), namely the Six Forces Model (Hill and Jones, 2013). This tool investigates the competitive structure of an established industry with regards to competitive structure, industry demand, cost conditions and exit barriers (Hill and Jones, 2013). Surrounding the established industry are five other forces that may influence the competitiveness. The first is the risk of new entrants which may be measured by, among others, customer switching costs, governmental regulations and economies of scale. The second and third forces are the bargaining power of suppliers and customers, which may be measured by the relative size and number of firms between the buyer and seller side, switching costs, and the ability of vertical integration. The fourth force is the substitutes that focus on other products or services, but at the same time can provide the same or similar customer needs. If there are many substitutes to choose from, this makes the competitive force high. Complementary products are the last force, and will increase the value of other products. However, the focus in this paper is on the four former mentioned parts of the Six Forces Model.

The institution-based view may be divided in a formal and an informal group (North, 1990), or it may be divided in a regulative, normative and cultural-cognitive pillar (Scott, 2008). Peng et al. (2009) do argument that the regulative falls under the formal, while the normative and cultural-cognitive is a part of the unformal group. In this paper an extended part of the formal institutions is utilized, where both regulations and incentives are included, while the parts concerning culture and ethics from the informal institutions are briefly discussed.

3.3 Technology

The PV technology may be regarded as a resource from the resource-based view of Barney (1995), thus, an attempt to understand the basic principles of the PV technology should be conducted for a strategy study as such.

The sun is the Earth's primary energy source (Chang and Overby, 2011). The degree to which energy is converted to the desired form can be calculated by dividing the actual energy output, in the form of the desired energy form, by the energy input. This results in the term efficiency, which is an important term within PVs.

The sun's radiation can be utilized to make electricity, which is one example of energy conversion. The photoelectric effect is defined as the ejection of electrons from a material that is exposed to light with at least a certain minimum frequency (Chang and Overby, 2011). This utilization of light particles, also called photons, can generate current or voltage, thus giving rise to the phenomenon of the photovoltaic (PV) effect. This can happen in numerous ways, where the use of semiconductors is the abundant method.

There exist 3 or 4 generations of PV technologies, depending on the definition of these. The distinction between these generations is not necessarily apparent, and the grouping is not consistent. While some researchers divide the generations by inorganic, organic and hybrid PVs (Babu et al., 2014), other researchers divide the generations based on a chronological and problem-solving manner (Smets et al., 2015; Jayawardena et al., 2013). Because this paper investigates a development over time, the latter definition of the different PV technological generations is the chosen one. The 3rd and 4th generations are viewed together because there are disagreements regarding what is what, and if there even exists a 4th generation. We have chosen to include it due to the importance of covering all of the aspects in the PV technology.

Crystalline silicon is the most widely used semiconductor in PVs (Office of Energy Efficiency and Renewable Energy, 2013), and is regarded as the traditional component in the 1st generation of PVs. Crystalline silicon wafers are often divided in two groups, namely polycrystalline silicon (p-Si) and monocrystalline silicon (mono-Si). The first mentioned type consists of several crystals, while the last mentioned only consists of one crystal, just as the names imply. p-Si has shown to transform around 21% of the energy from solar radiation, into electricity. Mono-Si is more effective and can transform almost 26% of the energy into electricity (Fraunhofer ISE, 2016:24), but in turn, the production of these cells requires a lot more energy. This is due to the need for cleaner feedstock materials, better control and energy during production.

The product, either it is mono-Si or p-Si, originate from a production of solar grade silicon, also known as silicon feedstock. This needs to be properly pure, depending on either of the two groups. After this, an ingot is produced, which is a block of pure silicon. Last, the wafers are cut out of this, which can be seen as thin slices of silicon, before cells are put together into modules.

The development of 2nd generation of PVs began due to the wish to produce PVs at a lower cost, but in return, they have lower efficiency (Jayawardena et al., 2013). The 2nd generation PV focused on using less material, and less energy for production, lowering cost per watt and the time needed for the PV to generate the same amount of energy. The semiconductors in 2nd generation PVs are thin films, making them flexible, and are mainly based on amorphous silicon (a-Si), Cadmium Telluride (CdTe), Copper Indium Selenide (CIS) and Copper Indium Gallium Selenide (CIGS).

With 3rd generation PVs, the goal is to utilize a larger part of the radiation from the sun, thus giving higher efficiency pr. m2, and to lower the cost of production at the same time (Jayawardena et al., 2013). 3rd generation PVs are also based on semiconductors. From this, the 3rd generation of PVs are comprised of the utilization of, among other, Titanium dioxide nanoparticles, quantum dots, nanocrystalline films, perovskite, spectral conversion and multi-junction, including organic materials (polymers) and dye-sensitized solar cells (DSSC). Jayawardena et al. (2013) also include 4th generation PVs in the division of PV generations, which aims at taking advantage of the low cost and flexibility of thin films, in addition to the stability of inorganic nanostructures.

4. Results

Three patterns in the Norwegian development of jobs in the PV industry were found. A growing start from 2001 to 2010 (pattern 1), followed by a rapid decline in 2010/11 (pattern 2), and a more recent growth again from 2011 to 2014 (pattern 3), which may be seen in figure 2. This answers the first research question of how the Norwegian development in the number of jobs in the PV industry has been evolving. Is the German development similar?

From figure 2 it is apparent that the development of the PV industry in Germany showed a similar growth as pattern 1. The decline in pattern 2 could also be seen for Germany, but it was not until 2011 it began, and the Norwegian job crisis in the PV industry was more dramatic. Pattern 3 reveals the largest difference in the two countries' PV job development, namely an opposite development. Germany's number of jobs in the PV industry has kept on decreasing since 2011. The strategy tripod seeks to discover the explanations for this development, thus answering the next research question.

This is done in a chronological manner where each pattern is studied one by one. Some explaining factors are only mentioned, this is due to the necessity to keep the paper short.

4.1 Pattern 1

The growing market, especially from Japan and Germany (Smets et. al, 20115), and with that, low entry barriers, from Porter (1980), opened up doors for new companies to emerge. This made it possible for Norway to be a part of this growing industry. After several R&D collaborations, which may be seen as a form of institution from Scott (2008) and North (1990), within the country, across borders in Europe and in the rest of the world, more competence was shared (IEA PVPS Norway, 2001-2010). The technology of 1st generation of PVs may have contributed to the growth in both countries. This was possible due to the dominance of this technology at the time, which has been claimed to originate from the already constructed knowledge and experience base from the use of silicon in electronics worldwide (Goetzberger et al., 2003, referred in Hanson, J., 2006).

The use of p-Si in the beginning, however, may have been a result of the timing of the rapid growth of the PV market, where, among others, Germany had been a huge contributor. The German government's timing of the market incentives may have resulted in the choice of p-Si, where the p-Si was the technology that was developed most, in both efficiency and cost at that time (Fraunhofer ISE, 2016:18-19), making this the most valuable of the technologies, from Barney (1995). If these market incentives had been conducted at a different point of time, we could have seen another dominant technology today,

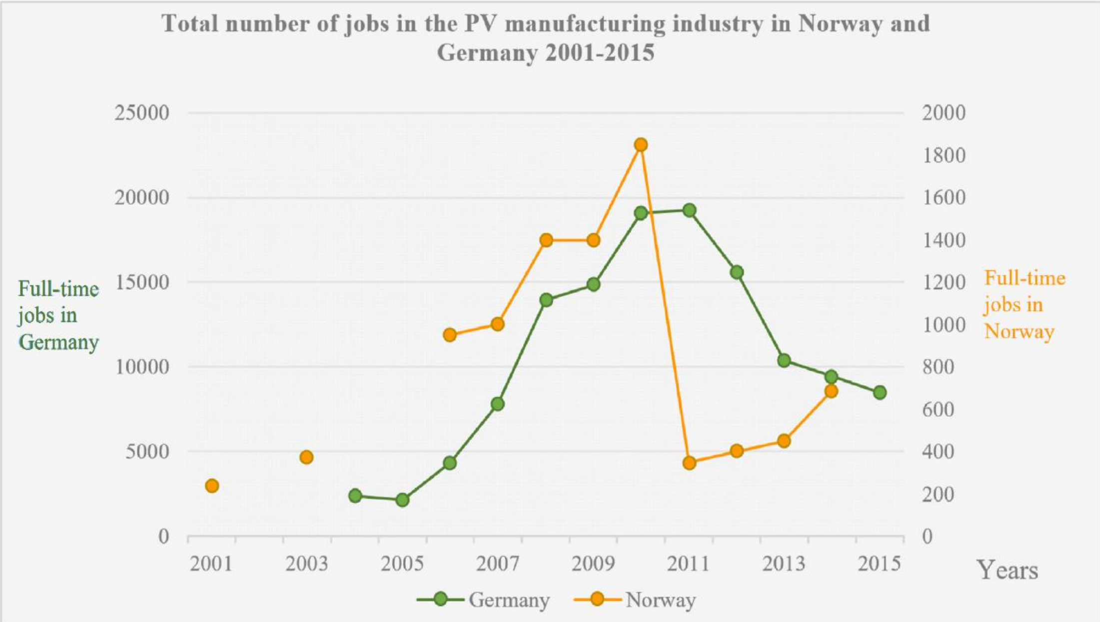


Figure 2: A comparable representation of the job development in the PV industry in Norway (orange) and Germany (green). The numbers represent the jobs in the PV companies, not including public PV R&D jobs. Source: IEA PVPS Norway 2001-2014, IEA PVPS Annual 2004-2015 and GTAI 2004-2015

making the timing evaluation apparent (Peng et al., 2009). This shows the correlation between resources, institutions and market, in addition to timing, in the choice of technology, and may have enabled for a growth in both countries.

This technology made it even easier for an entrance of new companies, easing the way in for Norway, due to the competence and knowledge from the metallurgic industry (Bjørseth, 2016), and from silicon production (IEA PVPS Norway, 2010), in addition to less costly energy prices for production in the country (Stokkan, 2015). Additionally, Norway had invested in R&D projects as far back as the oil crisis in the 1970s, resulting in early knowledge and competence within the PV field (Klitkou and Godoe, 2013). Furthermore, public incentives in areas subject to earlier factory closures and rural districts from the government and from Hydro (Tvedt, 2013; Klitkou and Godoe, 2013) may have helped facilitate, not only a better economy for the operation of the factories, but also enthusiasm and community spirit in the local communities, due to new job creation. All of these factors show Norway's advantages for an entrance in to the PV industry and for growth. The fast growth however, was primarily a result of the companies' contracts and acquisitions of foreign suppliers of silicon, creating a secure supply, which was an important strategic advantage in times of silicon deficiencies (Bjørseth, 2016). This shows the importance of all of the three theories of the strategy tripod, in particular the industry-based view, for the growth of pattern 1.

4.2 Pattern 2

For pattern 2, the main reason for the decline in both countries, was the rapid expansion of the Chinese manufacturers. The Chinese government's incentives and loans to its producers resulted in artificially low prices and extreme price wars in the PV industry (IEA PVPS Norway, 2011). With low switching costs and economies of scale, from Porter (1980), the Chinese manufacturers could grow even bigger. However, this was not a favorable situation for China in the long run either. Minimum Import Price (MIP) with the EU and antidumping-tariffs with the US, together with non-competitive prices, lowered the profits, increased the debt and resulted in a negative lock-in for many of the Chinese PV manufacturers (Meza, 2013). The financial crisis could also have assisted the process. Many PV producers, not only in Norway and Germany, experienced tough times in this period.

The rapid decline in the number of jobs in Norway, compared to Germany, could be a result of lack of innovation, quality (Bjørseth, 2016), and the main choice of technology in Norway, namely 1st generation PVs, and of that, p-Si, which resulted in a weak p-Si lock-in. Germany had been producing both 1st and 2nd generation PVs (see figure 3 and 4), thus differentiating the risk of decline on two technological generations. The 1st generation of PV technology was at one point necessary for Norway to enter the industry and market, but it may have showed a less dramatic decline if p-Si gradually had been replaced by mono-Si at an earlier stage. This can be stated due to the ongoing production of mono-Si through the slump. Even though this production was negatively affected as well, this was only to a small degree and at a slower pace, compared to the p-Si decline.

Not only did Germany differentiate in technology, but also in several parts of the value chain, and among a large number of companies (IEA PVPS Norway and Germany, 2001-2014). This made the country more resistant towards changes in the market and industry, resulting in a slow decline in the number of jobs, in contrast with Norway. This shows a learning from the German development.

Norway had few (although some large) companies, where REC used a lot of resources building a cell and module factory in Singapore in 2005 (Ceccaroli, 2012). A lot of money was invested in this new factory, and many Norwegian workers travelled to teach the new employees their knowledge and competence. This has, seen in retrospect, led to REC surviving the sudden price reduction, and may have contributed to an even bigger growth in the PV market. However, seen in the light of the Norwegian workforce at that time, this was not a positive strategy, where much of the competitive advantage of REC in Norway were lost. This may have troubled the outcome for the Norwegian company of REC, and for the outcome of the whole PV industry in the country in this period, seen together, due to the small number of firms.

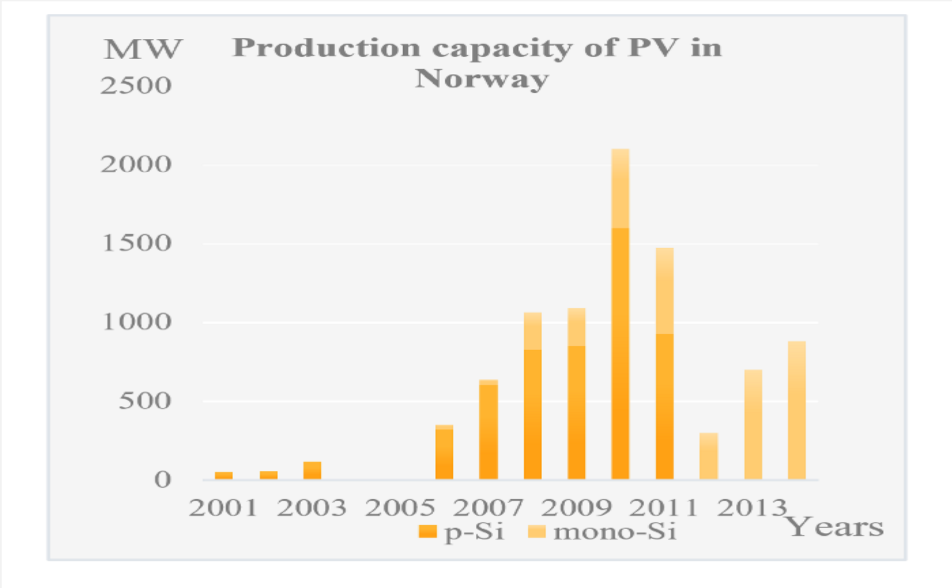
The capital tax may be a reason for the slow-down of the growth of jobs in the PV industry in Norway, and even the reversing, especially for new establishments (Bjørseth, 2016). In addition, too few industry-aimed incentives may have resulted in companies establishing in other countries instead. Marstein (2016) wish for a Norwegian government that is more industry friendly. These institutions, and lack thereof, may have been contributing factors to a decline in Norway. As can be understood, the situation of industry-aimed incentives is completely opposite in Norway compared to China. For both countries, however, it resulted in a negative lock-in of some sort, namely a decline in the production or in profits.

4.3 Pattern 3

Our data revealed that the growth in the Norwegian PV industry today is mainly a result of a shift towards mono-Si (see figure 3) and more experience in production (Bjørseth, 2016). The less costly electricity and abundance of water for cooling, reduces the imitability (Barney, 1995), thus increasing the competitive advantage of producing mono-Si in Norway, as well as making the product more environmentally friendly. The latter may be regarded as an informal institution, where an environmentally friendly product may show to have some advantages in regards to ethics in today’s market. The Chinese PV products have a higher carbon footprint than the European PVs (Yue et al., 2014).

In addition, a concentration around a small and competitive advantageous part of the value chain, may explain a further growth of the PV industry in Norway today. More and more of the production has been focused around feedstock, ingots and wafer the last few years (IEA PVPS Norway 2001-2014). Concentrating the organization of the firm around one part can make the company’s operation more susceptible to fluctuation and changes, but may also give opportunities in the form of more flexibility due to less tied up resources and assets, in addition to less bureaucratic costs (Hill and Jones, 2013). This may be a reason for the Norwegian industry still growing, giving rise to further job creation, namely that the country has found the part of the value chain that can have competitive advantage in this country.

However, caution needs to be taken to prevent a decline due to a low differentiation, as may have been the case for pattern 2.



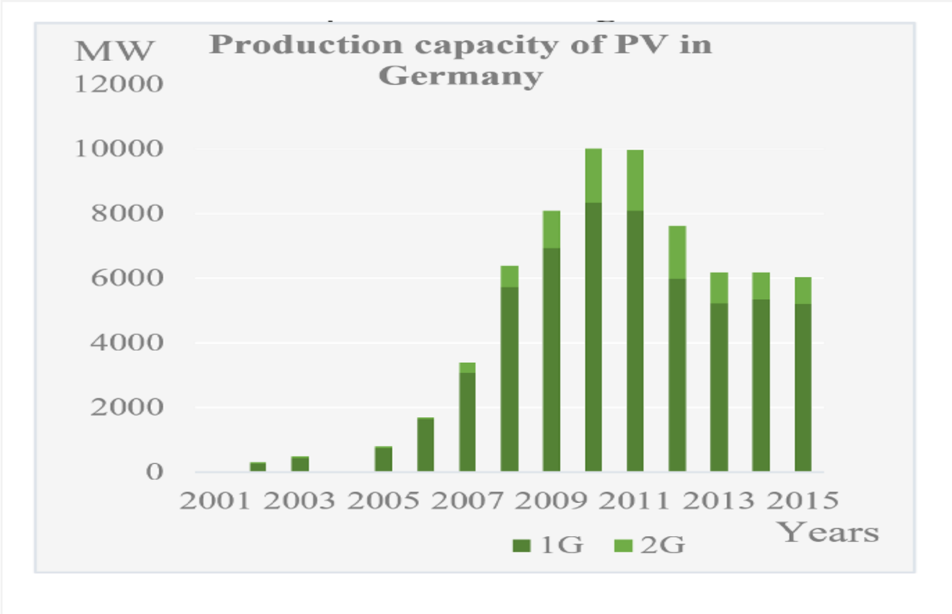


Figure 3 and 4: The production of PV in Norway (orange) from 2001 to 2014. Only 1st generation technology has been produced, and the division for each year has been made on p-si or mono-si. The production capacity of PV in Germany (green) from 2001 to 2015. Both 1st (1G) and 2nd generation (2G) have been produced. (IEA PVPS Norway/Germany 2001-2014).

Looking at figure 2, both Norway and Germany witnessed a turn in 2013, where Norway's number of jobs increased even more, and Germany's number of jobs decreased less. This may be a result of the introduction of the MIP this year. This was an agreement between the EU and the Chinese government in an attempt to stop the over-subsidies and resulting price dumping of PVs from China (Fuhs, 2015). The effects of the MIP have been shown to be hard to estimate. It has been stated that this regulation, in many ways, only favor the module producers in Europe (Fuhs, 2015), and in 2015 a review of whether to keep it or not started (Cuff, 2015). From these discussions it is difficult to conclude on its effect for the PV producers in Norway and Germany, but the possibility of such an impact exists, especially for the module producers.

The PV R&D funding was growing through the slump/pattern 2 (IEA PVPS Norway, 2008-2014), and may have been important for the growth we see today, where there must be expected a delay in the effect of such a strategy towards R&D. The decrease in the number of jobs in the PV R&D area in 2013 and 2014 is therefore not promising for the future. The internal R&D in the companies may however have increased, but this is difficult to say anything specific about, without access to their numbers.

In 2009, The Norwegian Research Centre for Solar Cell Technology was established, a collaboration between PV companies and research institutions. This center has been an important institution, and according to Marstein (2016), all of the Norwegian companies currently participating in the center have been working in at least one innovation project based on, among other things, knowledge and competence from the center, in parallel with the center. This indicates the center's importance in innovations in R&D in the PV industry in Norway. This technological development is essential for gaining competitive advantage and profitability, says Bjørseth (2016). This formal institution has been important, and may be a vital factor in the technology choice in Norway now, and in the future, thus influencing the resources of the firm.

Why has Germany not witnessed the same growth? IEA's (2015b) report stated that all countries in Europe have experienced a decrease in the number of jobs in the PV sector from 2011 to 2014, except for the UK. This report deals with the entire value chain from the upstream activities like feedstock production, cells and modules, to the downstream activities like administration, installation and maintenance. Germany is no exception to this decrease, but from 2013 to 2014, the number of jobs in the entire PV sector actually increased in the country (GTAI, 2014). Knowing that the PV manufacturing industry at that time, was still decreasing, from figure 2, this increase should therefore be expected to originate from another part of the value chain. During 2000s, Germany's focus in the PV sector has been on cell and module production, which has given the biggest contribution to the production capacity (IEA PVPS Germany, 2001-2015). In 2014, however, Balance of System (BoS), which is production of contact, switches, circuits, etc. for the PVs, gave the biggest contribution to the PV sector (IEA, 2015b). The jobs have moved downstream in the value chain.

This may be a mixed result of the market situation in the country and prior experience. Germany has a significant PV market, even though decreasing, making it possible to move the jobs to a more secure part of the value chain, namely downstream. This may be due to the volatile nature of the PV industry through the years, together with past experience in China taking over industry jobs, for instance in magnesium and rare earth element production (Bjørseth, 2016).

In the downstream part however, it may be more difficult for the Chinese to take over. Norway has not had the possibility to move the jobs downstream, due to a small domestic PV market.

The lack of a domestic market, together with a high community spirit (Bjørseth, 2016), may have resulted in the ongoing growth of the upstream part of the value chain today. The district-aimed incentives, mentioned for pattern 1, resulted in an ongoing growth of jobs for the local communities, which again kept the community spirit and enthusiasm up and running. These two factors together, originating from the formal and informal institutions of North (1990), respectively, may have shown to be important factors for Norway's all-over survival in the PV-industry. The community spirit was not sufficient to withstand the price war, resulting in pattern 2, but together with a shift in the PV technology, among others, the community spirit helped facilitate a new growth in the PV industry in Norway.

The explanations for the three patterns of the development in the number of jobs in the PV industry in Norway have been summarized in figure 5. Some parts have only been mentioned, and some parts have been described more in detail. This was a result of an evaluation based on each of the explanations importance for the development.

5. Policy implications

Knowing that China was the biggest contributor to the global renewable investment in 2015 (UNEP and Bloomberg, 2016), in addition to the country's great market growth and industry growth (Smets et al., 2015), Norway and Germany should keep on paying close attention to this country, in addition to other emerging countries. India, for instance, is emerging, and may be an important competitor in the years to come (IEA, 2015a), especially considering the population size of India. It is difficult to compete with these countries when it comes to price. Innovation and uniqueness should be key factors in the production facilities in Norway, as it has been the last few years. However, IEA (2015b) went as far as advising the European countries to focus on creating jobs in the downstream part of the PV sector, just as Germany has done. This may be possible in Norway as well, as we have seen the market growing slightly the last couple of years. In addition, expanding the operation in PV markets in emerging countries, like Scatec Solar has done, is a good example of creating more jobs in this part of the value chain of PVs. An even more expanding market would also benefit the Norwegian PV producers.

Germany has increased its industry by increasing the market, not only by creating a positive culture from the informal institutions of North (1990), but also by actually creating customers of a relatively small market at that time (IEA PVPS Germany, 2001-2014). Norway is too small, and too late to do this with the same impact, but it is still possible for the government to steer the choice of technology. The small market in Norway today may be an unused resource that can be utilized in direction steering the technology development. By utilizing formal institutions in the form of incentives towards technology specific PVs in the growing Norwegian market, a door towards technology development can show to open. Focusing R&D towards growth of a new, industrialized, and superior 3rd or 4th generation PV could not only lead to a more differentiated production, learning from the rapid decline in the past, but it could also lead to a growth in the job creation in the farthest downstream part of the value chain, learning from Germany's early growth. If Norway manages to stay at the forefront in the production, it can lead to a promising future for Norway's PV industry. Bjørseth (2016) specifies that a radical innovative PV technology can be difficult to penetrate into the established PV market today.

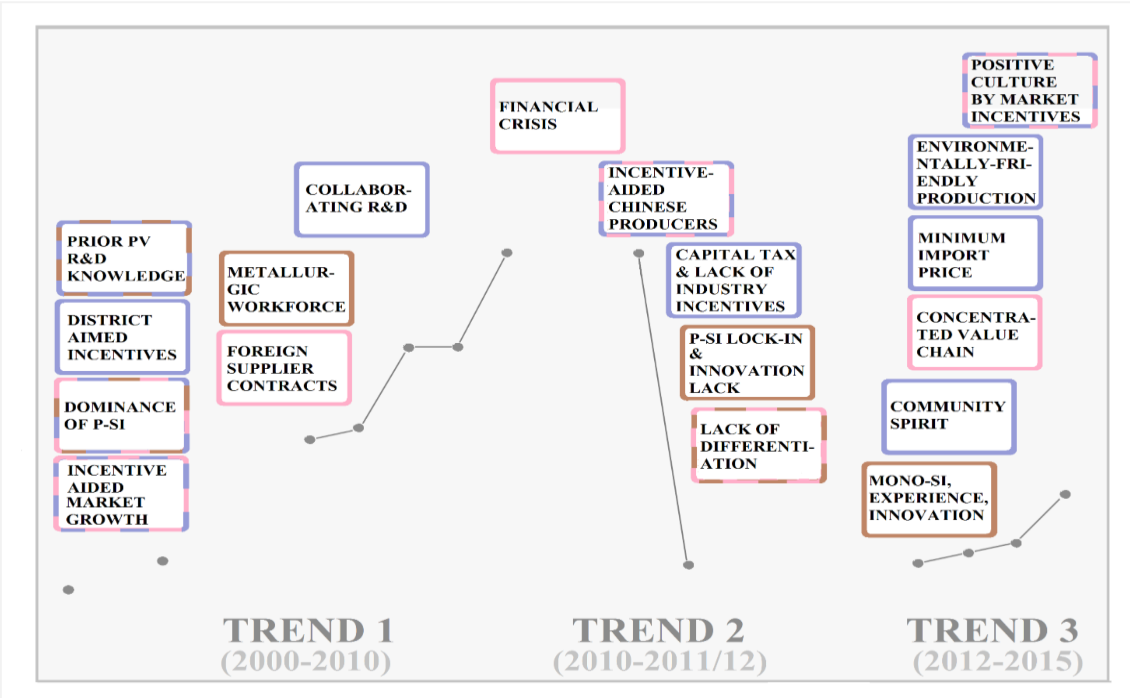


Figure 5: A summary of the results. The development of the number of jobs in Norway is the graph that is presented, where it has been divided concerning the three patterns in an attempt to visualize the results. The brown color represents the resources, the pink represents the industry, while the purple represents the institutions. Some boxes have several colors, meaning the results originate from combined effects of the strategy tripod.

Marstein (2016) agrees with this. However, a collaborative strategy like the above mentioned, could show to ease this entry. After all, the market is generally acknowledged to be one of the biggest contributors to innovation (Klitkou and Godoe, 2013), and several examples of penetrating an established market, or disruption, has been proved before (Tushman and Rosenkopf, 1992, and Bower and Christensen, 1995).

6. Conclusion

As the discussion, has shown, the development of the jobs in the PV industry in Norway has shown in particular, three main patterns. A growing start (pattern 1), followed by a rapid decline (pattern 2), and a more recent growth again (pattern 3).

For pattern 1, the growing market, due to Germany, among others, represented low entry barriers, resulting in a possible emergence of a Norwegian PV industry. The competence and knowledge from a former metallurgic industry, from silicon production and from early PV R&D were a good combination with the p-Si dominance at that time. In addition, district-aimed incentives were important for growth. The relatively rapid growth, however, showed to be a result of contracts with foreign suppliers. For pattern 1, both the resource- and the institution-based view were important for finding explanations for the growth, but the industry-based view was particularly essential.

Pattern 2 showed a rapid decline in Norway. The Chinese government's subsidies and loans to its companies took advantage of the fragmented industry, and this was presented as the primary reason for this development. A weak p-Si lock-in, with resulting lack of innovation, quality and uniqueness, capital tax, lack of industry-aimed incentives, and the financial crisis were also mentioned as explanations. The reason for the rapid decline in Norway, compared to Germany was claimed to be because of a lack of differentiation in technology generation, and within the 1st generation of PVs, and in the number of firms. For pattern 2, the industry-based view revealed the primary reason for the decline, but the resource-based view was also important.

For pattern 3, a focus on a less imitable technology, in the form of mono-Si, that Norway has several years of experience from producing, is claimed to be an essential explanation for the growth we see today. With this, it has been possible to focus on quality, innovation, competence and efficiency in production, which may also be a result of R&D collaborations. The Norwegian community spirit may have contributed as well, in regards to not giving up, as Germany may have done due to former experiences in loss of tradable jobs and the possibility of moving downstream in the value chain. These mentioned factors may explain the growth in Norway, and why Germany is not growing. The concentrated part of the value chain is another strength. In addition to this, the MIP may have improved the conditions for manufacturers. From pattern 3 it was clear that the industry- and the institution-based views showed some explanations for the recent growth, but that the resource-based view presented the primary explanation.

Together, the three theories of the strategy tripod have been able to uncover the explanations for the development of the number of jobs in the PV industry in Norway, where the case of Germany has helped reveal new explanations within the strategy tripod.

The third and last part of the research questions did also open up for a discussion on taking learning from the past and from Germany in order to better the conditions for job creation in the PV industry in the future for Norway. The tripod tool has shown that today, the market is characterized by a predominance of 1st generation PVs, but we have also seen that this has been shifting due to an unstable industry through the years. Even though it has been claimed that penetrating the industry with a new technological generation may be difficult in the relatively mature market today, it is not unthinkable. Several examples from other industries have shown this possible. This makes it very important for the Norwegian PV industry to focus on other technologies than 1st generation as well. The lack of a PV market in Norway could be a unique possibility. Expanding the market in Norway, may create jobs in the downstream part of the value chain, but it may also create possibilities for incentive-aided technology development, in favor of new 3rd and 4th generation technologies.

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Feasibility assessment of geothermal pellet production from agricultural residues in medium-sized municipality in north Greece

by

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Abstract

Municipalities hold a key role in the transition towards low carbon economy. Biomass is considered as the most common RES that is widely available. However, it is accompanied by exploitation disadvantages such as low energy content, high dispersion, high moisture content and heterogeneity. Biomass pellets have gained considerable interest due to the increased quality of fuel, their use in highly automated heating systems and their wide application range. The utilization of residual biomass from the agricultural and the agro-industrial sector does not face environmental issues, as well as other issues related to competitive uses of biomass.

This paper investigates the techno-economic feasibility of pellet production from agricultural residues in Municipality of Alexandroupolis (MoA), utilizing low-enthalpy geothermal energy. The biomass potential from agricultural residues has been calculated and assessed and proved to be a challenging process that entails significant assumptions due to lack of available data. A drying system utilizing the locally available low enthalpy geothermal energy is proposed and results in significant costs reduction. A geothermal pellet production unit of 1,2 t/h covers the heating needs of 50 municipal buildings and results in 1.392 tCO_2/y reduction. The pellet production cost breakdown highlights the significant importance of the raw materials (31%), as well as the pelletizing process (13%). A sensitivity analysis has been performed pinpointing the importance of maintenance and personnel costs, as well as raw material costs. The study concludes in financial sustainability of the pellet production unit, with IRR over 10% and payback period at 8,2 years.

1. Introduction

Biomass is considered as the most common Renewable Energy Source (RES) that is widely available. Biomass utilisation is strongly promoted by the EU policy for climate change mitigation, energy security and green growth. However, it is accompanied by exploitation disadvantages that arise from the low energy density, the high dispersion, the high moisture content and the heterogeneity. The issues of conventional utilisation of biomass are reduced by the use of biomass pellets, which are characterized by stable quality, high level of automation in their use in heating systems and wide application range. All types of biomass (ligno-cellulose, herbaceous, putrescible, other) are suitable for pellet production. Nevertheless, the utilisation of residual forms of biomass, that can be obtained from the agricultural and the agro-industrial sector, does not face environmental issues that might arise from the sustainable energy use, as well as other issues related to competitive uses (e.g. food) of biomass.

This paper investigates the technical biomass potential from agricultural residues of the region of MoA and assesses techno-economically the development of an innovative geothermal pellet production plant for self-consumption of pellets in municipal buildings of Alexandroupolis, Greece. In order to estimate the biomass potential, the available cropland data from Greek Statistics Authority (ELSTAT) and Payment and Control Agency for Guidance and Guarantee Community Aid (OPEKEPE) are utilised. The proposed pellet production plant is dimensioned according to the heating demand of fifty (50) municipal buildings and is assessed in respect to the economic feasibility for the Municipality of Alexandroupolis.

The purpose of this research project is identified on the commitments of the MoA to reduce its carbon footprint by 20% by 2020, as stated in its Sustainable Energy Action Plan (SEAP) submitted in the Covenant of Mayors initiative. The development of the proposed pellet production plant is projected to significantly contribute to the primary energy saving targets of MoA and particularly the reduction of heating oil consumption. According to the latest update of MoA's SEAP (MoA, 2013), the heating oil consumption of all municipal buildings in 2013 was 560,000 lt comprising a significant portion of the overall municipal carbon footprint and holding an important energy, expenditure and CO_2 saving potential.

In 2010, biomass was responsible for approximately 62% of the renewable energy generation in European Union (Szabo M. et al., 2011). This percentage is expected to be reduced to 57% by 2020 with simultaneous increase of the absolute value of energy generation from 3,600 PJ (2010) to 5,900 PJ (2020) (Szabo M. et al., 2011). The European Policy to support the energy utilisation of biomass is depicted in European Directive 2009/28/EC. European Commission (EC) also recognizes the need to support the efficient and sustainable utilisation of biomass for energy generation. In 2014, the EC published a report on the sustainability of the energy utilisation of biomass that include all actions the EC is going to adopt in order to increase the advantages of biomass utilisation avoiding the environmental consequences (European Commission, 2014). The sustainability issue of energy utilisation of biomass is still under investigation, as shown by a recent tender issued by BirdLife Europe for the study "Potential and implications of using biomass for energy in the EU". Additionally, the competitive uses of biomass and the need for sustainable utilisation are highly discussed in the Bioeconomy Strategy included in EC report "Innovating for Sustainable Growth: A Bioeconomy for Europe".

2. Biomass potential of Municipality of Alexandroupolis

The first step to achieve sustainable development is the adaptation of people to consume the actually existing natural sources of the earth. In the context of sustainability requirements, there are significant differences in respect to the world biomass potential. According to the International Energy Agency and its report "Potential Contribution of Bioenergy to the World's Future Energy Demand", the long-term bioenergy potential from the available areas of the earth (by 2050) is from 50 to 1100 EJ/year (IEA, 2007). However, several studies conclude to significantly different results, highlighting the importance of sustainable energy utilisation of biomass (European Commission, 2014).

According to the specific report for Greece of the program EUBIONET (EUBIONET, 2003), the estimation of available biomass from agricultural residues is based on production data of each cultivation using a specific residue per product ratio. The report concludes that the available biomass is approximately 3.8 mi t (dry matter) per annum. Another report investigates the potential energy utilisation of olive pruning and estimates the annual average pruning production for Greece at approximately 1,6 mi t, which is mostly found in Peloponnese (30.14%) and Crete (22.85%) regions (Elaiourgiki S.A., 2007). Several studies have also been elaborated for the estimation of the biomass potential of the region of Crete (Tzineurakis M., et al., NTUA, 1993, IMPAX SA, 1998). As far as the region of interest is concerned, a study developed on behalf of joint prefecture Rodopi – Evros estimates the annual agricultural biomass potential of the Municipality of Alexandroupolis at 118,329 t developed in 296,033,000 m^2 of cultivated land. Additionally, this study concludes that the biomass potential from industrial agricultural residues is very low and does not take into consideration the biomass potential from residues of local wood industries.

3. Methodological approach

The methodological approach for the quantitative and qualitative estimation of the biomass potential of MoA adopted in this project includes four stages. The first stage includes the recognition of the available biomass for the production of pellets and highlights the categories and the types of biomass that could be used as raw material for the production of quality pellets according to the European Standard EN 14961. Second stage includes the collection and processing of the available data of biomass production for each type of biomass recognized in stage one and specifically for the region of interest (MoA). In this stage the theoretical biomass potential that includes realistic assumptions for the energy content of the available biomass through analysis of its physic-chemical characteristics of each biomass type (higher heating value, moisture, ass, etc), is estimated. The third stage includes the estimation of the theoretically available biomass potential that entails several local technical and environmental restrictions (soil morphology, competitive uses, etc), as well as restrictions that arise from the logistics of the biomass agricultural residues (collection, transportation, storage, etc). The fourth stage includes the estimation of the technical biomass potential for the region of MoA that is defined as the energy content of the produced biomass pellets from the proposed municipal pellet production plant according to the theoretically available biomass potential, the technical restrictions and the efficiency factors of the production processes.

4. Estimation of MoA's biomass potential

The estimation of biomass potential of the Municipality of Alexandroupolis follows the above-described methodological approach. The categories recognized consist of ligno-cellulose and herbaceous biomass that is considered suitable for biomass pellet production. The types of biomass of theses categories include forest biomass, biomass from cultivation of trees and agro-industrial residues, as well as agricultural biomass of annual crops. In order to estimate the biomass potential of these categories within the administrative boarders of MoA, this study utilises the available statistical data from 2005 to 2011 of the Agricultural Statistical Report of the Ministry of Agricultural Development produced by ELSTAT (Elstat, 2015). The available data include the cultivated area and the annual crop production in MoA. Additionally, this study utilises the available data from OPEKEPE (OPEKEPE, 2015). The study takes into consideration average values of the available data in order to minimize the influence of production factors, such as climatological conditions and the Common Agricultural Policy (CAP).

Forest biomass, as well as biomass from industrial residues, are neglected within this study due to the very small contribution to the overall biomass potential of MoA. Nevertheless, it has to be mentioned that the future utilisation of forest biomass is significant and enhances the security of raw biomass supply for the proposed municipal pellet production plant, in case of favorable change of the Greek legislation.

The agricultural ligno-cellulosic biomass is an important source of energy mostly in the Mediterranean region of Southern Europe (Bioenarea, 2015) where crops such as olive groves and vineyards are extremely common. It consists of two types of residues; the pruning residues and the uprooting residues. According to the available data of OPEKEPE (OPEKEPE, 2015) the tree cultivation within MoA includes olive trees and vineyards, as it is the case in the Mediterranean region. The total area in 2011 was 3,217.19 ha, in 2012 3,179.19 ha and in 2013 3,169.57 ha. Table 1 presents the available data in crop production by the tree cultivation in MoA, as provided by ELSTAT (ELSTAT, 2015). In order to estimate the theoretical biomass potential of the second stage of the methodological approach, a residue per product ratio (RPR) is utilised for each type of tree (Faaij et al., 1997, Borjesson, 1996). Besides RPR ratio, it is possible to use a residue per cultivated area ratio (Voivontas et al., 2001) or a residue per tree ratio (Esteban et al.). However, since the values of theses ratios are strongly related to the geographical position, the climatological conditions and the specific type of tree cultivation, their selection is significant in order to obtain reliable and realistic theoretical biomass potential results. As shown in table 1, olive trees provide with approximately 75% of the theoretical agricultural ligno-cellulosic biomass potential originating from pruning residues in the Municipality of Alexandroupolis.

In order to calculate the theoretically available agricultural lingo-cellulosic biomass potential of MoA, this study takes into consideration technical and environmental limitation factors, such the competitive use of big pruning from olive trees in fire places. Other limitation factors include the location accessibility (for collection) and the stages of the supply chain of pellet production. The availability of different types of pruning in different stages of the supply chain is presented in table 2. By employing these factors, the theoretically available biomass potential from tree cultivation residues (pruning residues) in MoA is estimated at 1,671.45 t/year or 59,914.54 GJ/year (table 3).

Herbaceous biomass, a very significant raw biomass energy source of the future, is divided into two basic categories; the agricultural residues and the energy crops. The agricultural residues refer to the parts of the crop cultivation that are not harvested during the agricultural operation and therefore are left on the field since they do not have any nutritional value for humans and their application in the production process of other competitive products (e.g. paper or animal feed) is fairly limited (Bioenarea, 2015). Similarly to other studies, the estimation of the herbaceous biomass potential of MoA follows the above presented methodological approach (Biomasspolicies, 2015). However, the collection of real data of residues' production by agricultural cultivation of a specific area and the extrapolation to the area of interest has often been used (Gemtos, 2006). Nevertheless, this method requires significant effort and time and it is characterized by the low quality of the collected data. According to the available data of OPEKEPE and ELSTAT, the annual crop cultivations which are located in the area of MoA and constitute potential raw biomass for pellet production are the soft and hard wheat, the oat, the tobacco, the cotton, the sunflower, the rice and the maize. The theoretical herbaceous biomass potential is estimated utilizing specific residue per product ratio for each annual crop (Vlyssides et al.) (table 4).

Table 1: Available raw biomass from pruning residues in Municipality of Alexandroupolis.

Tree Cultivation	Cultivated area (ha) (AVE of 2011, 2012, 2013) OPEKEPE, 2015	Residue per product ratio Altener, 2003	Production in kg (AVE of 2005-2011) ELSTAT,2015	Moisture % EUBIONET, 2003	Biomass of pruning residues dry t/yr	Higher Heating Value of pruning Dry MJ/kg	Theoretical Biomass Potential of pruning residues Dry GJ/yr
Olive	1,240.47	0.98	3,713,402.00	35%	2,462.97	18.10	44,579.77
Almond	22.09	0.28	116,663.14	40%	249.99	18.40	4,599.86
Walnut	84.79	1.9	220,412.57	40%	249.52	19.28	4,810.82
Pear	6.12	1.26	103,762.57	40%	49.41	19.30	953.63
Apple	3.18	1.20	117,627.86	40%	58.81	17.80	1,046.89
Peach	3.30	2.51	41,468.57	40%	9.91	19.40	192.31
Vineyard	39.52	1.20	371,174.17	45%	170.12	18.90	3,215.30
Apricot	3.88	2.84	65,799.29	40%	13.90	19.30	268.29
Cherry	6.26	1.2	28,145.43	40%	14.07	17.60	247.68
TOTAL					3,278.72		59,914.54

Table 2: Availability of different type of raw biomass at different stages of the biomass supply chain (Boukis et al., 2009).

Type of raw biomass	Performance of each supply chain stage (%)					Total availability (%)
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	
Olive tree pruning	95	80	95	95	95	65.16
Residues from olive pomace	95	100	95	95	100	68.59
Vineyards pruning	95	90	95	95	95	73.31
Grape pomace	95	100	95	95	95	81.45
Residues from greenhouse crops	95	100	95	95	90	77.16

Table 3: Estimation of theoretically available biomass potential of pruning residues in MoA.

Tree Cultivation	Theoretical Biomass Potential of pruning residues Dry (GJ/yr) (Stage 2nd)	Availability of supply chain (%)	Availability due to limitations (%)	Theoretically Available Biomass Potential of pruning residues Dry GJ/yr (Stage 3rd)
Olive	44,579.77	65.16%	70.00%	20,333.72
Almond	4,599.86	75.00%	90.00%	3,104.91
Walnut	4,810.82	75.00%	90.00%	3,247.30
Pear	953.63	75.00%	90.00%	643.70
Apple	1,046.89	75.00%	90.00%	706.65
Peach	192.31	75.00%	90.00%	129.81
Vineyard	3,215.30	73.31%	90.00%	2,121.42
Apricot	268.29	75.00%	90.00%	181.10
Cherry	247.68	75.00%	90.00%	167.18
	59,914.54			30,635.79

Table 4: Agricultural residues of herbaceous biomass of MoA according to the average production of 2005 to 2001 (ELSTAT, 2015 and own processing).

Cultivation	Type of residue	Harvesting period	Average 2005-2011		M%	RPR	Agricultural residue biomass	Higher Heating Value	Theoretical biomass potential
			Area ha	Production t/yr			dry t/yr	dry MJ/kg	dry GJ/yr (Stage 2nd)
Soft wheat	Straw	June	1,646.88	2,673.28	15%	1.00	2,272.29	17.90	40,673.96
Hard wheat	Straw	June	10,735.78	17,335.34	15%	1.00	14,735.04	17.90	263,757.26
Barley	Straw	June	1,400.61	3,238.10	15%	0.80	2,201.91	17.50	38.533.39
Cotton	Stems, leaves	October	4,970.68	11,050.34	45%	2.10	12,763.14	18.00	229,736.57
Sunflower	Stems, leaves	September	586.76	810.71	40%	2.00	972.85	17.30	16,830.30
Tobacco	Stems, leaves	October	118.43	185.15	85%	1.10	30.55	16.20	494.90
Oat	Straw	June	12.65	24.65	15%	0.79	16.55	17.40	288.01
Sugar beet	Stems, leaves	August	489.80	27,992.43	75%	0.40	2,799.24	17.10	47,867.06
Rice	Straw	October / November	119.10	609.31	25%	1.00	456.98	16.70	7,631.58
Maize	Stems, leaves	August - October	602.57	6,308.89	60%	0.70	1,766.49	18.00	31,796.81
TOTAL			20,683.25	70,228.20			38,015.05		677,609.85

Table 5: Estimation of theoretically available biomass potential from agricultural residues in MoA.

Cultivation	Availability due to competitive uses and removal rate	Available agricultural residue biomass dry t/yr	Theoretically available biomass potential dry GJ/year (Stage 3rd)
Soft wheat	15%	340.84	6,101.09
Hard wheat	15%	2,210.26	39,563.59
Barley	15%	330.29	5,780.01
Cotton	60%	7,657.89	137,841.94
Sunflower	60%	583.71	10,098.18
Tobacco	60%	18.33	296.94
Oat	15%	2.48	43.20
Sugar beet	50%	1,399.62	23,933.53
Rice	60%	274.19	4,578.95
Maize	60%	1,059.89	19,078.08
TOTAL		13,877.50	247,315.52

The theoretically available herbaceous biomass potential from agricultural residues is then estimated by employing specific limitation factors that include the removal rate and the percentage of competitive uses. The removal rate is related to the way and the equipment of harvesting process, the specific type of each annual crop, the high of harvesting, as well as environmental limitations, such as the maintain of organic carbon of the soil. The removal rate used within this study is drawn by literature (Bioenarea, 2015) and adapted to specific locations through personal interviews with farmers and agronomists of the region of Alexandroupolis. Table 5 presents the availability percentage and the theoretically available herbaceous biomass potential of MoA. As shown, the cultivation of cotton is the most significant annual crop in MoA (59%), followed by hard wheat (17%) and are considered as the most significant raw biomass for pellet production. The energy crops of MoA are of 1,231.62 ha (2013) and are almost 100% used for the production of biodiesel. Therefore, they are neglected by this study and are not further discussed.

As shown, the theoretically available biomass potential of MoA is identified in pruning residues of specific tree cultivations and in agricultural residues of specific annual crops. According to the estimations of this study, the overwhelming percentage of the theoretically available biomass potential originates from the herbaceous biomass residues and in particularly the annual crops of cotton, hard wheat and sugar beet. In addition, the available pruning residues from the tree cultivations in MoA consist mainly of olive tree pruning, as well as pruning of walnut and almond trees and vineyards. In order to estimate the technical biomass potential of MoA, an efficiency factor is utilised that is related to the production process. For conventional pellet production processes this factor is between 91% and 95%. This study adopts an efficiency factor of 92%. Therefore, the technical biomass potential for pellet production in MoA is estimated at 208.504,40 GJ/yr (dry matter), taking into consideration that 3% of the available raw biomass cannot be collected due to financial reasons. Table 6 presents the biomass potential of MoA for each type of cultivation.

5. Municipal pellet production plant and logistics of Alexandroupolis

In accordance with the European Standard EN 14961 that categorises the solid biofuels and the technical biomass potential of MoA, the proposed municipal pellet production plant can deliver either wood-pellets from the available olive tree pruning, or agro-pellets (often mentioned as agri-pellets) from the available stalk-stock-like biomass residues of cotton, wheat, sunflower and maize. Additionally, the mixture of MoA's biomass potential offers the possibility to produce pellets of the category of defined/undefined mixtures, which are often called mixed biomass pellets (MBP). Taking into consideration the quality standards set by EN ISO 17225 that updates EN 14961, as well as the mixture of the available raw biomass of MoA, it is possible to produce A or B-labeled non-wood pellets using the available herbaceous biomass mixed with olive tree pruning residues biomass (EN ISO 17225-6) (mixed biomass pellets – MBP).

Municipality of Alexandroupolis, according to its Sustainable Energy Action Plan (SEAP), owns more than hundred buildings of different types and area (MoA, 2013). The total consumption of heating oil in 2013 of the municipal buildings was 562.063 lt. For the purpose of preliminary design of the proposed pellet production plant of MoA this study selects 50 municipal buildings (school buildings) that will be heated by pellets, with total heating oil consumption of 336,080 lt (in 2013). Assuming an average efficiency of 85% of the installed boilers and a heating value of pellet of 4.1 kWh/kg, the pellet demand is estimated at 772 t/year. Taking into consideration the widely highlighted by the municipal buildings' users issue of reduced thermal comfort, as well as the potential increase of future pellet demand, a total 60% increase of the pellet demand is assumed, resulting in 1,250 t/year. This number is increased to 1,500 by considering the innovative proposal of engaging farmers in the supply chain of biomass that they will be paid in pellets (calculated by the cost of collection and transport, plus profit) produced by the municipal unit.

According to the available raw biomass, the municipal plant pellet production includes the following processes: size reduction (grinding), drying, transport, pelletizing, cooling, screening, packaging and storage. Since the usage of pellets is mostly performed in small or medium sized pellet boilers (of municipal buildings), the diameter of pellets should be 10 mm. Therefore, the raw biomass must be reduced in size of maximum 8.5 mm. Drying is a very significant process since the moisture of raw biomass affects the process of densification in the pelletizer. Additionally, the intermediate storage of raw biomass for 10 to 24 hours favors the stabilization of heterogeneity of moisture in the product. In general, drying process is highly energy intensive and requires the consumption of approximately 1,000 kWh per ton of evaporated water (Obernberger et al., 2010). Therefore, this study proposes the introduction of geothermal energy into the drying process of the municipal pellet production plant. MoA owns the exploitation of the low-enthalpy geothermal field of Traianoupolis, located east of the city of Alexandroupolis near villages Antheia and Aristino. The temperature of the geothermal fluid is measured at 88 to 90oC (MoA, 2014). This temperature determines which drying technology that must be utilised in the proposed municipal pellet production plant. The types of dryers that operate at these temperatures are belt, vacuum and low-temperature dryers. Taking into consideration the specificities of geothermal energy and the available raw biomass in MoA, the type of belt dryer is proposed.

The capacity of the proposed municipal pellet production plant is determined by the following factors: a) the quantity and quality of the available raw biomass, b) the total annual pellet demand that the plant will cover, c) the technical properties of the commercially available pellet production technology in respect to the raw biomass available, d) the technical and energy-wise limitations from the exploitation of the available geothermal energy (e.g. competitive use of geothermal energy for district heating of buildings – limited time of operation). Therefore, the capacity of the municipal plant proposed is 1.2 t/h and characterizes the unit as a medium-sized pellet production unit. The capacity of the pellet production plant determines the required thermal energy from the low enthalpy geothermal field of Traianoupolis. As estimated, the plant will operate in full capacity for 1,250 hours per year in order to produce the total annual pellets required (1,500 tons), which results in approximately 450,000kWh/year of thermal energy consumption. Thus, the municipal pellet production plant is estimated to use approximately 39,405 m3 of geothermal fluid per year with temperature exploitation of 10 K (89 to 79oC).

In addition to drying, pelletizing is a very important process for the production of qualitative pellets according to the EN ISO 17225 standard. As stated by Garcia-Maraver et al. (2015), the produced pellets from olive tree pruning cannot satisfy the requirements of the EU standards, in respect to the ash, nitrogen and sulfur values. Therefore, taking into consideration the mixture of available raw biomass of MoA that mostly includes agricultural residues of wheat and cotton, the selection of appropriate pelletizers is substantial in order to achieve the required friction levels in and the lignin release during the densification process of the biomass. The friction can be increased by increasing the length of compression and should be followed by enhancement of the materials of the dies to withstand the increased friction forces (EUBIA, 2002). Therefore, considering the available raw biomass and the quality requirements of EU standards, the municipal plant is proposed to produce mixed biomass pellets.

6. Logistics

The supply chain of biomass pellet production includes harvesting, collection, transport, storage, pelletisation, storage and distribution of pellets. The supply chain includes differences between the ligno-cellulose and the herbaceous biomass. The collection of herbaceous biomass residues requires less effort in contrast to pruning residues, since the access to the cultivated land is smoother making the collection with machinery easier. However, the collection of herbaceous biomass residues is characterised by the limited collection period that is also different for each type of annual crop. Additionally, its transportation is more expensive due to the lower energy density of the raw biomass. A limit of 100km distance is usually adopted in the supply chain of herbaceous biomass pellet production (Bioenarea, 2015). The limited collection period also results in higher storage periods that negatively affects for the quality of the produced pellets. As far as ligno-cellulose biomass is concerned, there are different types of supply chains that can be utilised and are related with the type of ligno-cellulose biomass collected (forest, agro-industrial, etc). As it regards the pruning residues, an important aspect is to reduce their size on site in order to minimise the transportation costs and improve the supply chain efficiency. The proposed supply chain for the municipal pellet production plant is shown in figure 1 and takes into consideration the specificities of the available raw biomass, the location of geothermal field and the municipal buildings.

Table 6. Biomass potential of Municipality of Alexandroupolis.

Cultivation	Area ha	Available biomass Dry t/yr	Percentage of total %	Theoretically Available Biomass Potential GJ/yr (Stage 3rd)	Technical Biomass Potential Dry GJ/yr (Stage 4th)
Soft wheat	1,646.88	340.84	2.20%	6,101.09	5,330.74
Hard wheat	10,735.78	2,210.26	14.23%	39,563.59	34,568.47
Barley	1,400.61	330.29	2.08%	5,780.01	5,013.80
Cotton	4,970.68	7,657.89	49.59%	137,841.94	116,951.30
Sunflower	586.76	583.71	3.63%	10,098.18	7,641.70
Tobacco	118.43	18.33	0.11%	296.94	227.66
Oat	12.65	2.48	0.02%	43.20	37.65
Sugar beet	489.80	1,399.62	8.61%	23,933.53	15,451.80
Rice	119.10	274.19	1.65%	4,578.95	3.556.79
Maize	602.57	1,059.89	6.86%	19,078.08	16,186.64
Olive	1,812.93	1,123.41	7.32%	20,333.72	17,704.49
Almond	50.79	168.74	1.12%	3,104.91	2,701.19
Walnut	89.50	168.43	1.17%	3,247.30	2,820.19
Pear	5.04	33.35	0.23%	643.70	558.41
Apple	9.89	39.70	0.25%	706.65	614.33
Peach	4.04	6.69	0.05%	129.81	112.82
Vineyard	39.52	112.24	0.76%	2,121.42	1,807.06
Apricot	3.89	9.38	0.07%	181.10	156.20
Cherry	6.26	9.50	0.06%	167.18	145.08
TOTAL		15,548.94		277,951/31	226,255.59

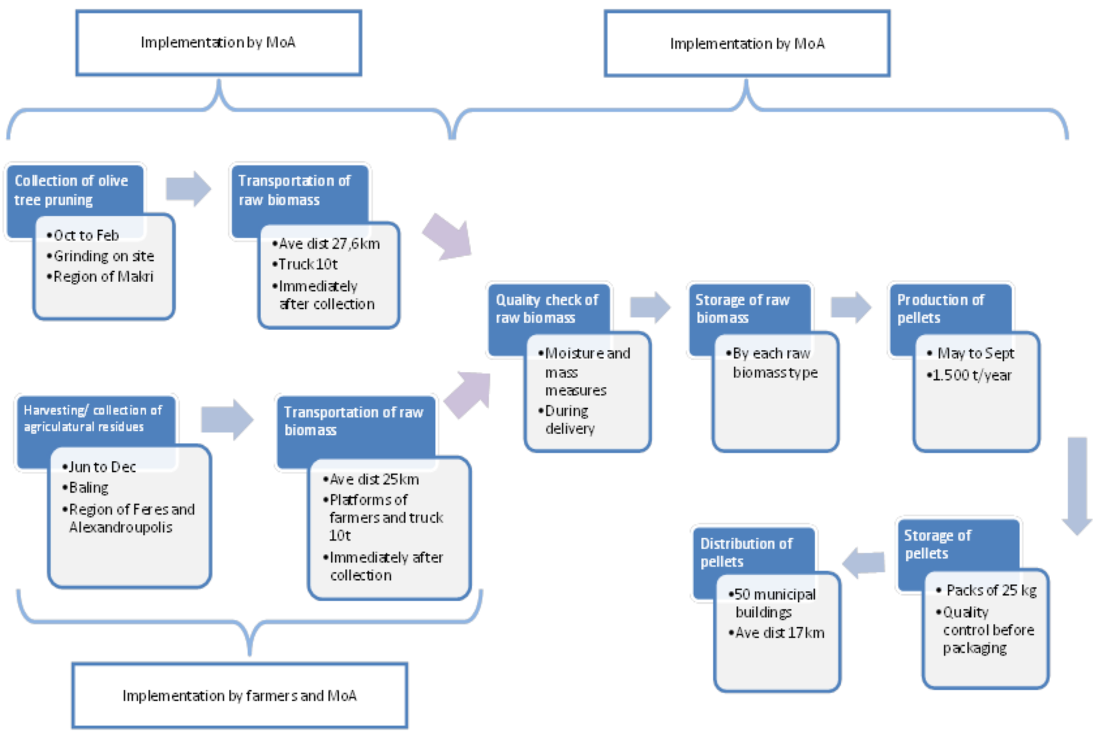

Figure 1: Diagram of biomass supply chain of the municipal pellet production plant.

7. Cost analysis of pellet production

The calculation of the cost of pellet production follows the guideline VDI 2067 and is divided to four cost groups: a) cost based on capital (capital and maintenance costs), b) consumption costs, c) operating costs and d) other costs. The capital costs can be calculated by the capital recovery factor (CRF) multiplied with the investment costs. The maintenance costs are calculated as percentage of the investment costs and are equally spread over the years of utilisation period. The consumption costs include the cost of procurement of raw biomass, the thermal energy consumption for drying process and the electrical energy consumption for the operation of the mechanical equipment. The operating costs refer to costs that originate from the operation of the pellet production unit, such as personnel costs. Other costs may include insurance costs, taxes, administration costs, etc.

Table 7 presents some basic parameters adopted for the calculation of production cost of pellets from the proposed municipal plant. Following the guidelines of VDI 2067 the costs for production of pellets are calculated and presented in table 8. The costs for building and other facilities' development include the construction of new building of 600 m2, the landscaping, the connection with electricity grid and geothermal district heating network. The use of geothermal energy for drying process significantly lowers the drying costs, as compared to other examples (Obernberger et al., 2010). It has to be mentioned that the energy costs for the heat demand of drying process using heating oil would be approximately 45,000 EUR/year, resulting in double specific pellet production cost. The costs of grinding include the procurement and operation of one portable pruning chipper, one straw shredder and one hammer mill, as well as auxiliary equipment. It also includes consumption costs of electricity and diesel and maintenance costs of 2% of specific investment costs. Maintenance costs for the pelletizer are calculated at 5% of the specific investment costs and contributes to the important cost of pelletizing process that is estimated at 32.30 EUR per ton of product (pellet). Storage costs include the outdoor storage, the silo storage and the pellet storage. The auxiliary equipment includes the conveyor systems, sieving machines, fans, rotary valves, biological additive feeding system and conditioning. Personnel costs are calculated for the employment of 4 persons for each shift (double shift operation – 8 hours per shift) and 2 persons for administration. The raw biomass costs include the costs for harvesting and collection, as well as the transportation costs and is different for herbaceous and ligno-cellulose raw biomass.

As shown in table 8 the total cost of pellet production for the proposed municipal unit is 257.50 EUR per ton of produced pellet (w.b.). Figure 2 shows the breakdown of production costs and highlights the importance of raw biomass costs and personnel costs. Drying costs are still important besides the availability of thermal energy from the geothermal field. Figure 3 presents the breakdown of production costs according to guideline VDI 2067 and highlights the importance of capital and consumption costs. In order to assess the economic feasibility of the development of the proposed municipal pellet production unit, the calculation of the distribution costs of pellets is essential. Taking into consideration the distance of the municipal buildings from the proposed location of the pellet production plant, it is possible to calculate the consumption and personnel costs, as well as the investment costs for the procurement of appropriate vehicles that constitute the distribution costs. The distribution costs for the proposed base case scenario in MoA are estimated at 19.90 EUR per ton of distributed pellets. The total production and distribution cost is estimated at 277.40 EUR/t and is similar to the average retail price of pellets in Greece (including VAT 24%).

8. Sensitivity analysis

In this section, sensitivity analysis of some important parameters is carried out in order to investigate the effect these parameters have on the total specific pellet production costs of the base case scenario. Single parameters are varied in a certain range that seems possible and reasonable. Subsequently, the total specific pellet production costs are calculated with each of these new values.

The purpose of the sensitivity analysis is to highlight potential cost savings and important parameters that affect the economic pellet production, as well as to determine the extent of possible errors in the choice of parameters.

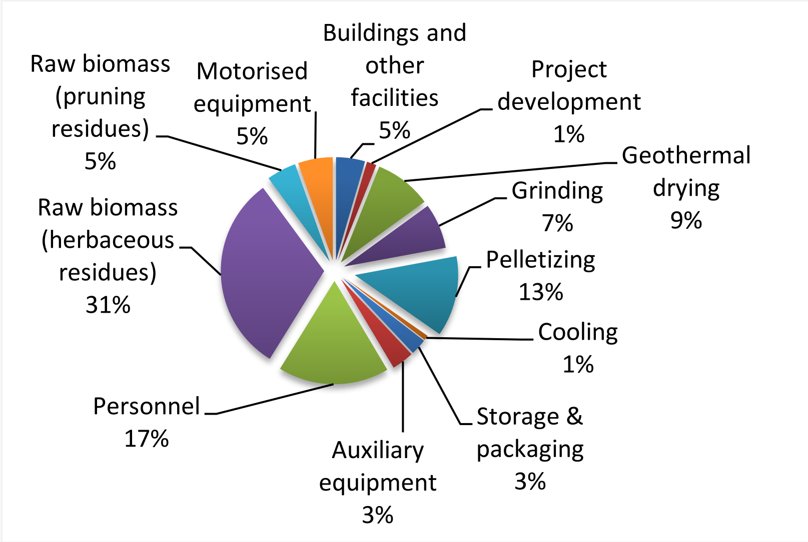

Figure 6: Breakdown of pellet production cost.

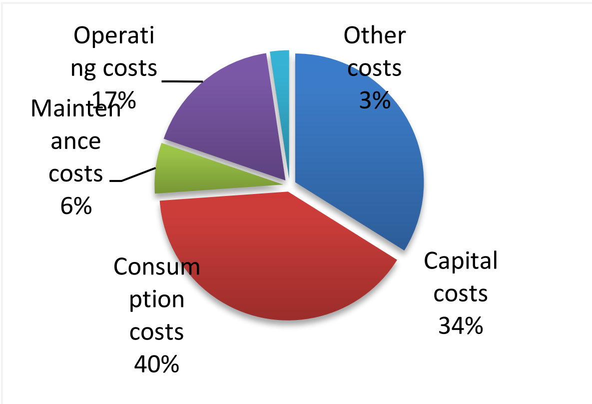

Figure 7: Breakdown of pellet production cost according to VDI 2067.

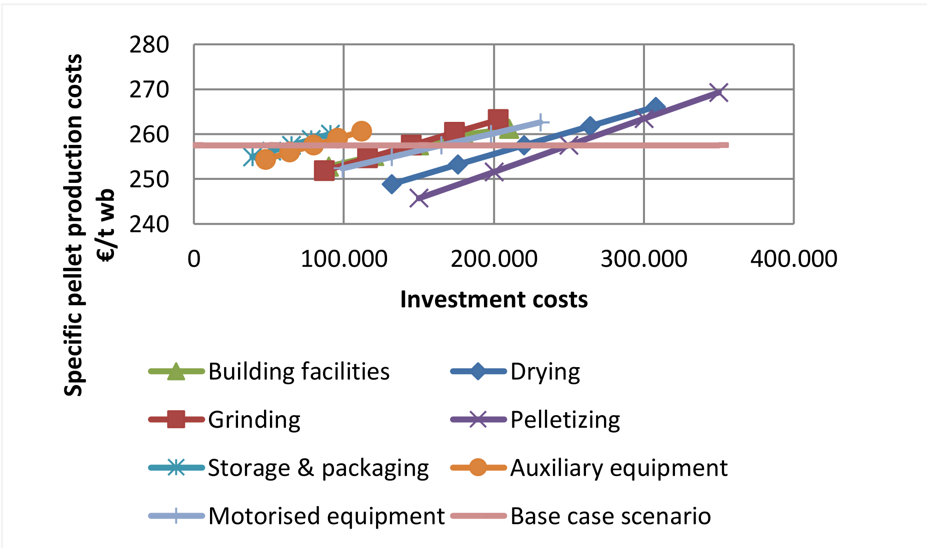

Figure 8: Sensitivity analysis of specific pellet production cost to investment costs.

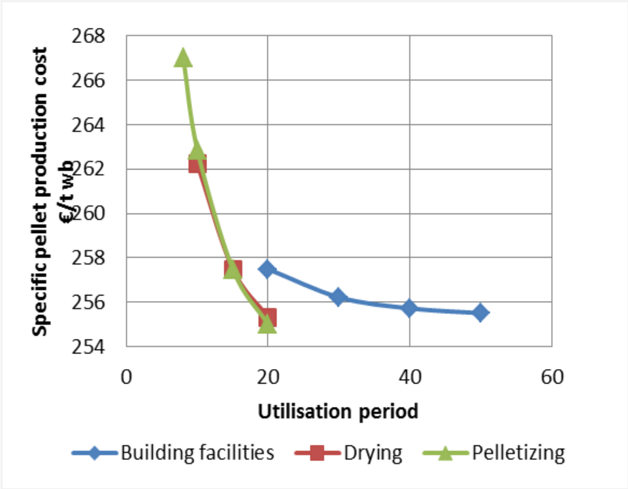

Figure 9: Sensitivity analysis of specific pellet production cost to utilisation period.

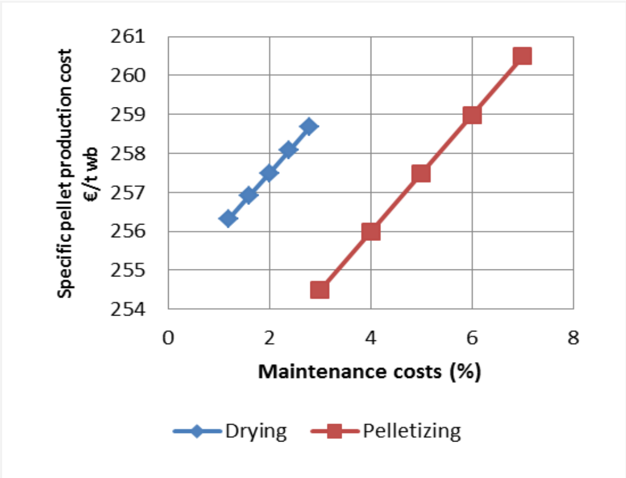

Figure 10: Sensitivity analysis of specific pellet production cost to maintenance costs.

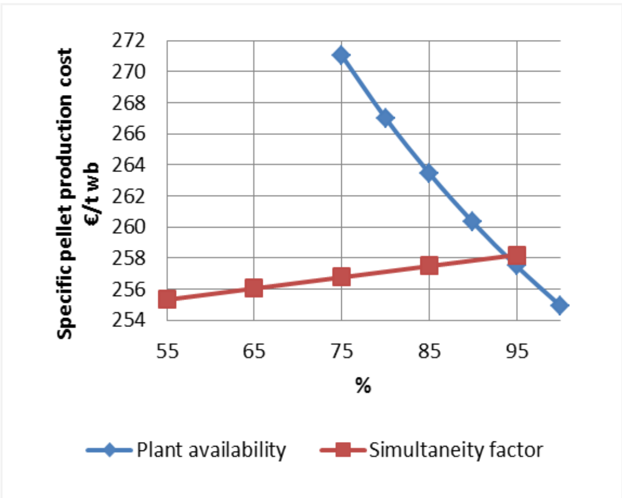

Figure 11: Sensitivity analysis of specific pellet production cost to plant availability and simultaneity factor of machinery.

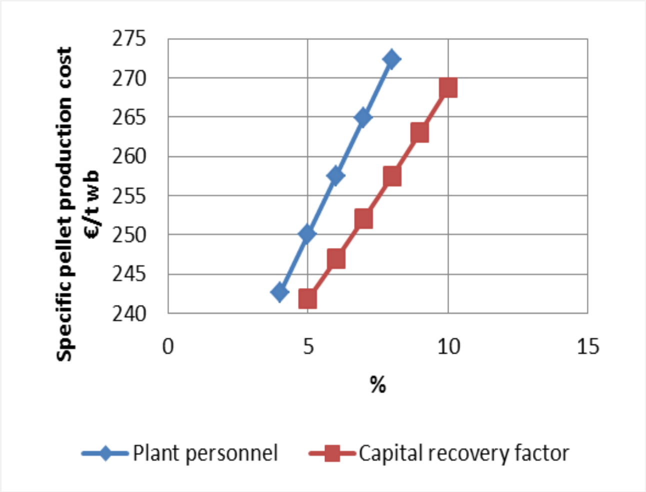

Figure 12: Sensitivity analysis of specific pellet production cost to plant personnel and CRF.

Figure 4 presents the sensitivity analyses of investment costs for different plant processes of the municipal pellet production unit. The investment costs for the pelletizing process has the most influence on the specific pellet production costs of the base case scenario. Therefore, the choice of suitable and reliable pelletizer is significant, considering the fact that the specific properties of the available raw biomass will probably result in increased wear and maintenance costs. Figure 5 shows the sensitivity analyses of investment costs for different utilisation periods and highlights the increase of specific pellet production costs with declining utilisation periods. The mechanical equipment seems to have high sensitivity in utilisation periods, mainly due to high investment costs required for the procurement of pellet mill, dryer and auxiliary equipment. The relatively low influence of maintenance costs on the specific pellet production costs of drying and pelletisation processes is shown in figure 6. On the contrary, the influence of the plant availability parameter is considered significant as depicted in figure 7.

Reduced plant availability, be it by scheduled or unscheduled outages, raises the specific pellet production costs significantly. Increased plant availability can actually clearly decrease the specific pellet production costs. The simultaneously factor, also shown in figure 7, refers to the operation of the machinery (electrical installations) and its influence is considered as moderate. Figure 8 presents the influence of personnel needed per shift, as well as the influence of the capital recovery factor on the specific pellet production costs. As shown, the automation of the production process is significant in order to minimize the personnel costs, which are substantially influencing the specific pellet production costs. Similarly, the increase of CRF results in important increase of the specific pellet production costs. Figures 9 and 10 present the sensitivity analyses of raw biomass costs and plant capacity, respectively. The increased influence of the raw biomass costs highlights the need of realistic and detailed design of the supply chain of the proposed municipal pellet production unit. Additionally, the reduction of production rate significantly raises the specific pellet production costs, highlighting the importance of the design of the production process and the selection of the specific machinery.

9. Cost benefit analysis

The economic feasibility of the proposed municipal pellet production unit is assessed by a cost benefit analysis. Table 9 includes the parameters adopted for the cost benefit analysis. In order to calculate the cost of heating oil consumption for the municipal buildings included in the pellet supply chain, the average price of heating oil for 2014 is used (0.985 EUR/lt).

Table 7: Basic parameters for calculation of pellet production cost.

Basic Parameter	Value	Basic Parameter	Value
Shift per day	2	Maintenance costs of building facilities	0.5 %/y
Work days per week	5	Maintenance costs of machinery	2.0 %/y
Availability of plant	95%	Other costs	1.0 %/y
Annual full load operating hours	1,250 h/y	Real interest rate	8%
Simultaneity factor of machinery	85%	Lifespan of mechanical equipment	15 years
Pellet production capacity	1.2 t/h	Lifespan of building facilities	20 years
Cost of electricity	75 €/MWh		

Table 8: Overview of pellet production costs of the proposed municipal plant.

	Investment Costs (€)	Capital Costs (€/y)	Consumption Costs (€/y)	Maintenance Costs (€/y)	Operating Costs (€/y)	Other Costs (€/y)	Total Costs (€/y)	Specific Costs (€/t)
Buildings and other facilities	150,000.00	15,270.00	-	750.00	-	1,500.00	17,520.00	11.68
Project development	50,000.00	5,840.00	-	-	-	-	5,840.00	3.89
Geothermal drying	220,000.00	25,696.00	2,250.00	4,400.00	-	2,200.00	34,546.00	23.03
Grinding	145,000.00	16,936.00	6,085.94	2,900.00	-	1,450.00	27,371.94	18.25
Pelletizing	250,000.00	29,200.00	5,289.06	11,750.00	-	2,500.00	48,739.06	32.49
Cooling	15,000.00	1,752.00	796.88	300.00	-	150.00	2,998.88	2.00
Storage & packaging	65,000.00	7,592.00	398.44	1,150.00	-	650.00	9,790.44	6.53
Auxiliary equipment	80,000.00	9,344.00	1,593.75	1,600.00	-	800.00	13,337.75	8.89
Personnel	-	-	-	-	67.065,00	-	67,065.00	44.71
Raw biomass (herbaceous)	-	-	120,124.40	-	-	-	120,124.40	80.08
Raw biomas (pruning)	-	-	17,910.00	-	-	- €	17,910.00	11.94
Motorised equipment	165,000.00	19,272.00	-	1,724.40	-	-	20,996.40	14.00
TOTAL	1,140,000.00	130,902.00	154,448.46	24,574.40	67.065,00	9,250.00	386,239.86	257.49

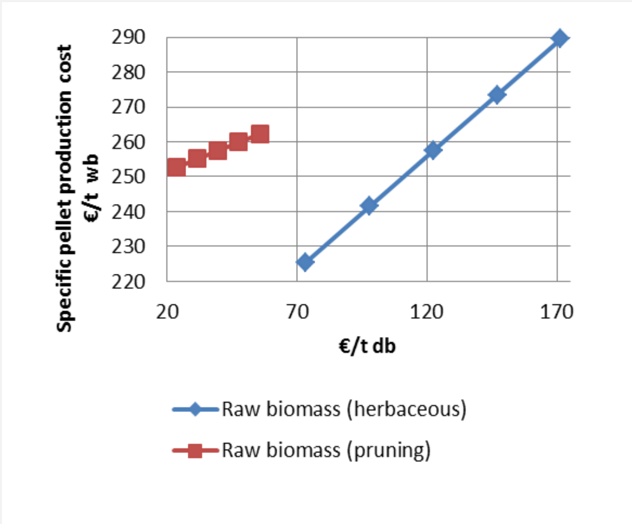

Figure 13: Sensitivity analysis of specific pellet production cost to raw biomass.

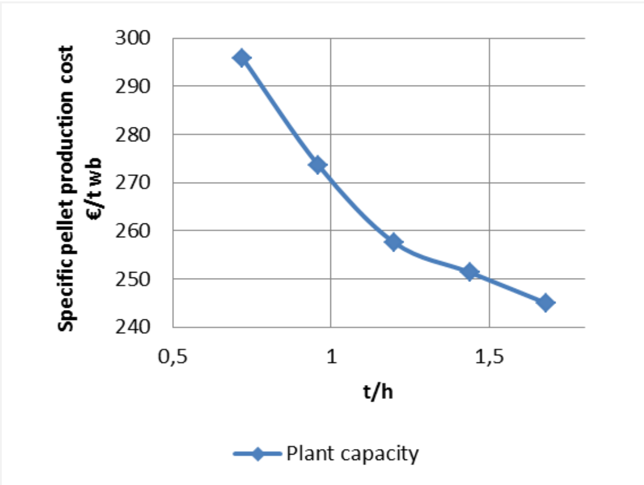

Figure 14: Sensitivity analysis of specific pellet production cost to plant capacity.

Table 9: Entry data for the cost benefit analysis.

Description	Unit	Value
Pellet production	t/y	911
Thermal energy of produced pellets	MWh/t	4.1
Lifespan	years	20
Buildings costs	€	150,000.00
Equipment costs	€	1,988,040.00
Project development costs	€	50,000.00
Consumption and maintenance costs	€/kWh	31.37
Inflation	%	2.0
Operating costs	€/yr	70,865.00
Construction period	months	9
Lending	%	0
Equity	%	100
Profit	€/MWh	123.16
Average increase rate of diesel price	%	0.5

The cost of heating oil is calculated at 123.16 EUR/MWhth and represents the economic gain from the operation of the proposed municipal pellet production unit and the replacement of 50 municipal buildings' boilers with pellet boilers. No lending has been included in the cost benefit analysis (100% equity), since the proposed investment is considered as eligible for funding from the European Regional Development Fund. The study includes depreciation values of 4% for buildings, 10% for mechanical equipment and 20% for studies according to Greek Law 4110/2013. The Internal Rate of Return (IRR) of the investment in 20 years period is 10,19% and it is considered as satisfying. The Net Present Value (NPV) for reporting period of 20 years is estimated at 2,893,744.63 EUR and the payback period at 8.2 years. The results of the cost benefit analysis for the proposed municipal pellet production unit and the replacement of boilers show the economic feasibility of the proposed investment. In addition, the investment's eligibility for EU funding increases dramatically the economic viability, since the capital and development costs are eliminated resulting in approximately 100,000 EUR/year for operation and maintenance costs, as opposed to the current 336,000 EUR/year cost of heating oil for the targeted 50 municipal buildings.

The feasibility of the proposed investment is also supported by the accompanied environmental benefits. The shift from heating oil to pellets for 50 municipal buildings results in primary energy savings and reduction in CO_2 emissions. The heating oil consumption within the MoA that is reduced from the operation of the proposed municipal pellet production plant is estimated at 634,080 lt or 1,693 tCO_2, using the standard emissions factors (European Commission, 2010). Nevertheless, the operation of the pellet production plant and the total supply chain (distribution) results in CO_2. Using the emissions factors calculated in Alexandroupolis' SEAP (MoA, 2013). Therefore, the reduction in CO2 emissions is estimated at 1,392 t/year, which corresponds to 0.35% of the total carbon footprint of MoA and contributes by 1.6% to CO_2 emissions reduction target set by MoA in its SEAP (MoA, 2013).

10. Conclusions

In conclusion, the proposed solution of the geothermal municipal pellet production plant is considered as technical and economically feasible for the Municipality of Alexandroupolis and strongly contributes to the overall target of climate change mitigation. The estimation of the technical biomass potential of MoA, as presented in this study, documents the security of supply of the available raw biomass. The evaluation of the available technologies for the pellet production processes in respect to the available raw biomass support the technical feasibility of the municipal pellet production plant. The sensitivity analysis performed indicates the points of intervention for the reduction of specific pellet production costs, while the indices calculated by the cost benefit analysis confirm the economic viability of the proposed investment, even without the support of EU or national funding. Finally, the contribution of this overall action of the implementation of a pellet production plant and the consumption of pellets in municipal buildings to the achievement of the specific CO_2 reduction targets of the Municipality of Alexandroupolis is significant.

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Session 6: Programs and Projects

RENEWABLE ENERGY SOURCES

CERTIFHY

AT A GLANCE

Title: CertifHy: A European Framework for the generation of guarantees of origin for green hydrogen

Funding mechanism: Fuel Cells and Hydrogen Joint Undertaking (FCH JU)

EC Contribution: 432K€

Duration: 24 months

Start Date: November 2014

Consortium: 4 partners from 3 countries

Project Coordinator: Hinicio (Belgium)

Project Web Site: http://www.certifhy.eu/

Key Words: green hydrogen, guarantee of origin, certificate, scheme, DG Energy

CHALLENGE

Hydrogen is expected to play a key role in the transition towards a low-carbon economy, especially within the transport sector, the energy sector and the (petro)chemical industry sector. However, the production and use of hydrogen only makes sense if the production and transportation is carried out with minimal impact on natural resources, and if greenhouse gas emissions are reduced in comparison to conventional hydrogen or conventional fuels.

PROJECT OBJECTIVES

The CertifHy project, supported by a wide range of key European industry leaders (gas companies, energy utilities, green hydrogen technology developers and automobile manufacturers, as well as leading industry associations) therefore aims to:

1. Define a widely acceptable definition of green hydrogen;
2. Determine how a robust Guarantee of Origin (GoO) scheme for green hydrogen should be designed and implemented throughout the EU.

METHODOLOGY

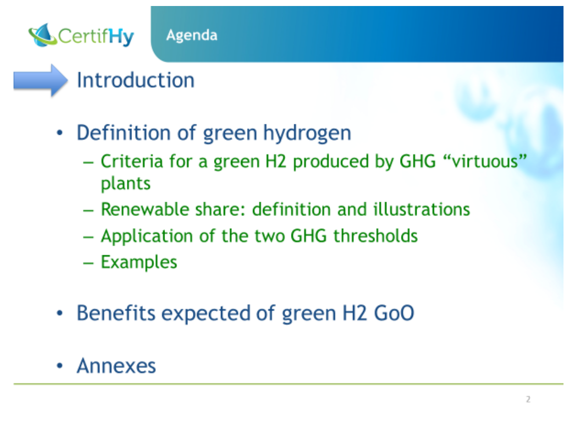
1. **Generic market outlook for green hydrogen:** overview of future trends, market outlooks, application areas and segmentation for green hydrogen. Evidence of existing industrial markets and the potential development of new energy related markets for green hydrogen in the EU (Work Package, WP1).
2. **Definition of "green" hydrogen**: common definition of green hydrogen which can be applied to all stakeholders (market players and regulators) in the EU (WP2).
3. **Review of existing platforms and interactions between existing GoO and green hydrogen**, benchmarking (WP3).
4. **Definition of a new framework of guarantees of origin for "green" hydrogen**: technical specifications of the framework of guarantees of origins, rules and obligations for the GoO, impact analysis (WP4).

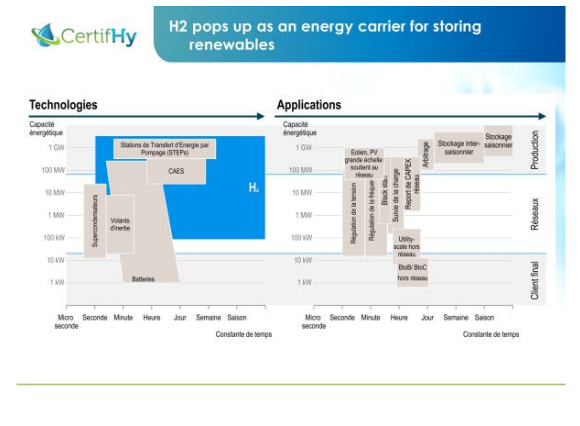
5. **Roadmap for the implementation of an EU-wide GoO scheme for green hydrogen**: synthesise and "initiate" recommendations of the project in practical terms. The roadmap will be presented to the FCH JU and the European Commission as the key outcome of the project and will be shared with stakeholders before finalisation (WP5 and 6).

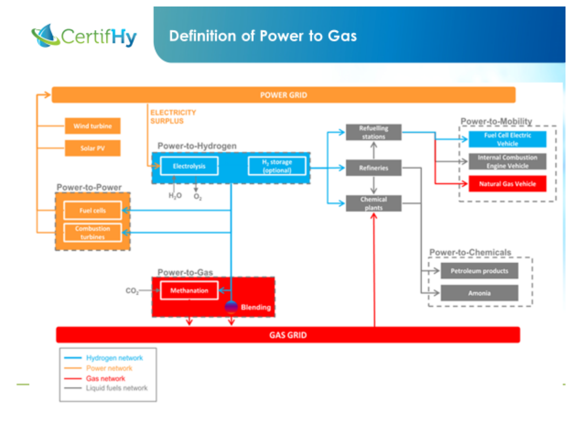
PROJECT PARTNERS	
Hinicio (coordinator)	Belgium
Energy Research Centre of the Netherlands (ECN, Sticchting Energieonderzoek Centrum Nederland)	The Netherlands
Tüv Sud Industrie Service GmbH	Germany
Ludwig-Boelkow-Systemtechnik GmbH	Germany

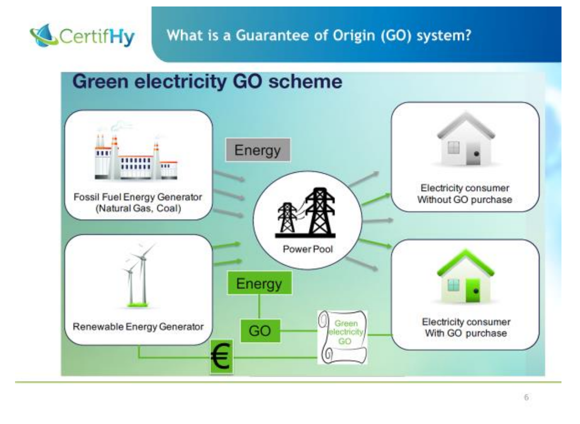
CERTIFHY: Developing a European Framework for the generation of guarantees of origin for green hydrogen

Presentation by **Mr. Wouder VANHOUDT**, HINICIO - Belgium

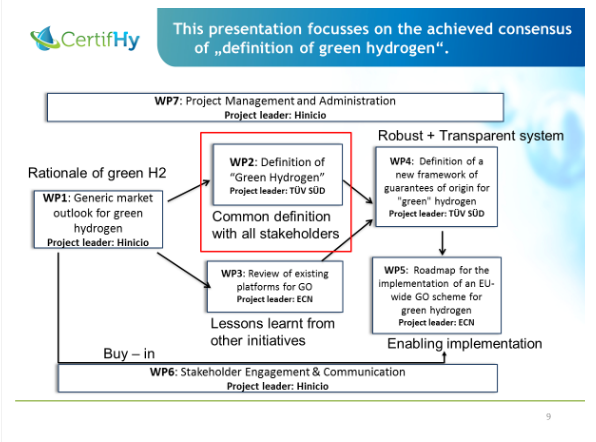


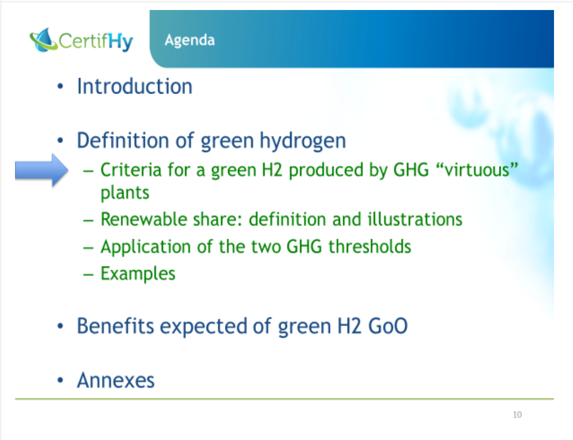


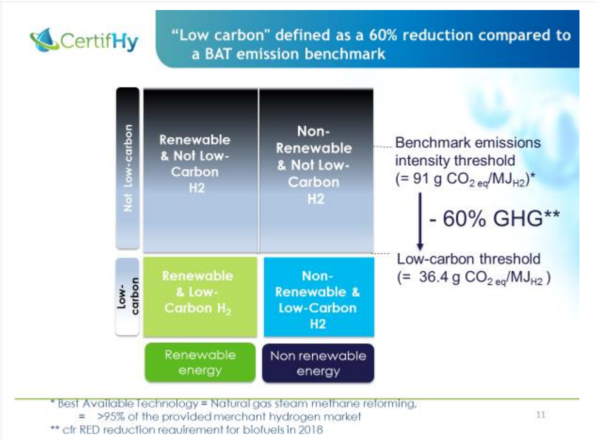


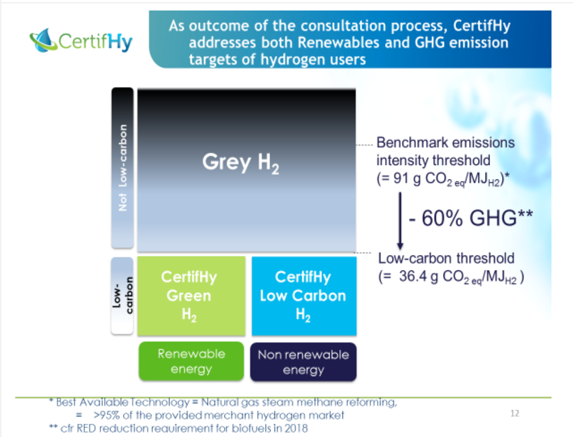


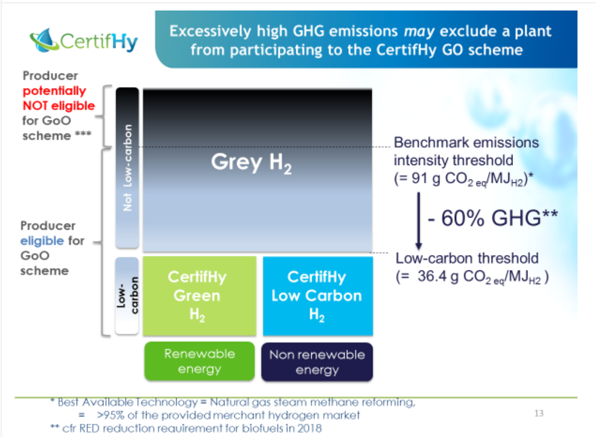

CertifHy
CertifHy will boost demand and supply of green hydrogen throughout Europe: by the creation of a market for green H2
Objective: Define a widely acceptable definition of green hydrogen; and Determine how an EU wide robust GO scheme should be designed and implemented.
Consortium
ECN
Hinicio
Step by step consultation process
Affiliated Partners
AIR LIQUIDE
AIR PRODUCTS
AkzoNobel
AREVA H2Gen
colruyt
EDF
HYDROGENICS
Linde
MACHIELS
OMV
TOTAL
uniper
Other Partners: Associations, NGO's, Policy Makers,..
"Supply green H2 where is not produced, improving the business case for green H2"
8


CertifHy
This presentation focusses on the achieved consensus of „definition of green hydrogen".
WP7: Project Management and Administration
Project leader: Hinicio
Robust + Transparent system
Rationale of green H2
WP1: Generic market outlook for green hydrogen
Project leader: Hinicio
WP2: Definition of "Green Hydrogen"
Project leader: TÜV SÜD
Common definition with all stakeholders
WP4: Definition of a new framework of guarantees of origin for "green" hydrogen
Project leader: TÜV SÜD
WP3: Review of existing platforms for GO
Project leader: ECN
Lessons learnt from other initiatives
WP5: Roadmap for the implementation of an EU-wide GO scheme for green hydrogen
Project leader: ECN
Enabling implementation
Buy – in
WP6: Stakeholder Engagement & Communication
Project leader: Hinicio
9


CertifHy
Agenda
Introduction
Definition of green hydrogen
– Criteria for a green H2 produced by GHG "virtuous" plants
– Renewable share: definition and illustrations
– Application of the two GHG thresholds
– Examples
Benefits expected of green H2 GoO
Annexes
10


CertifHy
"Low carbon" defined as a 60% reduction compared to a BAT emission benchmark
Not Low-carbon
Renewable & Not Low-Carbon H2
Non-Renewable & Not Low-Carbon H2
Benchmark emissions intensity threshold (= 91 g $CO_{2\,eq}/MJ_{H2}$)*
- 60% GHG**
Low-carbon threshold (= 36.4 g $CO_{2\,eq}/MJ_{H2}$)
Low-carbon
Renewable & Low-Carbon H_2
Non-Renewable & Low-Carbon H2
Renewable energy
Non renewable energy
* Best Available Technology = Natural gas steam methane reforming,
= >95% of the provided merchant hydrogen market
** cfr RED reduction requirement for biofuels in 2018
11


CertifHy
As outcome of the consultation process, CertifHy addresses both Renewables and GHG emission targets of hydrogen users
Not Low-carbon
Grey H_2
Benchmark emissions intensity threshold (= 91 g $CO_{2\,eq}/MJ_{H2}$)*
- 60% GHG**
Low-carbon threshold (= 36.4 g $CO_{2\,eq}/MJ_{H2}$)
Low-carbon
CertifHy Green H_2
CertifHy Low Carbon H_2
Renewable energy
Non renewable energy
* Best Available Technology = Natural gas steam methane reforming,
= >95% of the provided merchant hydrogen market
** cfr RED reduction requirement for biofuels in 2018
12


CertifHy
Excessively high GHG emissions may exclude a plant from participating to the CertifHy GO scheme
Producer potentially NOT eligible for GoO scheme ***
Producer eligible for GoO scheme
Not Low-carbon
Grey H_2
Benchmark emissions intensity threshold (= 91 g $CO_{2\,eq}/MJ_{H2}$)*
- 60% GHG**
Low-carbon threshold (= 36.4 g $CO_{2\,eq}/MJ_{H2}$)
Low-carbon
CertifHy Green H_2
CertifHy Low Carbon H_2
Renewable energy
Non renewable energy
* Best Available Technology = Natural gas steam methane reforming,
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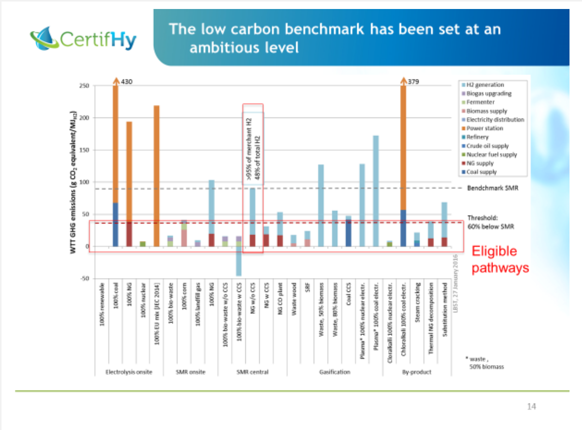
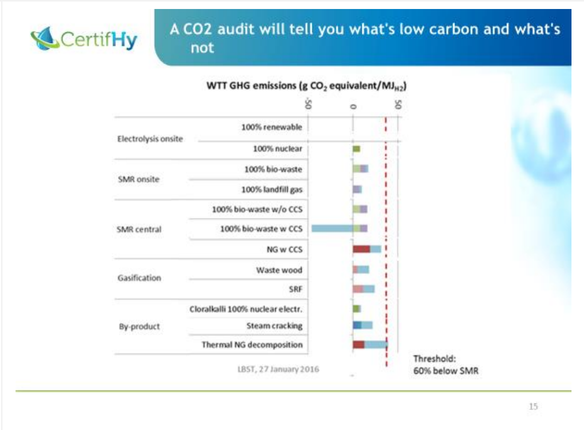
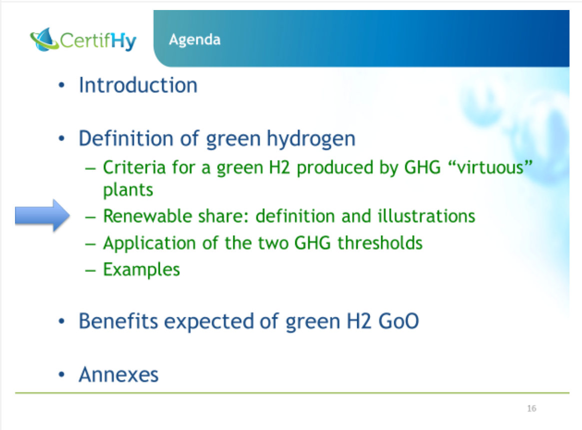
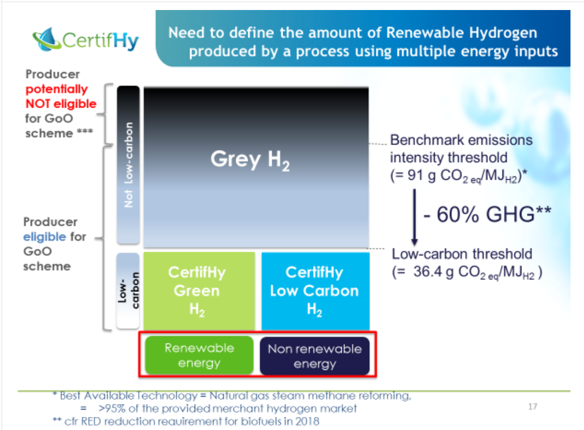
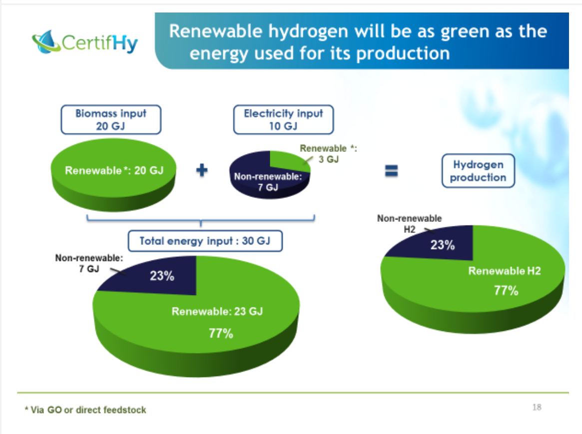
** cfr RED reduction requirement for biofuels in 2018
13

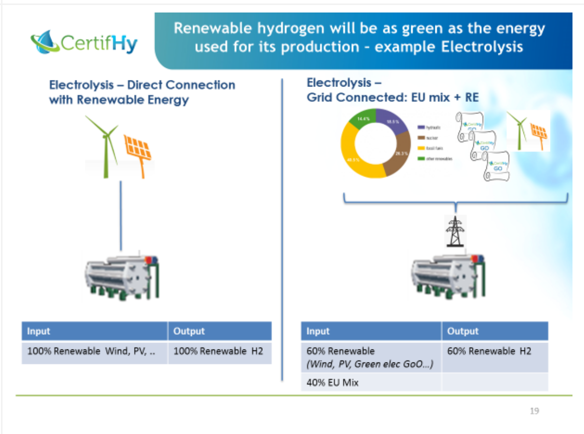

CertifHy
The low carbon benchmark has been set at an ambitious level
WTT GHG emissions (g CO2 equivalent/MJH2)
430
379
Benchmark SMR
Threshold: 60% below SMR
Eligible pathways
Electrolysis onsite
SMR onsite
SMR central
Gasification
By-product
14

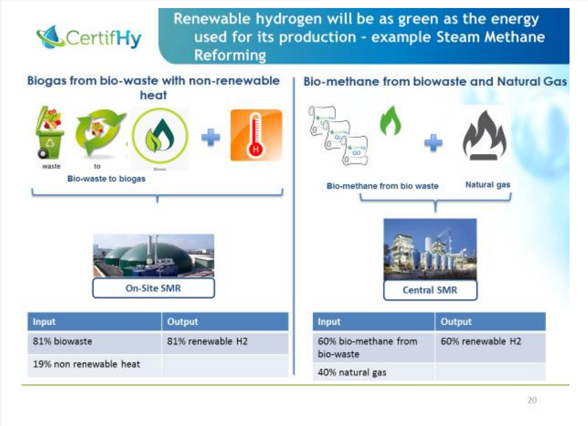

CertifHy
A CO2 audit will tell you what's low carbon and what's not
WTT GHG emissions (g CO2 equivalent/MJH2)
Electrolysis onsite
100% renewable
100% nuclear
SMR onsite
100% bio-waste
100% landfill gas
SMR central
100% bio-waste w/o CCS
100% bio-waste w CCS
NG w CCS
Gasification
Waste wood
SRF
By-product
Cloralkali 100% nuclear electr.
Steam cracking
Thermal NG decomposition
LBST, 27 January 2016
Threshold: 60% below SMR
15

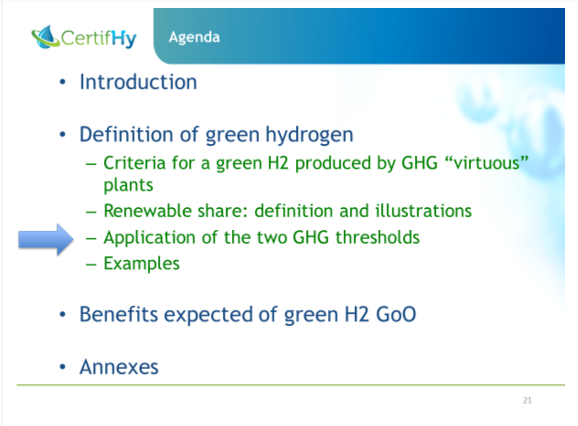

CertifHy
Agenda
Introduction
Definition of green hydrogen
– Criteria for a green H2 produced by GHG "virtuous" plants
– Renewable share: definition and illustrations
– Application of the two GHG thresholds
– Examples
Benefits expected of green H2 GoO
Annexes
16


CertifHy
Need to define the amount of Renewable Hydrogen produced by a process using multiple energy inputs
Producer potentially NOT eligible for GoO scheme ***
Not Low-carbon
Grey H2
Benchmark emissions intensity threshold (= 91 g CO2 eq/MJH2)*
- 60% GHG**
Low-carbon threshold (= 36.4 g CO2 eq/MJH2)
Producer eligible for GoO scheme
Low-carbon
CertifHy Green H2
CertifHy Low Carbon H2
Renewable energy
Non renewable energy
* Best Available Technology = Natural gas steam methane reforming,
= >95% of the provided merchant hydrogen market
** cfr RED reduction requirement for biofuels in 2018
17


CertifHy
Renewable hydrogen will be as green as the energy used for its production
Biomass input 20 GJ
Electricity input 10 GJ
Renewable *: 20 GJ
Renewable *: 3 GJ
Non-renewable: 7 GJ
Hydrogen production
Total energy input : 30 GJ
Non-renewable: 7 GJ
23%
Renewable: 23 GJ
77%
Non-renewable H2
23%
Renewable H2
77%
* Via GO or direct feedstock
18


CertifHy
Renewable hydrogen will be as green as the energy used for its production - example Electrolysis
Electrolysis – Direct Connection with Renewable Energy
Electrolysis – Grid Connected: EU mix + RE
Input
Output
100% Renewable Wind, PV, ..
100% Renewable H2
Input
Output
60% Renewable (Wind, PV, Green elec GoO...)
60% Renewable H2
40% EU Mix
19


CertifHy
Renewable hydrogen will be as green as the energy used for its production - example Steam Methane Reforming
Biogas from bio-waste with non-renewable heat
Bio-waste to biogas
On-Site SMR
Input
Output
81% biowaste
81% renewable H2
19% non renewable heat
Bio-methane from biowaste and Natural Gas
Bio-methane from bio waste
Natural gas
Central SMR
Input
Output
60% bio-methane from bio-waste
60% renewable H2
40% natural gas
20


CertifHy
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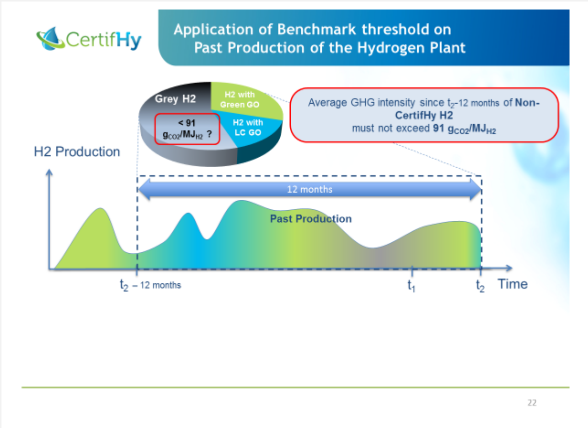
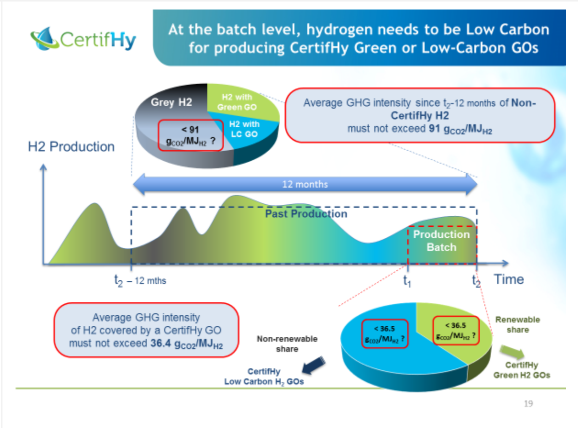
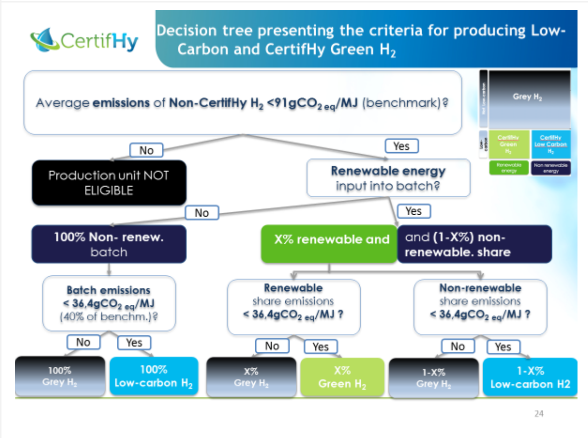
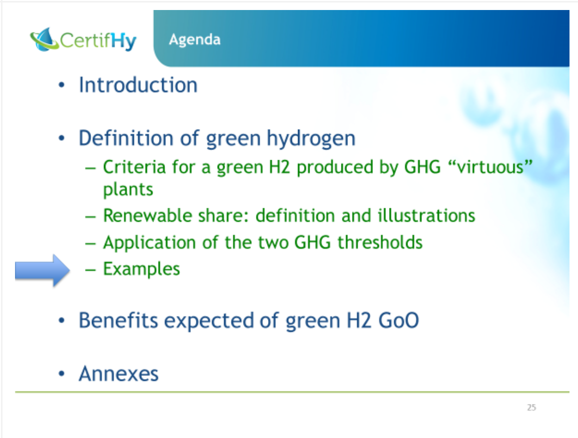

CertifHy
Application of Benchmark threshold on Past Production of the Hydrogen Plant
Grey H2
H2 with Green GO
H2 with LC GO
Average GHG intensity since t2-12 months of Non-CertifHy H2 must not exceed 91 gCO2/MJH2
H2 Production
12 months
Past Production
t2 – 12 months
t1
t2
Time
22


CertifHy
At the batch level, hydrogen needs to be Low Carbon for producing CertifHy Green or Low-Carbon GOs
Grey H2
H2 with Green GO
H2 with LC GO
Average GHG intensity since t2-12 months of Non-CertifHy H2 must not exceed 91 gCO2/MJH2
H2 Production
12 months
Past Production
Production Batch
t2 – 12 mths
t1
t2
Time
Average GHG intensity of H2 covered by a CertifHy GO must not exceed 36.4 gCO2/MJH2
Non-renewable share
Renewable share
CertifHy Low Carbon H2 GOs
CertifHy Green H2 GOs
19


CertifHy
Decision tree presenting the criteria for producing Low-Carbon and CertifHy Green H2
Average emissions of Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Grey H2
No
Yes
Production unit NOT ELIGIBLE
Renewable energy input into batch?
No
Yes
100% Non- renew. batch
X% renewable and
and (1-X%) non-renewable. share
Batch emissions < 36,4gCO2 eq/MJ (40% of benchm.)?
Renewable share emissions < 36,4gCO2 eq/MJ ?
Non-renewable share emissions < 36,4gCO2 eq/MJ ?
No
Yes
100% Grey H2
100% Low-carbon H2
X% Grey H2
X% Green H2
1-X% Grey H2
1-X% Low-carbon H2
24


CertifHy
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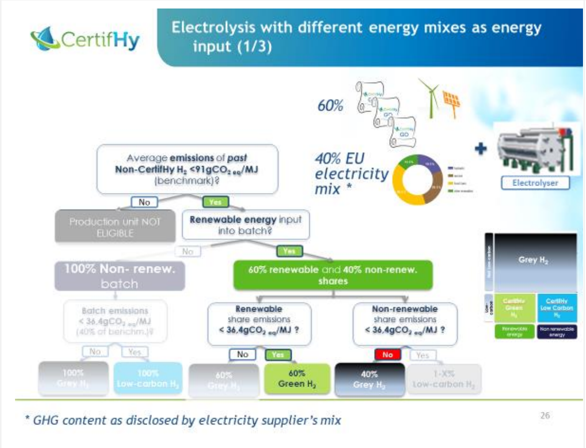
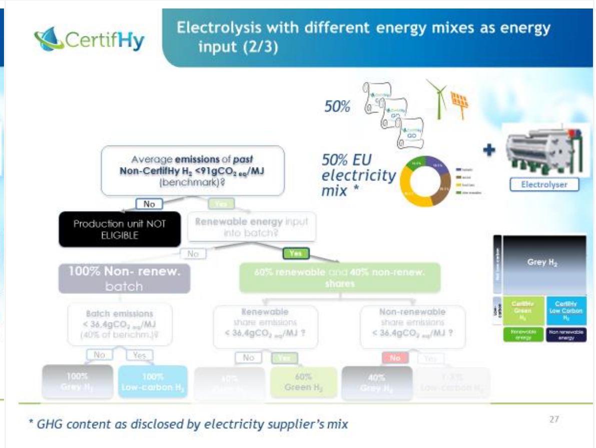
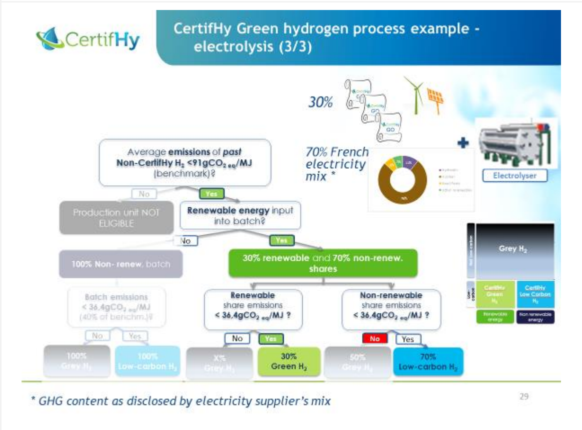
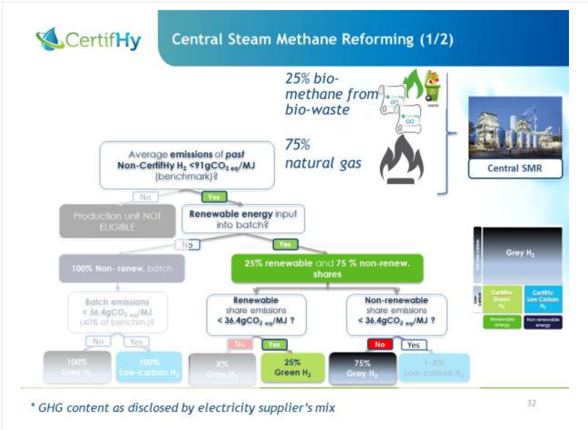
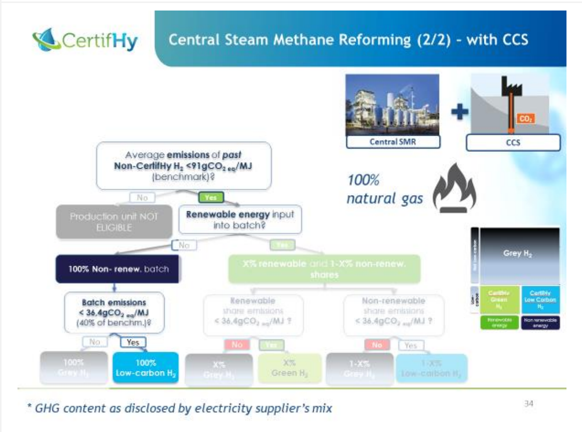
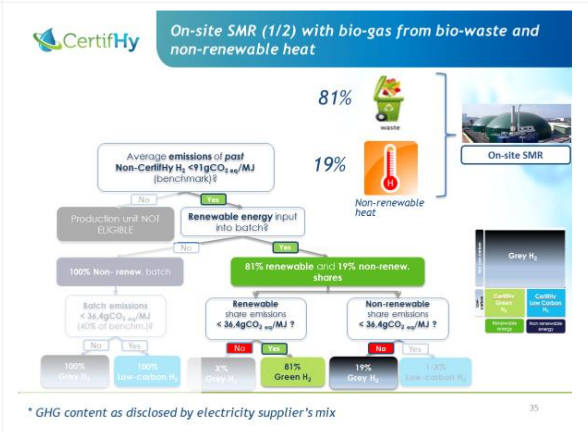

CertifHy
Electrolysis with different energy mixes as energy input (1/3)
60%
40% EU electricity mix *
Electrolyser
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Production unit NOT ELIGIBLE
Renewable energy input into batch?
100% Non- renew. batch
60% renewable and 40% non-renew. shares
Renewable share emissions < 36.4gCO2 eq/MJ ?
Non-renewable share emissions < 36.4gCO2 eq/MJ ?
60% Green H2
40% Grey H2
Grey H2
* GHG content as disclosed by electricity supplier's mix
26

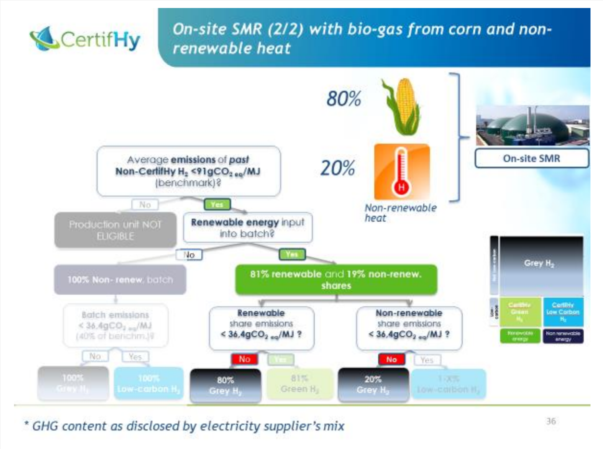

CertifHy
Electrolysis with different energy mixes as energy input (2/3)
50%
50% EU electricity mix *
Electrolyser
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Production unit NOT ELIGIBLE
100% Non- renew. batch
Grey H2
* GHG content as disclosed by electricity supplier's mix
27

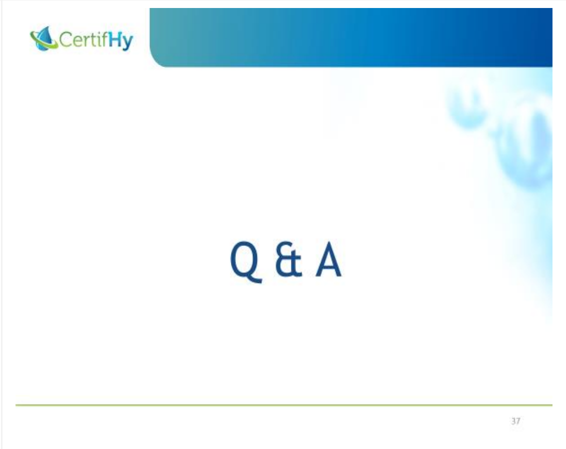

CertifHy
CertifHy Green hydrogen process example - electrolysis (3/3)
30%
70% French electricity mix *
Electrolyser
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Production unit NOT ELIGIBLE
Renewable energy input into batch?
30% renewable and 70% non-renew. shares
Renewable share emissions < 36.4gCO2 eq/MJ ?
Non-renewable share emissions < 36.4gCO2 eq/MJ ?
30% Green H2
70% Low-carbon H2
Grey H2
* GHG content as disclosed by electricity supplier's mix
29


CertifHy
Central Steam Methane Reforming (1/2)
25% bio-methane from bio-waste
75% natural gas
Central SMR
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Production unit NOT ELIGIBLE
Renewable energy input into batch?
25% renewable and 75 % non-renew. shares
Renewable share emissions < 36.4gCO2 eq/MJ ?
Non-renewable share emissions < 36.4gCO2 eq/MJ ?
25% Green H2
75% Grey H2
Grey H2
* GHG content as disclosed by electricity supplier's mix
32


CertifHy
Central Steam Methane Reforming (2/2) - with CCS
Central SMR
CCS
100% natural gas
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Production unit NOT ELIGIBLE
Renewable energy input into batch?
100% Non- renew. batch
Batch emissions < 36.4gCO2 eq/MJ (40% of benchm.)?
100% Low-carbon H2
Grey H2
* GHG content as disclosed by electricity supplier's mix
34


CertifHy
On-site SMR (1/2) with bio-gas from bio-waste and non-renewable heat
81%
19%
Non-renewable heat
On-site SMR
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
Production unit NOT ELIGIBLE
Renewable energy input into batch?
81% renewable and 19% non-renew. shares
Renewable share emissions < 36.4gCO2 eq/MJ ?
Non-renewable share emissions < 36.4gCO2 eq/MJ ?
81% Green H2
19% Grey H2
Grey H2
* GHG content as disclosed by electricity supplier's mix
35


CertifHy
On-site SMR (2/2) with bio-gas from corn and non-renewable heat
80%
20%
Non-renewable heat
On-site SMR
Average emissions of past Non-CertifHy H2 <91gCO2 eq/MJ (benchmark)?
No
Yes
Production unit NOT ELIGIBLE
Renewable energy input into batch?
No
Yes
100% Non- renew. batch
81% renewable and 19% non-renew. shares
Batch emissions < 36.4gCO2 eq/MJ (40% of benchm.)?
Renewable share emissions < 36.4gCO2 eq/MJ ?
Non-renewable share emissions < 36.4gCO2 eq/MJ ?
No
Yes
No
Yes
No
Yes
100% Grey H2
100% Low-carbon H2
80% Grey H2
81% Green H2
20% Grey H2
1-X% Low-carbon H2
Grey H2
CertifHy Green H2
CertifHy Low Carbon H2
Renewable energy
Non renewable energy
* GHG content as disclosed by electricity supplier's mix
36


CertifHy
Q & A
37

CLIMATE CHANGE

CASI

AT A GLANCE

Title: Public Participation in Developing a Common Framework for Assessment and Management of Sustainable Innovation

Funding mechanism: Coordination and support actions, FP7

FP7, Funding Scheme

Total Cost: 4.378.995,34 €

EC Contribution: 3.897.381 €

Duration: 42 months

Start Date: 1/1/2014

Consortium: 19 partners from 12 countries

Project Coordinator: ARC Fund (Bulgaria)

Project Web Site: http://www.casi2020.eu/

Key Words: sustainable innovation, climate action, resource efficiency and raw materials, assessment, social innovation, technological innovation, public participation, mobilisation and mutual learning

THE CHALLENGE

Tackling climate change and the myriad of issues pertinent to it is among the most pressing challenges of today's global community. Addressing it requires the development of solutions with reduced environmental impact, which at the same time consider the financial and social implications of their implementation. Sustainable innovation (SI) is within the center of this effort. Yet, it is a concept not sufficiently explored and not adequately supported by the relevant actors. The CASI project contributes to addressing this gap by fostering sustainable innovation (SI), both technological and social, at the *operational*, *programming* and *strategic level* through a holistic participatory approach. The CASI consortium shares the understanding of innovation as a key driver of societal progress in the age of technology and of imminent uncertainty about the future. Sustainable innovation enhances this understanding by introducing sustainability as a focal core of the innovation process.

PROJECT OBJECTIVES

CASI aims to foster SI through developing a coherent **methodology for the assessment and management of sustainable innovation practices**, based on a sound conceptual framework and a shared understanding of sustainability in innovation among stakeholders. The development of the framework (CASI-F) – a key product of the project – reflects expertise from various disciplines, academic research, lessons from practitioners' experiences, and not least – citizens' aspirations. It further draws on an extensive database of innovation practices from across the European Union, mapped in detail as part of the project activities. The database, which is publicly accessible and can be updated with new cases by innovators themselves, provides an ample opportunity for **improving the understanding of sustainable innovation management practices.**

At a strategic level, CASI aims to develop **specific policy recommendations on how to improve innovation management and how sustainability considerations can be incorporated** into it based on the findings of the assessment framework and a series of public consultations with citizens and relevant stakeholders. In achieving these objectives, the CASI consortium developed **a working definition of sustainable innovation**, building on common definitions, academic literature as well as expert advice internal and external to the project consortium.

METHODOLOGY

To achieve its objectives CASI mobilises multi-actor and multi-disciplinary cross-national intelligence in formulating strategic tools and guidelines on three levels (or sources of *strategic intelligence*): i) **Mapping SI practices, outcomes and players.** CASI partners developed a database (CASIPEDIA) covering cases from all 28 EU countries and beyond. The large database supports innovators through providing a rich qualitative perspective on critical factors for the success of SI practices (i.e. uptake/implementation/diffusion), such as barriers, drivers, opportunities, and threats; ii) **Public engagement** – within CASI more than 300 citizens from 12 EU countries were involved in the development of visions on sustainable future, on the basis of which research priorities were developed by experts and prioritised by the involved in CASI citizens. Thus, CASI provides a unique citizen-based perspective in the development of EU and national level research agenda in the field of climate action, environment, resource efficiency and raw materials; iii) **Policy monitoring** – CASI developed a mechanism for national and EU level policy monitoring on topics related to SI, which helps extract key messages from current SI policy discourses. Furthermore, following numerous stakeholder consultations, EU-wide policy recommendations will be elaborated with the ambition to improve the integration of sustainability and innovation support actions into addressing the underlying issues embedded into the “Climate action, resource efficiency and raw materials” Grand Societal Challenge.

EXPECTED RESULTS

The CASI’s method has successfully integrated the viewpoints of lay citizens with expert knowledge in order to provide a much more solid evidence base when proposing policy solutions to sustainability related challenges.

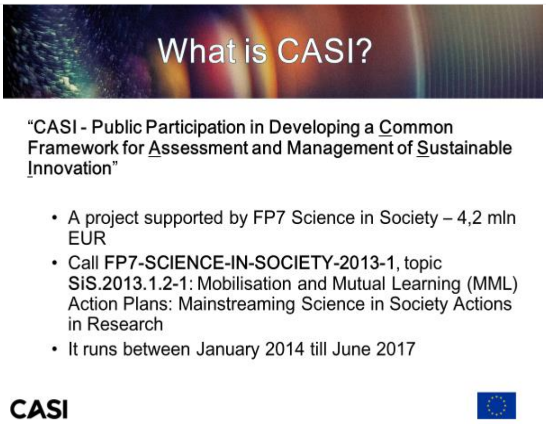
A key product of CASI is the common framework for assessment and management of sustainable innovation (CASI-F), which can be used as a strategic management instrument by a variety of innovation stakeholders, including business, research and academia, civil society, and government actors. It enables organisations to devise action plans at three levels of complexity – strategic, programing and operational, and to analyse those critical issues, which drive or hinder their success, with a strong focus on sustainability aspects.

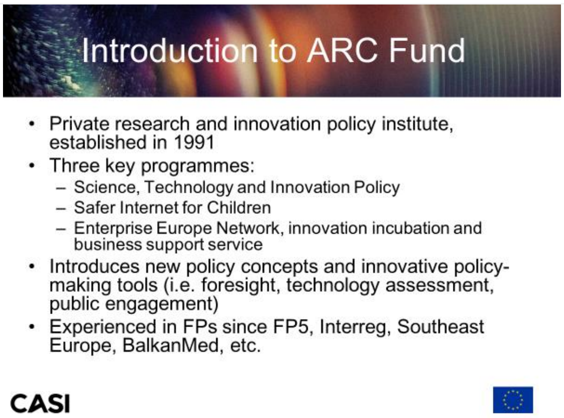
Project Partners	Country
Applied Research and Communications Fund (Coordinator)	Bulgaria
Coventry University Enterprises Ltd	United Kingdom
Danish Board of Technology Foundation	Denmark
University of Helsinki	Finland
Technical University of Dortmund	Germany
University of Primorska	Slovenia
Poznan Science and Technology Park of Adam Mickiewicz University Foundation	Poland
INOVAMAIS	Portugal
META Group	Italy
Increase Time	Portugal
Municipality of Monza	Italy
Espinho City Council	Portugal
Centre for Social Innovation	Austria
Interuniversity Research Centre for Public Services, University of Milano	Italy
Cleantech Bulgaria Foundation	Bulgaria
Manchester Institute of Innovation Research, University of Manchester	United Kingdom
Catholic University of Leuven	Belgium
TechnoLogica EAD	Bulgaria
Futures Diamond	Czech Republic

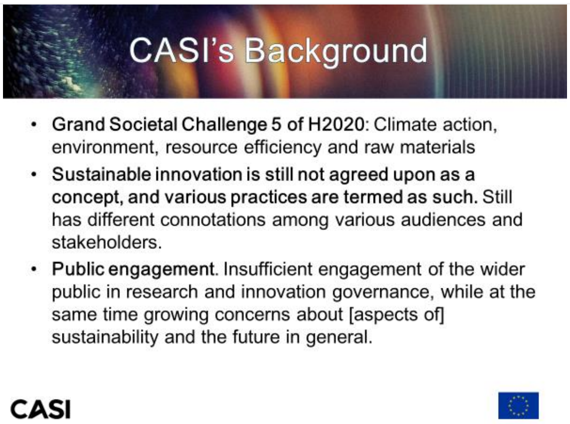
Public Participation in Developing a Common Framework for Assessment and Management of Sustainable Innovation (CASI)

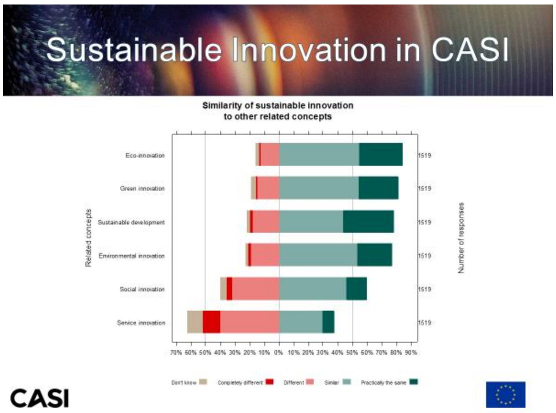
presentation by **Mr. Ventseslav KOZAREV**,

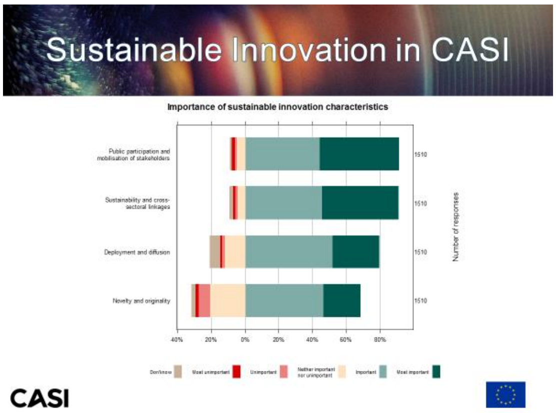
Applied Research and Communications Fund (ARC Fund) – Bulgaria



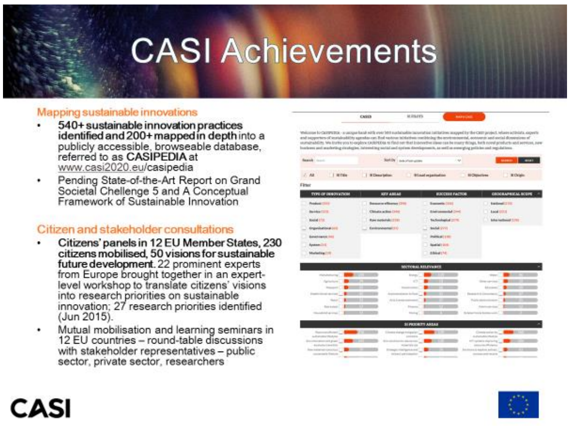


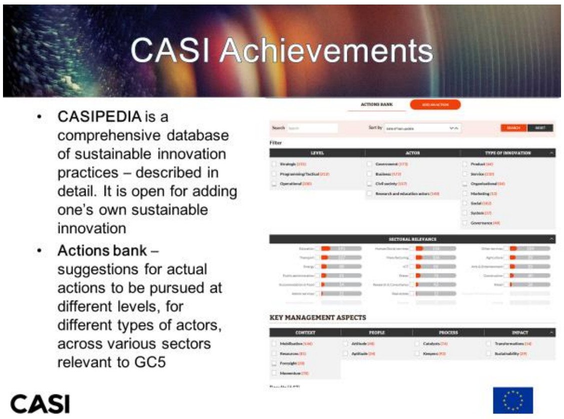



Sustainable Innovation in CASI
Similarity of sustainable innovation
to other related concepts
Related concepts
Eco-innovation
Green innovation
Sustainable development
Environmental innovation
Social innovation
Service innovation
1519
Number of responses
70% 60% 50% 40% 30% 20% 10% 0% 10% 20% 30% 40% 50% 60% 70% 80% 90%
Don't know
Completely different
Different
Similar
Practically the same
CASI


Sustainable Innovation in CASI
Importance of sustainable innovation characteristics
Public participation and mobilisation of stakeholders
Sustainability and cross-sectoral linkages
Deployment and diffusion
Novelty and originality
1510
Number of responses
40% 20% 0% 20% 40% 60% 80%
Don't know
Most unimportant
Unimportant
Neither important nor unimportant
Important
Most important
CASI


Sustainable Innovation in CASI
Sustainable innovation may be conceived as
– any incremental or radical change
– in the product, service, system, organisational, governance, social and marketing landscape
– that leads to positive environmental, economic and social transformation
– without compromising the needs and welfare of future generations
CASI


CASI Achievements
Mapping sustainable innovations
• 540+ sustainable innovation practices identified and 200+ mapped in depth into a publicly accessible, browseable database, referred to as CASIPEDIA at www.casi2020.eu/casipedia
• Pending State-of-the-Art Report on Grand Societal Chellenge 5 and A Conceptual Framework of Sustainable Innovation
Citizen and stakeholder consultations
• Citizens' panels in 12 EU Member States, 230 citizens mobilised, 50 visions for sustainable future development. 22 prominent experts from Europe brought together in an expert-level workshop to translate citizens' visions into research priorities on sustainable innovation; 27 research priorities identified (Jun 2015).
• Mutual mobilisation and learning seminars in 12 EU countries – round-table discussions with stakeholder representatives – public sector, private sector, researchers
CASI


CASI Achievements
• CASIPEDIA is a comprehensive database of sustainable innovation practices – described in detail. It is open for adding one's own sustainable innovation
• Actions bank – suggestions for actual actions to be pursued at different levels, for different types of actors, across various sectors relevant to GC5
KEY MANAGEMENT ASPECTS
CASI


CASI Achievements
• Key product of CASI – Common Framework for Assessment and Management of Sustainable Innovation (CASI-F) – provides guidance on three levels of management – strategic, programming and operational
• Online survey on the characteristics of sustainable innovation – 1793 respondents, experts in innovation and/or sustainability, from across the EU
• Consultation workshops on CASI-F: 12 workshops in 12 EU countries with 140 stakeholders attending and discussing, providing an initial round of feedback
• Piloting CASI-F with 46 innovators across the EU, with a focus on social vs. technical innovations.
• Policy Watch – national and EU-level policy briefs are being published regularly on current policy topics.
• Annual policy reports – second annual policy report will be published in November 2016
• Policy blog – kick-starting discussions on sustainability topics and exploring their policy relevance in a less formal way
CASI

CASI Achievements

- **CASI-F** is now being finalised as a **comprehensive tool** to be used in the analysis of sustainable innovations, and for generation of management actions at strategic, programming and operational level
- An **online training** is being designed, and will be open to all interested in learning about the CASI-F, how they could apply it, and what benefits that would bring

CASI

Policy Conference

- Policy Conference **"Public Engagement for Research, Practice and Policy: Exploring Policy Options for Responsible Research, Sustainability and Innovation"**
- **Brussels, November 16-17, Committee of the Regions**
- A joint event by the **CASI** project and the **PE2020** (Public Engagement Innovations for Horizon2020) project
- Registration is still open - http://www.casi2020.eu/casi-policy-conference-2016/

CASI

The CASI Partnership

CASI

Thank you!

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Blagovesta Chonkova, Project Coordinator
blagovesta.chonkova@online.bg

Applied Research and Communications Fund
http://www.arcfund.net
http://www.casi2020.eu

CASI

DAFNI NETWORK

AT A GLANCE

Title: Network of Sustainable Aegean and Ionian Islands – DAFNI

Members: The Region of North Aegean, the Region of South Aegean and the island municipalities of: Aegina, Alonissos, Amorgos, Andros, Antiparos, Thira, Ios, Kalymnos, Kea, Kimolos, Kythnos, Kos, Lipsi, Lesbos, Limnos, Milos, Mykonos, Naxos and Small Cyclades, Nissyros, Patmos, Paros, Rhodes, Samothraki, Sikinos, Sifnos, Skopelos, Skyros, Syros-Ermoupoli, Tilos, Tinos, Ydra, Folegandros, Fournoi-Korseon, Chios

Start Date: 2006

THE CHALLENGE

The balanced economic, social, environmental and cultural development of Greek Islands, paying special attention to the unique natural and cultural environment

OBJECTIVES

To provide Greek islands with access to programmes, projects and activities supported by local, national and EU funds and thus create the necessary economies of scale for effective project realization

METHODOLOGY

1. To empower islands' local societies and authorities to make decision-making around key topics such as local economic development, environmental protection and preservation of cultural heritage more participatory.

2. To put forward integrated, innovative and smart solutions in the field of renewable energy and energy efficiency, sustainable transport and mobility, sustainable waste and water management.

3. To leverage financing from EU programmes to the benefit of island-members of the Network.

4. To promote investment schemes and governance practices that foster innovation and social inclusion.

5. To preserve and protect islands' natural environment, which represents a key economic resource at local and national level.

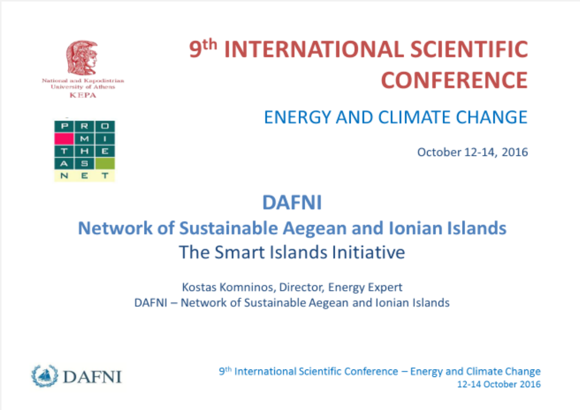
6. To support quality tourism and alternative tourism

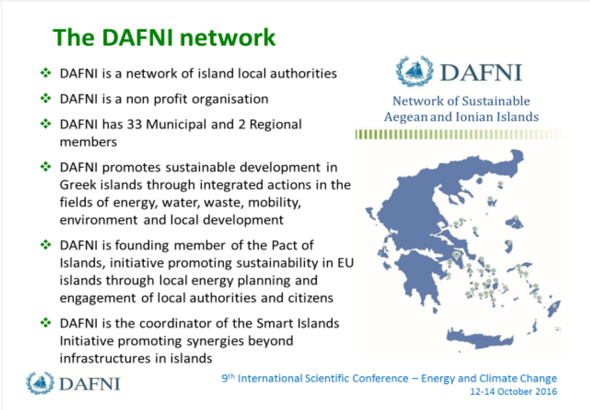
7. To participate in international organizations that enable the sharing of experience and knowledge exchange.

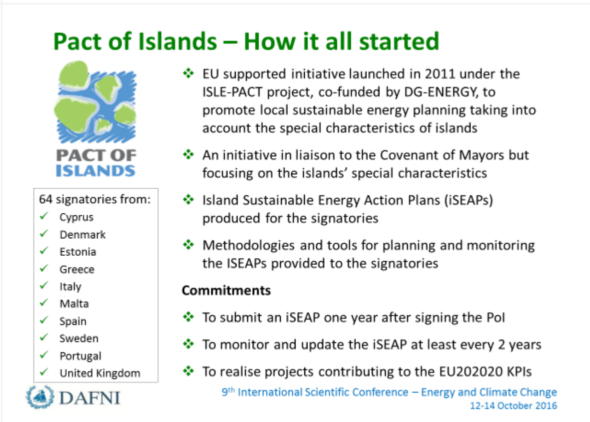
PAST PROJECTS	
Enhancing effective implementation of sustainable energy action plans in European islands through reinforcement of smart multilevel governance/SMILEGOV	Intelligent Energy Europe
Development of smart-grid infrastructure in 5 autonomous island grids of the Aegean Sea in Greece	ELENA Fund, EIB
ISLEPACT	DG ENERGY
Upgrading of Energy Efficient Public Procurement for a balanced economic growth of SEE area/EFFECT	South East Europe Territorial Cooperation Programme
ACTIVITIES	
Sustainability Reports	The reports are the result of DAFNI's extensive field research in collaboration with the National Technical University of Athens. The reports provide valuable information on the progress of each island with regards to specific sustainability indicator set for each island-member
Covenant of Mayors	DAFNI represents the official supporting structure for the Covenant of Mayors – CoM in the Aegean Islands having developed Sustainable Energy Action Plans (SEAPs) for 10 island municipalities in collaboration with local authorities, complemented by a methodology for the inventory of energy consumption, monitoring of CO_2 emissions and implementation of SEAPs
Pact of Islands	Establishment in 2011 of the European initiative "Pact of Islands" in collaboration with other island actors across Europe. The Pact of Island is similar to the "Covenant of Mayors", has been officially recognized by the European Institutions and addresses island authorities who are willing to exceed the European Union climate targets for 2020. 26 island local authorities along with the two regional authorities of North and South Aegean (members of DAFNI) have signed the Pact, and so has the Region of Crete
Smart Islands Initiative	The Smart Islands Initiative is inspired by the Smart Cities and Communities initiative of the European Commission and advocates in favour of a place-based, transformative development agenda that taps into islands' competitive advantages, generates local growth and prosperity and contributes to EU policy goals in the fields of energy, climate, innovation, circular economy, transport and mobility, blue growth, and the digital agenda

DAFNI Network of Sustainable Aegean and Ionian Islands – the Smart Islands Initiative

Presentation by **Mr. Konstantinos KOMNINOS**, Network DAFNI – Hellas







Current PoI Signatories

Signatories = Islands

- Cyprus – 16 municipalities
- Denmark – 1 island
- Estonia – 3 islands
- Finland – 4 islands
- France – 5 islands
- Greece – 32 islands
- Ireland – 1 island
- Italy – 11 islands
- Malta – 5 municipalities
- Portugal – 11 islands
- Spain – 11 islands
- Sweden – 11 islands
- UK – 1 island
- Cape Verde – 10 islands

117 islands have signed the Pact of Islands as of today

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What is special about Islands

Political dimension

- Recognition of insularity by European Treaties (Article 174 of the Lisbon Treaty) and in the European Directives
- Political support from the European Parliament
  - Musotto Declaration (2007), Written Declaration 37 (2011)
- Call for tenders of the European Commission – Preparatory Action for Islands (2008)
- Political support and Declaration from major island authorities and regions (through the Islands Commission of the CPMR)
- “Smart Islands” is the new strategy for the European Islands (September 2013) – drawing inspiration from Smart Cities and Communities
- “Smart Islands” is an own-opinion by the European Economic and Social Committee (March 2015)

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What is special about Islands

Structural handicaps related to energy

- Energy planning based on seasonality
- High reliance on hydrocarbons, high potential for emissions reduction
- Obstacles to reduce emissions for interconnected islands due to low capacity cables that do not allow high RES penetration
- Obstacles to reduce emissions for non-interconnected (NI) islands due to technical restrictions in the grid that does not allow high RES penetration
- First line of defence and most severe impact from climate change compared to continental regions
- Difficulty to introduce natural gas in the islands’ energy market
- Cost of energy is significantly higher due to transportation costs
- Often scarce water resources – Energy intensive desalination plants

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What is special about Islands

Opportunities

- Many islands regions (NI ones), unlike mainland regions, are locally producing CO_2 emissions in their territories and can commit to reduce them.
- Islands host locally all the energy, water, waste and waste water management utilities. The integrated management of these infrastructures may create interesting paradigms and accumulated results.
- Insularity issues faced by islands are in many cases similar with the insularity issues faced by mountainous and geographically isolated areas of continental Europe. The experiences of islands can be easily replicated and transferred to these areas too.
- Investments such as smart grids, energy storage and efficiency have a much higher impact on islands; especially non-interconnected ones.
- Islands can function as test beds for different innovative technologies in the sustainability area which then can be scaled up to towns and cities of continental Europe

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What is special about Islands

EURELECTRIC report – June 2012

“EU islands: Towards a sustainable energy future”

The report makes the following recommendations to national and European policymakers to incentivise the transition towards a sustainable energy future

1. *Set up an EU Island Sustainable Energy Action Plan 2020*
2. *Improve security of supply through diversification of power generation technologies, as well as interconnection where possible*
3. *Use islands as a priority test-bed for innovative technologies such as storage, smart grids and RES. Foster RD&D on islands*
4. *Use exemptions appropriately and address the market failures that often occur as a result of limited size and isolation*

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What’s next?

Smart Islands Initiative

Is inspired by the Smart Cities and Communities initiative of the European Commission and seeks to demonstrate that islands can host pilot projects and produce knowledge on smart and efficient resource and infrastructure management, which may be then transferred in mountainous, rural and generally geographically isolated areas but also scaled-up in big cities of continental Europe and beyond

SI Initiative advocates in favour of a place-based, transformative development agenda that taps into islands’ competitive advantages, generates local growth and prosperity and contributes to EU policy goals in the fields of

- energy, climate,
- innovation, circular economy,
- transport and mobility,
- blue growth, and
- the digital agenda

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Smart Islands Initiative

- **Smart Island** refers to an insular territory that creates local sustainable economic development and a high quality of life for the local population by putting in place smart and integrated solutions to the management of infrastructures and natural resources, namely energy, transport and mobility, waste and water, all while promoting the use of innovative and socially inclusive governance and financing schemes.
- **Smart** is used to refer to the adoption of an integrated approach to the management of islands' infrastructure and natural resources and thus create an enabling environment for sustainable economic activities to flourish.

The Smart Islands initiative unfolds in three main directions

Smart Islands Initiative

Smart Islands Forum
An annual event for networking, knowledge exchange and project development

Smart Islands Declaration
A manifest to mobilize political and financial support towards islands seen as field of innovation and excellence

Smart Islands Platform
An EU scale legal entity to promote smart, integrated and sustainable policies and projects of interest for its members

DAFNI

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Smart Islands Initiative

Where we stand today

1. **1st Smart Islands Forum** took place in Athens in June 2016 with the participation of over 40 island representatives from Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Italy, Malta, Spain, Sweden, the Netherlands and the UK setting the foundations for the Initiative
2. **Smart Islands Own Declaration** is currently being signed by local island authorities and Letters of Support to the Initiative are signed by representatives of the Quadruple Helix
3. **Smart Islands Event: Creating new pathways for EU islands** is planned and organised for February 2017 as an outgoing Brussels event with the support of MEPs to present to key stakeholders the Initiative

DAFNI

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Thank you

KEEP CALM
AND
THINK ABOUT THE ISLANDS

For more information
director@dafni.net.gr
kk@aegean-energy.gr

DAFNI

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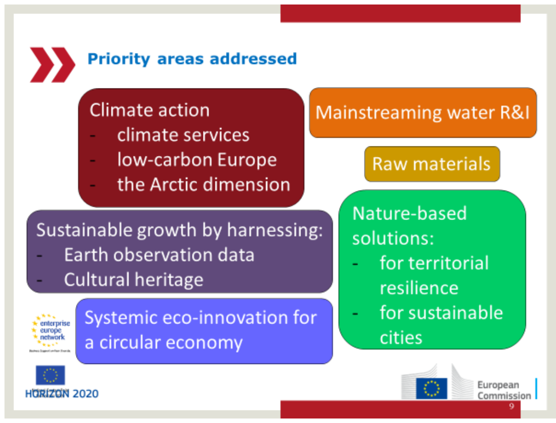
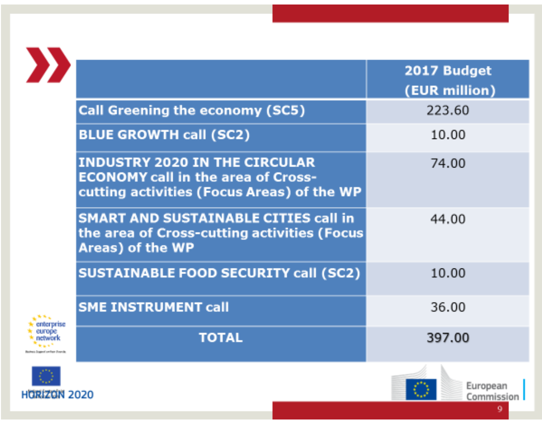
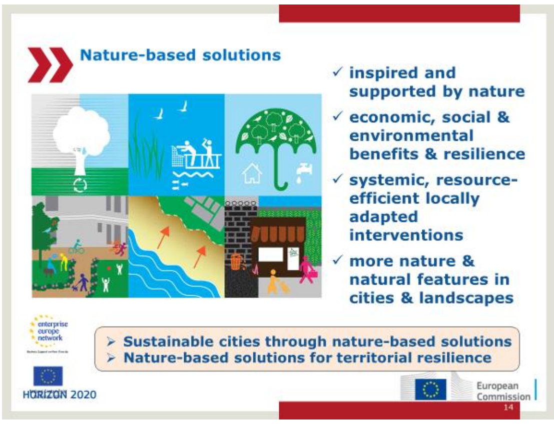
HORIZON2020 -Climate Action

Presentation by **Dr. Aggeliki-Eleni VROCHIDOU**, PRAXI - Hellas





	2017 Budget (EUR million)
Call Greening the economy (SC5)	223.60
BLUE GROWTH call (SC2)	10.00
INDUSTRY 2020 IN THE CIRCULAR ECONOMY call in the area of Cross-cutting activities (Focus Areas) of the WP	74.00
SMART AND SUSTAINABLE CITIES call in the area of Cross-cutting activities (Focus Areas) of the WP	44.00
SUSTAINABLE FOOD SECURITY call (SC2)	10.00
SME INSTRUMENT call	36.00
TOTAL	397.00


Nature-based solutions
✓ inspired and supported by nature
✓ economic, social & environmental benefits & resilience
✓ systemic, resource-efficient locally adapted interventions
✓ more nature & natural features in cities & landscapes
➢ Sustainable cities through nature-based solutions
➢ Nature-based solutions for territorial resilience
HORIZON 2020
European Commission
14


Nature-based solutions
Where?
Topics on Sustainable cities through nature-based solutions in cross-cutting call 'Smart and Sustainable Cities':
• SCC-02-2016-2017: Nature-based solutions for inclusive urban regeneration (IA)
➢ Nature-based solutions for inclusive urban regeneration
€44M
Topics on Nature-based solutions for territorial resilience in SC5 call 'Greening the economy':
SC5-08-2017: Large-scale demonstrators on nature-based solutions for hydro-meteorological risk reduction (IA)
€29M
HORIZON 2020
European Commission
15


Nature-based solutions
- where to find topics
Topics on Sustainable cities through nature-based solutions
✓ in cross-cutting call 'Smart and Sustainable Cities'
✓ Total indicative budget in 2017: €44M
Topics on Nature-based solutions for territorial resilience
✓ in SC5 call 'Greening the Economy'
✓ Total indicative budget in 2017: €29M
Calls open:
08 Nov 2016
First deadline:
07 Mar 2017 (First stage)
05 Sep 2017 (Second stage)
HORIZON 2020
European Commission
16

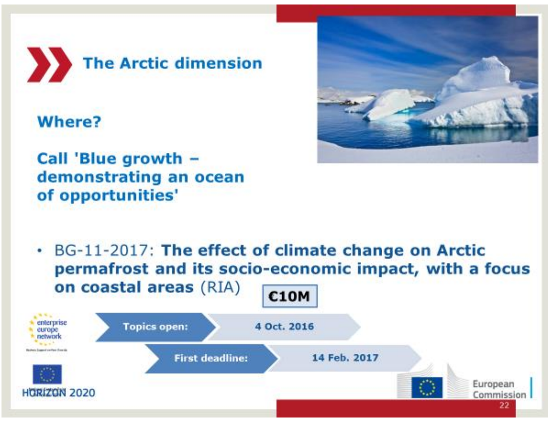

Climate services
✓ building Europe's capacity to respond to and improve resilience to climate change
✓ strengthening significantly the nascent global market for demand-driven climate services
✓ addressing both climate change mitigation and adaptation needs
HORIZON 2020
European Commission
17


Climate services
Where?
Call 'Greening the economy':
• SC5-01-2016-2017: Exploiting the added value of climate services
€43M
➢ From climate service concepts to piloting and proof-of-concept (RIA)
• SC5-02-2017: Integrated European regional modelling and climate prediction system (RIA)
SC5-04-2017: Towards a robust and comprehensive greenhouse gas verification system (RIA)
HORIZON 2020
European Commission
19


Towards a low-carbon Europe
✓ deepening the analysis of possible and cost-effective trajectories for Europe to achieve its medium and long-term climate objectives
✓ maximising societal benefits and economic prosperity
HORIZON 2020
European Commission
18


Towards a low-carbon Europe
Where?
Call 'Greening the economy':
• SC5-06-2016-2017: Pathways towards the decarbonisation and resilience of the European economy in the timeframe 2030-2050 and beyond
➢The risks and costs of climate change for Europe (RIA)
• SC5-07-2017: Coordinating and supporting research and innovation actions on the decarbonisation of the EU economy (CSA)
€2M
HORIZON 2020
European Commission
20


Climate services and Towards a low-carbon Europe
-where to find topics
➢ Topics in call 'Greening the Economy'
➢ Total indicative budget for these topics in 2017: €45M
Calls open:
08 Nov 2016
First deadline:
07 Mar 2017
HORIZON 2020
European Commission
21


The Arctic dimension
Where?
Call 'Blue growth – demonstrating an ocean of opportunities'
• BG-11-2017: The effect of climate change on Arctic permafrost and its socio-economic impact, with a focus on coastal areas (RIA)
€10M
Topics open:
4 Oct. 2016
First deadline:
14 Feb. 2017
HORIZON 2020
European Commission
22


Raw materials
✓securing the EU's supply of primary and secondary raw materials through research and innovation
✓EU Policy "Raw Materials Initiative"
- non-energy, non-agricultural raw materials
- list of Critical Raw Materials (CRM)
✓European Innovation Partnership on Raw Materials
HORIZON 2020
European Commission
23


Raw materials
Where?
Call 'Greening the economy':
• SC5-13-2016-2017: New solutions for sustainable production of raw materials (RIA)
➢ New sensitive exploration technologies
€10M
• SC5-14-2016-2017: Raw materials Innovation actions (IA)
➢ Processing of lower grade/ complex primary/ secondary raw materials
➢ Sustainable metallurgical processes
€56M
• SC5-15-2016-2017: Raw materials policy support actions (CSA)
➢ Good practice in waste collection systems
➢ Optimising collection of raw materials data in Member States
➢ Linking land use planning policies to national mineral policies
€10M
• SC5-16-2016-2017: Raw materials international co-operation
➢ International network of raw materials training centres (CSA)
HORIZON 2020
European Commission
24


Raw materials
- where to find topics
➢ Topics on raw materials production in call 'Greening the Economy'
➢ Total indicative budget for 2017: €76M
o substitution of critical and scarce raw materials -> LEIT-NMBP 'Advanced materials and nanotechnologies'
o recycling, re-use and secondary raw materials -> 'Industry 2020 in the Circular Economy' cross-cutting call
o bio-based materials (wood-based & natural rubber) -> Societal Challenge 2 and Joint Undertaking for Bio-Based Industries (BBI)
Topics open:
8 Nov. 2016
First deadline:
7 March 2017
HORIZON 2020
European Commission
25


Earth observation
✓ maximising benefits of E.O. infrastructure for European citizens
✓ developing innovative services to support more sustainable production & consumption patterns & resilient societies
✓ completing the in-situ component of GEOSS & Copernicus
✓ enabling the sharing & full, open & unrestricted access to validated E.O. datasets
✓ engaging with the private sector to leverage emerging technologies & develop services
HORIZON 2020
European Commission
26


Earth observation
Where?
Call 'Greening the economy':
• SC5-18-2017: Novel in-situ observation systems (IA) €15M
• SC5-19-2017: Coordination of citizens' observatories initiatives (CSA) €1M
Call 'Sustainable Food Security – resilient agri-food chains':
➢ SFS-43-2017: Earth Observation services for the monitoring of agricultural production in Africa (RIA)
€10M
HORIZON 2020
European Commission
27


Earth observation -where to find topics
➢ Call 'Greening the Economy'
✓ Total indicative budget* for topics in 2017: €16M
Calls open: 08 Nov 2016
First deadline: 07 Mar 2017 (First stage)
05 Sep 2017 (Second stage, where relevant)
➢ Call 'Sustainable Food Security – Resilient and resource-efficient value chains'
✓ Total indicative budget for topic in 2017: €10M
Topics open: 4 Oct. 2016
First deadline: 14 Feb. 2017
HORIZON 2020
European Commission
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Earth observation
Where else?
Call 'Earth Observation' (H2020-EO-2017)
• EO-1-2017: Downstream applications
• EO-2-2017: EO Big Data Shift
€12+6.5M
Call 'Competitiveness of the European Space Sector: Technology and Science' (H2020-COMPET-2017)
• COMPET-2-2017: Competitiveness in Earth observation mission technologies €7M
Call 'SME Instrument' (H2020-SMEInstr-2016-2017)
• SMEInst-04-2016-2017: Engaging SMEs in space research and development €1.26M
• SMEInst-12-2016-2017: Boosting the potential of small businesses in the areas and priorities of SC5 €1.14M
HORIZON 2020
European Commission
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Cultural heritage for sustainable growth
✓ A more dynamic approach to cultural heritage, beyond mere conservation
✓ cultural heritage as a production rather than a cost factor, and a strategic resource
✓ cultural heritage as a catalyst for regeneration, sustainable development, economic growth and quality of life
✓ European reference framework and robust EU-wide evidence
HORIZON 2020
European Commission
30


Cultural heritage for sustainable growth
Where?
Call 'Greening the Economy'
• SC5-21-2016-2017: Cultural heritage as a driver for sustainable growth
➢ Heritage-led rural regeneration (IA) €14M
• SC5-22-2017: Innovative financing, business and governance models for adaptive re-use of cultural heritage (RIA) €5M
HORIZON 2020
European Commission
31


Cultural heritage for sustainable growth
- where to find topics
Call 'Greening the Economy'
Total indicative budget for these topics in 2017: €19M
Calls open: 08 Nov 2016
First deadline: 07 Mar 2017 (First stage) 05 Sep 2017 (Second stage, where relevant)
HORIZON 2020
European Commission
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Water
mainstreamed through WP 2017, as part of the systemic approach
exploit possibilities for European industry to become global market leader
continuity with 2014-2015 Focus Area call 'Water Innovation: Boosting its value for Europe'
HORIZON 2020
European Commission
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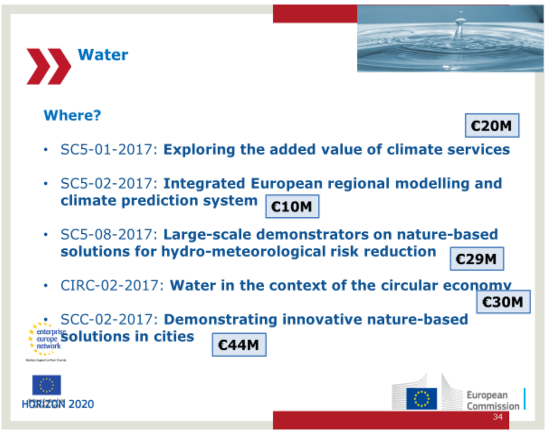
Water
Where?
€20M
SC5-01-2017: Exploring the added value of climate services
SC5-02-2017: Integrated European regional modelling and climate prediction system €10M
SC5-08-2017: Large-scale demonstrators on nature-based solutions for hydro-meteorological risk reduction €29M
CIRC-02-2017: Water in the context of the circular economy €30M
SCC-02-2017: Demonstrating innovative nature-based solutions in cities €44M
HORIZON 2020
European Commission
34


Water
- where to find topics
Call 'Greening the Economy'
Total indicative budget for these topics in 2017: €133M
Calls open: 08 Nov 2016
First deadline: 07 Mar 2017 (First stage) 05 Sep 2017 (Second stage, where relevant)
HORIZON 2020
European Commission
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Support to policy & preparing for innovation procurement
Where?
Call 'Greening the Economy'
€0.6M
SC5-23-2016-2017: Support to confirmed Presidency events (conferences) – UK and Estonia (CSA)
Calls open: 17 Oct 2016
First deadline: 24 Jan 2017
SC5-26-2017: Pre-commercial procurement on soil decontamination €5M
Calls open: 08 Nov 2016
First deadline: 07 Mar 2017
HORIZON 2020
European Commission
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SME Instrument call: SC5 topic
SMEinst-11-2016-2017: Boosting the potential of small businesses in the areas and priorities of climate action, environment, resource efficiency and raw materials €3.6M
commercialising innovative solutions for green growth
targeted at all types of eco-innovative SMEs with a strong ambition to develop, grow and internationalise
HORIZON 2020
European Commission
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For further information
Research Participant Portal
http://ec.europa.eu/research/participants/portal/desktop/en/home.html
Horizon 2020 Helpdesk
http://ec.europa.eu/research/enquiries
Expert evaluators needed!
http://ec.europa.eu/research/participants/portal/desktop/en/experts/index.html
Learn more about Horizon 2020
http://ec.europa.eu/horizon2020
Social media network on 'Yammer'
http://www.tinyurl.com/greenRTD
enterprise europe network
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enterprise europe network
HORIZON 2020
European Commission


NCPs CaRE – Partner search tool
NCPs CaRE
http://partnersearch.ncps-care.eu/
Register in the platform:
create cooperation profile
search for cooperation opportunities
Partner search tool
Search
Partner Login
enterprise europe network
HORIZON 2020
European Commission
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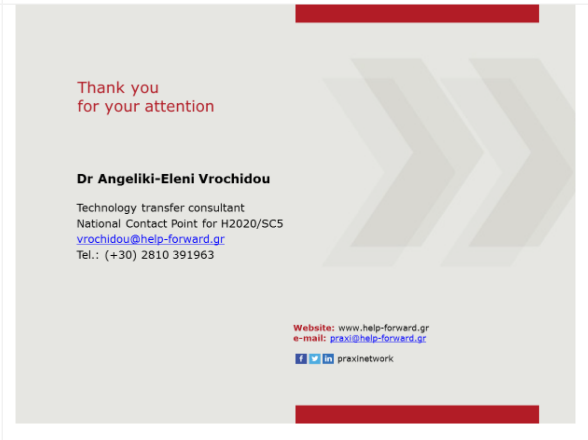
Thank you
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praxinetwork

Project proposals of BSEC- Green Energy Network

Presentation by **Ms. Aliki-Nefeli MAVRAKI**,

National and Kapodistrian University of Athens – Hellas

Project proposals BSEC-Green Energy Network

Ms. Aliki-Nefeli MAVRAKI

Research Associate – KEPA

9th International Scientific Conference – Energy & Climate Change | October 2016, Athens

BSEC – Green Energy Network

- The BSEC – Green Energy Network was founded by the BSEC Working Group on Energy in 4th November 2014.
- It is a network of cooperation between centres and national administrative bodies/ organizations and academic institutions.
- Its aim is **to promote renewable energy sources and energy efficiency measures and policies.**
- It functions under the supervision of the BSEC – PERMIS and receives members not only from the BSEC member states but also from the BSEC Observers and Sectoral Dialogue Partners, as well.
- Coordinator: Prof. Dimitrios MAVRAKIS

BSEC Green Energy NETWORK

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Four proposals

- The leaders
  - **Leadership:** Permanent International Secretariat of the Organization of the Black Sea Economic Cooperation (BSEC PERMIS)
  - **Coordination:** BSEC – Green Energy Network
- The participants
  - Academic institutions, research centers, market stakeholders, decision makers and SMEs from all the BSEC countries and abroad
- The thematic areas
  - Energy Efficiency
  - Climate Change
  - Innovation
- The funds
  - International organizations (UNDP -The United Nations Development Programme, UNEP - The United Nations Environment Programme, BSTDB – Black Sea Trade and Development Bank, etc)
  - Governments of BSEC member states

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BSEC – HERON

A forward-looking socio-economic research on Energy Efficiency in all BSEC countries

- Aim

This proposal aims at facilitating policy makers of multi-level governance in BSEC region, to develop and monitor energy efficiency policies in buildings, through forward-looking socio-economic research.

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BSEC – HERON

- Objectives
  1. identifying the impact of socio-economic and institutional factors on implementing energy efficiency policies and measures
  2. the development of energy efficient pathways to the horizon 2030 and beyond incorporating social, educational and cultural factors so as to reflect the end-user behavior
  3. the establishment of communication channels between researchers, decision makers of different governance levels and social and market stakeholders.

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BSEC – HERON

- Expect Impact

Positive impacts on Energy Efficiency policy development, evidenced for example by reference to impact assessments, strategy papers or other policy documents.

- Indicative Budget & Duration

1 million Euro , 3 years

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BSEC – IRIS

Progress assessment of efforts towards decarbonized and resilient economies for the BSEC Member States

- Aim

The proposal aims to contribute substantially to the efforts of the BSEC Member States in turning their current economies into decarbonized and resilient ones, in consistency with the recent outcomes of the UNFCCC negotiations (December 2015, Paris).

BSEC – IRIS

- Objectives

1. To **build a tailor-made** to the needs of BSEC Member States **framework** so as to allow them to assess the progress of their efforts towards the targets set under the Paris Agreement (2oC – 1.5oC);
2. to **develop** for the BSEC countries (cooperation of participating institutes coming from these countries with well-known research institutes from EU), **3 emission pathways** ("BAU", "NDCs", "below 2oC") and their underpinning policies in the time frame 2030-2050 and beyond using 3 different energy system models (E3GM, TIAM, LEAP);
3. to **establish a policy dialogue** with policy makers, scientists and key market actors coming from the EU and the BSEC region **for better understanding** of the current and future efforts of BSEC Member States, along with needs, risks and opportunities;
4. to **conclude** with policies and revised **emission targets** based on previous objectives.

BSEC – IRIS

- Expected Impact

1. provide a thorough analysis about the efforts of the BSEC Member States towards the long term climate goal (assessment framework, combined modelling and policy dialogue in national, regional and international level);
2. identify cooperation areas, investment opportunities, conditions for effective exploitation of international climate finance within the BSEC region;
3. increase the contribution of the BSEC region during future UNFCCC negotiations;
4. support relevant Goals and priority areas of the BSEC Economic Agendas 2012 and 2013.

- Indicative Budget & Duration

2 million Euro, 3 years

BSEC – ETAIRIOS ZEUS

A bottom-up process as a paradigm to encourage R&I cooperation between BSEC and EU

- Aim

The concept of this proposal is to enhance the effectiveness of Research and Innovation (R&I) cooperation actions between BSEC and EU through the development of a bottom – up integrated process.

This bottom-up process is synthesized along two main axes starting:

i) from two specific key Societal Challenges (Climate Action and Clean & Efficient Energy) and moving towards the whole spectrum of R&I thematics, and

ii) from the narrowed group of researchers, policy makers and market stakeholders working on specific thematics towards the broader group of all involved R&I actors.

BSEC – ETAIRIOS ZEUS

- Objectives

1. **Involve and mobilize national policy, research & innovation stakeholders with the creation of an interactive international community.** It will be achieved by the development and enactment of an engagement strategy, supported by a methodological roadmap;
2. **Examine the state of R&I cooperation on specific key Societal Challenges reviewing lessons learnt, good practices, obstacles, synergies between policies and programmes of EU and BSEC countries highlighting cooperation and H2020 opportunities.** It will be achieved by 1. Networking and clustering actors/activities, 2. Mapping and reviewing of the status quo for R&I on Climate Action, Clean and Efficient Energy in all Black Sea, and 3. Priority setting;
3. **Promote BSEC and EU principles for international cooperation.** It will be achieved by elaborating appropriate framework conditions and facilitation measures for international cooperation;
4. **Interact with a broad spectrum of multidisciplinary R&I actors: low and high-level policy makers** (ministries, agencies, BSEC, EaP Panel on R&I, SFIC), **researchers, market actors and civil society members** (EaP Civil Society Forum). It will be achieved by enriching the BSEC-EU multi-level policy dialogue.

BSEC – ETAIRIOS ZEUS

- Expected Impact

This proposal will strengthen the BSEC role as an important R&I actor in the region by promoting its principles for international cooperation, especially among their governments, attracting local and EU stakeholders to work with BSEC and EU colleagues on common top-priority issues and create win-win situations.

- Indicative Budget & Duration

1.5 million Euro, 3 years

BSEC – PROMITHEAS 14

Identifying Climate Change mitigation options through a policy dialogue in BSEC

- Aim

The overall aim of BSEC-PROMITHEAS-14A is to strengthen the evidence base on Climate Change Mitigation Options in order to facilitate all multi-disciplinary stakeholders on decision making in BSEC countries.

BSEC – PROMITHEAS 14

- Objectives

1. Develop and strengthen an evidence base on Climate Change Mitigation Options of the participating countries
2. Enable policy dialogue among multi-disciplinary stakeholders from the participating countries in the context of COP21 results and other UNFCCC processes, by developing an international multi-clustered interactive network.
3. Foster international cooperation on areas of common interest among the participating countries.

9th International Scientific Conference – Energy & Climate Change | October 2016, Athens

BSEC – PROMITHEAS 14

- Expected Impact

The proposal plans to develop and strengthen the evidence base on Climate Change Mitigation options of the participating countries and to support the appropriate, cost-effective management, planning and adaptation decisions by the public sector, businesses, industry and society through the provision and effective communication of trustworthy and timely science-based information.

Moreover, BSEC-PROMITHEAS-14 will have an enhanced impact of research and innovation activities through better identification of climate change R&I priorities, improved coordination of BSEC and EU R&I programmes and funded activities, and synergies with international R&I programmes and actions.

- Indicative Budget & Duration

2 million Euro for 3 years

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Aliki-Nefeli MAVRAKI
Energy Policy and Development Centre (KEPA)
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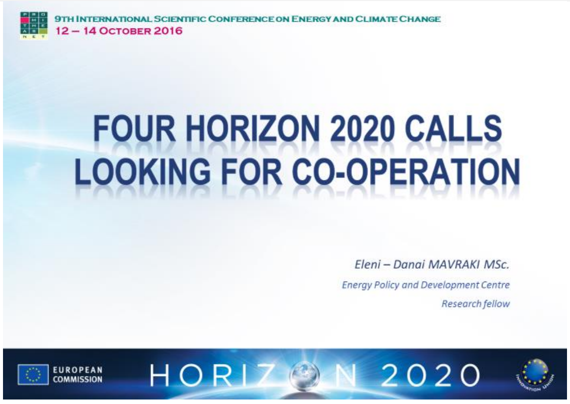
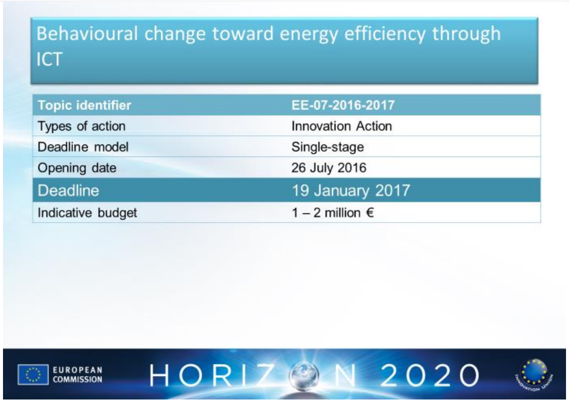
9th International Scientific Conference – Energy & Climate Change | October 2016, Athens

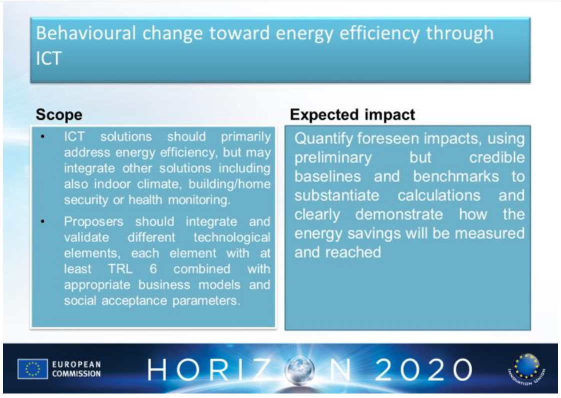
4 Horizon2020 calls looking for co-operation

Presentation by **Ms. Eleni-Danai MAVRAKI**,

National and Kapodistrian University of Athens – Hellas








Specific Challenge
Engagement actions are needed across Europe in order to achieve behavioural change towards more sustainable choices and decisions for energy.
This includes increasing and understanding consumer 'apetite' for higher efficiency products.
Although awareness on EE and RES has increased in past years, such action is still hampered by a number of barriers, including financial and regulatory barriers and inconsistencies in grid integration practice.
Cross-cutting Priorities:
Gender
EUROPEAN COMMISSION
HORIZON 2020


Engaging private consumers towards sustainable energy
Scope
Develop and roll out tailored and effective and innovative engagement actions to motivate changes in consumers' sustainable energy behaviour that would result in reduced energy consumption in buildings, heating/cooling systems and/or appliances.
Expected impact
Primary energy savings triggered by the project within its duration
Number of people changing their behaviour and taking informed decisions
Renewable Energy production and Investments in sustainable energy triggered by the project within its duration
etc
EUROPEAN COMMISSION
HORIZON 2020


Engaging and activating public authorities
Topic identifier EE-09-2016-2017
Types of action Coordination and support action
Deadline model Single-stage
Planned Opening date 19 January 2017
Deadline 07 June 2017
Indicative budget 1 – 2 million €
EUROPEAN COMMISSION
HORIZON 2020


Specific Challenge
One of the key challenges remains in linking up public bodies at the national, regional and local level through effective multi-level governance to realize an energy transition driven from the local level with concerted planning and implementation of energy projects, as well as in achieving a coherent transformation of the energy system capitalizing on synergies and economies of scale.
Cross-cutting Priorities:
Open innovation
EUROPEAN COMMISSION
HORIZON 2020


Engaging and activating public authorities
Scope
Proposals demonstrating an innovative approach in empowering public authorities to step up their active role to develop, finance and implement ambitious sustainable energy plans and measures on the basis of reliable data. Public actors are encouraged to adopt a multi-stakeholder approach and to look at sectors with high energy saving potential such as buildings, industry and urban mobility.
Expected impact
Primary energy savings, renewable energy production and investments in sustainable energy triggered in the territory of participating parties by the project within its duration
Number of integrated plans, vertically and or horizontally
Number of certified municipalities
Etc…
EUROPEAN COMMISSION
HORIZON 2020


Overcoming market barriers and promoting deep renovation of buildings
Topic identifier EE-011-2016-2017
Types of action Coordination and support action
Deadline model Single-stage
Planned Opening date 19 January 2017
Deadline 07 June 2017
Indicative budget 1 – 2 million €
EUROPEAN COMMISSION
HORIZON 2020


Specific Challenge
Many barriers, which are not necessarily technological, hamper the implementation of these provisions.
There is therefore, a need to overcome these regulatory and non-regulatory barriers to facilitate the renovation of existing building stocks.
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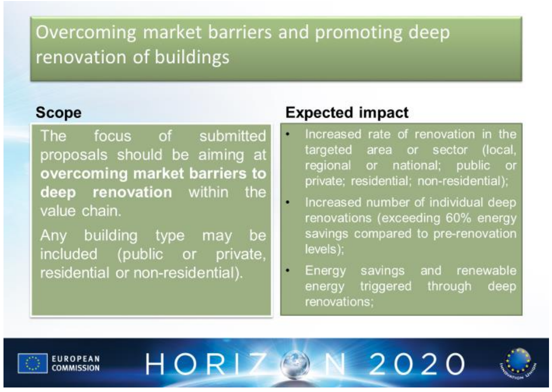
Overcoming market barriers and promoting deep renovation of buildings
Scope
The focus of submitted proposals should be aiming at overcoming market barriers to deep renovation within the value chain.
Any building type may be included (public or private, residential or non-residential).
Expected impact
Increased rate of renovation in the targeted area or sector (local, regional or national; public or private; residential; non-residential);
Increased number of individual deep renovations (exceeding 60% energy savings compared to pre-renovation levels);
Energy savings and renewable energy triggered through deep renovations;
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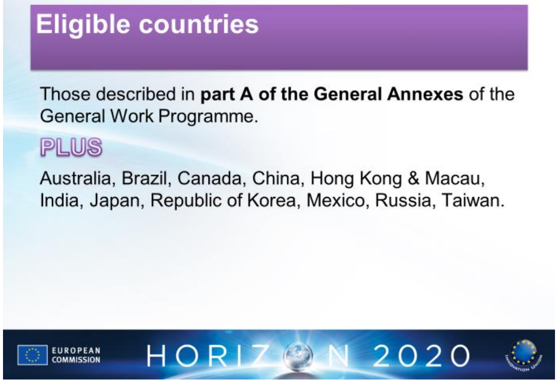
Eligible countries
Those described in part A of the General Annexes of the General Work Programme.
PLUS
Australia, Brazil, Canada, China, Hong Kong & Macau, India, Japan, Republic of Korea, Mexico, Russia, Taiwan.
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Useful links
Horizon2020 general programme: ec.europa.eu/research/horizon2020
Part A of General Annexes of the General Work Programme: http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-a-countries-rules_en.pdf
Behavioural change toward energy efficiency through ICT: https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ee-07-2016-2017.html
Engaging private consumers towards sustainable energy: https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ee-06-2016-2017.html
Engaging and activating public authorities:https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ee-09-2016-2017.html
Overcoming market barriers and promoting deep renovation of buildings: https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ee-11-2016-2017.html
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4 H2020 calls looking for partners
Strong consortiums with variety of expertise
Networks
New ideas
Smart cities
Energy models
Energy efficiency
EUROPEAN COMMISSION
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9TH INTERNATIONAL SCIENTIFIC CONFERENCE ON ENERGY AND CLIMATE CHANGE
12 – 14 OCTOBER 2016
THANK YOU FOR YOUR ATTENTION
NKUA
KEPA
Eleni – Danai MAVRAKI MSc.
Energy Policy and Development Centre
Research fellow
epgsec@kepa.uoa.gr
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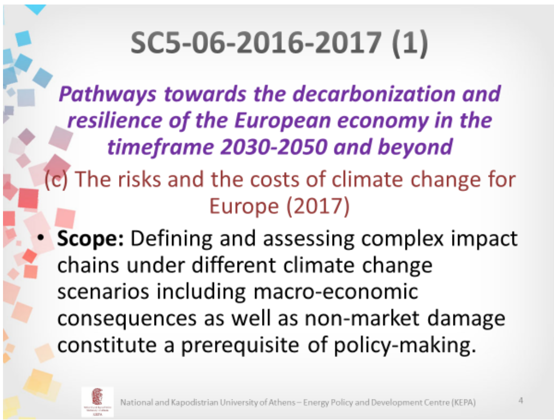
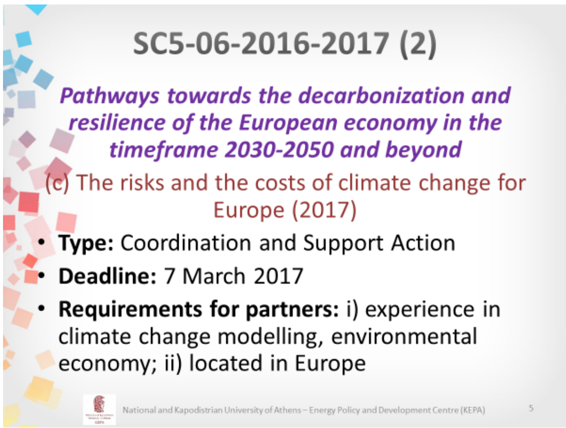
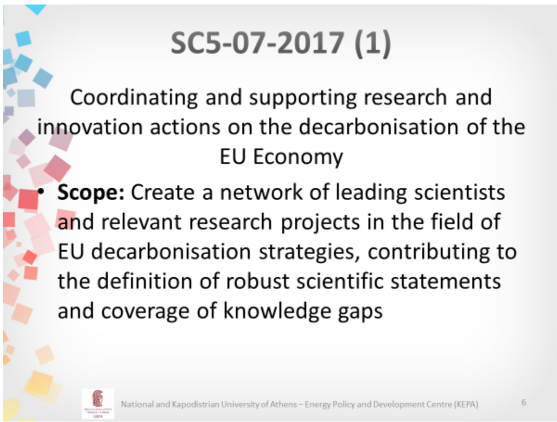
HORIZON 2020

Proposing cooperation on Horizon open calls for Climate Action

presentation by **Dr. Popi KONIDARI**, National and Kapodistrian University of Athens - Hellas








SC5-07-2017 (1)
Coordinating and supporting research and innovation actions on the decarbonisation of the EU Economy
• Type: Coordination and Support Action
• Deadline: 7 March 2017
• Requirements for partners: i) experience in climate change, issues of decarbonization of the EU economy; ii) institutes from EU Member States
National and Kapodistrian University of Athens – Energy Policy and Development Centre (KEPA)
7


Thank you
September 2016, Popi KONIDARI
National and Kapodistrian University of Athens – Energy Policy and Development Centre (KEPA)
8

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