14th International Scientific Conference

Energy and Climate Change

PROCEEDINGS

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Energy Policy and Development Centre (KEPA)

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BSEC GEN Green Energy Network

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Black Sea Economic Cooperation Organization

Green Energy Network

8th Green Energy Investments Forum

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Co-chair	**Prof. Dimitrios MAVRAKIS** Director of KEPA, BSEC -GEN Welcome
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	Mr. Christos DIMAS Deputy Minister of Research and Technology, Hellas **(On line)**
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Co-chair	**Prof. Dimitrios MAVRAKIS** Director of KEPA, BSEC -GEN
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	Mr. Aristotelis SPILIOTIS Secretary General, Black Sea Trade and Development Bank
	Mrs. Athina CHATZIPETROU President, Hellenic Development Bank
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University of Belgrade, Serbia

Prof. Milton A. TYPAS
National and Kapodistrian University of Athens, Hellas

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Dr. George TZAMALIS, Hystore Tech Ltd – Cyprus

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Dr. George TZAMALIS, Hystore Tech Ltd – Cyprus

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Δημοκρίτειο Πανεπιστήμιο Θράκης

καθ. Δημήτριος ΜΑΥΡΑΚΗΣ
BSEC – GEN, UNAI Hub SDG7

Ομιλητές κα. Κωνσταντίνα ΑΓΚΡΑ, Πράσινο Ταμείο

κ. Αθανάσιος ΝΑΣΙΑΚΟΠΟΥΛΟΣ, Πρόεδρος Περιφερειακής Ένωσης Δήμων Θεσσαλίας

κ. Βασίλης ΞΟΥΡΑΦΑΣ, ΕΡΓΟΣΕ

κ. Ιωάννης ΚΑΡΤΑΛΗΣ, Αντιδήμαρχος, Δήμος Πυλαίας – Χορτιάτη

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BSEC – GEN, UNAI Hub SDG7

Dr. Popi KONIDARI
NKUA – KEPA

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Ms Katerina PAPADOULI, PRAXI Network
National Contact Point in Horizon Europe

“Innovation Fund”
Mr. Georgios Zisis – TEGOS, Ministry of Environment and Energy – Hellas

“Presentation of envena”
Dr. Stavros MAVROUDEAS, envena – Hellas

“An SRI based approach to increase building smartness by
Mr. Konstantinos TSATSAKIS, Suite5 Data Intelligence Solutions – Cyprus

“A holistic flexibility management framework for energy aggregators”
Mr. Konstantinos TSATSAKIS, Suite5 Data Intelligence Solutions – Cyprus

“**Energy upgrade of a hospital building into a Nearly Zero Energy Building**
Prof. Argyro DIMOUDI, Democritus University of Thrace - Hellas

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Prof. Andonaq Londo LAMANI, Polytechnic University of Tirana – Albania

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Dr. Popi KONIDARI, NKUA-KEPA – Hellas

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List of participants

No.	Title	First Name	Last Name	Organization
1.	Mrs.	Konstantina	Agra	Green Fund, Hellas
2.	Mr.	Michalis	Anastasakis	Hellenic Municipality
3.	Prof.	Margarita-Niki	Asimakopoulou	National and Kapodistrian University of Athens, Hellas
4.	Mrs.	Eleni	Baltogianni	Democritus University of Thace, Hellas
5.	Mrs.	Laoura	Boretti	Eurogas
6.	Dr.	Rita	Buzinskiene	Vytautas Magnus University, Siauliai State College of Applied Sciences, Lithuania
7.	Mrs.	Deimantė	Bužinskaitė	Lithuania
8.	Dr.	Gerfried	Cebrat	SEnerCon GmbH Berlin Germany
9.	Ms	Stefanie	Chan	Fachhochshule Salzburg, Austria
10.	Mrs.	Athina	Chatzipetrou	Hellenic Development Bank, Hellas
11.	Amb.	Traian	Chebeleu	Black Sea Economic Cooperation-PERMIS
12.	Amb.	Lazar	Comanescu	Black Sea Economic Cooperation-PERMIS
13.	Dr.	Athanasios	Dagoumas	RAE, Hellas
14.	Mrs.	Hasmik	Dashtoyan	Embassy Armenia in Hellenic Republic
15.	Dr.	Christos	Dimas	Ministry of Development & Investments, Hellas
16.	Prof.	Argyro	Dimoudi	Democritus University of Thace
17.	Amb.	David	Dondua	Embassy of Georgia in Hellenic Republic
18.	Prof.	Olga	Efimova	Finance University under the Government of Russian Federation, Russian Federation
19.	Mr.	Andreas	Efthimiou	Municipality of Moschato – Tavros, Hellas
20.	Mr.	Martinos	Gaitlih	Hellenic Municipality
21.	Mrs.	Panagiota	Gazi	KEDE, Hellas

22.	Mr.	Georgios	Georgakos	Municipality of Vari, Voula, Vouliagmeni, Hellas
23.	Mr.	Spyridon-Adonis	Georgiadis	Ministry of Investments, Hellas
24.	Mr.	Zaruchi	Gharagyozyan	R2E2, Armenia
25.	Mrs.	Nikoletta	Golfinopoulou	Municipality of Hrakleio Crete, Hellas
26.	Mr.	Khagani	Hajiev	Embassy Azerbaijan in Hellenic Republic
27.	Prof.	Asaf	Hajiyev	PABSEC
28.	Mrs.	Athina	Hatzipetrou	Hellenic Development Bank, Hellas
29.	Dr.	Valasia	Iakovoglou	UNESCO chair Con-E-Ect, Hellas
30.	Prof.	Dejan	Ivezic	University of Belgrade, Serbia
31.	Prof.	Thor	Jensen	University of Bergen, Norway
32.	Mr.	Evgaggelos	Karagiannakos	Hellenic Development Bank, Hellas
33.	Mr.	Charalambos	Karantonis	Municipality of Pirgos, Hellas
34.	Mr.	-	Karvounis	Hellenic Municipality
35.	Mr.	Ioannis	Kartalis	Municipality of Pilea-Chortiati, Hellas
36.	Mrs.	Maria	Kiriakidou	Municipality of Pilea-Chortiati, Hellas
37.	Mr.	Evangellos	Kiritsis	Agricultural University of Athens, Hellas
38.	Dr.	Popi	Konidari	KEPA, Hellas
39.	Mr.	Mikhail	Lushin	Embassy of Russian Federation
40.	Dr.	Miltiadis	Makrigiannis	PABSEC
41.	Prof.	Kenichi	Matsumoto	Toyo University, Japan
42.	Mrs.	Eleni-Danai	Mavraki	KEPA, Hellas
43.	Prof.	Dimitrios	Mavrakis	KEPA, Hellas
44.	Mr.	Stavros	Mavroudeas	ENVENA Ltd., Hellas
45.	Mrs.	Stamatia	Milona	Hellenic Municipality
46.	Mrs.	Panagiota	Mpouga	Municipality of Eretreia, Hellas
47.	Mrs.	Polixeni	Nanou	Municipality of Almopias

48.	Mr.	Athanasios	Nasiakopoulos	Municipality of Killerer, Hellas
49.	Prof.	Nikitas	Nikitakos	Aegean University, Hellas
50.	Mr.	Konstantinos	Ntampegliotis	Municipality of Kileler, Hellas
51.	Ms.	Katerina	Papadouli	PRAXI Network, Hellas
52.	Mr.	-	Papamichail	Municipality of Vrilission, Hellas
53.	Mr.	Georgios	Patoulis	Regional Government of Attica, Hellas
54.	Dr.	Robertas	Poskas	Lithuanian Energy Institute, Lithuania
55.	Dr.	Egidijus	Puida	Lithuanian Energy Institute, Lithuania
56.	Dr.	Pantelitsa	Sfiniadaki	European University Cyprus, Cyprus
57.	Mr.	Giorgi	Shoshitashvili	Embassy of Georgia in Hellenic Republic
58.	Amb.	Sergii	Shutenko	Embassy of Ukraine in Hellenic Republic
59.	Prof.	Tom	Skauge	Bergen University College and University of Oslo, Norway
60.	Mr.	Georgios	Stamatis	Municipality of Argous-Mikinon, Hellas
61.	Prof.	Mariya	Stankova	South-West University "Neofit Rilski", Bulgaria
62.	Mr.	Aristotelis	Spiliotis	BSTDB
63.	Dr.	Arunas	Sirvydas	Lithuanian Energy Institute, Lithuania
64.	Mrs.	Aspasia	Triantafillidou	Hellenic Municipality
65.	Mr.	Kostas	Tsatsakis	Suite 5 Data Intelligence Solutions, Cyprus
66.	Mrs.	Maria	Tsarmpopoulou	Municipality of Vari, Voula, Vouliagmeni, Hellas
67.	Mr.	Ioannis	Tsopanoglou	Municipality of Chavala, Hellas
68.	Mr.	David	Tvalabeishvili	Ministry of Economy and Sustainable Development, Georgia
69.	Dr	George	Tzamalis	Hystore Tech Ltd, Cyprus
70.	Prof.	Milton	Typas	National and Kapodistrain University of Athens, Hellas
71.	Amb.	Anatol	Vangeli	Embassy of Republic of Moldova in Hellenic Republic

72.	Mrs.	Vaso	Vaka	Municipality of Irakeia Serron, Hellas
73.	Ms.	Anna	Vasylets	Embassy of Ukraine in Hellenic Republic
74.	Dr.	Leonardo	Vaz	Clean energy for EU islands secretariat
75.	Mr.	George	Zisis -Tegos	Ministry of Environment and Energy, Hellas
76.	Mr.	Kostas	Zounis	Municipality of Thessaloniki, Hellas
77.	Mr.	Vasileios	Xourafas	ERGOSE, Hellas

DAY 1: 8th Green Energy Investments Forum

Welcome address by Prof. Dimitrios MAVRAKIS

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

Dear and distinguished guests

It is my honor to welcome you at the 8th Green Energy Investments Forum in the frame of the 14th Annual International Conference on Energy and Climate Change.

This session will be chaired by his Excellency the Deputy Secretary General of PERMIS, Ambassador Traian CHEBELEU. I take the opportunity to announce you that his Excellency after a long term in office as Deputy Secretary General of PERMIS since 2009, he leaves PERMIS until 2022.

Ambassador CHEBELEU in his term in office has coordinated a broad spectrum of BSEC activities covering areas such as energy, transport, trade and economic development, custom matters, finance, small and medium enterprises, agriculture and agro-industry, information and communication technologies and change of strategical data.

Ambassador Chebeleu coordinated the special Ad-hoc of experts which elaborated the economic agenda 2012, a strategic document guiding the activity of the organization, The agenda was adopted by the Council of the Ministers of Foreign Affairs and of those at the Summit of Heads of the States and of governments of the BSEC Member States in Istanbul in 2012.

He undertook the preparatory work for the adoption of the decision of the Council of the Ministers of Foreign Affairs adopted in 2014 to establish a BSEC Green Energy Network coordinated by KEPA.

He supported the regular organization of the BSEC – Green Energy Investments Forum which emerged from the concentration between BSEC and KEPA as an important mean to the development and use of the green energy of the BSEC region.

He participated in many international meetings, conferences, seminars, workshops organized by international organizations and institutions with which the BSEC collaborates, informing about the relevant activities of BSEC and examining the possibilities to develop joint projects and other cooperation activities.

Since 2012 he attended the PROMITHEAS Scientific Conferences as well. As this will be his last participation in our activities as Deputy secretary of PERMIS I feel the obligation to recognize and pay honors to his devotion to regional cooperation and express my gratitude for his support to our common efforts to promote understanding in cooperation on the crucial issues of energy and climate change.

Your Excellency

Before I invite you to chair the session. Allow me to offer you a small symbolic token in memory of the years of common efforts to promote regional cooperation and understanding among the people living under the umbrella of BSEC and wish you all my best for you and your beloved wife…

Thank you very much for what you offered us.

Thank you.

Short CV

Prof. Dimitrios Mavrakis is the Director of KEPA, the UNAI hub for SDG7; coordinator of the "BSEC – Green Energy Network" focused on Renewable Energy Sources (RES) and Energy Efficiency (EE) for scientists, market stakeholders, and policy makers, from the countries of BSEC under the supervision of BSEC – PERMIS; coordinator of PROMITHEASnet, the Energy and Climate Change Policy Network, consisted of academic institutes from S.E. Europe, Black Sea and Central Asia; Chief editor of the "Energy View of the BSEC countries"; Chief editor of the "Energy View of the BSEC countries"; Chief editor of the "Euro-Asian Journal of Sustainable Energy Development Policy"; Editor of the worldwide disseminated "PROMITHEAS newsletter"; Chairman of the annual international scientific conference on "Energy and Climate Change" (13th year); Initiator of the European Energy Community.

His main studies and activities are related with energy geopolitics, development of regional energy markets, energy interconnections, transcontinental energy corridors, design of climate policy instruments, exploration of interactions between climate policy tools, development and assessment of mitigation/adaptation policy mixtures.

He was appointed as member of the Advisory Groups on Energy (AGE) of E.C. for FP6 and FP7 and was the Project Coordinator of several FP6, FP7 and H2020 projects.

Current activities: He currently promotes the "UNAI Hub SDG7 Society", the "75 UN – 75 Trees UNAI SDG7" initiative and the Green Energy Investments Fora among the BSEC - MS. He also promotes regional cooperation on Climate Change Policy issues among academic institutions, governmental authorities and market stakeholders from the countries of EU and the BSEC; knowledge transfer about climate change, EE, RES, development of scenarios for mitigation/adaptation, looking-forward energy modelling; he participates in the BSEC Working Group on energy.

Opening speech
Mr. Spyridon - Adonis GEORGIADIS

Minister of Development & Investments, Hellas

First, I would like to thank you for the invitation and to apologize, that unavoidable obligations do not allow me to attend in situ, but I considered it very important for the signal that our government wants to send to your conference even by sending this opening speech via video.

The government of Kyriakos Mitsotakis has changed the energy orientation of the country. The decision for rapid de-lignification is already in consultation since yesterday with the bill for the National Waste Management Plan, the plan for the fair development regarding the transition of the area, which had lignite. Western Macedonia, Peloponnese and others.

But also there is great motivation through the acceleration of the licensing process concerning all investments in renewable energy sources and the setting up of the entire Recovery Fund, but also the new Corporate Pact for the Development Framework on Green energy and in confronting climate change, that I believe that they form in Greece the objective conditions to make very large investments in this area.

After all, such investments have already started from financial giants coming from abroad and other parks have started to be installed. Others are in the process of licensing and all together they are moving very fast in the complete change of the country's energy mix.

In addition to all this, Greece, by my own decision and that of Mr. Skrekas, the Minister of Environment, requested and now participates in the joint European programs IPCIS for hydrogen with important proposals of several billion euros in the coming years in this fuel, which seems to be the fuel of the future.

So I welcome you to the conference. I consider that it is very important that it takes place and Greece can and I am saying this, will play a leading role and I assure you that we will do everything possible for the country so that to perform this role as it deserves.

Short CV

Mr. Spyridon – Adonis Georgiadis is a graduate of the Department of History and Archeology of the Philosophy School of the National and Kapodistrian University of Athens. In 1993 he undertook the management of the publications "GEORGIADIS - LIBRARY OF GREEKS". In 1994 he founded the Center for Free Studies "HELLENIC EDUCATION". He was elected as a Member of the Parliament in the elections of 2007 and 2009 under the political party of Laos. In February 2012, he joined the political party of New Democracy, resigning from his parliamentary position. He was elected with the New Democracy Party in the 2012 and 2015 national elections. In 2011 he was Deputy Minister of Shipping in the Government of Mr. Loukas Papadimou and in 2013 Minister of Health in the Government of Mr. Antonis Samaras. On January 18, 2016, he was appointed by the decision of Mr. Kyriakos Mitsotakis, the President of the New Democracy party, as one of the two Vice-Presidents of the party to supervise the parliamentary work of the party. On July 9, 2019, Mr. Georgiades was sworn as Minister of Development and Investments in the government of Mr. Kyriakos Mitsotakis.

Χαιρετισμός

κ. Σπυρίδων - Άδωνης ΓΕΩΡΓΙΑΔΗΣ

Υπουργός Ανάπτυξης και Επενδύσεων, Ελλάδα

Θα ήθελα καταρχάς να ευχαριστήσω για την πρόσκληση και να ζητήσω συγγνώμη, που ανειλημμένες υποχρεώσεις δεν μου επιτρέπουν να παρευρεθώ εκ του σύνεγγυς, αλλά θεώρησα εξαιρετικά σκόπιμο για το σήμα, που θέλει να στείλει η κυβέρνηση μας στο συνέδριο σας έστω με την αποστολή αυτού του μικρού χαιρετισμού μέσω του βίντεο.

Η κυβέρνηση του Κυριάκου Μητσοτάκη έχει αλλάξει τον ενεργειακό προσανατολισμό της χώρας. Η απόφαση για ταχεία απολιγνητοποίηση είναι ήδη σε διαβούλευση από χθες με νομοσχέδιο ΕΣΔΑ για το σχέδιο για την δίκαιη αναπτυξιακή μετάβαση της περιοχής, που είχε λιγνίτη. Δυτική Μακεδονία, Πελοπόννησο και αλλού.

Αλλά και η μεγάλη κινητροδότηση μέσω της επιτάχυνσης της αδειοδοτικής διαδικασίας όλων των επενδύσεων σε ανανεώσιμες πηγές ενέργειας και η δημιουργία όλου του Ταμείου Ανάκαμψης, αλλά και του νέου ΕΣΠΑ πάνω στην Πράσινη ενέργεια και στην αντιμετώπιση της κλιματικής αλλαγής πιστεύω ότι δημιουργούν στην Ελλάδα τις αντικειμενικές προϋποθέσεις για να γίνουν πολύ μεγάλες επενδύσεις πάνω σε αυτό τον τομέα

Άλλωστε ήδη τέτοιου είδους επενδύσεις έχουν ξεκινήσει από κολοσσούς του εξωτερικού και που άλλα πάρκα έχουν ξεκινήσει να εγκαθίστανται, άλλα είναι στη διαδικασία της αδειοδότησης και όλα μαζί προχωρούν με πολλή μεγάλη ταχύτητα στην αλλαγή πλήρως του ενεργειακού μίγματος της χώρας.

Επιπροσθέτως σε όλα αυτά η Ελλάδα με δική μου απόφαση και του Υπουργείου Περιβάλλοντος του κ. Σκρέκα αιτήθει και συμμετέχει στα κοινά Ευρωπαϊκά προγράμματα τα IPCIS για το υδρογόνο με σημαντικές προτάσεις αρκετών δισεκατομμυρίων ευρώ μέσα στα επόμενα χρόνια στο καύσιμο, που φαίνεται ότι θα είναι και το καύσιμο του μέλλοντος

Χαιρετίζω λοιπόν το συνέδριο. Θεωρώ ότι είναι πολύ σημαντικό το ότι διεξάγεται και η Ελλάδα μπορεί και το λέω αυτό να παίξει πρωταγωνιστικό ρόλο και σας διαβεβαιώ ότι θα κάνουμε ότι είναι δυνατόν για να τον διαδραματίσει όπως της αξίζει.

Σύντομο βιογραφικό

Ο κ. Σπυρίδων – Άδωνις Γεωργιάδης είναι απόφοιτος του Τμήματος Ιστορίας και Αρχαιολογίας της Φιλοσοφικής Σχολής του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών. Το 1993 ανέλαβε τη διεύθυνση των εκδόσεων «ΓΕΩΡΓΙΑΔΗΣ – ΒΙΒΛΙΟΘΗΚΗ ΕΛΛΗΝΩΝ». Το 1994 ίδρυσε το Κέντρο Ελεύθερων Σπουδών «ΕΛΛΗΝΙΚΗ ΠΑΙΔΕΙΑ». Εξελέγη βουλευτής στις εκλογές του 2007 και του 2009 υπό το πολιτικό κόμμα του Λάος. Τον Φεβρουάριο του 2012 εντάχθηκε στο πολιτικό κόμμα της Νέας Δημοκρατίας, παραιτούμενος από τη βουλευτική του θέση. Εξελέγη με το Κόμμα της Νέας Δημοκρατίας στις εθνικές εκλογές του 2012 και του 2015. Το 2011 διετέλεσε Υφυπουργός Ναυτιλίας στην Κυβέρνηση του κ. Λουκά Παπαδήμου και το 2013 υπουργός Υγείας στην κυβέρνηση του κ. Αντώνη Σαμαρά. Στις 18 Ιανουαρίου 2016 ορίστηκε με απόφαση του Προέδρου της Νέας Δημοκρατίας κ. Κυριάκου Μητσοτάκη ως ένας εκ των δύο Αντιπροέδρων του κόμματος ως επίβλεψη του κοινοβουλευτικού έργου του κόμματος. Στις 9 Ιουλίου 2019 ο κ. Γεωργιάδης ορκίστηκε Υπουργός Ανάπτυξης και Επενδύσεων στην κυβέρνηση του κ. Κυριάκου Μητσοτάκη.

Speech of Dr. Christos DIMAS

Deputy Minister for Research and Technology, Hellas

I wish to congratulate everybody that contributed in the organization of the 14th International Conference on Energy and Climate Change.

The climate crisis is undeniably the most important and critical contemporary issue. The Paris Agreement has been the milestone in global climate policies and even as a potential turning point in humanity's efforts to address the climate crisis.

The European Union has gradually become the leading international environmental pair and over the past decades has improved the ways in which it masters its strategy and diplomacy.

The ambitious European Green Deal will transform the European Union into a modern, sustainable, and competitive economy.

Greece is one of the countries that has called upon to manage and deal with the negative effects of climate change and the government has already started implementing a very ambitious decarbonization policy plan.

Research and innovation play a difficult role in solving environmental problems. Scientific research proves that innovative countries have the potential to tackle the climate crisis more effectively.

Indicatively, the establishment of the national network on climate change and its impacts, the IMPACT, under the coordination of the National Observatory of Athens is an initiative forming the basis for a comprehensive and effective national environmental policy.

Th IMPACT targets the creation of an interdisciplinary consortium that will unify and optimize the current climate services and early warning systems for natural disasters connected with climate change including observational networks from various national infrastructure across the country

We are really looking forward for the results of the conference and thank you very much for the organization of today's event.

Short CV

Dr. Christos Dimas is a lawyer and a Member of the Hellenic Parliament, representing Nea Demokratia in the district of Korinthia. He was born on the 29th of May 1980 and graduated from Athens College. Christos obtained his LLB degrees from the Law School of the National and Kapodistrian University of Athens and from Queen Mary University of London. He completed his Masters Degree in Comparative Politics at the London School of Economics and Political Science (LSE). At the LSE, he finished his PhD in European Political Economy, as a scholar of the Alexander Onassis Public Benefit Foundation. His thesis title was «National institutional contexts and domestic discourse during proposed transformative policy change. The case of the telecoms privatization in Greece and the Republic of Ireland».

During his studies, he worked as the London correspondent of Apogevmatini newspaper and practiced journalism at the BBC.

At the age of 25, Christos taught the course «Introduction to Comparative Politics» at the LSE Government Department. He has also taught the course «Mass Media and Social Regulation» at ICON College, University *of Leicester and worked as a research associate at the European Centre of Excellence «Jean Monnet». He has published many articles in Greek and international journals.*

Before entering politics, he worked in the private sector as a business consultant for the Boston Consulting Group (BCG).

Since 2012, Mr Dimas serves as Member of Hellenic Parliament for Corinthia and from July 2019 he is Deputy Minister for Research and Technology.

In his spare time, he enjoys playing football and basketball and reading history books.

He is married to Nikoleta Syrengela and they have one daughter and one son.

Speech of Mr. Georgios PATOULIS

Regional Governor of Attiki, Hellas

Ladies and gentlemen,

After a literally hot summer with catastrophic fires, the discussion on climate change which has now become an obvious climate crisis is even more imperative and urgent.

A key element of our discussion must be the EU's new strategy for climate change adaptation. Achieving this goal will require smarter, faster and more systematic adaptation. First, adaptation must be made smarter, faster and more systematic adaptation. First, adaptation must be made smarter and based on new technologies and the achievements of artificial intelligence.

Secondly, we want a much faster adaptation in line with the speed with which the climate crisis is evolving.

A key element in a faster adaptation is the issue of energy. Regarding energy in Attica, energy consumption is expected to change as energy requirements for heating during the winter fall, while during the summer the demand for energy for cooling will increase greatly due to high temperatures. This is the most significant impact of climate change on energy as total energy consumption has increased in recent years due to the increased energy demand during summer.

This means that additional capacity is necessary to be installed in addition to that required to meet the underlying on-going economic growth.

Third, adaptation needs to be more systemic and systematic. What does this mean?

This means that individual and piecemeal efforts and improvements are not enough if they are not inspired by a comprehensive and integrated plan. Actions to tackle climate change need to include a change in the existing growth model towards a sustainable green economy with low or even zero carbon emissions using modern technology.

In this context, in the Attica region, we intensified our efforts, to reduce waste and energy consumption, strengthened innovation in the field of environment, supported the creation of new markets based on circular economy and the demand of green technologies, goods and services. In addition, we are implementing projects related to the upgrading of school and municipal buildings, energy savings in road network lighting, the promotion of electromobility and cycling and the strengthening of the energy saving – autonomy program for buildings. In cooperation with the state, the municipalities and the civil society, we are building a strong network for the management of the environment that will meet the challenges of the time. With those thoughts in mind, I would like to wish good luck in the work of your conference and to assure you that we are awaiting its conclusions to incorporate them into our political practices.

Thank you

Short CV

He was born in Athens in 1961, while his family comes from Crete. In 1981 he was admitted to the Medical School of Athens and specialized as an orthopedic surgeon at the People's Hospital of Athens, where he prepared my doctoral dissertation. I worked as a doctor and at the same time, in the period 1998-2000, he specialized in Health Economics and graduated from the National School of Public Health. His activity in the field of Health begins in 1996, while from 2011 until today he is President of the Medical Association of Athens. He has been active in the field of Local Government since 1998, when he was elected for the first time Municipal Councilor in the Municipality of Pefki. In 2006 he was elected Mayor of Maroussi, laying the foundations for Maroussi to become a sustainable city again and significantly improving its image. In the Local Elections of May 2019, he was elected Governor of Attica with 66%.

Ομιλία του κ. Γεώργιου ΠΑΤΟΥΛΗ

Περιφερειάρχης Αττικής

Κυρίες και κύριοι

Μετά από ένα κυριολεκτικά καυτό καλοκαίρι με καταστροφικές πυρκαγιές η συζήτηση για την κλιματική αλλαγή η οποία πλέον έχει γίνει ολοφάνερη κλιματική κρίση, είναι ακόμα πιο επιτακτική και επείγουσα.

Σοβαρό στοιχείο της συζήτησης μας πρέπει να είναι η νέα στρατηγική της Ευρωπαϊκής Ένωσης για την προσαρμογή στην κλιματική αλλαγή. Για την επίτευξη του σκοπού αυτού θα απαιτηθεί εξυπνότερη, ταχύτερη και πιο συστηματική προσαρμογή.

Πρώτον η προσαρμογή πρέπει να γίνει εξυπνότερη και να στηριχθεί στις νέες τεχνολογίες και τα επιτεύγματα της τεχνητής νοημοσύνης.

Δεύτερον, θέλουμε μία προσαρμογή πολύ πιο γρήγορη σε αντιστοιχία με την ταχύτητα εξέλιξης της κλιματικής κρίσης και κομβικό βεβαίως στοιχείο σε μία πιο γρήγορη προσαρμογή είναι το θέμα της ενέργειας. Αναφορικά με την ενέργεια στην Αττική η κατανάλωση της ενέργειας αναμένεται να αλλάξει καθώς οι ενεργειακές απαιτήσεις για θέρμανση κατά τη διάρκεια του χειμώνα πέφτουν, ενώ κατά τη διάρκεια του καλοκαιριού η ζήτηση ενέργειας για ψύξη θα αυξηθεί σε μεγάλο βαθμό λόγω των υψηλών θερμοκρασιών.

Αυτό αποτελεί το σημαντικότερο αντίχτυπο της κλιματικής αλλαγής σε σχέση με την ενέργεια καθώς η συνολική κατανάλωση ενέργειας έχει αυξηθεί τα τελευταία χρόνια με την αύξηση της ζήτησης ενέργειας κατά τη διάρκεια του καλοκαιριού. Αυτό σημαίνει ότι θα χρειαστεί να εγκατασταθεί πρόσθετη παραγωγική ικανότητα πέραν εκείνης, που απαιτείται για την κάλυψη της υποκείμενης οικονομικής ανάπτυξης. Τρίτον, η προσαρμογή πρέπει να είναι πιο συστημική. Τι σημαίνει αυτό; Αυτό σημαίνει ότι μεμονωμένες και αποσπασματικές προσπάθειες και βελτιώσεις δεν αρκούν εφόσον δεν διαπνέονται από ένα συνολικό και ολοκληρωμένο σχέδιο.

Οι δράσεις για την αντιμετώπιση της κλιματικής αλλαγής είναι ανάγκη να περιέχουν μία αλλαγή του υφιστάμενου αναπτυξιακού μοντέλου προς την κατεύθυνση μιας βιώσιμης, πράσινης οικονομίας χαμηλών ή και μηδενικών εκπομπών άνθρακα με τη χρήση της σύγχρονης τεχνολογίας.

Στα πλαίσια αυτά στην Περιφέρεια Αττικής εντείναμε τις προσπάθειες μας για μείωση των αποβλήτων και της κατανάλωσης ενέργειας, ενισχύσαμε την καινοτομία στον τομέα του περιβάλλοντος, στηρίξαμε την δημιουργία νέων αγορών στη βάση της κυκλικής οικονομίας και της ζήτησης πράσινων τεχνολογιών, αγαθών και υπηρεσιών.

Επιπροσθέτως προχωράμε στην υλοποίηση έργων, που αφορούν την αναβάθμιση σχολικών και δημοτικών κτηρίων, την εξοικονόμηση ενέργειας, στο φωτισμό του οδικού δικτύου, την προώθηση της ηλεκτροκίνησης και της ποδηλασίας με την ενίσχυση του προγράμματος Εξοικονομώ – Αυτονομώ. Σε συνεργασία με το κράτος, τους δήμους και την κοινωνία των πολιτών χτίζουμε ένα ισχυρό δίκτυο για τη διαχείριση του περιβάλλοντος που θα απαντά στις προκλήσεις της εποχής. Με τις σκέψεις αυτές θα ήθελα να ευχηθώ καλή επιτυχία στις εργασίες του συνεδρίου σας και σας διαβεβαιώνω ότι αναμένουμε τα συμπεράσματα του για να τα εντάξουμε στις πολιτικές μας κατευθύνσεις.

Σας ευχαριστώ

Σύντομο βιογραφικό

Γεννήθηκε στην Αθήνα το 1961 με καταγωγή από την Κρήτη. Το 1981 εισάχθηκε στην Ιατρική Σχολή Αθηνών και ειδικεύτηκε ως ορθοπεδικός–χειρουργός στο Λαϊκό Νοσοκομείο Αθηνών, όπου και εκπόνησέ την διδακτορική tου διατριβή. Εργάστηκε ως ιατρός και παράλληλα, την περίοδο 1998-2000, ειδικεύτηκεε στα Οικονομικά της Υγείας και αποφοίτησέε από την Εθνική Σχολή Δημόσιας Υγείας. Η συνδικαλιστική του δράση στο χώρο της Υγείας ξεκινά το 1996, ενώ από το 2011 μέχρι σήμερα είμαι Πρόεδρος του Ιατρικού Συλλόγου Αθηνών. Στο κομμάτι της Τοπικής Αυτοδιοίκησης δραστηριοποιείται από το 1998, οπότε και εκλέχτηκε για πρώτη φορά Δημοτικός Σύμβουλος στο Δήμο Πεύκης. Το 2006 εξελέγην Δήμαρχος Αμαρουσίου, θέτοντας τις βάσεις ώστε το Μαρούσι να ξαναγίνει βιώσιμη πόλη και βελτιώνοντας σημαντικά την εικόνα του. Στις Αυτοδιοικητικές Εκλογές Μαΐου 2019, εκλέχθηκε Περιφερειάρχης Αττικής με 66%.

Speech of Mr. David TVALABEISHVILI

Deputy Minister of Economy and Sustainable Development of Georgia

Ladies and gentlemen,

It is a great honor for me to represent my country in the Black Sea Economic Cooperation today and have the opportunity to engage in discussions in the Green Energy Network on such an important topic as the energy transition in Georgia and in the post Covid era.

The government of Georgia is firmly committed towards its targets.

Georgia's political Association and economic integration with the European Union and notably we appreciate the fundamental principles of the European Union energy market architecture which builds on the merit of the market opening and competition, security of supply and extensively deployment of renewables, energy efficiency promotion and low carbon energy developments. Georgia has already defined its energy future even in the Covid 19 pandemic comprehensive mechanisms along with relevant legislation country's energy sector was concerned have been established and adopted it. The international best practice shows that sustainable energy development is a key for achieving a low emission economy as it is about using energy wisely and using energy generated from clean energy sources and technologies.

However, sustainable energy development is not only renewable energy utilization, it is synergies between energy efficiency, renewable energy technologies and policy which requires availability of resources, proper investment and strong political will and regional cooperation.

Responsibilities towards local communities and ensuring the country's energy security and security of diversified energy supply by utilizing the local resources and the regional cooperation, led us toa comprehensive reform in the energy sector. In particular, establishment of organized energy markets in line with the European Union energy market principles is one of our top priorities together with creating a sound legislative framework for attracting investments. Furthermore, establishment of precondition for a stable and secure energy sypply is essential for economic development and social stability. Since 2016 when the Association Agreement to sign with the European Union, Georgia has been progressing in harmonizing its legislation with the European Union's relevant energy Directives, In this regard, we have in act several primary legislation such as law on energy and water supply, law in energy efficiency, law on energy efficiency in buildings, law on promotion of production for utilization from renewable energy resources and law on energy labelling.

Georgia's one of the main challenges is dependency on imported energy, unfortunately Georgia is not reaching for renewable resources but its hydro potential is still to be fully deployed and utilized.

Dependence on imported electricity to meet seasonal demand is raising concerned on security supply.

The country's energy consumption peaks in winter when hydropower generation is the lowest. To meet winter, therefore, Georgia must rely on imported electricity and domestic thermos generation.

Dependence has greatly increased during the recent years to address these challenges . At least two thousand mega watt new generation facilities are planned to be build in Georgia till 2030. These are mainly source generation

Currently, the National Climate Integrated Plan (NCP) is being drafted by the Ministry of Economy and Sustainable Development of Georgia which will set the targets for 2030 in five Dimensions, such as energy efficiency, energy security, internal energy markets, decarbonization, research and development in competitiveness.

The Plan also includes Georgia's long term vision for the period 2040-2050 located at the crossroads of Europe and Asia, Georgia represents a natural corridor linking two continents.

For centuries this fact played an important role in shaping Georgia's statehood, its outful, culture and traditions. The route running through Georgia was an important segment of the silk road. Today the energy transit corridors passing through Georgia represent most attractive routes for supplying international markets with Caspian hydrocarbon resources. The Baku, the Baku Shu pa pipelines transport crude oil to international markets, while the Caucasus pipeline supplies Europe with natural gas. Georgia does not have a common border with the European Union in order to direct and connect with Europe's electricity transmission network. Georgia is considering implementation of diplexis cable project connecting Georgia with Romania. The project will significantly improve electricity supply and reliability in the country

Will make it possible to supply electricity on the other hand from renewable energy sources.

The project will significantly improve electricity supply and reliability in the country. On the other hand duplexis cable project, it will make it possible to supply electricity produced from renewable energy resources generated in Georgia to Europe.

We are working with the European Union to include this project in the list of projects of common interest. The work is currently funding a comprehensive feasibility study of the project.

Finally, I believe that discussions at the Green Energy Network will be productive and will agree on specific plans to extend and deepen existing cooperation in building secure, resilient climate conscious energy systems for the benefit of our countries.

Thank you vey much.

Short CV

David Tvalabeishvili was appointed at the position of a Deputy Minister of Economy and Sustainable Development of Georgia in May, 2019. Before that he used to hold a position of a chairman of the Management Board at Georgian State Electrosystem (GSE). In total David Tvalabeishvili has 23 year experience of working in Energy Sector that includes his position of Strategic Planning Manager at Georgian International Oil Corporation (1996-2005). Mr. Tvalabeishvili was involved in negotiations, as well as implementation of projects concerning the transit pipelines from the Caspian region via the territory of Georgia. Between 2006 and 2007 he worked as Carbon Finance Coordinator for the South Caucasus at the World Bank office in Tbilisi. In 2008 he was appointed as Energy Project Director at the Millennium Challenge Georgia Fund (MCG), where he managed Georgia's main gas pipeline rehabilitation project, as well as a study of possibility of constructing gas storage facility in Georgia. Between 2010 and 2012 as Energy Projects Manager at the United States Agency for International Development Georgia (USAID) he continued working on main gas pipeline rehabilitation projects within the frames of the US Assistance to Georgia. From November 2012 through September 2018, Mr. Tvalabeishvili worked as the General Director of Georgian Oil and Gas Corporation. In 1999 David Tvalabeishvili received the Medal of Honor for his contribution into development of the Baku-Supsa Oil Pipeline.

Speech Amb. Lazar COMANESCU

BSEC – PERMIS Secretary General

Prof. Mavrakis, Ambassadors,

Dear friends, dear participants,

First of all, I do apologize for the inconvenience that I might have created in the appropriate carrying out of this conference. You know I have to attend another one and it is the technicalities and lack of synergies that do this inconvenience. I do apologize.

Dear participants

Ladies and gentlemen

I would like first to thank the Director of Energy Policy and Development Centre (KEPA) of the National and Kapodistrian University of Athens, Prof. Mavrakis for his kind invitation to convent to me to participate to this 8th Green Energy Investments Forum. It is my first participation in such an important gathering, and I thank very much again the Professor for including me among those distinguished personalities addressing this Conference.

As always, we are happy to take this event under the auspices of the BSEC – PERMIS. As you all know the idea of the organization of the BSEC - Green Energy Investments Forum, emerged from consultations between KEPA and PERMIS. This Forum which traditionally gathers high level officials, policy makers and market players (very important market players) has evolved into becoming an important tool for attraction of investments and boosting regional cooperation in the promotion of the Green Energy and the achievement of the 7th Sustainable Development Goal "Clean, Affordable and Modern Energy".

Well being convinced that today's Forum with focus on Georgia will be another step forward in BSEC, I would like to take the opportunity to express my high appreciation to KEPA for their comprehensive activities covering a wide range of topics including Energy Geopolitics, Regional Energy Markets, the promotion of Energy Investments and Climate Change and Green Economy.

I was referring to Geopolitics because I think all of you here would agree that the Black Sea area, the Black Sea region and with your permission, the Black Sea Organization are key in many respects for the economy.

I am referring to the fact that the Black Sea area is actually the link, the bridge between Asia and Europe, between north and south, East and West. It is about energy and I am glad to see that there is an increased awareness outside of the Black Sea region and the BSEC about the importance of this issue for the global economy.

Now, I may remember that the BSEC – Green Energy Network was established in 2015 and is operated by KEPA under the supervision of the BSEC – PERMIS. Thanks to cooperation with KEPA and the BSEC Green Energy Network, PERMIS has accumulated valuable experience in the formulation of complete projects of regional scope. What as I said last night to those who were there and may remember is that one of my top priorities as the Secretary General of the organization of PERMIS is that of substantiating even more the project oriented activity of the organization and this cooperation we have with KEPA is just one example that we can do that.

We are confident that the Network will continue its active involvement in the development and promotion of green Energy projects for the benefit of the BSEC Member States. This is of almost importance for in house regional cooperation especially in the kind of conditions caused by the propriate pandemics. This is all the more in the case of energy which is one of the key areas of cooperation among BSEC Member States and which has been seriously affected by the coronavirus.

In order to reduce the negative impacts on the renewable energy, governments should encourage investments in this sector, which is essential for countries to achieve their sustainable development goals. It is also important for the environment as it replaces the negative effects of sulphicious with more environmentally friendly alternatives creating pathways for fostering a climate neutral energy industry. In line with the commitments of the Paris agreement, we believe that the efforts for more concern, together with the activities of the relevant BSEC Working Groups offer the wider flexible area a variable for addressing the negative impact of climate change. In this regard, we highly command the initiative “75 UN - 75 Trees UNAI SDG7” proposed by KEPA in its dual capacity as the coordinator of BSEC – GEN and as the UN Academic Impact hub for the 7th Sustainable Development Goal.

Dear participants, we all know that these are issues we have planned together with systematic and well-structured cooperation on the basis of the experience gained and, on the work, so far accomplished.

We fully support investments in the renewable energy in the BSEC region with a view to increase energy security, diversity of energy resources and develop energy transportation routes and new infrastructures. For three such an important objective, also requires working with other market organizations and institutions and concentrating on project-oriented approaches. Again, I may recall what I said last night, I need much more intensive involvement of the right local actors of the private sector and they will flag to do what we can

The BSEC Member States should spare no more efforts to materialize the vision of transforming the BSEC region into a model for clean energy in the nearest future possible.

With all these in mind, let me wish all participants in this Conference a very productive day ana I am sure that it will be the case.

Thank you very much for your attention

Short CV

Lazar COMANESCU graduated from the Foreign Trade Faculty of the Academy of Economic Studies (ASE) in Bucharest (1972). Then he followed a course on civilization and contemporary French language in Paris - Sorbonne (1973). In 1982, he obtained a PhD in international economic relations at ASE.

After graduation, he entered the Department of International Economic Organizations of the Ministry of Foreign Affairs (1972-1982). After obtaining his doctorate, he lecturered at the Department of International Economic Relations of the Academy of Economic Studies (1982-1990).

After 1990, he returned to the Foreign Ministry, performing the functions of advisor and in 1993, minister-counselor at the Romanian Mission to the European Union - Brussels (1990-1994), Director of the European Union (1994-1995), general manager, advisor to the Minister of Foreign Affairs, director of cabinet (1995). In 1995 he was appointed as Secretary of State for Foreign Affairs (1995 to 1998) in the same period and associate professor at the ASE.

Since 1998 came a period of 10 years after Romania's diplomatic representation to the European Union, Ambassador Extraordinary and Plenipotentiary, Head of Mission of Romania to NATO and the EU (1998-2001), *Ambassador Extraordinary and Plenipotentiary, Head of the Mission of Romania to the European Union the (2001-2007), Ambassador Extraordinary and Plenipotentiary and, Permanent Representative of Romania to the European Union (2007-2008).*

On 14 April 2008, he was appointed by decree as the Minister of Foreign Affairs (April 15th. - December 22 2008). He was ambassador of Romania in Berlin (2009-2014). In February 2015 He was appointed presidential advisor, Head of Foreign Policy.

He is a member of the Scientific Advisory Board of the European Institute of Romania, member of the Scientific Council of the Romanian Institute of International Studies and a founding member of the Forum of Central Europe in Warsaw. In 2000, he was Awarded the National Order "Faithful Service" with the rank of Grand Officer. He is the author and coauthor of courses and textbooks including: 'The World Economy' (1985, 1990, 1995), 'International economic transactions Techniques' (1989), 'Dictionary of International Economic Relations' '(1993).

Lazar COMANESCU held two mandates as Minister of Foreign Affairs, between April and December 2008 and from November, 2015 to January, 2017. He was also Ambassador of Romania to Germany from 2009 to 2015 and head of the Romanian Representation to the EU from 2001 to 2008.

Remarks by Prof. Asaf HAJIYEV

Secretary General of PABSEC

Dear Professor Dimitrios Mavrakis, Ambassadors

Dear Friends,

Ladies and Gentlemen,

I am very privileged and happy to address you on behalf of Parliamentary Assembly of the Black Sea Economic Cooperation Organization and during this opportunity I would like to express our deep gratitude to Professor Dimitrios Mavrakis for inviting me to be here and also, I would like to congratulate Professor Mavrakis for organizing this important event and also for choosing I would say an extremely actual problem for the world

Because renewable and green energy are very important for the world now and raises the question why it is so important now because the world did not think about it for several years

There are many years ago several reasons. I start from the first reason. The first reason is energy of course. The world always needs energy. In the beginning of the twentieth century, the power the cost of the country was estimated by its nature in resources particularly in energy.

Today the energy sector is estimated in 4 trillion American dollars, but in the second part of the twentieth century, situation was changed. It was the rise of a new sector, the banking sector and today is estimated about 4.5 trillion dollars. But in the end of the twentieth century, the situation rapidly was changed, because in our life came information technology. The sector in estimated now at more than 5.5 trillion dollars. The country with the higher life status is Denmark, Finland, Singapore. They do not have any energy resources but use information technology there with high life standarded. Full use of wind energy, they have high life standards.

Look at Norway, it is very rich country in oil and gas but they do not spend this money from oil and gas. They just put it in the so-called Pension Factor. We just call it as controlleum fact.

They use this for investment in green energy. Today, there is a regional petroleum fund with1.4 trillion dollars and it invests only in green energy. So, this is very important because information technology allows to get solar and wind energy. This is one reason why the world is interested so much.

The second reason, I would like to say a few words about the Black Sea region which is presented here. The Black Sea region is the richest region in the world. As Ambassador Comanescu told that this is an intersection transportation road from East to West, circuaid from North to South like a bridge between Asia and Europe, but my vision, I think, the most important value is the people who live, here, in Black Sea.

Different nations with different culture, different religions and traditions and we are obliged to protect these people, to bring prosperity and first of all is the climate change problem and the environment problem and this is our obligation. And this is the second reason why renewable energy and green energy is important to the world, because it can help to solve the climate problem and also the environment problem

But of course, green energy needs high investment. If until 2017, it was invested three hundred billion dollars, to green energy, now it is expected that to 2027, it will be invested one point one trillion dollars which is huge amount that the world understands, but without investment it is not possible to do something. So, the matter is to invest in this sector.

Another reason according to international labor until year 2025, is the opening of 27 million jobs in the world thanks to green energy. It is also important for the world and these four reasons define why it is important.

Now, I would like to say a few words about investments, how to invite investments in the countries. I can give you some good examples. In 1998in Israel, they prepared very effective laws in the level of classic legislation and afterwards immediately company Microsoft invested there 8 billion dollars and so other representatives. The Parliamentary Assembly of the Black Sea Economic Cooperation were working with Parliaments. It is necessary to prepare effective legislation because our laws should be very attractive for investments and local governments should make these investments and also the private sector. But for all these first of all, they have to look at the legislation and moreover of course green energy sector and the project is very huge and needs high investments, So, it is necessary to have some law, credits from World Bank, International Financial Sector. As representative of Azerbaijan, we have to utilize huge project in energy, and I know that these organizations will give credit if only and only if this project will be discussed on the level of parliament and will be taken some law reflecting this project.

So in the level of parliament we have to think about it and the Parliamentary Assembly of the Black Sea Economic Cooperation several times will discuss issues of green energy, renewable energy. I do not want to concentrate now on European because the number of recommendations and reports which have been prepared by PABSEC, but we have sent these recommendations to parliaments and they can use it in their work.

The problem of green energy is not the problem of one country, it is not the problem of one region, it is the problem of the world and in this regard I think we have to unite our efforts to prepare some effective legislation. I think in this regards Black Sea should not divide us but should enlighten us.

Thank you very much for your attention and once again thank you very much professor for inviting me here because your offer is always very interesting and now I think I would like to use this opportunity and present a small souvenir on behalf of PABSEC, because several times I have participated in your conference. I like it vey much. Maybe I like it because I come from an energy country. Azerbaijan is the oil partner to world and recently it has finished the gas pipeline, TAP and already delivers to Greece and to Italy and to Albania.

Short CV

Dr. Asaf Hajiyev was born in 1951. 2001-2015 was Professor and Chair of the Department of Theory of Probability and Mathematical Statistics at the Baku State University. In 2014 he was elected Academician (Executive member) of the Azerbaijan National Academy of Sciences, Institute of Control Systems.

He holds the Dr. Sci. degree from Bauman Moscow State Technical University (1992) and has done Ph.D. (1979) and post-doctoral research (1985-1989) at Lomonosov Moscow State University. He has vast research and teaching experience as the Chair of the department of Probability and Statistics, and of the Department of Controlled Queues, Institute of Control Systems at the Azerbaijan National Academy of Sciences; Chair of the Department of Theory of Probability and Mathematical Statistics, Baku State University; Senior Scientific Researcher, Department of Probability Statistics, Royal Institute Technology in Stockholm. Being a renowned researcher, he has served at the several universities around the world including China, Germany, Italy, Portugal, Sweden, Turkey, and USA. He serves on the editorial boards of many prestigious national and international academic journals. He has been an organizing member and the Keynote speaker at numerous international conferences. He has been honored with many prestigious awards like: Azerbaijan Lenin Komsomol Prize Winner on Science and Engineering; Grand Prize at the International Conference "Management Science and Engineering Management" Macao; and Grand Prize at the İnternational Conference "Management Science and Engineering Management" at Islamabad, Pakistan.

He is the Honorary Academician of Academy of Sciences of Moldova, foreign member of the Mongolian National Academy of Sciences, Member of TWAS (The World Academy of Sciences), Honorary Professor of Chengdu university (China) and elected member of the International Statistical Institute.

He has also the honor of holding the office of the Vice-President and since 2015 the Secretary General of the Parliamentary Assembly of the Black Sea Economic Cooperation Organization. He serves on the boards of many international academic organizations and institution. He has more than 150 peer reviewed scientific publications to his credit, published in the highly reputed journals.

Speech of Amb. Anatol VANGHELI

Ambassador of the Republic of Moldova to the Hellenic Republic

Dear Minister Georgiadis
Dear Deputy Minister Fragogiannis
Dear Secretary General,
Dear Deputy Secretary-General,
Dear Profesor Mavrakis,
Excellences Ambassadors, Representatives of state and academic institutions,

Dear participants,
1. I'm honored to take part once again in this important event, already in a usual format of the Forum, regretfully for the last time due to the completion of my term of duties as Ambassador in the Hellenic Republic

2. The post COVID era it's a new practice for all of us like it was the COVID period itself, but we try to adapt and to learn on the go in order to find the best resources for the management of the current issues that need to be addressed.

3. Let me further, underline some key points regarding the renewable energy sector in Moldova in the next future.

By the end of this year, Moldovan authorities plan to approve the draft Government Decision on approving capacity limits, maximum quotas, and capacity categories in the field of electricity from renewable resources by 2025. The extension of the period covered by the decision until 2025 will provide the investor community with the predictability expected from the Government of the Republic of Moldova. The above-mentioned project will have a positive impact on the economy of the country and on the state budget with investments between 450 million and 900 million euros in the private sector that will create new incomes and new jobs.

4. The Ministry plans for 2022 the initiation of the consultation process on the draft amendment to the Law on the promotion of the use of energy from renewable resources (no. 10/2016.) It will contribute to the adjustment to the international practices, the clarification of all the aspects related to the activity of electricity production, costs and policies, as well as will clarify the element of the state assistance in this filed.

5. Another important project is **"Energy efficiency in the Republic of Moldova"** for 2022-2025, which was developed according to the commitments made by the Republic of Moldova in the field of sustainable development/energy efficiency, which involves mobilizing the necessary financial resources for this purpose, following cooperation and dialogue with Development Partners, such as the European Union (EU), European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB). The project is aimed at implementing a national energy rehabilitation program of the real estate fund of the Republic of Moldova which includes public central and local buildings as hospitals, schools and kindergartens, with a total budget of 75 mln Euro.

6. Ladies and Gentlemen, let me finalize by reiterating that the authorities of the Republic of Moldova are involved and ready to contribute and accelerate the country's transition to a sustainable energy future and remain committed to the objectives of the Paris Agreement by setting an unconditional target of reducing greenhouse gas emissions to 64-67% below 1990 by 2030.

7. I thank you for your attention and wish you fruitful and constructive discussions

Short CV

He studied at the State University of Balti in Moldova. His master degree was in Cultures and Economies of Central and Eastern Europe at the University Grenoble III in France. His PhD studies were in political science at the Institute of Political Studies in Grenoble of France. He has also a diploma in Law studies from the State University of Moldova.

He served for the period 1996-2013 as Attaché at the Political Analysis Department of the Ministry of Foreign Affairs, First and Secondary Secretary at the International Security Department of the Ministry of Foreign Affairs of Moldova and Deputy Director of the Economic International Relation Division of MFAEI. He also joined the OSCE mission to Kosovo and Georgia.

For the period 2010-2015 he was the Counsellor and later the Ambassador of the Republic of Moldova to Israel. For the period April 2015 – July 2017 he was the Secretary General of the Ministry of Foreign Affairs and European Integration of Moldova.

He is the Ambassador of the Republic of Moldova to the Hellenic Republic since July 2017 and to the Republic of Cyprus since July 2018.

Speech of Amb. Sergii SHUTENKO

Ambassador of Ukraine to the Hellenic Republic

Distinguished participants,

Ladies and gentlemen,

I am delighted to join the 8th Green Energy Investments Forum. My greetings and good wishes to all participants.

The Ukrainian government continues to undergo the systematic democratic and economic transformation. It is integrating even deeper to the global economic architecture. Ukraine's renewable sector is posed for epic growth. In recent years a number of global renewable brands entered Ukraine's which boosted electricity production from renewable resources.

Ukraine is above average annual amount of solar radiation of Germany, the industry leader, and this makes Ukraine and attractive producer of solar energy. Particularly for existing industrial facilities and the growing agribusiness sector. From 2018 to 2020 solar power capacities gained growth almost five times and by 2021 exceeds 78 percent of all renewable energy capacities in Ukraine.

Ukraine's agricultural sector is the fastest growing industry of the economy, and it is expected to generate increasing amounts of agricultural and forestry waste, the keen sources needed for biomass based heat and power generation.

Between 2015 and 2020 the overall capacity of solar power plants in Ukraine grew twelve times, while that of wind power plants tripled.

Ukraine has adopted the EU climate ambitions to move towards climate neutral development by 2050 within the framework of the European Green Deal and should become an internal part of it. In order not only to combat the effects of climate change in synergy with the EU, but the economic strategy development also aimed to enhance security and create new opportunities for Ukrainian business. The European Green course is one of our government's priorities. We are keen on the joint efforts targeted to the achievement of the goals of the Green Deal and our interest in the development of alternative energy technologies.

Ukraine has potential to become a favourable destination for hydrogen producers due to its resources due to its resources that allow to produce different types of hydrogen and geographical position granting access to the European market.

In its energy strategy, the European Union has identified Ukraine as a priority partner in the supply of green hydrogen to the EU market and Ukraine is persistent working to prepare for this expertise, becoming an important hydrogen node. Ukraine can mitigate its energy security dangers and deliver on its duty to reduce green house gas emissions as well. Last but not least I would like to stress the opportunities to invest in Ukraine in the alternative energy sector. They are exceedingly favourable as the country has diverse resources of raw material and a well-educated workforce processing the technical "know-how"required to develop and introduce the latest commercial advances in this sector. Renewables enter the top five sectors for investment in Ukraine.

In 2020 the country was ranked fourteenth out of one hundred and eight developing countries world wide for the attractiveness for investment in the renewable energy sector according to Climate Scope Rating 2020. There are Norwegian, German, French and also Chinese companies that operate in the Ukrainian renewable energy market, as many Ukrainian domestic companies. Ukraine remains industrial and European country offering opportunities for investors and industrial professionals including the renewable energy.

So by concluding I would like to wish all participants a fruitful work and the outcomes of this meeting to be carried out in the future for all countries in our region.

Thank you for your attention.

Short CV

He graduated from the Kyiv Engineering and Construction Institute in 1993 and the Young Diplomats School of the Ministry of Foreign Affairs of Germany in 1996. He received in 1999 his Master of Art in International Management and Planning from the US Naval Postgraduate School (Monterrey, CA).

His career as diplomat started in 1995 when he was placed as the Attaché, Third Secretary of the Arms Control and Disarmament Department of the Ministry of Foreign Affairs of Ukraine. He has served as the Second and First Secretary of the Ukrainian mission to NATO; as the Deputy Director and Director General of the Office of the Minister for Foreign Affairs of Ukraine. He was also at the MFA of Ukraine, the Deputy Director of the Arms Control and Military-Technical Cooperation Department; the Deputy Director and Director General of the Human Resources Department; the Director-General of the International Security Department; and the Ambassador at large, Non Proliferation and Arms Control Division, International Security Department. For the period 2006-2010 he was the Consul General of Ukraine in Thessaloniki-Greece. Since 2018, he is the Ambassador Extraordinary and Plenipotentiary of Ukraine to the Hellenic Republic.

Key-note

By
Prof. Dimitrios Mavrakis

Thank you, Mr. Chairman,

There is no doubt that this forum is taking place in a time of great challenges and uncertainties.

Uncertainties that have arisen from the combination of the negative effects of the pandemic, the unprecedented disturbances in the smooth functioning of the world economy and of course the increase in the magnitude and frequency of the disasters caused by climate change.

Disruptions caused by rising global demand are causing, among other things, an unprecedented rise in energy fuel prices, threatening efforts to develop and implement resilient and sustainable global economic recovery plans.

The magnitude of the problems and the solutions associated with them leads to the need to strengthen international and regional cooperation and even more, according to the UN Secretary-General's calls, to the need to raise public awareness at local, regional and international levels.

The Black Sea Economic Cooperation Organization (BSEC), as a well- established intergovernmental organization for economic cooperation, offers the frame to strengthen and implement specific actions and programs capable of helping to alleviate the negative effects of the aforementioned challenges.

Having a long-lasting experience of cooperation with PERMIS, either in the frame of EU projects that were implemented in the BSEC - MS or in my capacity as coordinator of the BSEC - Green Energy Network, in activities and procedures of PERMIS and the BSEC Working Group on Energy, I dare to mention some ideas their implementation of which could be beneficial for the BSEC - Member States.

The perspective of the establishment an integrated Black Sea Energy Market, consists a permanent aim of the BSEC – Member States, as it is mentioned in the Declaration of the Ministers of Energy in Sofia in 2010 when they have agreed to cooperate to the end of establishing an efficiently operating energy market in the Black Sea Region. Due to the complexity and the political nature of the aim, apart from the continuously expressed political agreement, its implementation remained unfulfilled and pending until last year when the Member States were invited to express their opinion on whether were interested to proceed establishing three (3) regional wholesale electricity markets, in Romania, Russian Federation and Turkey reflecting the existing technical and socio-economic conditions with the perspective of their future cooperation,

In addition, it was proposed the establishment of a regional wholesale natural gas market in Greece or Bulgaria in combination with the establishment of a multilateral legal entity consisting of the existing or underground gas storage facilities to be developed in the area.

Regardless of the received answers, from the member-states it is now evident that the establishment of a wholesale electricity market in Romania, with the participation of Ukraine could offer a price - stabilizing dimension in the electricity markets of the region.

Concerning now the exponential rally of natural gas price in global markets it is now evident the need for developing strategic reserves at national and most important regional level.

This need could be served if the proposed complex of underground gas storages combined with a regional wholesale natural gas market had been established.

Consequently, I think that this set of proposals may be resubmitted for consideration among the BSEC - Member States and the relevant energy market players.

The issue of energy poverty and the ways to face it, has increased its priority in the agenda of our governments and social authorities.

The BSEC - Green Energy Network has already presented a detailed roadmap, based on the integrated policy dialogue procedures, at the BSEC headquarters since 2019.

A roadmap, based on the work of a team consisting of high skilled university-professors from the BSEC - Member States and of the EU can lead through the procedures of the integrated policy dialogue to green and permanent solutions.

The BSEC - Green Energy Network has already presented a detailed roadmap, based on the procedures of "integrated policy dialogue", at the BSEC headquarters in Istanbul, since 2019.

Funding of such projects can be secured through a combination of state subsidies and the Green Climate Fund, functioning under UN, in the frame of its efforts to accelerate the implementation of Energy Efficiency programs.

Armenia and Georgia, already beneficiated from GCF, can provide valuable assistance in BSEC - MS with developing economies in developing and implementing similar programs through the BSEC - Green Energy Network in the frame of the BSEC - PERMIS activities.

Therefore BSEC - MS, with developing economies, can take advantage of the Green Climate Fund facilities to tackle issues of energy poverty and energy efficiency, based on cooperation that can be offered by the BSEC -GEN in the frame of the BSEC - PERMIS activities.

Promotion of Green Energy Investments through this Forum are related to the double aim to support cooperation for the economic development of our countries and contribute to global efforts to mitigate Climate Change.

Although this is not the proper place to resume global policies to limit the increase of mean atmospheric temperature below 2.0oC or even 1.5oC the sixth assessment report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) includes clear warnings that our societies should be adapted to the emerging extreme weather phenomena.

Many changes in the climatic system become larger in direct relation to increasing global warming. They include increases in the frequency and the intensity of hot extremes, marine heatwaves and heavy precipitation, agricultural and ecological droughts in some regions, and proportion of intense tropical cyclones, as well as reductions in Arctic sea ice, snow cover and permafrost.

The emerging negative repercussions of the occurring climate change impose the necessity of increasing the level of regional cooperation to confront the catastrophic impacts of the increasing severity of extreme weather phenomena.

It is virtually certain that the land surface will continue to warm in the coming years and this is translated to increased number of wild fires, dense precipitations and extreme floods.

It is now time for action at all levels of our societies.

We need new and more effective policies and measures, we need innovative solutions and local and regional cooperation to avoid or minimize the catastrophes.

It is necessary not only to warn our citizens but to train them how to react before and during those forthcoming catastrophic phenomena.

It is time to allocate funds and efforts to convince our societies to protect their wealth, to protect forests and plant new ones.

As BSEC – GEN we have included in the agenda of the Forum a session for adaptation encouraging municipalities and academic communities to find ways of cooperation on the aforementioned issues.

Responding to the catastrophic wildfires of the last years we have released a global initiative in close cooperation with UNAI and BSEC encouraging simple people, legal entities, academic institutions, local municipalities and regional governments to plant trees and new forests, further to their governmental policies.

Eleven million trees have been planted in 2020 and the first conference will take place next month with the aim to exchange lessons learned and good practices from our one-year experience.

Seven BSEC – MS (Armenia, Azerbaijan, Bulgaria, Moldova, Romania, Serbia, Turkey, Greece) and more than sixty (60) Greek municipalities, participate in this initiative while our aim is to motivate private sponsors and funds to support it with the perspective to upgrade it to an International Cooperative Initiative (ICI) under UNAI and UNFCCC.

Planting and looking after trees and forests, we restore what wildfires destroy, we protect land from floods, we create income for people who look after them, we contribute to CO2 reductions and create the perspective of editing and negotiating emission reduction certificates in countries with developing economies.

In this context I invite you to support the efforts of BSEC – PERMIS to promote cooperation, especially in the sectors of green investments, and of mitigation and adaptation to Climate Change.

Regulatory developments in support of the energy transition

By
Prof. Athansios DAGOUMAS

President of RAE

Short CV

Assistant Professor in Energy and Resource Economics and Director of the Energy and Environmental Policy laboratory at the University of Piraeus. He holds a Diploma in Electrical and Computer Engineering from the Aristotle University in Thessaloniki, where he elaborated his PhD in Energy Economics. He is Member of the Board of the Cambridge Trust for New Thinking in Economics. He has more than 15 years of work and research experience in energy related issues, including working as a Senior Researcher at the University of Cambridge and as a Senior Energy Analyst at the Transmission System Operator and at the Electricity Market Operator in Greece. His extensive experience builds his capacity for an in-depth understanding of multidisciplinary aspects of the energy sector: economic, engineering, environmental and policy. He is keen on developing models for the energy system, the economic-energy-environment (E3) systems and the real energy markets.

REGULATORY DEVELOPMENTS IN SUPPORT OF THE ENERGY TRANSITION

Assoc. Prof. Athanasios Dagoumas
President of RAE

EU Policy Objectives

- **Energy security, solidarity and trust**
- **A fully-integrated internal energy market**
- **Energy efficiency** contributing to moderation of demand
- **Decarbonising the economy**
- **Research**, innovation and competitiveness

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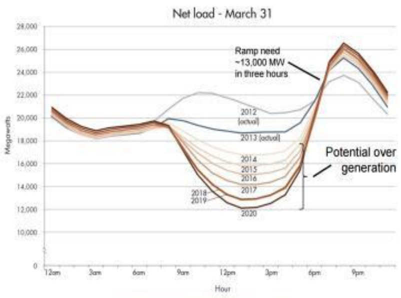
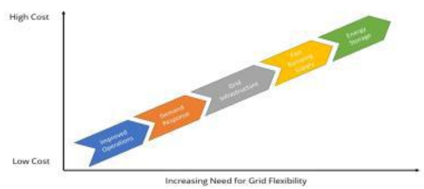
RES & Flexibility Challenges



Duck-Curve of California from 2012 to 2020

- Inertia & Ramping Capabilities
- Energy Storage Systems (ESS)
- Demand Response
- Interconnections
- **Market Framework**



Flexibility Source Supply Curve

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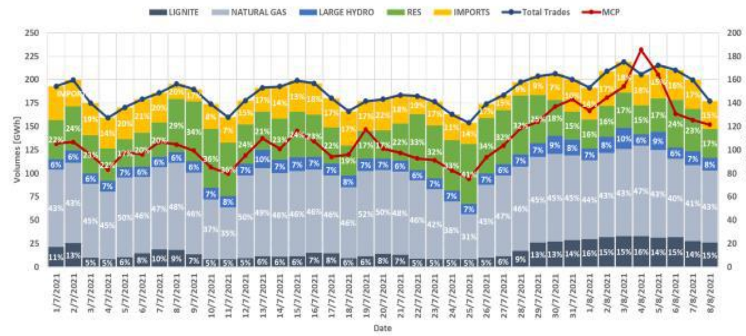
DAM Supply Mix (daily)



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DAM Supply Mix (monthly)

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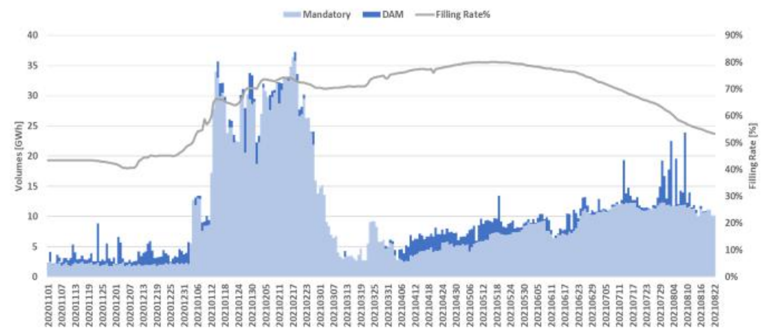
Hydro to Lakes Filling Rate



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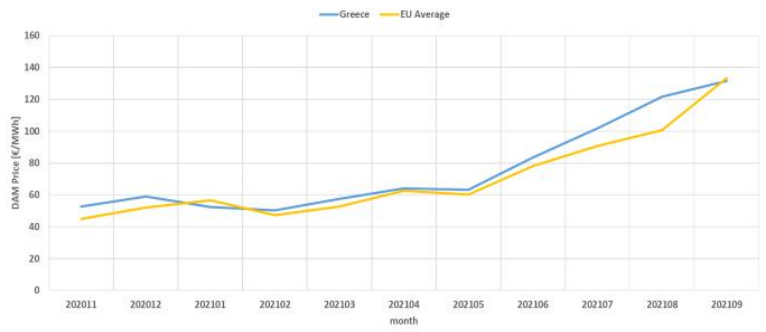
DAM MCP – GR to EU Average



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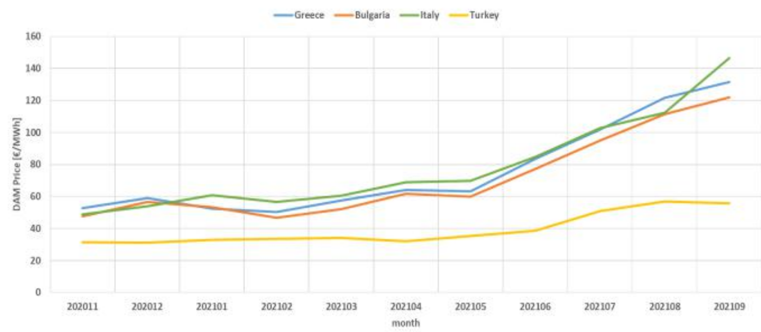
DAM MCP – Regional



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DAM to IDM Traded Volumes (<2%)

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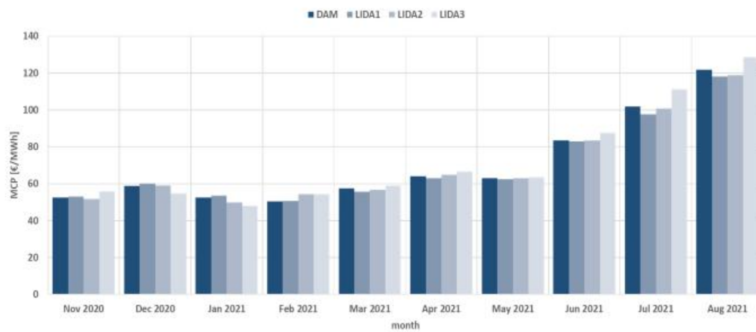
DAM & IDM Market Clearing Prices (MCP)



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Market Reform Plan

Implementation plan in the scope of Art. 20 of 943/2019 EU Regulation

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Market Reform Plan actions

- RAE, in close cooperation with IPTO, HEnEx, HEDNO, RES&GO Operator **identified priorities**
- **Reforms** are classified in 2 generic categories:
- **Short-term with specific deadlines**
- **Medium-term**
  - Under further elaboration (major reforms)
  - Specific deadlines

- **Short-term reforms** are of high priority, such as
- **Flagging of redispatch volumes in Balancing Market** (Regulation 2019/943)
- **Integration of Intra-day market** (CRIDAs, X-BID)
- **Further enhancement of competition** through increasing market participation
  - **Demand aggregators, RES aggregators, Traders, Storage**

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Market Reform Plan actions

- **Medium-term reforms concerns measures, such as:**
- **Scarcity pricing mechanism**
- **Portfolio-based bidding**
- **Self-scheduling and central dispatch**
- **EU balancing platforms (MARI/PICASSO)**
- **TSO-DSO Coordination Platform**

- That either require **further elaboration, and/or considerable changes in IT systems and market design.**

- At the same time, **YPEN is exploring further state-aid schemes, such as:**
- **Support of RES**
- **Support of Storage**
- **RES-PPAs and support of energy intensive industry**

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Market reform action list (Part B. Interconnections and grid reinforcement)

1. Distinction of Balancing Energy and Energy due to Re-dispatching → early 2022
2. Distinct portfolio-based reserves market establishment → to explore
3. Participation of Demand Response in the wholesale markets → early 2022
4. Participation of storage in the wholesale markets → end 2022
5. Participation of dispatchable RES units and RES portfolios as BSPs in the Balancing Market → early 2022
6. Launch of Complementary Regional Intraday Auctions (CRIDAs) → 2021
7. Participation of Traders in the Intraday market - Launch of Intraday PTR Auctions for non-EU bidding zone borders → 2022, conditional
8. Launch of Continuous Intraday Coupling → 2022
9. Resumption of the possibility of BSPs to submit Balancing Energy bids with negative prices → end 2021 linked to A1
10. Participation of RES units in the Electricity Markets having full balancing responsibilities → early 2022
11. Activation of scarcity pricing mechanism → to explore
12. Exploration (pros/cons) portfolio-based bidding in DAM and IDM and nomination platforms → to explore
13. Exploration of self-scheduling and central dispatch → to explore
14. Participation in the EU balancing platforms (MARI/PICASSO) → 2024
15. 70% target (margin available for cross-zonal trade) → mid or end 2022
16. TSO-DSO Coordination Platform →2024

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Market reform action list (Part B. Interconnections and grid reinforcement)

1. Cross-border interconnection projects
   1. New interconnection Greece-Bulgaria → 2022
   2. Italy (pre-feasibility studies)
   3. North Macedonia (feasibility study)
   4. Turkey (pre-feasibility study)
   5. Albania (very preliminary)
2. Southeast Electricity Network Coordination Centre (SEleNe CC)
3. Islands interconnection projects
   1. Crete Phase 1 → operational
   2. Crete Phase 2 → mid 2023
   3. Skiathos → end 2022
   4. Cyclades Phase D → 2024
   5. Dodecanese → 2028
   6. North East Aegean islands → before 2030
4. Reinforcement of transmission system
   1. Completion of the 400 kV backbone Peloponnese → high priority
   2. Compensation and stability enhancement → Q1 2022
   3. Rouf EHV S/S
   4. Argyroupoli EHV S/S
   5. Filippi-Santa
   6. Nevrokopi etc.
   7. Kerkyra
   8. Halkidiki
   9. Katerini and others
   10. South Ionian loop
   11. Various others

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Market reform action list (Parts C, D, E and F)

C. Retail Market Competition

1. Market Monitoring and Surveillance Mechanism → 2021
2. Antitrust case - energy release by PPC → end 2021
3. RES-PPA and support of energy intensive industry → 2021-2022

D. Liquidity of Forward Market

1. Software extension and enhancement → 2021-2022
2. Customized products for hedging DAM and Balancing transactions → end 2021
3. Antitrust case - energy release by PPC → end 2021
4. RES-PPA and support of energy intensive industry → 2021-2022

E. Investment support

1. Support of RES (separate action)
2. Support of Storage (Resilience and Recovery Plan)
3. Interruptibility scheme (phased out in Sept.)
4. Strategic Reserve → 2022 and 3Q 2023
5. Capacity Remuneration Mechanism with Reliability Options and flexibility enhancements → end 2023 onwards

F. Price limits and other restrictions - lifting

1. Lifting of 20% cap on physical contracts of vertically integrated suppliers → explore
2. Complex bids in DAM → explore
3. After continuous ID trading -9,999 EUR/MWH to +9,999 EUR/MWH
4. Negative balancing energy offers allowed → end 2021
5. Balancing energy offers up to +9,999 EUR/MWH after CRIDAs
6. Balancing energy offers -99,999 EUR/MWH to +99,999 EUR/MWH after MARI/PICASSO

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Summary

Market Reform Plan is **comprehensive and holistic**, well **elaborated by the RAE staff**

- Although its need resulted from the support of a state-aid scheme, **RAE staff incorporated major reforms in the plan**, under elaboration over the last months.
- It is a result of **close cooperation** among RAE, IPTO, HEnEx, HEDNO, RES&GO Operator and YPEN
- It incorporated **concerns form Market Participants** following public consultation
- Aims to **tackle market deficiencies** (mainly expand market participants and further developments in the balancing market)
- It is important to follow the **tight time-schedule** but the implementation is challenging – essentially a **huge reform has to complete end 2022**.
- There is optimism about acceptance of the Plan by the EU institutions
- The European Commission will put the Market Reform Plan in **international consultation**

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Thank you for your attention

Assoc. Prof. Athanasios Dagoumas

President of RAE

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BSTDB: Promoting Regional Prosperity and Economic Growth

Mr. Aristotelis SPILIOTIS

Secretary General, Black Sea Trade and Development Bank

Short CV

Mr. Aristotelis Spiliotis was appointed Secretary General of the Black Sea Trade and Development Bank (BSTDB) as of 16 March 2019, for a period of four years.

Mr. Spiliotis is a national of Greece, born in 1965. He holds a Ph.D. degree from the University of York, UK, in Money, Finance and Banking and a B.Sc. degree in Economics from the University of Piraeus, Greece. He also holds a Certified Investment Portfolio Manager certificate from the Hellenic Capital Market Commission, Greece.

Mr. Spiliotis started his professional career in the private sector (1994), as an Investment Director of the mutual funds company DIETHNIKI S.A., NBG Group. In 1999, he co-founded and managed a venture capital fund, 4E. He has served as Vice President of the Hellenic Venture Capital Association. He was board member in several Greek companies and banks. He was Director of Investment Participations of Omega Bank and Proton Bank, Chairman of the Board of the Omega Mutual Fund Management Company, Board member and Chairman of the Investment Committee of the business incubator Thermi S.A. and Board member of Panellinia Bank. In 2012, he joined the Economic Analysis and Research Department of the Bank of Greece.

Before joining BSTDB, Mr. Spiliotis served as special Economic Advisor to the Deputy Prime Minister and Minister of Economy and Development of Greece. His areas of responsibility included the banking sector, financing tools, capital and money markets, investments and project financing, international economic relations.

He has taught in the universities of York and Leeds, U.K. and he is currently lecturing on banking and finance in Greek universities. He has published several articles in scientific and professional journals. Mr. Spiliotis is fluent in English and Greek. He is married and has two children.

Intervention of the Secretary General of BSTBD Mr Aristotelis Spiliotis

During the current decade, we aspire the role of the Black Sea Trade and Development Bank, as an IFI with a regional character, to be crucial for the development of the countries of the Black Sea region.

This goal is clearly reflected in the Bank 's long - term strategy for the period up to 2030, where priority is given to increasing funding for large - scale public infrastructure projects, in critical areas such as energy and transport. As typical examples of the current activity of BSTDB in this direction can be mentioned, indicatively, the financing of projects such as:

• The modernization of the 14 regional airports of Greece (62 million €)

• The support of the investment program of Aegean Airlines (18 million €)

• The construction of the new Sofia airport in Bulgaria (€ 83 million)

• The expansion of Izmir Airport in Turkey (€ 40 million)

• The expansion of the metro network in Istanbul and Izmir in Turkey (€ 167.5 million)

• The support of PPC's investment program (€ 160 million) in Greece

• Expansion of the electricity transmission network in Bulgaria (€ 42 million)

• The construction of a solid waste treatment and energy production plant of the Municipality of Istanbul in Turkey (€ 40 million)

In particular, with regard to the transition to the "green economy", it is worth mentioning the BSTDB's strategy for tackling climate change, which represents the Bank's vision and approach to tackling climate-related issues over the over the next ten-year period and beyond, via enhancing the support for its shareholders in both mitigating and better addressing the effects of climate change.

Through this strategy, the Bank aims to better align its financing actions with the climate priorities of its Member States and is committed to achieving the following three strategic objectives:

1) gradually reduce "net pollutant emissions" in the portfolio by setting periodic emission targets with a view to achieving zero net emissions by 2050;

2) to gradually increase its share of funding to at least 30% in climate-positive actions and actions with climate benefits; and

3) to acquire improved technical skills to support public and private actors in its Member States in their efforts to mitigate the effects of transition to "green economy".

In this overall context, investments

* in renewable energy sources,
* in improving the efficiency of energy resources,
* in sustainable infrastructure,
* in green buildings and
* in electricity transmission systems

will be among its financial priorities.

At the same time, the Bank will gradually phase out support for sectors that rely on the intensive use of coal and hydrocarbons.

It should also be noted that in the context of the same strategy, BSTDB has included in its financial inventory the use of Green & Climate bonds, the revenues of which will primarily support financing of operations with clear environmental and climate benefits, such as lower carbon generation, renewables, and energy efficiency. The first such 10-year Environmental and Social Governance (ESG) notes were issued in February 2021, on the back of the Bank's Medium Term Note program, raising USD 85 million in a private placement with an Asian investor.

Hellenic Development Bank – You can bank on us

Mr. Evangelos KARAYANNACOS

Strategy Director of Hellenic Development Bank (HDB)

Short CV

Evangelos Karayannacos has a solid background of 19 years in the areas of SME Financing, Risk Management and Financial Engineering.

Evangelos has held various senior positions and he has been involved in several projects in HDB.

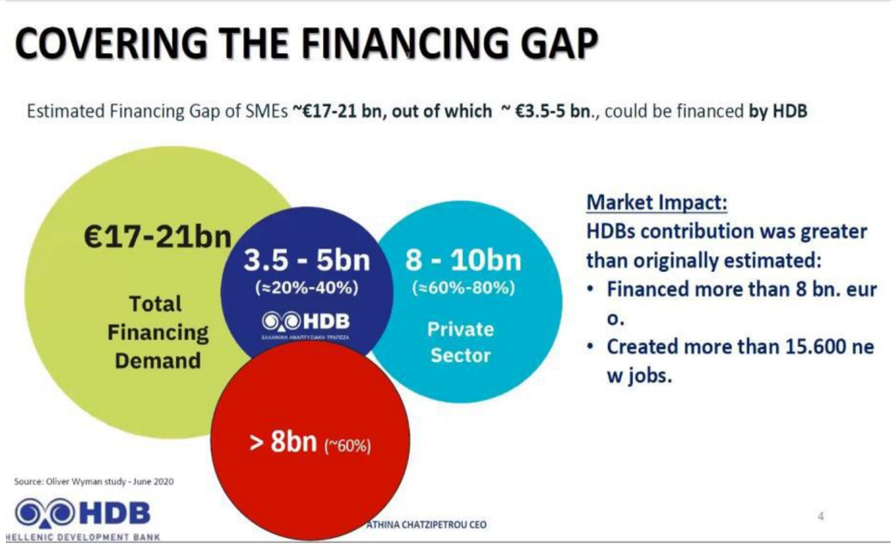
He was a member of the teams that set up and operate financial instrument schemes funded by Structural Funds or Public budget.

He is a Certified Expert in Risk Management from the Frankfurt School of Finance and Management, holds a MSc in Decision Science with a specialization in Financial Engineering from the Athens University of Economics and Business, and holds a BSc in Statistics and Actuarial Science from University of Piraeus.


HELLENIC DEVELOPMENT BANK
You can Bank on us!
HDB
ATHINA CHATZIPETROU CEO
13-10-2021


WHO WE ARE
Hellenic Development Bank is the National Promotional Institution authorized in providing leverage.
100% Owned by Hellenic Republic.
Our main mission: To support micro, small and medium enterprises by facilitating their access to financial sources to address and cover any market failures.
HDB
ATHINA CHATZIPETROU CEO
2


WHAT WE DO
We design and implement financial instru ments and products that promote access to finance.
We are the trusted partner that provides data for policy making.
01
02
03
04
We support necessary transformatio ns to promote sustainable development.
We effectively manage funds addressed to SME's
HDB
ATHINA CHATZIPETROU CEO
3


COVERING THE FINANCING GAP
Estimated Financing Gap of SMEs ~€17-21 bn, out of which ~ €3.5-5 bn., could be financed by HDB
€17-21bn
Total Financing Demand
3.5 - 5bn
(≈20%-40%)
HDB
8 - 10bn
(≈60%-80%)
Private Sector
> 8bn (~60%)
Market Impact:
HDBs contribution was greater than originally estimated:
• Financed more than 8 bn. eur o.
• Created more than 15.600 ne w jobs.
Source: Oliver Wyman study - June 2020
HDB
HELLENIC DEVELOPMENT BANK
ATHINA CHATZIPETROU CEO
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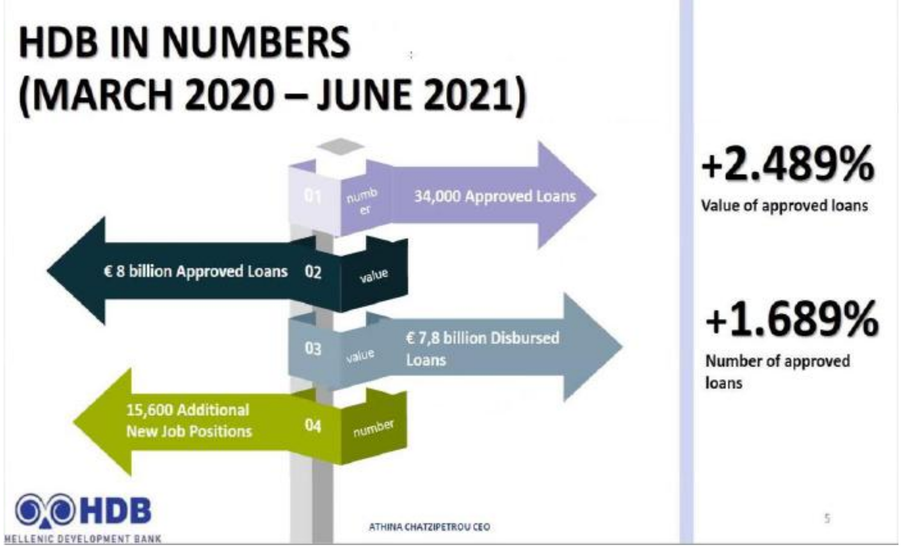
HDB IN NUMBERS
(MARCH 2020 – JUNE 2021)
01 number 34,000 Approved Loans
€ 8 billion Approved Loans 02 value
03 value € 7,8 billion Disbursed Loans
15,600 Additional New Job Positions 04 number
+2.489%
Value of approved loans
+1.689%
Number of approved loans
HDB HELLENIC DEVELOPMENT BANK
ATHINA CHATZIPETROU CEO
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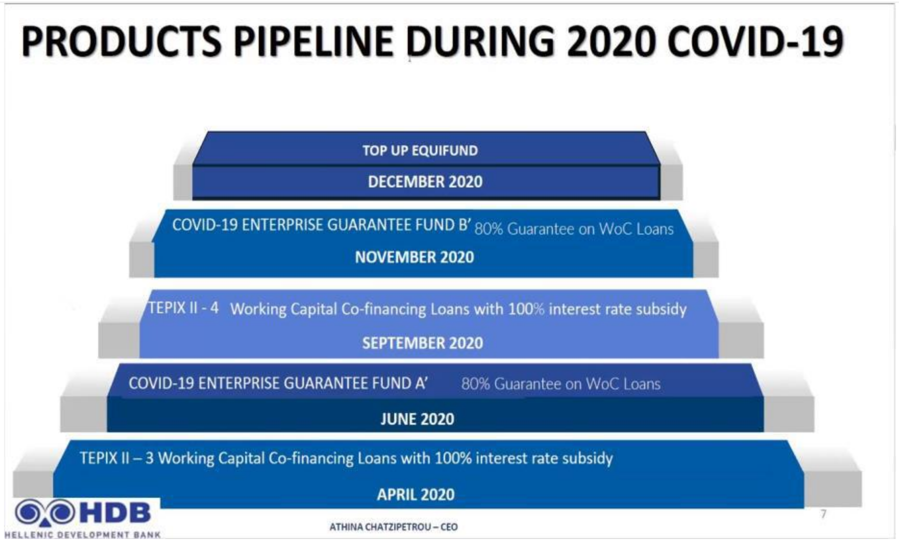
PRODUCTS PIPELINE DURING 2020 COVID-19
TOP UP EQUIFUND
DECEMBER 2020
COVID-19 ENTERPRISE GUARANTEE FUND B' 80% Guarantee on WoC Loans
NOVEMBER 2020
TEPIX II - 4 Working Capital Co-financing Loans with 100% interest rate subsidy
SEPTEMBER 2020
COVID-19 ENTERPRISE GUARANTEE FUND A' 80% Guarantee on WoC Loans
JUNE 2020
TEPIX II – 3 Working Capital Co-financing Loans with 100% interest rate subsidy
APRIL 2020
HDB HELLENIC DEVELOPMENT BANK
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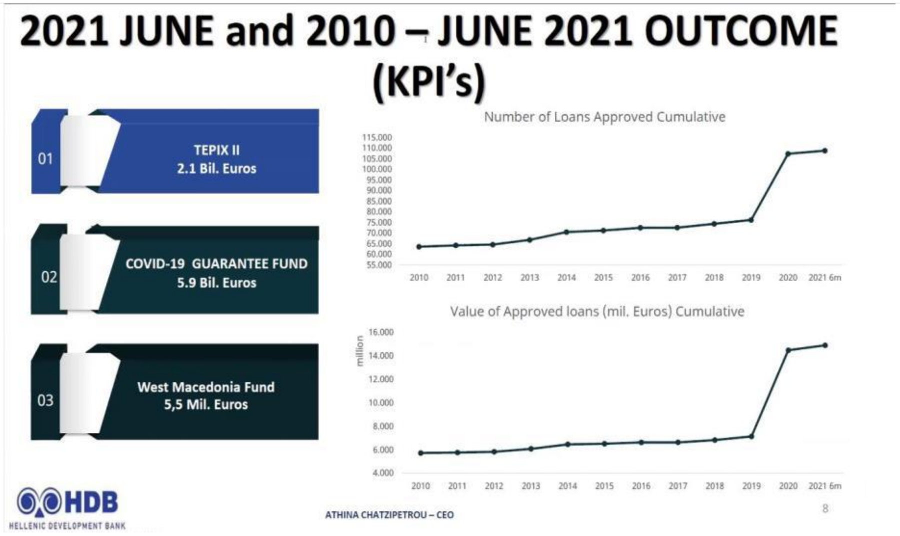
2021 JUNE and 2010 – JUNE 2021 OUTCOME (KPI's)
01 TEPIX II 2.1 Bil. Euros
02 COVID-19 GUARANTEE FUND 5.9 Bil. Euros
03 West Macedonia Fund 5,5 Mil. Euros
Number of Loans Approved Cumulative
Value of Approved loans (mil. Euros) Cumulative
million
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 6m
HDB HELLENIC DEVELOPMENT BANK
ATHINA CHATZIPETROU – CEO
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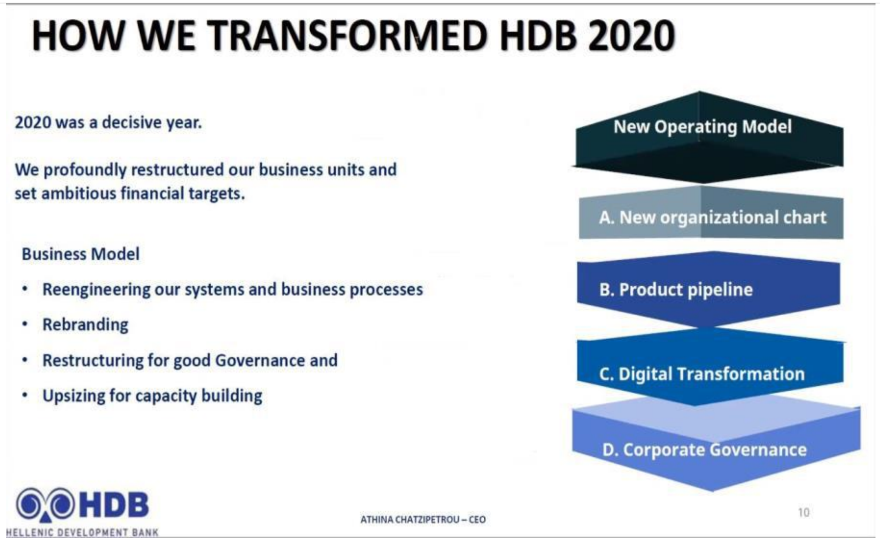
HOW WE TRANSFORMED HDB 2020
2020 was a decisive year.
We profoundly restructured our business units and set ambitious financial targets.
Business Model
• Reengineering our systems and business processes
• Rebranding
• Restructuring for good Governance and
• Upsizing for capacity building
New Operating Model
A. New organizational chart
B. Product pipeline
C. Digital Transformation
D. Corporate Governance
HDB HELLENIC DEVELOPMENT BANK
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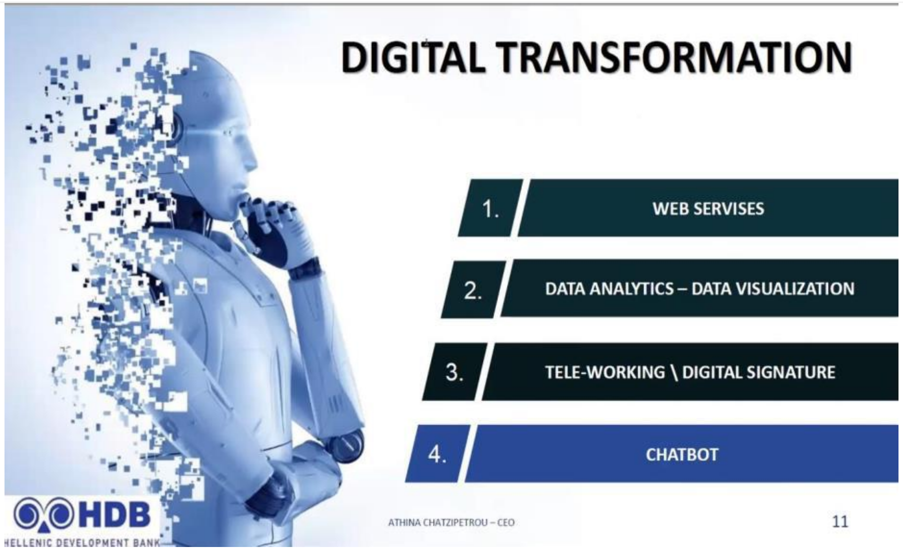
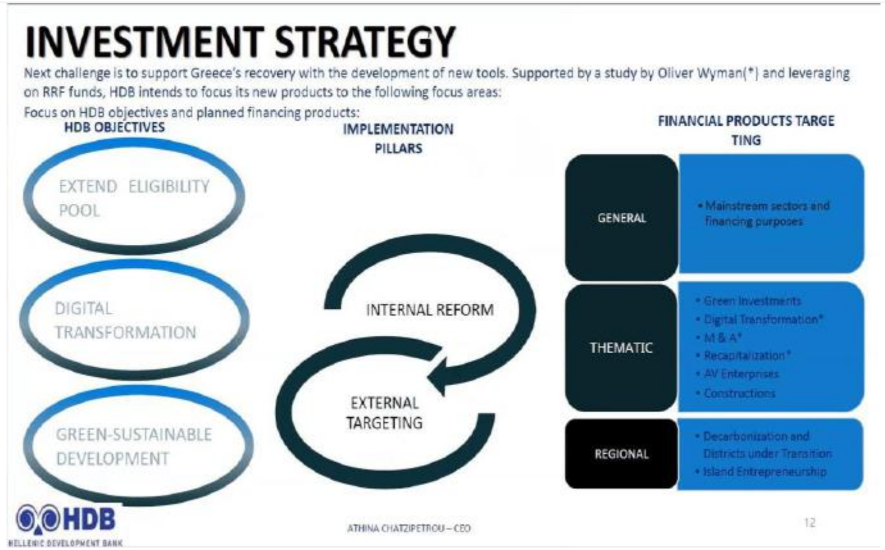

DIGITAL TRANSFORMATION
1. WEB SERVISES
2. DATA ANALYTICS – DATA VISUALIZATION
3. TELE-WORKING \ DIGITAL SIGNATURE
4. CHATBOT
HDB
HELLENIC DEVELOPMENT BANK
ATHINA CHATZIPETROU – CEO
11


INVESTMENT STRATEGY
Next challenge is to support Greece's recovery with the development of new tools. Supported by a study by Oliver Wyman(*) and leveraging on RRF funds, HDB intends to focus its new products to the following focus areas:
Focus on HDB objectives and planned financing products:
HDB OBJECTIVES
IMPLEMENTATION PILLARS
FINANCIAL PRODUCTS TARGE TING
EXTEND ELIGIBILITY POOL
DIGITAL TRANSFORMATION
GREEN-SUSTAINABLE DEVELOPMENT
INTERNAL REFORM
EXTERNAL TARGETING
GENERAL
• Mainstream sectors and financing purposes
THEMATIC
• Green Investments
• Digital Transformation*
• M & A*
• Recapitalization*
• AV Enterprises
• Constructions
REGIONAL
• Decarbonization and Districts under Transition
• Island Entrepreneurship
HDB
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FINANCIAL INSTRUMENTS
Co-Financing Products:
• Senior Loans
• Mezzanine Loans *
Guarantees:
• Capped Portfolio Guarantees
• Uncapped Guarantees
• Interest Rate Subsidies
• Grants
HDB needs to account for the specific characteristics of the Greek economy. In particular the proliferation of micro-SMEs relatively low levels of productivity and a structural financing gap.
HDB wants to place sufficient focus on:
• Methods to disburse
• The necessity of combining with the financial support and on tackling both demand and supply side of the equation.
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INNOVATION UNIT
• Dedicated Innovation Unit aiming at building up an operating model to support all stages of SMEs evolution & extroversion
• The Innovation Unit creates the right framework for both financial and non-financial support of SMEs and enables the market.
• It enhances HDB role in Greek economy by introducing innovative bundles of support mechanisms.
R&D stage Innovation
seed stage Innovation
initial revenue s Innovation
revenue growth stage Innovation
HDB
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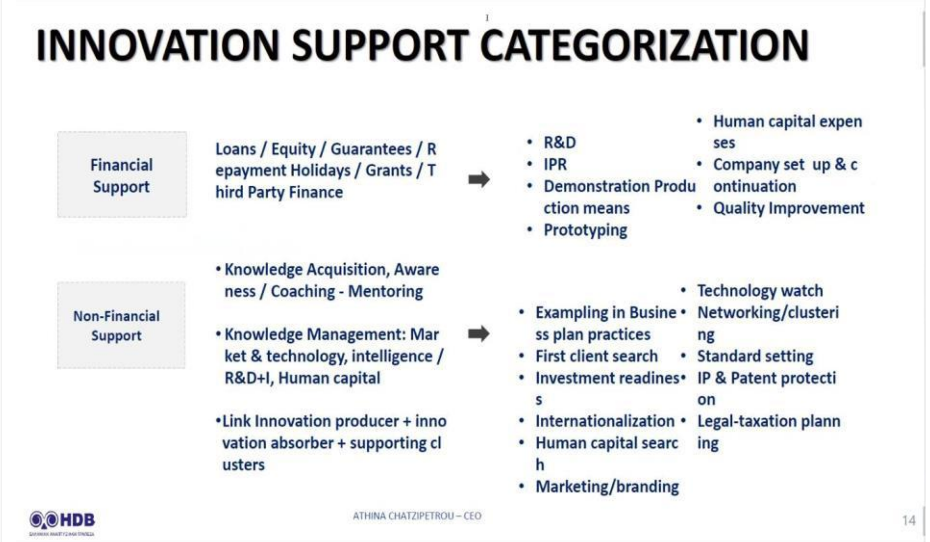
INNOVATION SUPPORT CATEGORIZATION
Financial Support
Loans / Equity / Guarantees / Repayment Holidays / Grants / Third Party Finance
• R&D
• IPR
• Demonstration Production means
• Prototyping
• Human capital expenses
• Company set up & continuation
• Quality Improvement
Non-Financial Support
• Knowledge Acquisition, Awareness / Coaching - Mentoring
• Knowledge Management: Market & technology, intelligence / R&D+I, Human capital
• Link Innovation producer + innovation absorber + supporting clusters
• Exampling in Business plan practices
• First client search
• Investment readiness
• Internationalization
• Human capital search
• Marketing/branding
• Technology watch
• Networking/clustering
• Standard setting
• IP & Patent protection
• Legal-taxation planning
HDB
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NON-FINANCIAL INSTRUMENTS
InnoAgora powered by HDB
"InnoAgora" powered by HDB, is a dynamic e-community that aims to offer international growth and matchmaking opportunities to selected Greek enterprises, by creating channels of communication with potential investors and other partners.
Goals and Objectives
members of the community can expect InnoAgora to:
• be an enterprise-to-investor matchmaking place.
• provide members with access to a wide range of resources and tools to help with their export orientation.
• connect with other relevant e-communities inside EuroQuity.
• offer online events, providing learning and growth opportunities.
• mobilise enterprises to create international synergies and partnerships.
• facilitate networking, knowledge exchange and links to relevant accelerators, incubators, clusters and business networks.
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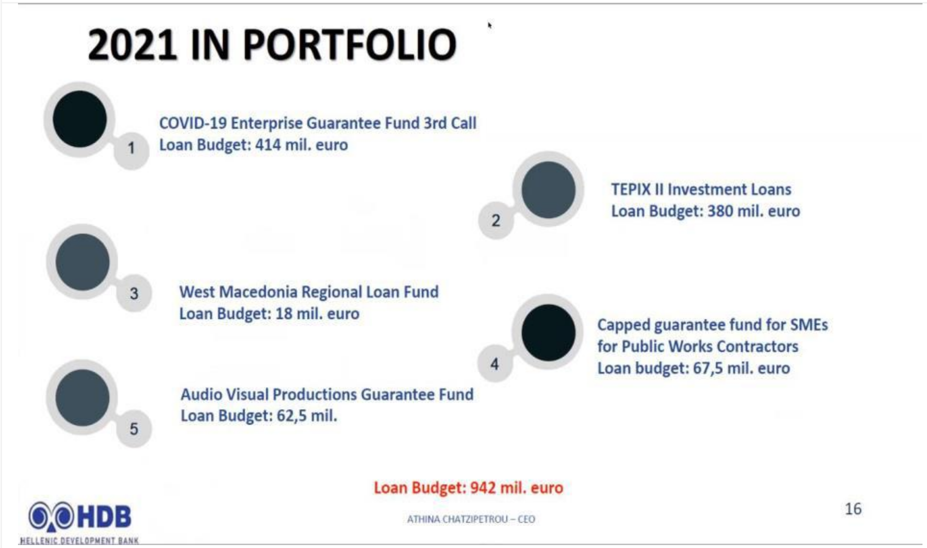
2021 IN PORTFOLIO
1
COVID-19 Enterprise Guarantee Fund 3rd Call
Loan Budget: 414 mil. euro
2
TEPIX II Investment Loans
Loan Budget: 380 mil. euro
3
West Macedonia Regional Loan Fund
Loan Budget: 18 mil. euro
4
Capped guarantee fund for SMEs
for Public Works Contractors
Loan budget: 67,5 mil. euro
5
Audio Visual Productions Guarantee Fund
Loan Budget: 62,5 mil.
Loan Budget: 942 mil. euro
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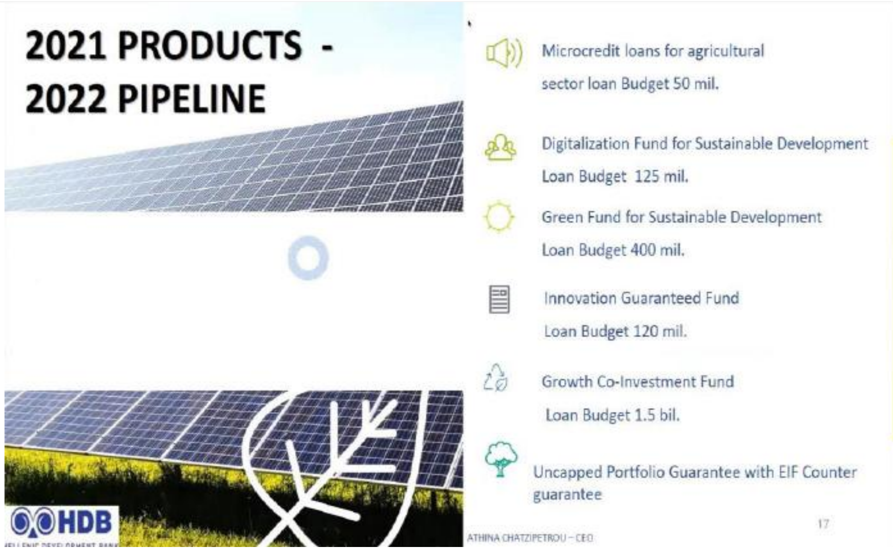
2021 PRODUCTS -
2022 PIPELINE
Microcredit loans for agricultural
sector loan Budget 50 mil.
Digitalization Fund for Sustainable Development
Loan Budget 125 mil.
Green Fund for Sustainable Development
Loan Budget 400 mil.
Innovation Guaranteed Fund
Loan Budget 120 mil.
Growth Co-Investment Fund
Loan Budget 1.5 bil.
Uncapped Portfolio Guarantee with EIF Counter
guarantee
HDB
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HDB GREEN PHILOSOPHY
We are in front of large environmental challenges and the government's ambition on this is clear.
HBD can help by developing green financial products and at the same time identifying projects worth investing in .
We are working to help attract more investments from the private sector.
We're committed to using our growing expertise in green finance to develop funding mechanisms that our partners can use to improve the environment.
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HDB GREEN
STRATEGY
• Aim: To promote financial support for environmental causes.
• Target: To increase the amount and to prioritize financing investments that promote the transition to low carbon and climate resilient growth and support the transition to a net zero global economy.
• Instrument: Green Fund for Sustainable Development. Co-Financing Loan Facility with a 40%-60% ratio and an initial Loan Budget of 400 mil Euro.
The Fund will have defined cross-cutting investment priorities which will deliver major mitigation and adaptation benefits:
• Transforming energy generation and access
• Encouraging low-emission and climate-resilient investments
• Scaling up finance for climate change
• Protection of the environment,
• Energy efficiency projects
• Rehabilitation of contaminated areas
• Production of electricity from renewable sources and for the promotion of energy from renewable sources in small - scale installations
• Energy infrastructure
HDB
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ESG
The Covid-19 pandemic has reminded us how interdependent we are and shifted society's focus to the human factor. Hellenic Development Bank adopts the ESG criteria and creates VALUE
➤ In the Thessaloniki International Fair 2021, together with Elevate Greece we announced an Innovation Challenge for the creation of toolkits based on Business Intelligence that will incorporate ESG and innovation scoring criteria for SMEs evaluation.
HDB's initiatives under ESG:
• Package of "green" financial instruments.
• Training of personnel in the ESG criteria and Climate Action.
• Development of mechanism and methodology for monitoring ESG criteria.
• ESG criteria to the partners' selection process.
• Corporate governance with high level of transparency.
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FUTURE GOALS
• To expand the number of businesses that are solvent with our approach described as a "B2B2B" system that supports small business plans.
• To train small businesses to have their own business plan to facilitate their access to sources of finance, automating bureaucratic procedures and enhancing transparency in decision-making. Technology is at the center of the new Hellenic Development Bank - HDB.
• To help small businesses compose their investments plans
• With an expanded and new "know your customer" we can evaluate the dynamic of businesses based on their overall action.
• Financial data will only be part of the credit rating.
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PARTNERS & MoU
European Investment Bank
European Bank for Reconstruction and Development
Black Sea Trade & Development Bank
EIF
Innovation Norway
HELLENIC REPUBLIC
MINISTRY OF DEVELOPMENT AND INVESTMENTS
bpifrance
DEMOKRITOS
TMEΔE
HELLENIC REPUBLIC
Ministry of Digital Governance
EquiFund
MINISTRY OF SHIPPING & ISLAND POLICY
GENERAL SECRETARIAT
FOR THE AEGEAN AND ISLAND POLICY
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Thank you
HDB
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ATHINA CHATZIPETROU – CEO

2050 Carbon Neutrality: A Eurogas Vision for an Affordable Energy Transition

Dr. James WATSON[1]
Warner Ten KATE[2]
Dr. Bent Erik BAKKEN[3]

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[2]MA MBA, Senior Consultant, Markets and Transaction Advisory, DNV GL
[3]Senior Analyst, DNV GL
Eurogas, Brussels, Belgium

Abstract

In November 2018, the European Commission proposed eight scenarios to achieving its vision of a carbon neutral 2050 energy system. Gas fuels are necessary in all the scenarios identified by the European Commission, but the need for gas is considerably higher in some.

To investigate these scenarios further and understand what would need to change in both our society and our energy mix, Eurogas commissioned a study with consultant DNV GL. This study demonstrates the savings associated with the scenarios that use more gas.

The study presents two competing scenarios Eurogas and 1.5TECH to achieve carbon neutrality by 2050 and compares those to a baseline (ETO2019). The baseline forecasts ‘a best estimate future’ reflecting current global decarbonisation policies. In this future, the Paris Agreement ambitions are not achieved. It forecasts that by 2050 only 76% of energy-related CO_2 emissions are mitigated.

Eurogas & 1.5TECH use largely identical assumptions (e.g. renovation rates, technology learning rates, technology efficiencies, etc.) and two of the three pillars of energy policy are fixed: ‘Availability’ (demand and supply are matched in a cost-efficient manner) and ‘Acceptability’ (the net zero CO_2 emissions target is met). The main differentiator between the two scenarios is subsequently ‘Affordability’ (the costs Europeans will incur).

The Eurogas scenario supports gaseous energy delivery through the existing gas infrastructure, which continues to be used. The gas system in this scenario is central to the transforming European economy. Gaseous energy is supplied to all sectors as a mix of natural gas, biomethane and hydrogen, complemented with carbon capture use and storage technology (pre-combustion and post-combustion).

The 1.5TECH scenario supports the decarbonisation of the individual sectors through the electrification of end uses and large renewable-based electricity supply. This scenario not an all-electric scenario. However, this scenario limits biomethane and hydrogen supplies to hard-to-decarbonise sectors.

Keywords: Study, Carbon neutral 2050, Decarbonization of the European energy system, Affordability of Energy, Decarbonising Gas Supply, Natural Gas, Biomethane, Hydrogen, CCUS

1. Introduction

Eurogas commissioned the study (DNV GL, 2020) a ‘Pathway to a carbon neutral 2050: the role of gas’, with international consultant DNV GL. The study achieves the EU’s climate goals at significantly lower costs than European Commission estimates and stresses the need for the development of a hydrogen economy in the 2020s.

Considerable efforts to mitigate and adapt to climate change are needed to keep Europe’s societies habitable. The European Commission (EC) is committed to tackling climate change head on and aims to make Europe the world’s first climate-neutral continent by 2050. The impact of transitioning to a net zero economy without greenhouse gas (GHG) emissions will be felt throughout the EU and in the energy sector in particular.

The European gas industry must find ways to thrive in a world where greenhouse gas emissions are gradually eliminated. This will mean supporting a vast expansion of renewable electricity generation and aggressively reducing emissions from fossil fuel use. This report was commissioned by Eurogas and investigates a continued and supporting role for gas in a decarbonized European economy by 2050.

The study presents two competing scenarios Eurogas and 1.5TECH (European Commission, 2018) to achieve carbon neutrality by 2050 and compares those to a baseline (DNV GL's Energy Transition Outlook, 2019).

2. Research methodology

To assess how to achieve a decarbonized future for the European energy sector and European consumers DNV GL developed a 100% CO_2 emissions reduction pathway (net zero) - labelled the 'Eurogas scenario'. This scenario builds on the strengths of the European gas sector and the advantages of energy delivery through existing gas networks. The Eurogas scenario was subsequently compared with an alternative pathway focusing on replacing gaseous energy with (primarily) electricity. This is called the 1.5TECH scenario in this report and is DNV GL's interpretation of the EC's 1.5TECH scenario presented in 2018 as part of the *"long-term strategic vision for a prosperous, modern, competitive and climate neutral economy"*.

In both scenarios, all sectors need extensive decarbonization to achieve the reductions in emissions needed to meet the EC's net zero target by mid-century. In particular, it is clear that the electricity generation and manufacturing sectors (in both scenarios) must go carbon negative to achieve this. In the Eurogas scenario, electricity generation and manufacturing use energy produced from biomethane and biomass – decarbonized through Carbon Capture and Storage (CCS) technology – to compensate for the remaining emissions produced by the increasingly less carbon-intensive buildings and transport sectors. The same occurs under the 1.5TECH scenario, although to a lesser extent. This scenario sees emissions reduced more evenly across all sectors.

There are several noteworthy similarities between both scenarios:

- Decarbonization of the electricity and manufacturing sectors depends on CCS technology and infrastructure being scaled
- Biomass use and second-generation biomethane technologies are pillars of Europe's decarbonization efforts. They are crucial for net negative emissions
- The road transport sector becomes increasingly electrified in both scenarios lead by battery electric vehicles (BEVs). Fuel cell electric vehicles (FCEVs) complement BEVs in commercial road transport.

In both scenarios, energy demand from the buildings sector does not reduce to the same extent as in other sectors in 2050. However, the energy carrier supplying this sector varies between the two scenarios. In the Eurogas scenario, natural gas and the scaled use of biomethane and hydrogen continues to deliver a substantial share of the sectors energy use. While in the 1.5TECH scenario a strong increase in the use of electricity for heating is observed.

The overall comparison of the two scenarios provides us with the following key findings:

2.1 Decarbonization of the European energy system

- In 2050 gaseous energy supply continues to play an important role delivering 32% of European final energy demand in the Eurogas scenario.

- The use of biogas and biomethane can result in significant negative carbon emissions (when coupled with CCS) making cost-efficient emission reduction available for otherwise hard-to-decarbonise sectors of energy demand.

- Hydrogen, biomethane and CCS can reduce the carbon footprint of the European gaseous energy supply chain by 89% in 2050 (and beyond if net negative emissions are included) in the Eurogas scenario.

2.2 Costs to society

- Continued gaseous energy supply in the Eurogas scenario delivers a net zero energy system at significantly lower cost (130 billion euro in annual savings) in 2050.

- Gaseous energy use reduces the cost of extensive renovation of the building sector and power grid expansion to accommodate for all-electric heating. It therefore provides society with a cheaper pathway to reducing emissions (~10 trillion euro in savings between 2018-2050).
- Continued use of gaseous energy in the Eurogas scenario reduces the estimated capex for European power grid expansion by around 1.3 trillion euros until 2050 (compared with the 1.5TECH scenario).

2.3 Decarbonization of gas supply

- Hydrogen production through methane reforming coupled with CCS (blue hydrogen) supplies the bulk of medium-term demand for hydrogen, reaching 820 terrawatt-hours (TWh) of supply in the Eurogas scenario in 2050.
- In both scenarios CCS is an indispensable technology for the decarbonization of the power and manufacturing sector with capacity between 895 and 1048 million ton of CO_2 sequestered per year (CO_2/yr) in 2050 for the 1.5TECH and Eurogas scenario respectively.
- Increasing availability of Variable Renewable Energy Supply (VRES) and cost reduction in electrolysis technology cause hydrogen production from renewable electricity ("green hydrogen") to reach 964 TWh in 2050 in the Eurogas scenario.
- Biomethane (second generation) can sustainably deliver 1014 TWh of energy in 2050, with supply costs impacted by feedstock scarcity in the longer run.

2.4 Infrastructure investment needs

- The combined effect of continuing the use of gaseous energy supply infrastructure and demand response technologies in the power sector reduce the peak-to-average capacity need by 19% from 2017 to 2050.
- Investment need for the continued use of gaseous energy is a fraction (11% of total capex in the Eurogas scenario) compared to the investment needed in the build-up of power grids to 2050.
- In the Eurogas scenario over 80% of the investment need in gaseous energy networks is for the accommodation of hydrogen into the networks (blended, retrofit and new build).

2.5 An energy supply for society

The energy sector underpins much of the lifestyle that citizens of advanced economies have become accustomed to, and that developing economies are increasingly relying on. Therefore, the symbiotic relationship between the need to decarbonise and the means that society has available to deliver decarbonized energy, are crucial to achieve deep decarbonization. As such, economic costs to society are of special concern, particularly to the economically disadvantaged.

In the Eurogas scenario, the total cost of delivering the EC's net zero ambitions by 2050 is 4.1 trillion euro (7%) lower than the 1.5TECH scenario. This difference approximates 0.5% of European GDP. This is equivalent to saving 130 billion euros per year or 600 euros per household per year over the 32-year period between 2018 and 2050. There are two primary reasons for the lower costs in the Eurogas scenario:

1. The subsidies required to incentivise/help consumers choose decarbonized energy are 80% or (10.1 trillion euros) lower in the Eurogas scenario. The comparable 1.5TECH scenario requires subsidies of 300 billion euros per year to electrify heating in the buildings sector.
2. The Eurogas scenario saves cost by repurposing the existing gas infrastructure instead of building new electricity infrastructure. The capex need in gas and electricity networks combined are 35% lower in the Eurogas scenario than in the 1.5TECH scenario.

3. Relevant data

3.1 Multi-vectored pathway achieves carbon neutrality

Increased electrification of economic sectors is a primary driver of energy efficiency for both scenarios. As the carbon price pressure increases at different levels different energy improvements are causing energy supply levels to diverge toward 2050.

3.2 Gaseous fuels allows for massive cost savings by 2050

Total costs for the Eurogas scenario over the period 2018-2050 are *4.1 trillion euro (7%) lower* compared to the 1.5TECH scenario. This equals to about *130 billion euro/year*. The main driver of the cost difference between the two scenarios is the electrification of heating, which requires *massive subsidies and imposes high costs* on society.

Gaseous fuels will be needed in all sectors – heating, power, industry, transport. *Sector integration is critical* to achieve carbon neutrality cost-effectively.

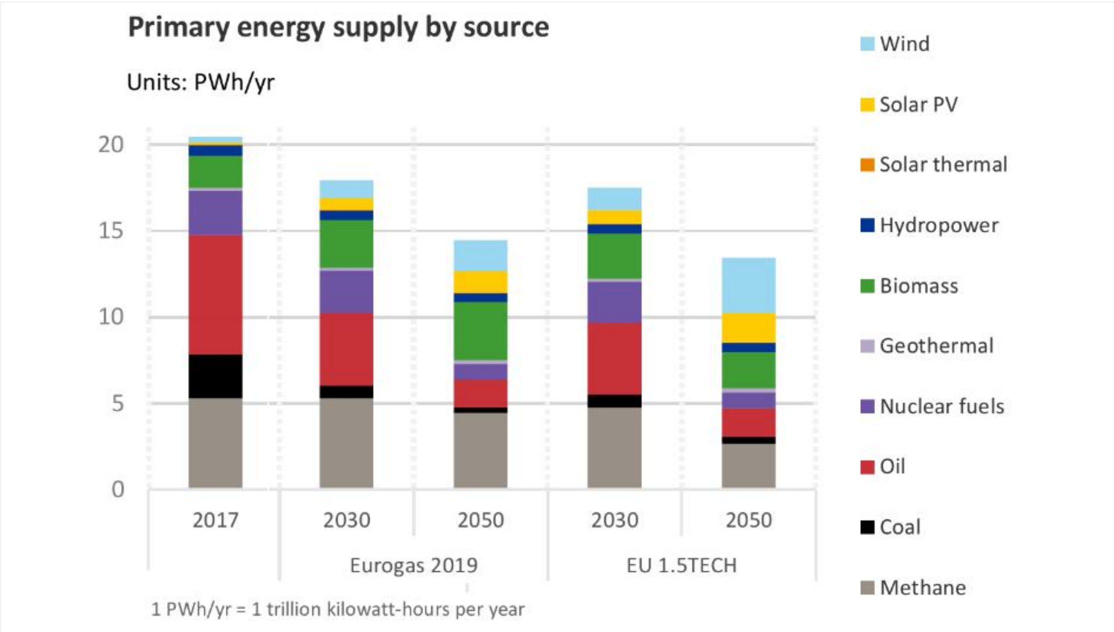

Figure 1: Data Source: DNV GL/Eurogas report (DNV GL, 2020).

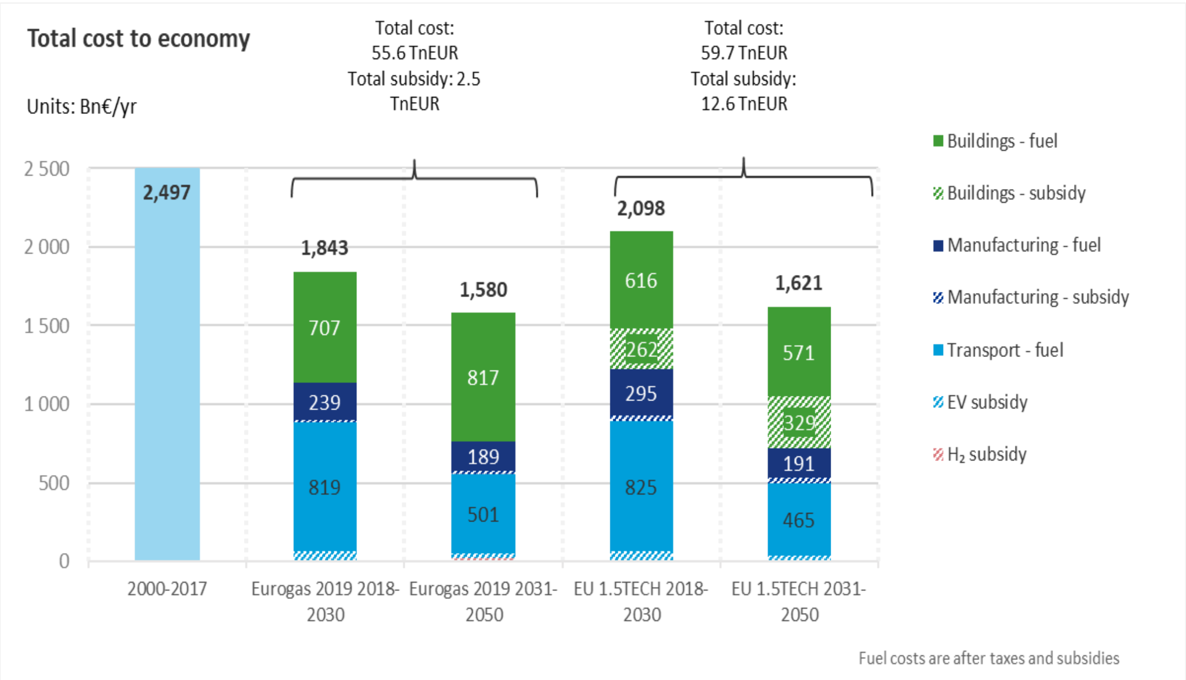

Figure 2: Data Source: DNV GL/Eurogas report (DNV GL, 2020).

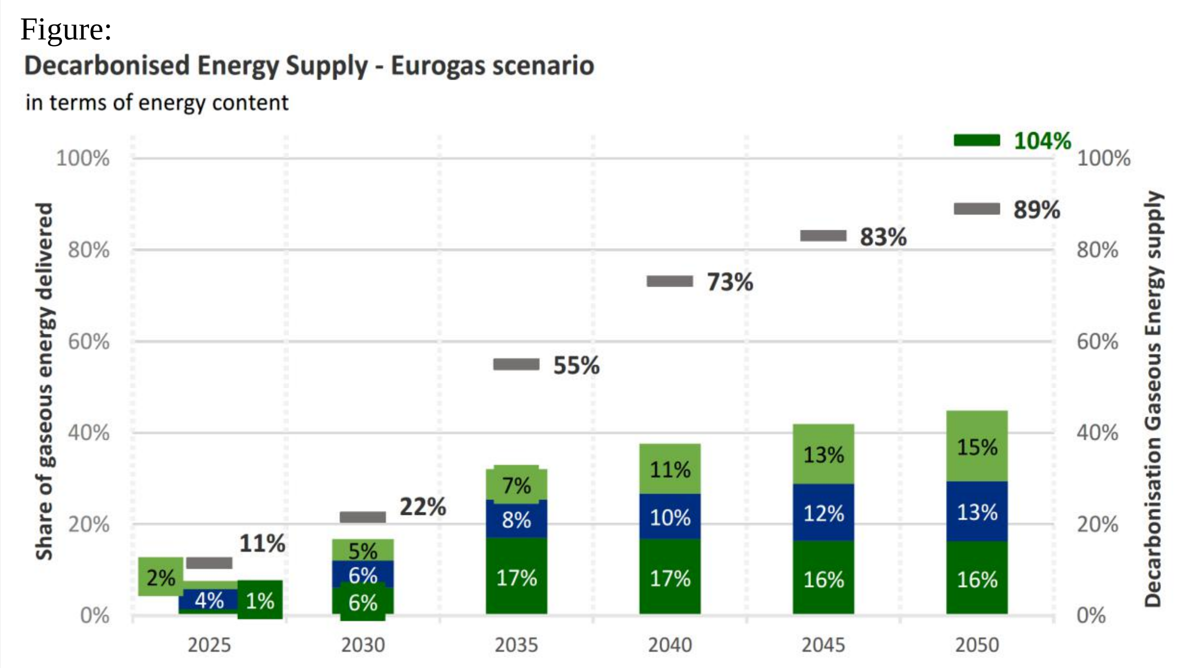

Figure 3: Data Source: DNV GL/Eurogas report (DNV GL, 2020).

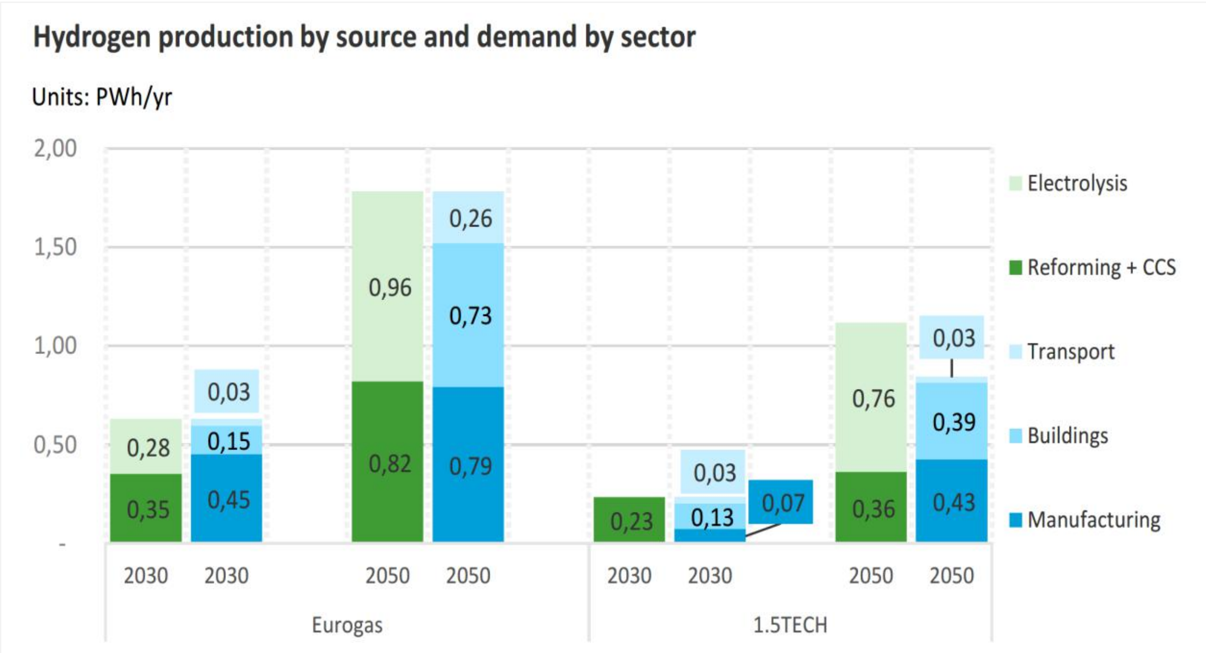

Figure 4: Data Source: DNV GL/Eurogas report (DNV GL, 2020).

3.3 A hydrogen economy is a necessity not an option

A *combination of clean gas technologies* is needed for a cost-efficient transition.

Coal has to be phased out from heating and power now, allowing gas to pick up the baseload in the 2020s, while *blending in more hydrogen and biomethane*.

3.4 All hydrogen technologies are integral to achieving carbon neutrality

Carbon capture and storage (CCS) is a cornerstone technology for decarbonisation. It can create negative emissions when coupled with biomethane. CCS has to be deployed in the 2020s.

Mass deployment of electricity is integral to producing more hydrogen from renewable electricity in 2050 than any other feedstock.

4. Conclusions

The Eurogas study demonstrates that the EU can save €4.1 trillion by 2050 – an amount equivalent to Germany's annual GDP in 2018 – by using a mix of energy carriers to achieve carbon neutrality. Major cost savings in applying this approach in the buildings sector are particularly key to saving this huge amount of money. This finding is of high importance as Europe needs funds to recover from Covid-19.

To achieve carbon neutrality by 2050, Europe must start the hydrogen economy now. There is no time for delay. This includes all clean hydrogen options: reforming natural gas through CCS, producing hydrogen from renewables, as well as blending it with methane. The need for CCS is not an option, it is a necessity – if we are to reach our climate ambitions.

The Eurogas study shows that climate objectives can be met more cost-effectively by using existing assets, limiting subsidy schemes, and leaving market fundamentals in place. The subsidies required to incentivise consumers to choose decarbonised energy are €10.1 trillion (80%) lower in the Eurogas scenario. Further cost savings are made by repurposing the existing gas infrastructure instead of building new electricity infrastructure.

This study demonstrates the savings associated with the scenarios that achieve carbon neutrality in 2050 while using a variety of energy carriers. Gas uses the infrastructure Europe already has, reducing the need for costly electricity infrastructure to be built.

Gas has an important role in all sectors – power, heat, industry and transport.

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European Commission, 2018. IN-DEPTH ANALYSIS IN SUPPORT OF THE COMMISSION COMMUNICATION COM(2018) 773 A Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy - European Commission's 1.5TECH scenario and compared to 7 other Commission's scenarios – Summary Graph p.56: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf and https://ec.europa.eu/clima/system/files/2018-11/com_2018_733_analysis_in_support_en.pdf

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Natural gas in the hydrogen transition

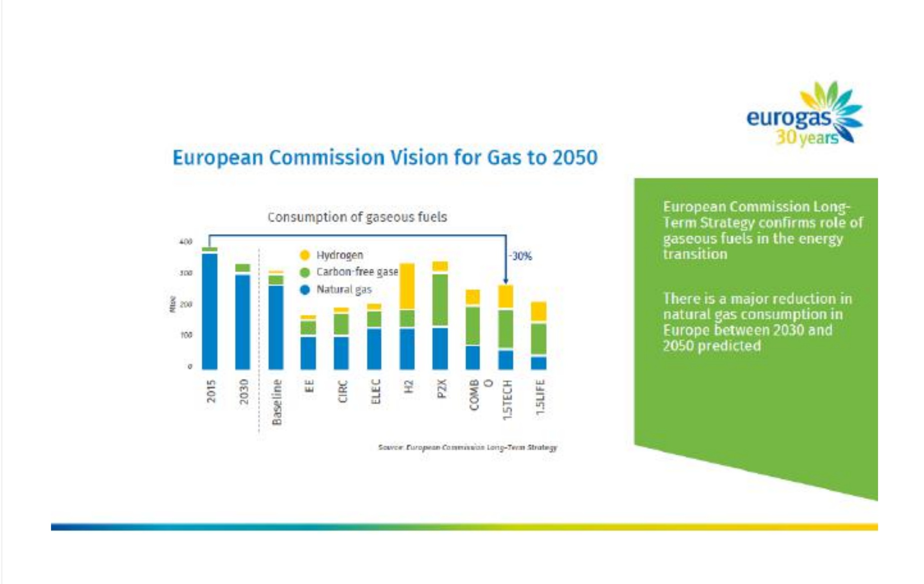
Ms. Laura BOSETTI

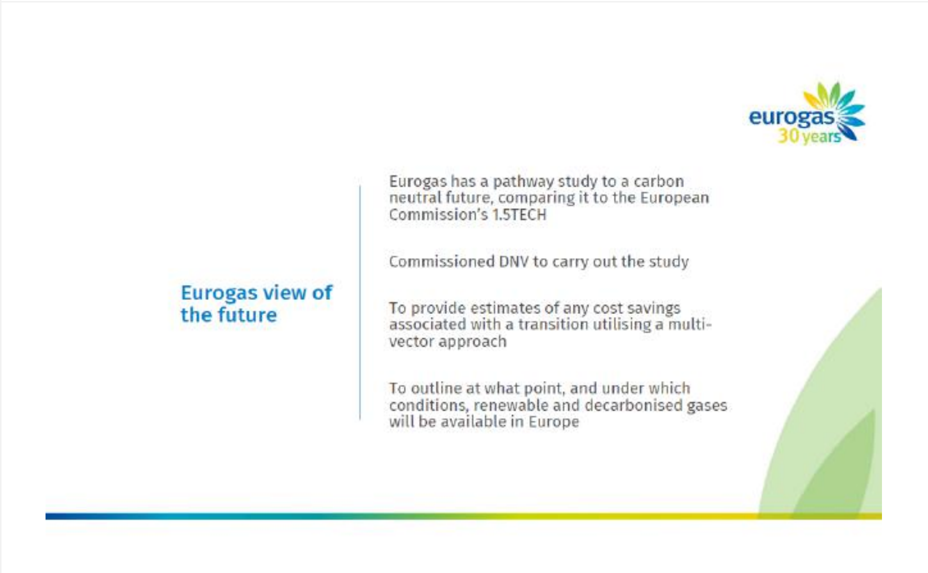
Policy Advisor, Eurogas

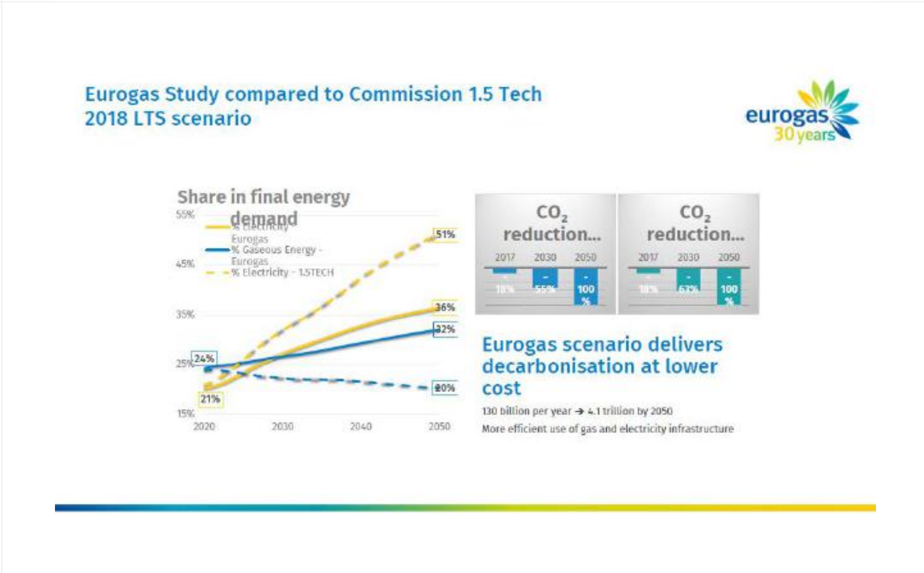
Short CV

Laura Bosetti joined Eurogas in June 2020, where she is responsible for the retail market committee and the sustainable finance files, with focus on Taxonomy. She is also responsible together with the Social Partners of the Social Dialogue study, funded by the European Commission. Previously, she worked at the European Parliament in DG COMM, following the Green Deal process from the communications perspective. Laura is fluent in English, Italian, Spanish and French. She holds an MA in political science from the University of Milan.


Natural Gas' role in the
Hydrogen Transition
Laura Bosetti, Policy Advisor Retail
eurogas 30 years

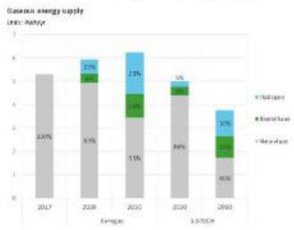

European Commission Vision for Gas to 2050
Consumption of gaseous fuels
Hydrogen
Carbon-free gase
Natural gas
-30%
2015
2030
Baseline
EE
CIRC
ELEC
H2
P2X
COMBO
1.5TECH
1.5LIFE
Source: European Commission Long-Term Strategy
European Commission Long-Term Strategy confirms role of gaseous fuels in the energy transition
There is a major reduction in natural gas consumption in Europe between 2030 and 2050 predicted
eurogas 30 years


Eurogas view of the future
Eurogas has a pathway study to a carbon neutral future, comparing it to the European Commission's 1.5TECH
Commissioned DNV to carry out the study
To provide estimates of any cost savings associated with a transition utilising a multi-vector approach
To outline at what point, and under which conditions, renewable and decarbonised gases will be available in Europe
eurogas 30 years


Eurogas Study compared to Commission 1.5 Tech 2018 LTS scenario
Share in final energy demand
51%
36%
32%
24%
21%
20%
2020
2030
2040
2050
CO_2 reduction...
2017
2030
2050
CO_2 reduction...
2017
2030
2050
Eurogas scenario delivers decarbonisation at lower cost
130 billion per year → 4.1 trillion by 2050
More efficient use of gas and electricity infrastructure
eurogas 30 years

The gaseous energy supply chain to 2050

Gaseous energy supply in the Eurogas scenario increases by 18% over 2017 levels (natural gas supply reduces by 35%) – Hydrogen accounts for 29%



Hydrogen is going to be important

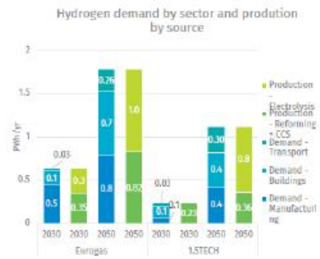
Eurogas scenario sees manufacturing lead hydrogen uptake until 2030

Hydrogen (*together with biomethane*) displaces natural gas in heating after 2030 towards 2050 – in the beginning blending will be especially important for this sector

The transition is gradual and requires appropriate framework conditions are set in 2020s

Both scenarios show an important role for hydrogen from reformed natural gas as an early driver to provide scale by 2030

The share of hydrogen from electrolysis overtakes hydrogen from reformed natural gas by 2050

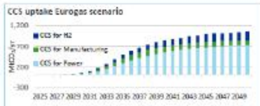


Whatever scenario we choose, CCS is not an option. It is a necessity.

Both scenarios rely on CCS, especially to decarbonize the power and manufacturing sector

Although the Eurogas scenario has a higher share of natural gas, it decarbonizes the energy system with 15% lower cumulative CCS deployment towards 2050 than 1.5TECH

Under conservative assumptions and restrictive policies, both scenario's use 11-13% of available storage capacity, and have between 114-130 years of storage left in 2050

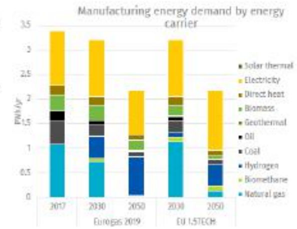


Manufacturing leads the uptake of hydrogen until 2030 according to Eurogas

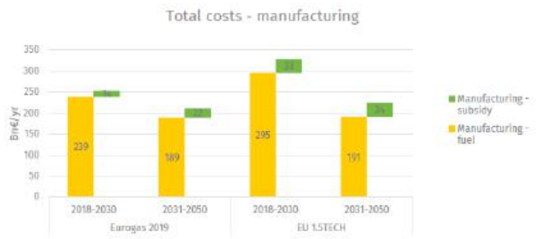
Manufacturing sector is the main driver for initial large-scale hydrogen demand

These volumes lead manufacturing to trigger the necessary infrastructure investments

Using hydrogen in manufacturing requires less subsidies and has lower energy costs than the strong electrification seen in 1.5TECH



More affordable to decarbonise manufacturing sector with hydrogen than electricity – save EU competitiveness



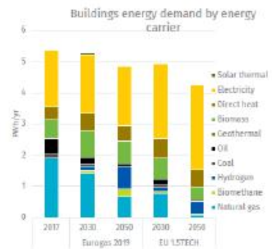
Gas is still needed in the building sector

Gaseous energy, delivers a more cost-effective pathway

True: Electrification of heating can reduce energy demand compared to gaseous solutions

Also true: **over €10 trillion in subsidies needed to transform Europe's buildings stock** and replace appliances in 1,5 TECH

Social acceptance is a barrier that should not be underestimated – gaseous solutions are easy to implement and affordable for households across Europe



Several countries already leading the way in promoting renewable and decarbonised gas

Industry led initiatives

Denmark: 12% of gas consumption renewable in early 2020 - 100% by 2035

Ireland: 20% of gas consumption to be renewable in 2030, potential for 100% in 2050 (50 TWh)

Sweden: 15 TWh of biogas by 2030

Government led initiatives

France: 10% of all gas in the grid to be renewable by 2030 and 100%+ potential by 2050 (400+ TWh) and 6.5GW electrolyser by 2030

Austria: 5 TWh by 2030 of renewable gas injected, equivalent to 6% of its natural gas consumption in 2018

Germany: 5 GW electrolyser capacity and 20% of all H_2 production to be renewable by 2030

Portugal: plans 2,5GW electrolyser by 2030

Poland: plans 2GW of electrolysers by 2030

Netherlands: plan 4 GW of electrolyser by 2030

Spain: plan 4 GW of electrolyser by 2030

United Kingdom: H2 to be used for heating by 2030 and 1 billion in CCS

Italy: 10 bcm biomethane in 2030 = 13% of 2017 gas demand. Plus 5 GW electrolyser by 2030

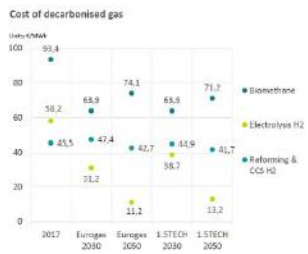
Technology cost development for Biomethane and Hydrogen

OPEX and CAPEX benefit from regional and global cost learning

Carbon price causes natural gas to become less competitive, but also pushes cost escalation in feedstock

Cost of electrolysis for hydrogen decreases faster in Eurogas scenario than in 1.5 TECH more cost learning due to higher installed capacity

Costs of reforming with CSS are relatively stable, as CCS is a minor part of total cost, while reforming is a mature technology with limited cost learning



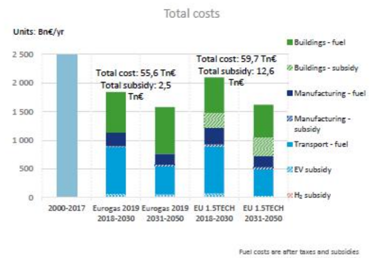
The energy transition in Europe requires trillion+ Euro Investments every year

A holistic energy system approach to the transition is the most cost-effective saving over 4 trillion Euros in the period

Rolling out gaseous solutions across all sectors, **using existing infrastructure, saves €130 billion per year until 2050**

Main cost driver of the European Commission's scenario is the electrification of heating

- Over €10 trillion in subsidies needed to retrofit buildings
- Over €1 trillion needed to match electricity infrastructure to meet peak demand



Clean Energy for EU Islands

Dr. Leandro VAZ

RdA Climate Solutions Operations Director of Clean Energy of EU Islands Secretariat

Short CV

Dr. Leandro Vaz (male, PhD) has more than 10 years of experience in research focused on sustainability and climate change. As result of this, he is author of several articles published in international indexed research journals, communications in international reference conferences, and has been involved in numerous national and European research projects.

Currently he is RdA Climate Solutions Operations Director (RdA Climate Solutions is an advisory boutique specialised in mitigation and adaptation strategies with special expertise in clean energy, climate change, and sustainable finance), and also project manager of sustainable finance.

More recently, it is worth highlighting his work on the Smart Cities Marketplace initiative integrating the matchmaking team, finding support and connect cities to smart city investors, and also on Clean energy for EU islands Secretariat by providing tailored technical assistance to islands and by being part of the initiative's matchmaking team.

8th Green Energy Investments Forum

Clean energy for EU Islands Secretariat

Leandro Vaz

Clean energy for EU islands
www.euislands.eu | leandro.vaz@euislands.eu

#CleanEnergyIslands

What are the Secretariat objectives?

Support a bottom-up approach to energy transition through processes that happen collectively and locally

Empower EU's island communities to move from clean energy vision to clean energy action

Match bottom-up initiatives with expert support that has a real impact on projects happening on the ground

- Reach over half of the EU's islands communities
- Provide technical assistance to 40 islands
- Address policy and regulatory barriers to energy transition
- Develop a pipeline of bankable clean energy projects

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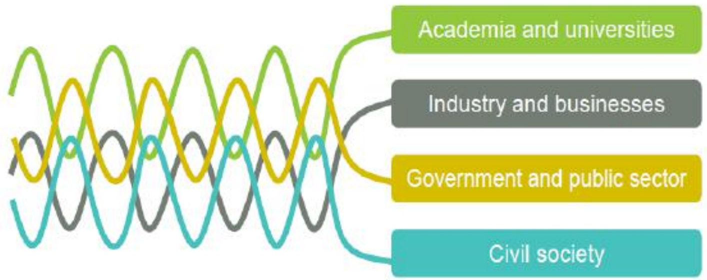
Community engagement as a key pilar for the energy transition



Our approach to support all EU islands

Explore
Islands just starting their energy transition.

Shape
Islands shaping concrete action plans and projects

Act
Islands ready to implement their energy projects

Technical assistance

A wide variety of topics will be covered

Clean energy transition agenda

Stakeholders' engagement

Energy communities

Solar PV

Solar thermal

Wind

Biomass

Hydrogen

Wave energy

Transition to e-mobility electric ferries & vehicles

CHP

District heating

Grid studies

Interconnection

Battery storage

Waste to fuel

But...

Financial support is also required:

- Overview of funding and financing opportunities
- Business and financial models development
- Risk assessment
- Development of investment term sheet/pitch
- Etc.

Marketplace

Financial gap

Marketplace

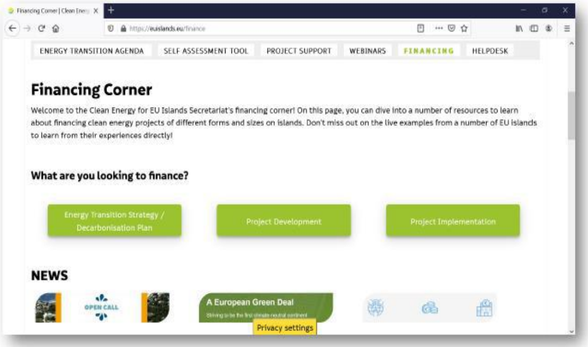
The Islands Marketplace will enhance the matchmaking between **island communities** with **investors** and **technology providers**;

https://euislands.eu/

No need to reinvent the wheel

Munich transport museum

Financial guidance available



https://euislands.eu/finance

Our newsletter

- **Hot news**
  - Regular updates on the clean energy transition on Europe's islands
- **CE4EUI Events**
  - By signing up to our list, we will also ensure to invite you to our workshops and Forums.


European Commission
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Conclusions

8th FORUM, BSEC – Green Energy Investments

Conclusions

The presentations and discussions highlighted that BSEC offers the frame to strengthen and implement specific actions and programs capable of helping to alleviate the negative effects of the pandemic and the serious disturbances in the functioning of the world economy, and of the increased number of the disasters caused by climate change.

The Energy sector was identified as one seriously affected by the current pandemic, causing excessive supply and low demand, and it was emphasized that, in order to adequately manage this negative impact, regional cooperation and coordination mechanisms are essential.

Possibilities of investments in the BSEC Member States for the green transformation of their economies and the achievement of the Sustainable Development Goals in the BSEC Region were thoroughly discussed.

The participants reaffirmed the commitment of their respective governments and institutions to the implementation of the United Nations Sustainable Development Goal 7 – ensuring access to affordable, reliable, sustainable and modern energy for all.

Investments in Green Energy are crucial for the modernization of the energy sector and for achieving SDG 7 and, more generally, for economic growth, job creation and increasing energy security. The BSEC Member States should create an appropriate administrative and legal framework for facilitating such investments.

Investments in Renewable Energy Sources require the development of adequate financial tools and a regulatory framework by the Member States.

The usefulness to create the necessary legal ground for the encouragement, promotion and consumption of energy from renewable sources was also emphasized.

In this regard, BSEC Member States, including those with a great potential in terms of energy supply, should focus on Energy Poverty and on how to improve the Energy Efficiency of Households and other buildings.

Research and Development of Clean Energy technologies in the BSEC Member States have to be further encouraged and, to this effect, advantage should be taken of the possibilities of communication and of sharing professional expertise, available through the BSEC Green Energy Network.

There is need to elaborate more projects promoting energy saving, energy efficiency and renewable energy in the BSEC Region and both the governments of BSEC Member States and the International Secretariat of the Organization should intensify their efforts to explore possibilities offered by the International Financial Institutions and the Green Climate Fund, functioning under UN, and by other sources that to finance such projects.

The participants highly appreciated the Initiative "75 UN – 75 trees UNAI SDG 7", proposed by KEPA, in its capacity as Coordinator of the BSEC - GEN and as the *UN Academic Impact Hub for the 7th Sustainable Development Goal*, implemented by 8 BSEC Member States, as a concrete contribution to the combat against the negative effects of climate change.

Professor Mavrakis mentioned some valuable ideas that should be considered by the BSEC Working Group on Energy, as their implementation could be beneficial for the BSEC - Member States, in particular:

- the establishment an integrated Black Sea Energy Market;
- the establishment of a regional wholesale natural gas market in interested Member States.
- Promotion of Green Energy Investments through this Forum are serving the double aim:
    - to support cooperation for the economic development of the BSEC Member States: and
    - to contribute to global efforts to mitigate Climate Change.

Given all the above, the participants in this Forum encourage the Working Group on Energy the municipalities and academic communities to find ways of cooperation and more effective policies and innovative solutions on the aforementioned issues.

DAY 2: Scientific Sessions

City of Vancouver (video)

On November 17, 2020, Council approved the Climate Emergency Action Plan. This puts Vancouver on track to reduce our carbon pollution by 50% by 2030, in alignment with the findings of the United Nations Intergovernmental Panel on Climate Change to limit global warming to 1.5°C.

Our plan builds on our previous climate plans and focuses on cutting carbon pollution from our biggest local sources - burning fossil fuels in our vehicles (37%) and in our buildings (57%).

This plan means change. It means residents, businesses, and the city are doing our part to transition off fossil fuels. It is designed to make it easier for you to live a carbon-free life.

Information at: https://vancouver.ca/green-vancouver/vancouvers-climate-emergency.aspx

CITY OF VANCOUVER | GREENEST CITY

City of Vienna, “Solar Power offensive” (video)

Vienna is stepping up its game and launching one of the biggest photovoltaic offensives ever. The goal is to be CO_2 neutral as a city by 2040. The game plan is a massive expansion of photovoltaics. In the coming years, we will create more photovoltaic solutions than in the past 15 years combined. Or in other words, 100 soccer fields of new photovoltaic coverage every year.

We want to use as much as urban area as possible for efficiency and practicality so we will be making use of spaces that already exist and are optimal for photovoltaic installations: roofs, facades, noise barriers and the like. There are endless possibilities and even better, some great examples we can already showcase. The reason for all these is because clean energy protects the climate and protected climate means that people are protected in return, too.

Information at: ttps://www.wien.gv.at/english/administration/organisation/authority/municipality/


Die Stadt Wien
informiert.
Wien startet größte Sonnenstrom-
Offensive der Geschichte
Stadt
Wien


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Offensive der Geschichte


Jürgen Czernohorszky
Klimastadtrat

Assessment of the environmental impact of biomass on bioenergy production

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Vytautas Magnus University, Lithuania

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Abstract

This paper discusses the environmental impact of agro-waste biomass utilization for bioenergy production. The methodology of research applied two aspects: i) assessment of agro-waste biomass yield using three kinds of second-generation biofuel: bioethanol, biodiesel and biogas and ii) nexus between environmental and agriculture activities, such as fertilization, irrigation, chemical inputs and mechanized machinery. The results of the research indicated that bioethanol production is most significant to produce utilization of the straw of wheat, barley, also stalks of maize, pods of legumes beans and stems/leaves of a pea. The most popular agro-waste for biodiesel production is the straw of rape. Biogas production is more useful to produce bioenergy production from switchgrass and leaves of sugar beet. However, in order to increase the potential for the use of agro-waste biomass, it is necessary to pay attention to the growth in agricultural activities. The nexus between agriculture activities and the environment is expressed as a negative impact in the fact for the too-high use of fertilization of nitrogen and phosphorus causes eutrophication of groundwater and terrestrial ecosystems. Overuse of irrigation causes salinization of the soil and the destruction of freshwater ecosystems. Chemical inputs, expressed using pesticides, cause the loss of biodiversity. Irresponsible use of mechanized machinery has effect on climate air pollutants and greenhouse gas emissions. The results of the paper are useful for further research in green energy and agricultural development.

Keywords: Agro-Waste Biomass, Environmental Impact, Bioenergy Production, Agriculture.

1. Introduction

The world is talking about the implementation of climate change mitigation measures and about new technologies that reduce the concentration of pollutants in the environment. Effective measures to reduce greenhouse gas emissions are needed to halt the increase in global average temperatures. The aim of the European Green Deal is to make the EU a modern, resource-efficient and competitive economy by 2050, so that there are no carbon or greenhouse gas emissions; economic growth is decoupled from resource use. Reducing the energy system's dependence on fossil fuels is crucial for the successful implementation of change during 2030-2050. Countries of the European Union decide independently on their energy production types, so it is important to ensure a responsible and socially justified transition to a Green Economy (Rural Biomass Energy Book, 2020).

The ever-growing industry, the increasing energy needs, and the at the same time decreasing traditional, fossil, energy resources (oil, coal, etc.), lead to the search for alternative, renewable resources for meeting humanity's emerging energy needs. The development of biomass sources is becoming an increasingly important energy policy. These are natural resources, the emergence and renewal of which are determined by natural processes. Agriculture is one of the key players in the development of a Green Economy, creating a sector that distinguishes between three areas of bioenergy - bioethanol, biodiesel and biogas for heat, electricity, transport generation associated with the processing of agricultural waste.

Hence, biomass in its solid, liquid, and gaseous forms can directly substitute fossil fuels. The use of biomass as an energy source will not only reduce greenhouse gas emissions (it is estimated that the CO_2 emissions from biofuel combustion are zero, as the same amount of CO_2 is emitted during vegetation), and also allow the more efficient use of land that is abandoned or unsuitable for agriculture.

Over the past decade, Lithuania has witnessed several energy transitions. With the closure of its only nuclear power plant (Ignalina's two reactors shut down in 2004 and 2009), Lithuania switched from the position of a net exporter to that of a net importer of electricity. Since then, the shares of electricity imports, natural gas and bioenergy have increased. Today, Lithuania imports over 70% of its electricity needs, while bioenergy is taking the lead in domestic energy supply. Most of Lithuania's co-generation (co-generation refers to the combined production of heat and power), district heating and residential heat have switched from natural gas to biomass. Since Lithuania regained its independence in 1990, its energy policy has continuously emphasized energy security. The 2012 National Energy Independence Strategy, which was updated in 2018, reflects these fundamental goals. Lithuania is commended for its ambitious 2050 targets for emissions reductions, renewables and energy efficiency under this strategy. Lithuania supports the EU climate neutrality goal and is starting to place greater emphasis on the mitigation of climate change while boosting economic growth and technology innovation (International Energy Agency, 2021).

The first biogas plants started operating with a useful life of 15 to 20 years in 2003. In this context, 14 biogas plants with a total installed capacity of 14,886 MW should be modernized in order to maintain their existing capacities. Given that biogas use is expected to be transport-oriented, it is estimated that the development of these power plants in the electricity sector will not be carried out in the 2020-2030 period. In 2007, the construction of the first biomass power plants, having a useful life of around 15 years, began. In this context, 9 biomass plants with a total installed capacity of 73.46 MW should be modernized in order to maintain their existing capacity. An increase in the capacity of new biomass power plants is expected in 2021 once the biomass power plant currently under construction is launched.

Research problem. This paper is analyses two research questions: 1. What is the agro-waste biomass utilization potential for bioenergy production in the agricultural sector? 2. What is the nexus between environmental and agricultural activities?

The aim of this study is to carry out an environmental impact assessment of the agro-waste biomass use on bioenergy production**.**

Methodology of research. The exploratory study consists of 2 main characteristics: assessment of the potential of agro-waste biomass and the environmental impact of agricultural activities. According to a technical mathematical formulation, agro-waste biomass bioenergy yield is assessed using three kinds of second-generation biofuel: bioethanol, biodiesel and biogas in Lithuania during the period 2017-2021. Each type of biofuel includes a variety of plant species wastes such as strew, stems, hulls, grain, grass/forages and others. The effect between environmental and agricultural activities is analysis from four positions, such as fertilization, irrigation, chemical inputs and mechanized machinery.

Others research methods: analysis, detailing, systematization, grouping, synthesis, generalization, graphical representation.

Data sources: Eurostat, Lithuanian Department of Statistics, Lithuanian Energy Institute (LEI), Renewable Energy Statistics (RES), Lithuanian Biomass Energy Association (Litbioma), Farm Accounting Network, etc.

2. Agro-waste biomass utilization on bioenergy production

According to the International Energy Agency, biomass is defined as any organic matter that comes from biogenic sources and is available on a renewable basis. This includes animals and plants sourced by wood and agricultural crops, and organic waste from municipal and industrial sectors (Ahorsu R. et al., 2018). Biomass is the only renewable energy not "freely" available (as opposed to wind and water) and has a long supply chain from planting, growing, harvesting, pre-treatment, and conversion (Rural Biomass Energy Book, 2020). Bioenergy is generated from organic substances usually referred to as biomass. Biofuels represent a subgroup of biomass which can either be in a liquid form such as bioethanol or biodiesel, or in a gaseous form such as biogas. The feedstocks for bioethanol are starch and sugar, whereas biodiesel is based on vegetable oils derived from oilseed crops (Ledebur, Oliver von et al., 2007). Biofuels reduce oil imports and CO_2 emissions. Biofuels may be carbon-neutral because the plants that are used to make biofuels (such as corn and sugarcane for ethanol and soy beans and oil palm trees for biodiesel) absorb CO_2 as they grow and may offset the CO_2 emissions when biofuels are produced and burned (Kathryn R., 2019). The term biomass means all carbon-containing materials (solids, liquids or gases) that can be converted into energy (bio-energy). These materials can be burned directly to produce heat, power or converted to biofuels (charcoal, biodiesel etc.) (Papoutsidakis M. et al., 2018).

Biomass energy products can be affordably established at both household and livestock farm scales, using readily available agricultural wastes, have few recurrent costs, need no highly specialized skills, and have a high potential for extra revenues through the Clean Development Mechanism because of the potential for greenhouse gas reduction (Zhang O. et al., 2010). Biomass utilization for energy production has not only advantages but also some disadvantages whose results are indicated in Table 1.

A major disadvantage of biomass is that some resources are seasonal. The exclusive advantage of biomass energy is given to the potential for the production and use of biofuels. It is a source that can change the use of fossil fuels and increase independence from imported fuels. The production of energy plants and agricultural waste in the agriculture sector can fundamentally change the situation on the market of bioenergy production. Agricultural households play the dual role of “supplier–consumer” in developing the biomass energy industry. The biomass generated on their farms can either supply their own household biogas system or be sold to industrial-size plants. (Zhang O. et al., 2010).

At present, the first generation of biofuels is mainly produced in Lithuania. First, their generation is made from food or feed plants. Bioethanol made from triticale, rye is added to petrol, and biofuels made from various vegetable oils (rapeseed, rapeseed oil, other vegetable oils) are added to diesel. However, first-generation biofuels face many challenges, as increasing their production threatens food production and biodiversity. In addition, their production is more expensive compared to the production of fuel from oil. In some cases, greenhouse gas emissions from biofuel production are more than those from conventional fuels when the whole life cycle is assessed, including fertilizer production, transportation, and so on.

The future therefore seems to belong to second-generation biofuels, which are produced from agricultural waste and other waste such as straw, manure and sewage raw materials. Second-generation biofuels are fuels for which lignocellulosic biomass is not normally produced from food crops and it is not suitable for human consumption.

Table 1: Advantages and disadvantages of biomass resources. *Source: formed by the author on the basis of publications of Zhang O, 2010, Sakalauskas A., 2012.*

Title	***Advantages***	***Disadvantages***
Biomass energy	• *Biomass fuels are relatively cheaper than fossil fuels;* • *Constant energy production;* • *Local biomass fuels can replace fossil fuels;* • *Various organic waste can be used to produce biomass fuels.* • *Biomass is CO_2 neutral;* • *Reduction of sulfur compounds emissions;* • *Ash fertilization of the soil increases its potassium and reduces its acidity.*	• *The preparation of biomass fuels (growing, transporting waste, crushing) requires a lot of energy;* • *Some biomass resources are seasonal.* • *When analyzing the properties of biofuels and their compounds with agrocrops, it is concluded that fuel from agromass is characterized by higher ash content and alkaline metal content than wood.* • *The maximum amount of ash is determined in straw.*

Growing and using energy crops for bioenergy would solve ecological problems: rational use of grasslands, preservation of biodiversity, protection and improvement of soil structure and quality, promotion of biofuels produced from local multidimensional grass species, improvement of environmental microclimate. Because combustion of biomass can reduce environmental pollution by harmful substances (Miežys A., 2016; Ministry of Energy of the Republic of Lithuania, 2019).

There are three main types of biofuels in Lithuania: bioethanol, biodiesel and biogas. The raw materials used to produce bioethanol contain mainly starch, sugar or lignocellulose. Recently, the first two groups of plant-based raw materials are used for bioethanol production: cereals (wheat, rye, triticale, barley, oats), corn grains, sugar beets, maize and etc. The efficiency of their use is determined by the yield of biomass and the amount of sugar or starch in the raw material. Rapeseed, sunflower, soybean, fiber hemp and etc are used for the production of biodiesel. Crude, refined, hydrated and neutralized oils can be used for oil production. Vegetable oil is transesterified with methanol. Biogas can be extracted from biomass anaerobically or thermochemically. During the anaerobic process, biomass is broken down into methane and carbon dioxide by bacteria in an anaerobic environment. The technology has been developed for the processing of liquid organic waste and has recently been applied successfully to the processing of plant biomass (switchgrass, miscanthus, sugar beet, other perennial grasses and etc.) into biogas. The structure agro-waste biomass of second-generation biofuel is shown in Figure 1.

Bioethanol production includes various waste of agricultural and energy crops. There are cereal straw, maize stalk, sugar beet leaves, pea stems and etc.

Bioethanol →	Wheat, Triticale, Rye, Barley, Oats, Buckwheat, Maize, Sugar beet, Legumes beans, Pea, Lentil, Jerusalem artichokes →	Straw, pods/straw, stems /leaves, hulls, grass biomass
Biodiesel →	Rape, Soybean, Fiber hemp, Flax, Sunflowers →	Straw, stems, hulls
Biogas →	Switchgrass, Goat's-rue, Sativa, Miscanthus, Sugar beet, Maize, Lupin, Millet, Sorghum, Honey clover, Lucerne, Serradella →	Grass/forages, stems, leaves, hulls, stalk, grain

Figure 1: The agro-waste biomass of second-generation biofuel. *Source: formed by the author on the basis of publications of Khan Z., Dwivedi A.K., 2013; Iye E. L., Bilsborrow P. E., 2013; Bioenergy Europe Statistical Report, 2018; Alhassan E. A. et al., 2019.*

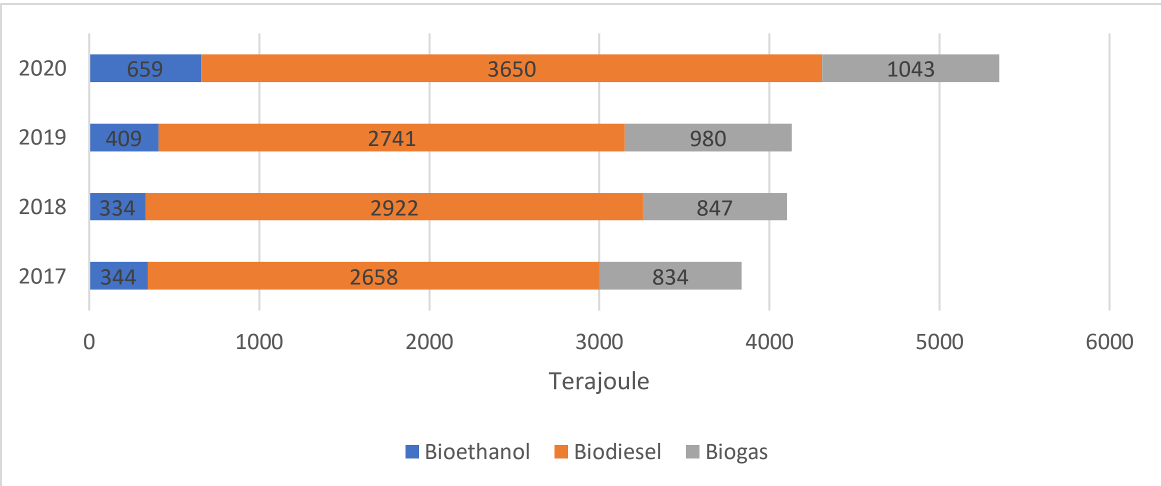

Figure 2: Total consumption of biofuels and biogas (TJ), 2017–2020 in Lithuania. *Source: formed by the author on the basis of Lithuanian Department of Statistics.*

Biodiesel production includes rape straw, soybean hulls, fiber hemp stems and sunflowers hulls. The main sources of biogas are switchgrass forages, maize stalk and sugar beet leaves. There are many non-traditional energy plants: miscanthus, sorghum, lucerne and others.

Dynamics of bioethanol, biodiesel and biogas energy consumption in Lithuania during 2017-2020 are presented in Figure 2. According to Lithuanian statistics data, the consumption of biodiesel during the period 2017-2020 was increased by 37% (in 2017 amounted to 2658 TJ (63,5 ktoe) and in 2020 to 3650 TJ (87,2 ktoe)). However, it can be noticed, that the biggest growth of consumption of bioethanol is increased by 92% (in 2017 amounted to 344 TJ (8,2 ktoe) and in 2020 to 659 TJ (15,7 ktoe). The consumption of biogas during the period 2017- 2020 increased by 25%.

The main factors influencing the consumption of biofuel products were the increase for demand production of electricity and district heat and the growing consumption of motor biofuels in the transport sector.

Hence, many forms of plant material can be used for energy. In human history, plants have always served different human needs: food, energy, medicine, material use and animal feed. As the fossil fuel age declines, biomass regains new importance (World Bioenergy Association, 2016). Various biomass classifications and biomass potential assessment methodologies are proposed in the scientific literature (Rogner H. H., 2012; Khan Z., Dwivedi A.K., 2013; Iye E. L., Bilsborrow P. E., 2013; Salazar G. et al., 2014; Iye E. L., Miežys A., 2016; Papilo P. et al., 2017; Alhassan E. A. et al., 2019).

Two levels of biomass energy potential are evaluated, the theoretical potential and the technical potential. The theoretical potential is defined as the maximum amount of biomass that can be used for energy purposes, explicitly excluding biomass used for food, fiber (e.g. round wood) and feedstock for the industry (e.g. co-products). The technical potential is defined as the fraction of the theoretical potential that is available for energy production at current conditions and constraints, after considering current energy utilization and competition with other uses and various constraints. The energy potential associated with agricultural residues is calculated using the crop production, by-product to crop ratio, moisture content and the lower heating value, as shown in (1) and (2) (Salazar G. et al., 2014).

This section presents the mathematical formulation of the methodology to calculate the theoretical and technical biomass energy potentials. The overall theoretical biomass energy potential (Q) is estimated as the sum of potential associated with each biomass category,

$Q_{AR} - agriculture\ residue$;

$Q_{AW}\ - animal\ waste$;

$Q_F - forestry$;

$Q_U - urban\ waste$, see (1). Similarly, the technical biomass energy potential (Q^T) is calculated by using (2):

$$Q = Q_{AR} + Q_{AW} + Q_F + Q_U \qquad (1)$$

$$Q^T = Q_{AR}^T + Q_{AW}^T + Q_F^T + Q_U^T \qquad (2)$$

The energy potential associated with agriculture residues is calculated using the crop production $P_i = CA_i\ x\ AP_i\ CA_i$ – the cultivated area for i-th crop, in hectares (ha); AP_i – the agricultural production for the i-th crop, in tons per hectare (t ha1) by-product to crop ratio k_{ij}, moisture content M_{ij} and the lower heating value LHV_{ij}, as shown in (3) and (4).

$$Q_{AR} = \sum_{ij} P_i \cdot k_{ij} \cdot \left(1 - M_{ij}\right) \cdot LHV_{ij} \qquad (3)$$

$$Q_{AR}^T = \sum_{ij} P_i \cdot k_{ij} \cdot \left(1 - M_{ij}\right) \cdot LHV_{ij} \cdot a_{ij} \ (4)$$

The mean values of biomass characteristic data using to evaluate agro-waste biomass potential are shown in Table 1.

The moisture content of biomass is the quantity of water existing within the biomass, expressed as a percentage of the total material's mass. The moisture content of biomass in natural conditions (without any further processing) varies enormously depending on the type of biomass, ranging from less than 6,5% in cereals straw to more than 15% as in grass biomass (energy crops). This is a critical parameter when using biomass for energy purposes since it has a marked effect on the conversion efficiency and heating value. The product to crop ratio is an important indicator for the evaluation of primary residues, ranging from less than 1 to more than 2,5. Biomass materials are very diverse, ranging from straw, stalk, stems, hulls and other agricultural residues, grasses and forages, and off-spec grains, etc. Despite this diversity, the composition of most biomass materials is relatively uniform. The energy content of most lower heating value biomass fuels is in the 14-20 MJ/kg range. Differences in energy content are due to differences in density and moisture content. According to Salazar G., et al., 2014 methodology, the energy biomass potential of bioethanol, biodiesel and biogas is calculated and presented in Table 2.

Table 2 describes the assessment results of agro-waste biomass bioenergy yield on three agricultural commodities: bioethanol, biodiesel and biogas in Lithuania. The bioenergy production potential from agro-waste biomass during the period 2017-2021 consists of 9,194 million GJ bioethanol, 1,306 million GJ biodiesel, and 3,085 million GJ biogas. The most popular agro-waste for bioenergy production is winter wheat. It can produce bioethanol of about 5,107 million GJ (55.5%), a little less from maize - 896.8 thsd. GJ (9,8 %), summer wheat 720,5 thsd. GJ (7,8 %), summer barley - 711,4 thsd. GJ (7,7 %), legumes beans - 563,1 thsd. GJ (6,1 %) and pea - 337,2 thsd. GJ (3,7 %). The most significant agro-waste of biodiesel during the period 2017-2021 is winter rape with 1,195 million GJ (91,5%) energy potential. Hence, other kinds of agro-waste consist of less than 10 %. The biogas production during the period 2017-2021 consists of switchgrass with 1,722 million GJ (55,8%) and sugar beet 690,5 thsd. GJ (22,4%).

Table 2: Mean values of qualitative characteristics of agro-waste biomass sources (calorific value, humidity). *Source: formed by the author on the basis of publications of the Žaltauskas A., Ramoška E., 2002; Lithuania's Minister of Agriculture, 2003; Graham R. L. et al., 2007; Scarlat N. et al., 2010; Clarke S. et al., 2011; Raila A., Zvicevičius E., 2015.*

Types of biomass	Type of agro-waste	Product to crop ratio	Lower Heating Value MJ kg^{-1}	Moisture Percentage (%)
Bioethanol				
Wheat winter/summer	straw	1,7	13,63	9,8
Triticale	straw	1,2	13,63	14
Rye	straw	1,5	13,63	14
Barley	straw	1	13,63	10,6
Oats	straw/hulls	1,3	13,63	14
Buckwheat	straw	1,1	13,63	14
Maize/Corn	stalk/cobs	2,5	17,48	7
Legumes beans	pods/straw	2,1	19,04	6,3
Pea	stems/leaves	1,3	17,48	14
Lentil	stems/leaves	1,7	17,48	14
Jerusalem artichokes	Grass/forages	1	16,08	9,5
Biodiesel				
Soybean	hulls	2,5	18,03	6,2
Sunflowers	hulls	2,2	20,04	6,2
Fiber hemp	stems	1,1	16,85	8,2
Flax	straw	0,3	17,48	5,6
Rape	straw	2	13,63	12
Biogas				
Switchgrass	Grass/forages	1	15,63	8
Sugar beet	leaves	0,6	17,83	12
Goat's-rue	stems	1	17,48	12
Sativa	stems	1	17,48	12
Miscanthus	Grass/forages	1	19,04	9,9
Lupin	grain	1	14,73	14
Millet	stalk	1,83	17,48	14
Sorghum	stalk	2,5	17,03	12
Honey clover	stems	1	17,48	12
Lucerne	hulls	2	15,63	12
Serradella	stems	1	17,48	12

Table 3: Technical potential of bioenergy yield from the agro-waste biomass in Lithuania during the period 2017-2021.

Types of Biomass	Agriculture residues of second-generation biofuel *, tons per year**	Bioenergy yield (output)	
		GJ/yr	%
	Bioethanol		
Winter wheat	17 396 710	5 106 869	55,5
Winter triticale	939 260	262 885	2,9
Winter rye	361 039	101 049	1,1
Winter barley	342 490	99 647	1,1
Summer wheat	2 454 533	720 537	7,8
Summer barley	2 445 045	711 386	7,7
Summer triticale	114 268	31 982	0,3
Summer rye	1 796	503	0,01
Oats	1 121 351	313 849	3,4
Buckwheat	155 428	43 502	0,5
Maize/Corn	2 309 446	896 868	9,8
Legumes beans	1 321 704	563 079	6,1
Pea	938 895	337 173	3,7
Lentil	78	28	0,0003
Jerusalem artichokes	13 588	4 723	0,05
Total:	**29 915 628**	**9 194 080**	**100**
	Biodiesel		
Soybean	20 997	8 483	0,6
Sunflowers	236	106	0,01
Fiber hemp	24 573	9 080	0,7
Linseed	205	83	0,01
Winter rape	4 173 353	1 195 223	91,5
Summer rape	327 020	93 657	7,2
Total:	**4 546 384**	**1 306 632**	**100**
	Biogas		
Switchgrass	5 014 918	1 722 338	55,8
Sugar beet	1 842 043	690 470	22,4
Goat's-rue	221	81	0,003
Sativa	259	95	0,003
Miscanthus	4 521	1 852	0,1
Lupin	12 386	3 747	0,1
Millet	1 471	528	0,02
Sorghum	1 066	382	0,01
Honey clover	1 229 034	451 631	14,6
Lucerne	652 990	214 467	7,0
Serradella	71	26	0,001
Total:	**8 758 979**	**3 085 617**	**100**

** Agriculture residues of second-generation biofuel calculation consist of 60 percent for all biomass raw material and include product to crop ratio (table 1).*
***Data reported in table 2 in thousand tonnes of oil equivalent have been prepared on the basis of 1 ton of oil equivalent having an energy content of 41.868 gigajoules (GJ).*

It can be noticed, that wheat is mostly grown and used for bioethanol production, rapeseed for biodiesel production, switchgrass and sugar beet for biogas production.

3. The agriculture activites-environment nexus

In order to increase the potential of biomass, it is necessary to pay attention to agricultural activities. As demand for energy and raw materials grows, agriculture is under greater pressure. As a result, the environmental impact of the agricultural sector has increased significantly in recent decades (Hasler et al., 2015). Biomass production is greenhouse gas emissions from land management and land use change. These refer to emissions of greenhouse gases (especially CO_2, CH_4, and N_2O) resulting from agricultural inputs, management practices, and land use changes associated with production of biomass. According to Konstantinavičiūtė, I. et al., 2020, Greenhouse Gas (GHG) emissions from agriculture sector in Lithuania include: methane (CH_4) emissions from enteric fermentation of domestic livestock; CH_4 and nitrous oxide (N_2O) (direct and indirect) emissions from manure management; direct and indirect N_2O emissions from managed soils; carbon dioxide (CO_2) emissions from soil liming and application of urea. The most important GHG gases in agriculture sector are N_2O and CH_4, in 2018 it contributed to the agriculture emissions respectively 58.8% and 40.6%. The major part of N_2O emissions comprises from agriculture soils – 55%. Application of inorganic N fertilizer and cultivation of histosols leads to substantial emissions of N_2O from agricultural soils. Digestive processes are responsible for the major part of CH_4 emissions from agriculture sector – 35.4%. Liming and Urea application are the two sectors that are responsible for CO_2 emissions from agriculture sector, accounting for 0.6% share of total agriculture emissions in 2018.

The following discusses the nexus between agriculture activity and the environment (Figure 3). The impact of the agriculture sector on the environment is expressed by four agricultural activities: fertilization, irrigation, chemical inputs, and mechanized machinery. These activities have a negative impact not only on the environment but also on human health. Therefore, in order to increase the potential for the use of biomass in bioenergy production, it is necessary to assess the potential impact of these agricultural activities on the environment, such as soil, air pollution and climate change. One of the most effective methods for studying the environmental impact of agricultural activities is lifecycle methods.

Fertilization: High use of nitrogen fertilizers causes eutrophication of aquatic and terrestrial ecosystems. If more phosphorus fertilizers are used than the plants consume, eutrophication of groundwater and freshwater occurs. According to Coleman, Crossley, 2003, intensive use of mineral fertilizers changes the composition of soil microorganisms, the soil becomes acidic. The concentration of heavy metals in acidic soils increases, and these metals also enter the human body through plants and the cattle that feed on them. This pollution occurs when rain-washed mineral fertilizers enter surface waters. Excessive water pollution with these organic compounds can lead to eutrophication (swamping) of lakes and rivers and disturb the balance of aquatic ecosystems.

Dynamics of mineral fertilizer consumption in Lithuania during the period 2011-2020 are shown in Figure 4. Nitrogen consumption was the most important fertilizer in Lithuania over the previous decade. Since 2011 the nitrogen consumption has been fluctuating with the smallest total amount of 147 thsd. tonne in 2011 and the largest portion of 185,8 thsd. tonne in 2020.

Total phosphorus consumption in 2011 amounted to 16,0 thsd. tonne and in 2020 – 23,8 thsd. tonne. It can be noticed, that the mineral fertilizer consumption by agriculture during the period 2011-2020 was increased by about 26,4 % nitrogen and about 48.8 % phosphorus. Mineral fertilizers, such as nitrogen and phosphorus, are widely used in agriculture to optimize production. They are important nutrients that are absorbed from the soil by plants for their growth. A surplus of nitrogen and phosphorus can, however, lead to environmental pollution like eutrophication of surface water. Therefore, it is important to reduce excessive use of the mineral fertilizers.

Irrigation: The agricultural sector is a major user of freshwater resources. The problem with the use of natural resources related to agriculture is the irrational use of fresh water. The irrational use of fresh water contributes not only to the depletion of these resources, but also to the salinization of the soil and the destruction of freshwater ecosystems. Overfishing can lead to lower groundwater levels, saline water infiltration, and loss of wetlands. Dynamics of water consumption in agriculture of Lithuania during the period 2015-2019 are shown in Figure 5.

Consumption of water during the period 2015-2019 increased by 21%. The higher total water consumption in 2019 amounted to 4 million m³. Water consumption during the period 2015-2019 was increasing by 21%. The highest total water consumption in 2019 amounted to 4 million m³. The results of the dynamic indicate that water consumption is growing every year with the smallest portion of 3% in 2016 and the largest portion of 12% in 2017.

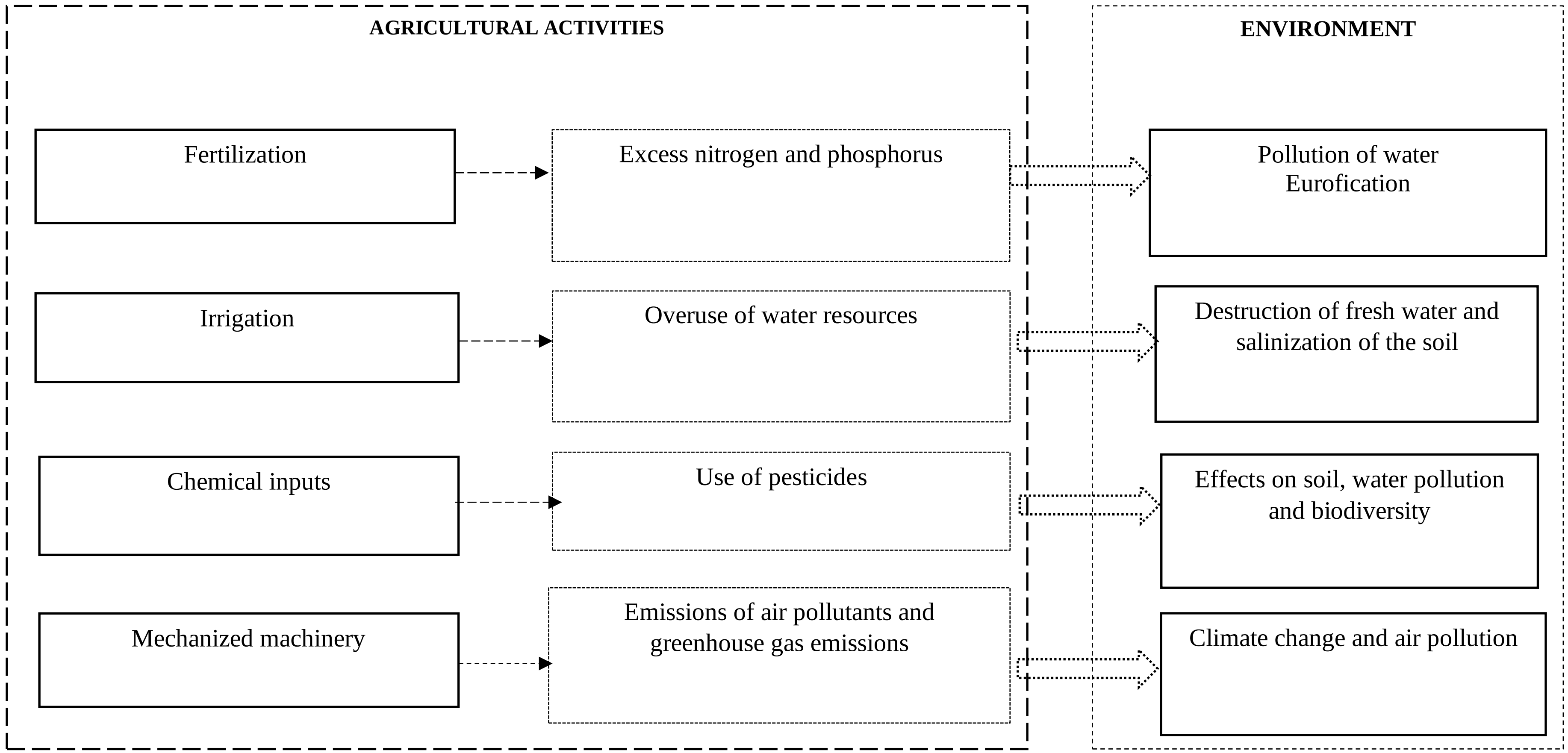

Figure 3: The agriculture activities–environment nexus. Sources: formed by the author on the basis of publications of the Jialing *Yu, Jian Wu, 2018; Konstantinavičiūtė, I. et al., 2020.*

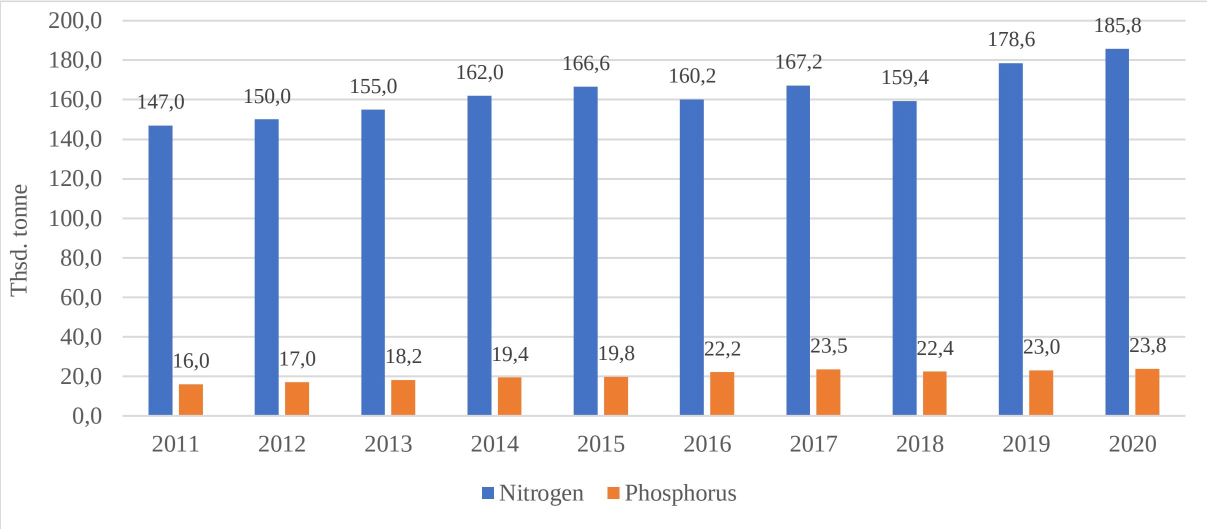

Figure 4: Estimated mineral fertilizer consumption by agriculture (thsd. tonne), 2011-2020 in Lithuania
Source: Eurostat database.

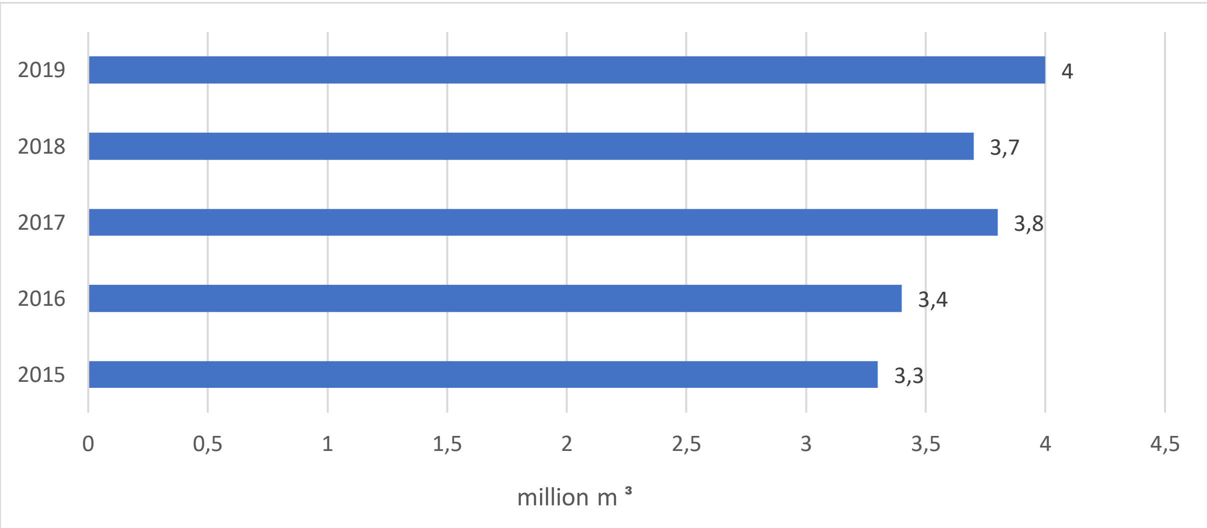

Figure 5: Water consumption in agriculture, million m³, 2015-2019 in Lithuania *Source: Eurostat database.*

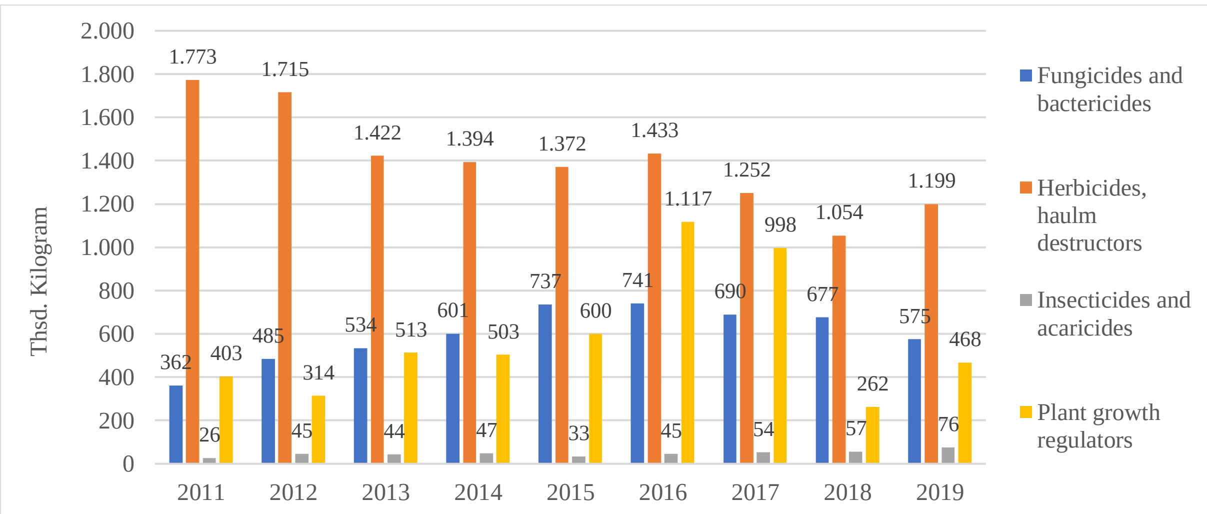

Figure 6: Sale of pesticides (thsd. kilogram), 2011 -2019 in Lithuania. *Source: Eurostat database.*

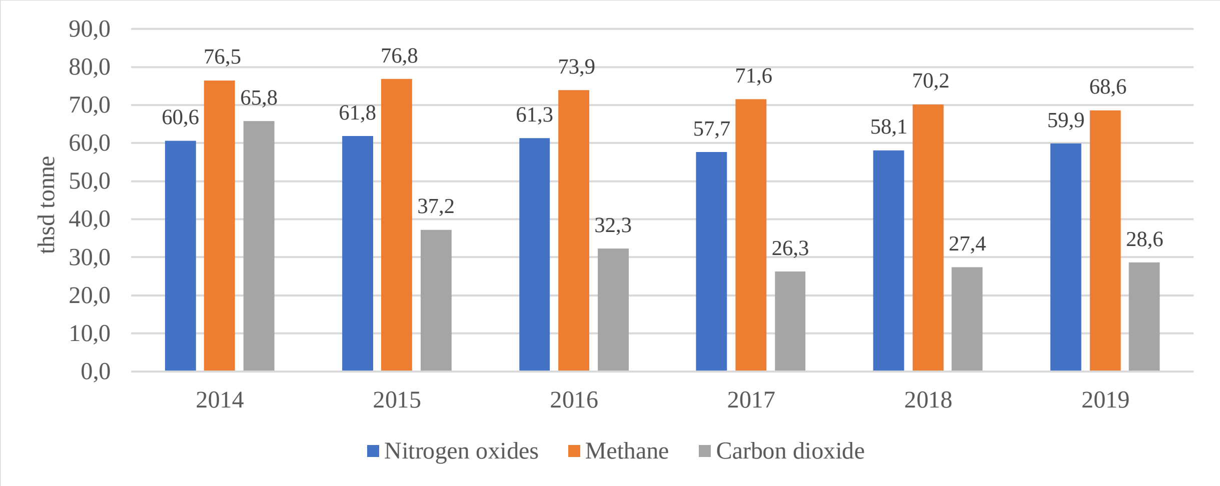

Figure 7: Emissions of air pollutants in agriculture (thsd. tonne), 2014-2019 in Lithuania. *Source: Eurostat database.*

Chemical inputs: The greatest impact on soil and water pollution in agriculture is caused using pesticides. In most countries, pesticides are mainly used for agricultural purposes. Pesticides are associated with effects on biodiversity and human health. The loss of biodiversity is related to the decrease in the area of natural grasslands, as only certain plant and animal species are common in those grasslands. The use of pesticides can be reduced by changing agricultural crop production technologies, improving pesticide application techniques and technologies, replacing old preparations with more effective ones, using lower rates, using pesticides only when there is a real economic need.

Dynamics of sale of pesticides during the period 2011-2019 are shown in Figure 6.

Herbicides consumption was the most significant pesticides of sale in Lithuania with the total amount of 1773 thsd. kilogram in 2011 and the total amount of 1199 thsd. kilogram in 2019. Consumption of herbicides during the period 2011-2019 decreased by 32,4%. It can be noticed that the sale of pesticides during the period 2011-2019 was increased by about 58,8 % fungicides, insecticides - 192 % and plant growth regulators – 16%.

Mechanized machinery: Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. The use of machinery has made it possible to increase agricultural productivity and improve yields and the supply of food. However, agriculture, as an energy user, contributes to the depletion of non-renewable energy resources and to global warming through energy-related emissions. The use of transport in soil preparation, sowing, fertilization, pesticide spraying, harvesting, incineration of residues is linked to climate change and increased air pollution.

Dynamics of emissions of air pollutants in agriculture during the period 2011-2019 are shown in Figure 7. The emissions of nitrogen oxides decreased by 1,6%. The emissions of methane decreased by 10,3% and carbon dioxide decreased by 56,5 %. It can be noticed, that the biggest decrease was carbon dioxide pollution.

Summarizing the results of the study, it is important to note that in order to grow used of agricultural activities for increasing the potential of agro-waste biomass, also, must take into account the impact on the environment. Hence, in order to reduce air pollution and, at the same time, global warming, it is necessary to promote and motivate the healthy benefits of green energy.

4. Conclusions

This study intended to perform the environmental effect of biomass on bioenergy production, considering agro-waste biomass bioenergy yield and analyzing the nexus between the main four agriculture activities and environmental. It is more profitable to produce second-generation biofuels from agricultural waste raw materials because there is no competition for food crops and it is not fit for human consumption.

This research offers to produce agro-waste biomass, considering three types of biofuel: bioethanol, biodiesel and biogas. Every type of biofuel has varieties of agro-waste biomass.

The results of agro-waste bioenergy yield showed, that the most significant to produce bioethanol production from the straw of winter/summer wheat, straw of summer barley, also a stalk of maize, pods/straw of legumes beans and stems/leaves of a pea. The most popular agro-waste for biodiesel production is the straw of winter rape. Biogas production is more useful to produce bioenergy production from switchgrass and leaves of sugar beet.

As regards the environmental aspect, the analysis results showed that the effect of the agriculture sector on the environment should analyze by four agricultural activities: fertilization, irrigation, chemical inputs, and mechanized machinery.

The nexus between agriculture activities and the environment is expressed in the fact for the high use of nitrogen fertilizers causes eutrophication of aquatic and terrestrial ecosystems and the high use of phosphorus fertilizers causes eutrophication of groundwater and freshwater occurs. Irrigation indicates that overuse of freshwater causes salinization of the soil and the destruction of freshwater ecosystems. Chemical inputs expressed by the use of pesticides cause the loss of biodiversity. Mechanized machinery is related to the changes in climate conditions to decrease air pollutants and greenhouse gas emissions.

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Novel Storage Concepts to increase RES penetration in autonomous systems. The case of Cyprus

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Abstract

The intermittent nature of RES and the variations between RES generation and demand profiles create a roadblock for the increased RES penetration into electric grids. Scope of this research paper is to examine the immense benefits offered by the application of RES-Storage hybrid technologies on the overall performance, resilience and sustainability of the transmission system of the republic of Cyprus. The RES plants, mainly represented by commercial solar photovoltaic systems, are optimally synthesized with pumped-hydro storage technology and battery energy storage systems, forming the so-called hybrid power park modules. The hybrid power parks are synergistically integrated into the power network aiming to maximize the RES penetration in the system and minimize the conventional power demand by the thermal units. For the specific study, the evaluation of RES potential in Cyprus together with the overview of the island's demand profiles were necessary in order to suggest best suited energy storage technology and most applicable hybridization concepts for Cyprus. The smart Grid approach is summarized in applying methods to smooth the demand side instead of cope generation to the demand only. Smart Grid techniques offer significant benefits if manage to transform the demand curve to cope with the most efficient generation mode. Expected implications to the Cypriot grid and sustainability are also examined through the change of the operation of the conventional units of Cyprus grid when 165 MW of storage capacity is applied, and 200 MW of additional PVs are installed.

Keywords: RES, Energy Storage, Pumped hydro storage, Hybrid.

1. Introduction

As Renewable Energy Sources (RES) use and development is regarded as a high priority to reach sufficient degree of sustainability, the limitations imposed by the intermittent nature of RES and the variations between RES generation and demand profiles create a roadblock for the 100% renewables goal. This is particularly true for the case of autonomous systems. There are currently several energy storage approaches and significant effort is being placed in developing electricity storage equipment to meet the need for higher RES penetration into the grids. Additionally, as the multiple power producers entering the grid affect the grid power quality, several approaches based on the smart grid concept i.e. the demand to cope with the generation and not the reverse i.e. generation to meet the demand, have been developed.

The present study focuses mainly on the following:

- Selection of the most appropriate storage and RES coupling approaches that would benefit Cyprus based on the RES availability and the demand profile of Cyprus,
- Examine the potential of combination of existing storage and Smart Grid technologies,
- Conclude to novel storage and/or Smart Grid concepts or combination of existing technologies that are beneficial for applications in Cyprus.

Although Cyprus met their targets regarding RES penetration into the grid, this task will be more complicated in the forthcoming years taking into account the unique characteristics of the island i.e. an autonomous grid with significant demand variation within various time scales i.e. daily, seasonally and yearly.

2. Evaluation of RES potential in Cyprus

The renewable source that is mostly available in Cyprus is the solar irradiation. Wind potential is generally low and the same is valid for other RES sources e.g., Hydro, Biomass. Solar Irradiation can be used to produce electricity mainly via Photovoltaics (PVs), and Concentrated Solar Power Plants (CSPs) - either with parabolic troughs or solar tower configuration. Other methods are in a pre-commercial stage of development.

Figures below show the measured and estimated solar and wind potential in Cyprus. Based on presently available data the per kW installed yearly yield of the various renewable energy plants in Cyprus benefits the solar power generation as wind speeds rarely exceed the 6m/s as a mean annual figure giving yearly capacity factors smaller than 25% even with the modern long blade wind turbines.

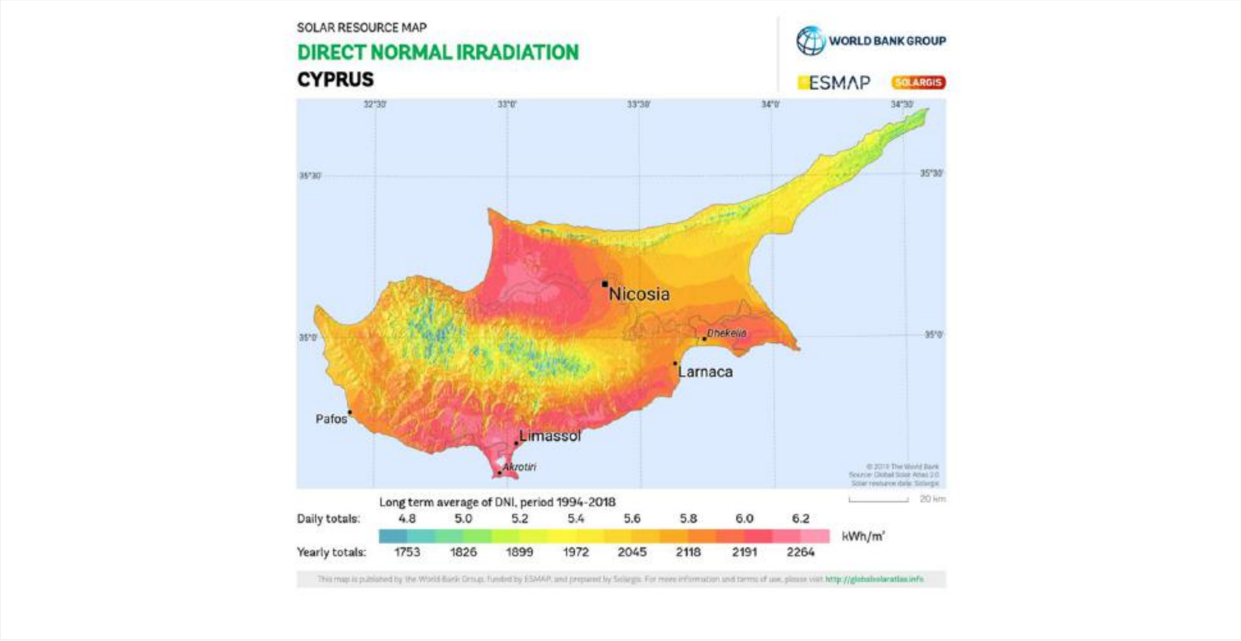

Figure 1: Contour map of the direct normal irradiation in Cyprus. Long term averages for the period 1994-2018 (Solar resource data, 2019, Solargis, https://solargis.com/maps-and-gis-data/download/cyprus).

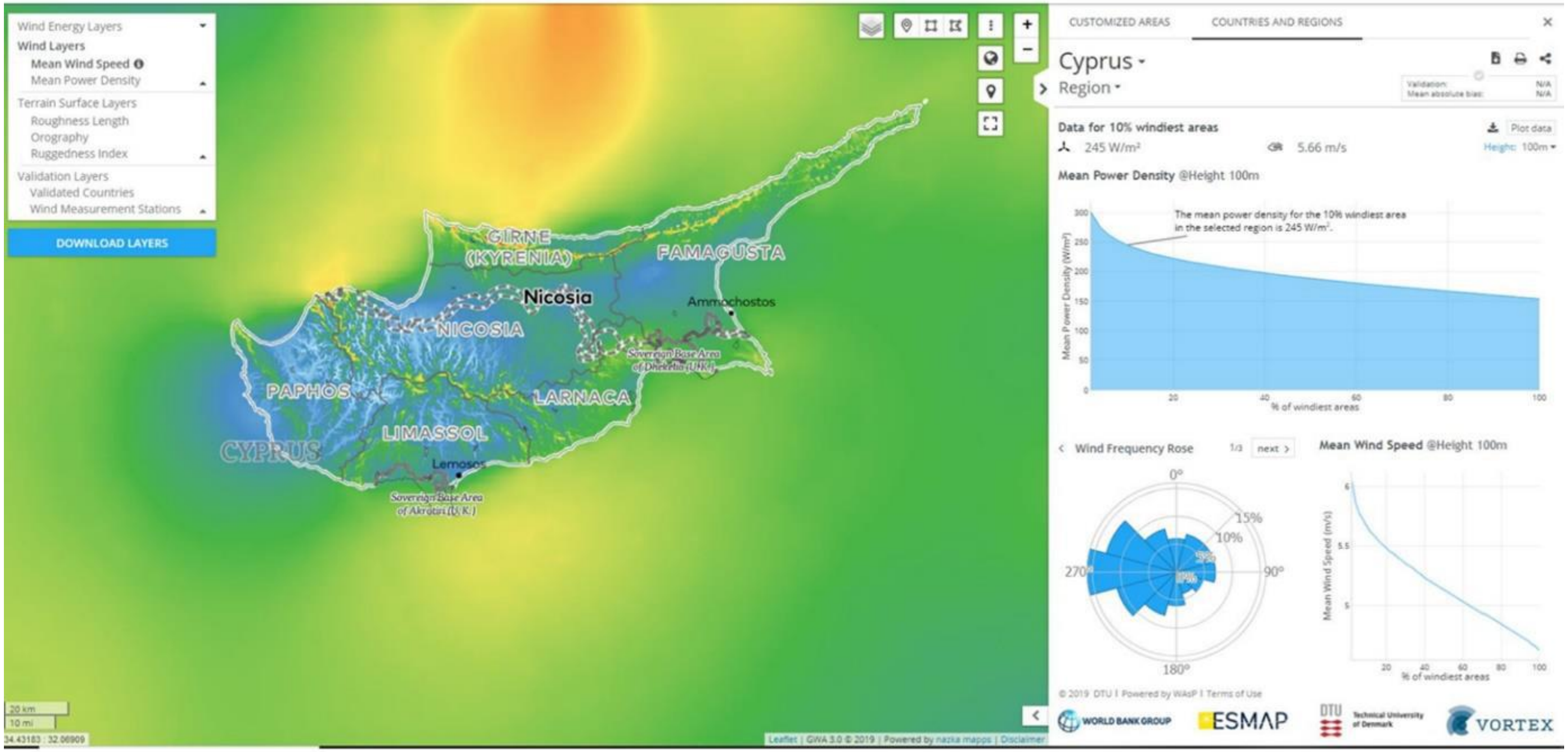

Figure 2: Overview of the Global Wind Atlas model for the whole Cypriot territory. Results at 100m AGL height (Global Wind Atlas 3.0, 2019, https://globalwindatlas.info/area/Cyprus)

Solar irradiation can be turned into electricity by PVs and CSPs. The choice between the two methods should be based on several parameters including:

- Maturity of technology
- Storage means
- Ease of construction and maintenance
- Capital Expenditure (CAPEX)- i.e. cost to build a ready to run plant
- Operating Expenditure (OPEX) - i.e. cost to run the plant
- Local added value
- Grid compatibility
- Demand compatibility
- Suitability to operate in parallel with Smart Grid operations
- Lifetime and Levelized Cost of Energy (LCOE)
- Efficiency, i.e., part of the Solar irradiation turned into useful electricity

An important characteristic of the CSP plants is their storage ability: part of the thermal energy produced during daylight hours can be stored in large tanks where specially developed salts are molten at temperature ranges up to 600°C. In this way their latent heat can be used to recover thermal energy during the night hours feeding with steam the plant's steam turbines.

Contrary to CSPs, PVs should collaborate with external storage facilities to store electricity which then can be used when needed by the grid e.g. during the night hours.

2. Overview of Cyprus demand profiles

An important parameter to achieve efficient match between RES generation and RES penetration into the grid is the grid demand profile. Figures below show typical demand profiles of the Cyprus grid. These Figures show typical day profiles all the year round split by season. As shown in the figures below, there does exist significant daily and seasonal variation all the year round. Peak values are reached during summer and the Christmas and New Year Holidays while demand drops during spring and autumn. The daily variation is considerably high and is smaller during spring and autumn. It is obvious that air conditioning and heating are driving factors as far as demand side concerns plus the increased users during the summer vacancies. As is the case most heating is based on heat pump equipment thus consuming power from the grid.

The low daily demand occurs during the early morning hours all the year round while the peak demand occurs in the late afternoon during winter days at about 19-20 hours every day. As environmental temperatures grow up approaching summer a second peak develops around noon.

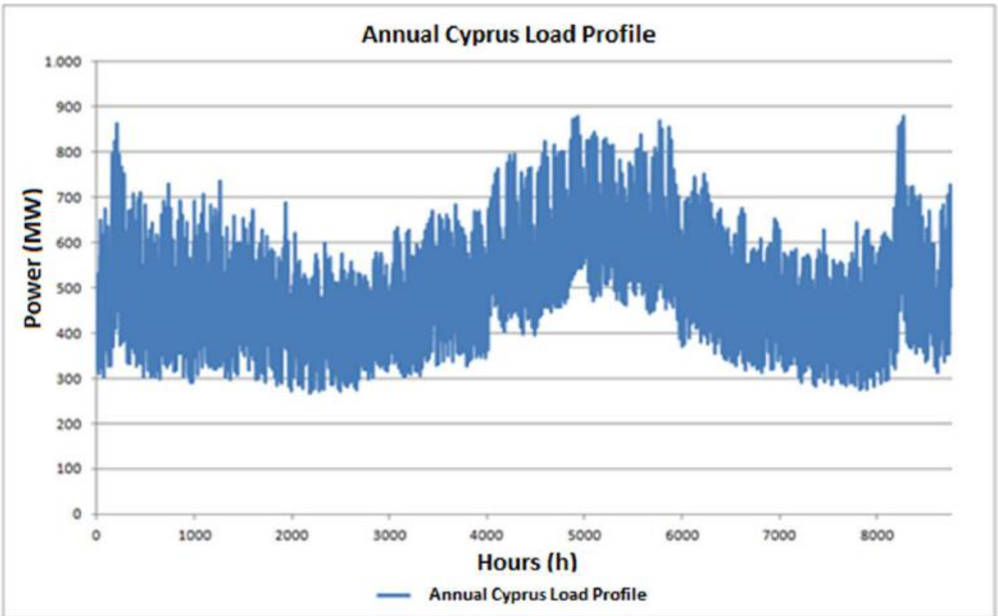

Figure 3: Overview of the yearly demand profile of the Cyprus grid starting from the first of January.

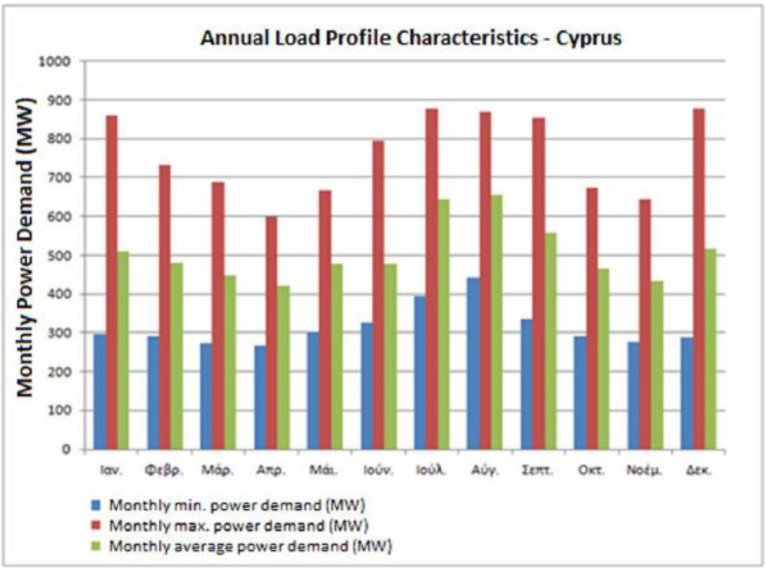

Figure 4: Monthly variation of demand profile of the Cyprus grid.

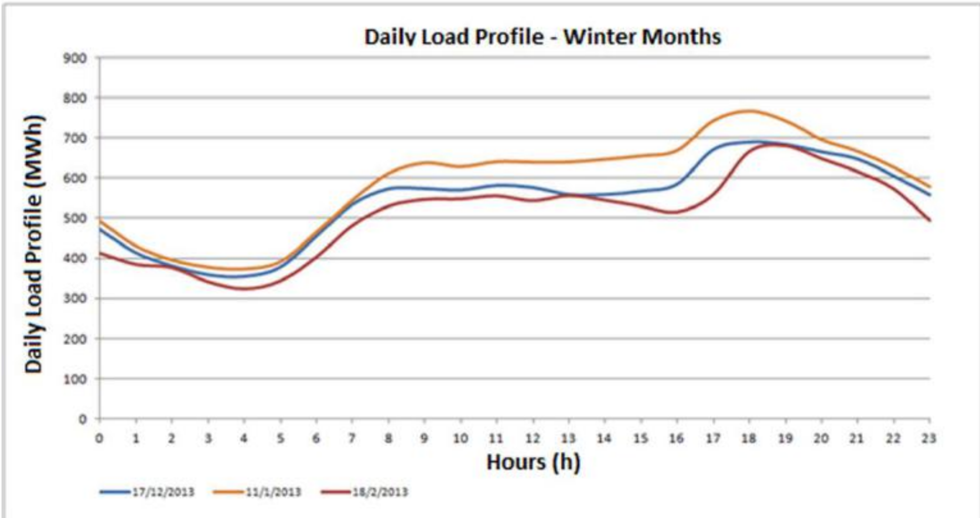

Figure 5: Specimen typical day demand profiles during winter.

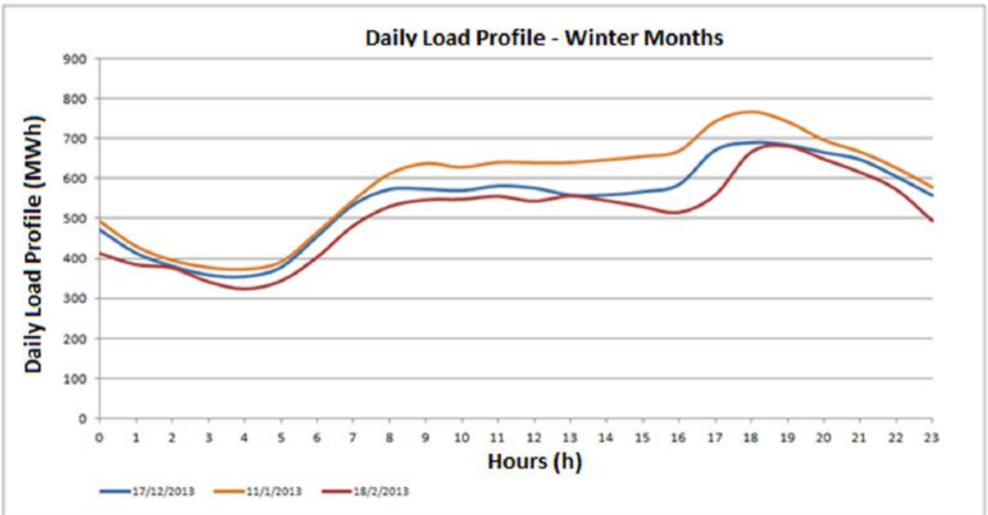

Figure 6: Specimen typical day demand profiles during spring.

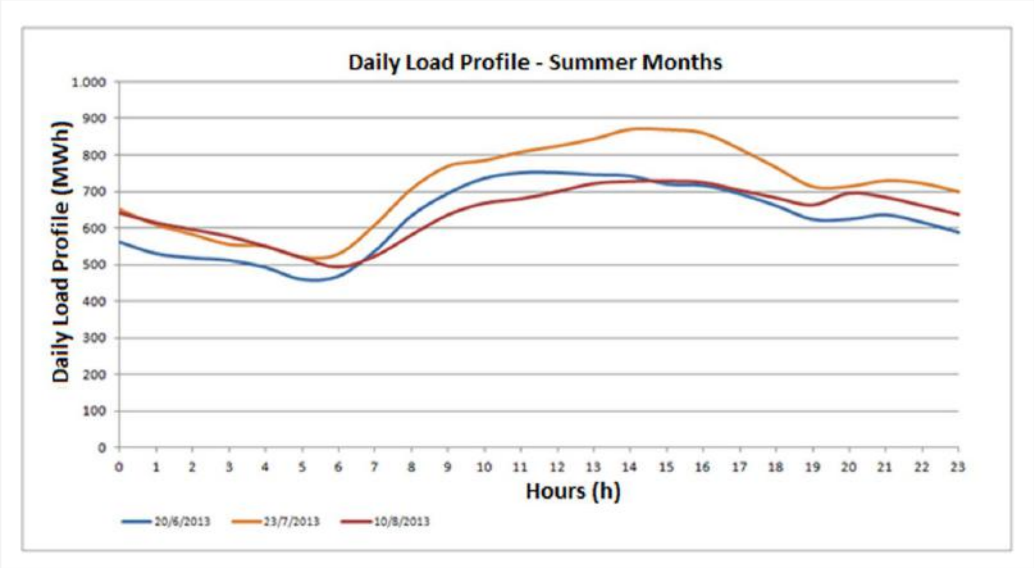

Figure 7: Specimen typical day demand profiles during summer.

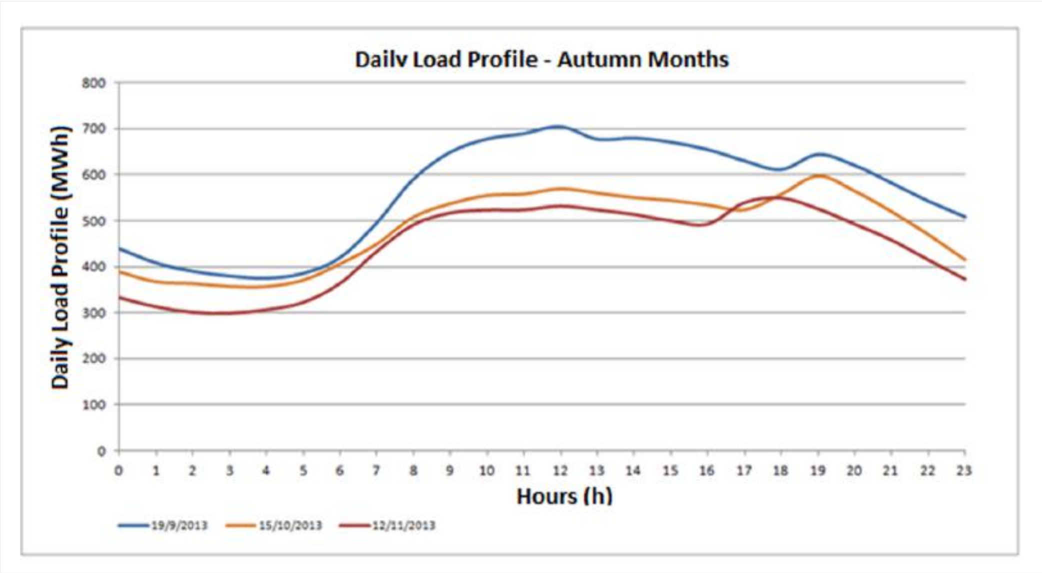

Figure 8: Specimen typical day demand profiles during autumn.

Table 1: Capacity characteristics of the storage systems for Cyprus.

Parameter	Capacity
Total energy content of electricity storage	800 MWh
Daily storage system discharge time	Up to 8 hours
Daily storage system recharge time	Up to 16 hours
Max power available from the electricity storage system	200 MW

This peak becomes higher than the one existing in the evening all the year round. The reason should be the air conditioning units and the increased demand due to increased users in the vacancies period. If a typical solar irradiation daily curve -the main RES existing in Cyprus- is placed on figures 5-8 it is easy to show that in the lack of storage, penetration of power generated by Solar irradiation or any other means of non-stable RE sources will create difficulties in the operation of the conventional units.

Taking into account the above figures and performing the calculations a need of 400- 800 MWh of daily storage is needed to smooth the operation of the conventional units of Cyprus grid or similarly to use efficiently with the less possible curtailment the RES electricity to be produced by solar power plants either PVs or CSPs. Additionally taking into account the daily and seasonal variation of power demand a total of at least 200 MW of stored electricity is needed to cover the demand differences between day and night and the seasonal variation.

Based on the above the parameters in Table 1 should be met by the potential storage systems in Cyprus. Figures may change depending on the power demand or on developments related with other sectors e.g. if penetration of electric vehicles take place then a dramatic change on the demand side of electricity may occur affecting also the daily demand profile.

Although storage can be applied at various system levels it is more efficient, as a first step, to be controlled centrally by the operator. This means that initial target should be to install few centrally controlled storage systems. Widely distributed storage can be applied at a second stage either at medium or small scale with the main goal to change the demand system curves under a Smart Grid approach.

3. Novel hybridization and/or storage concepts applicable in Cyprus

Based on the data recovered and presented above, the following results are concluded regarding novel hybridization and storage concepts applicable in Cyprus:

3.1 Best suited storage technology for Cyprus

In the following figure the classification of existing storage methods is classified against their nominal size and maturity.

It is shown that when selecting mature technologies for the size of storage needed in Cyprus Pumped hydro is better suited. If smaller units are planned, then the use of batteries is also possible.

Non matured technologies might be useful to examine but for application within a longer timeframe. If storage is planned for the management of the deviation of the demand and the increase of RES penetration in Cyprus grid, then the following figure is helpful.

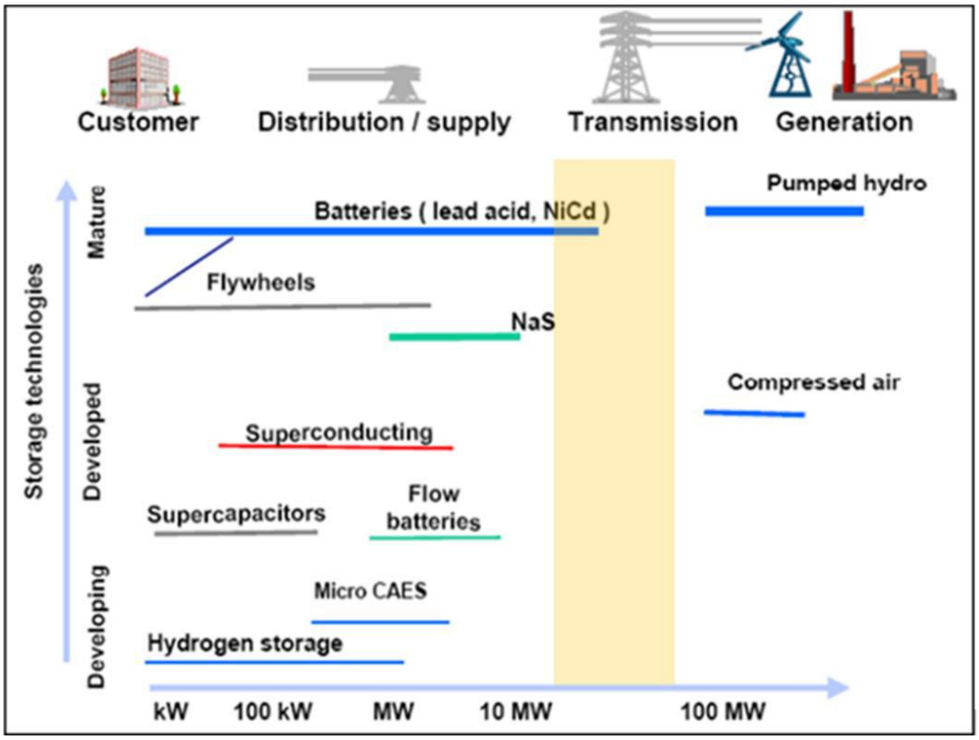

Figure 9: Classification of storage technologies against their maturity. Orange belt shows the range of capacity of storage needed in Cyprus grid and is added by the authors.

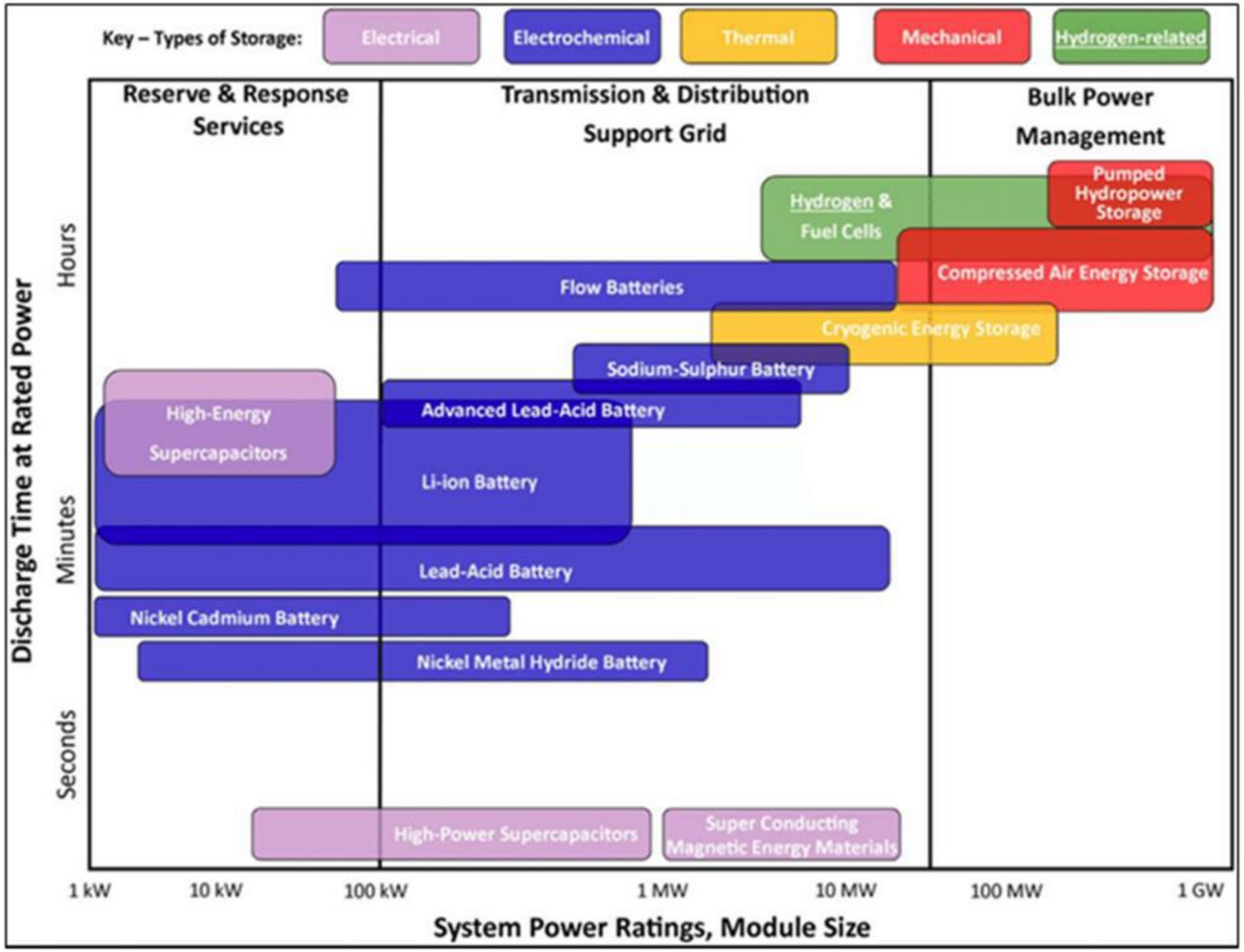

Figure 10: Classification of storage technologies against their time response parameter. Source: Kasper T. Møller et al., 2017.

It is shown that pumped hydro is suitable for operation within the scale of hours whereas batteries are better suited for the management of the characteristics of the distribution grid i.e. operating for minutes or seconds -frequency correction etc.- see figure below.

Based also on the real operational data of existing commercial plants it is shown that the most suited storage applications in Cyprus should be based on a big part of Pumped hydro storage to manage the shift of the demand curve and permit RES penetration together with a smaller part of Battery storage to handle the needs of the grid in terms of stabilization and smooth operation. The size and the distribution of the systems will be concluded by a joint approach taking into account technical and financial parameters.

Battery plants can be located anywhere however the pumping storage plants should use the existing reservoirs to save CAPEX costs and improve the water availability with all other positive side effects.

To decide for the potential locations of pumped hydro plants all existing reservoirs in Cyprus were examined taking into account various parameters. The results show that a storage capacity exceeding 400 MW of power lasting for up to 12 hours is possible using only the existing reservoirs thus minimizing CAPEX costs.

The figure below presents the location of the existing reservoirs which could be the lower reservoir in a potential pumping storage application together with the proposed location of the upper reservoir which could be built.

In all cases there are suitable areas to build the upper reservoir at acceptable distances from the lower existing reservoir achieving heads well exceeding the 200 meters.

Although there are dry seasons in Cyprus there are years where existing reservoirs are full and excess rainwater is guided to the sea. Pumping storage will add positive side effects by increasing the stored water volume of the present reservoirs by the volume of the upper reservoirs to be used primarily as energy storage means.

Existing reservoirs were classified in priority order taking into account several parameters. Results are shown in the table below. An initial of more than 200 MW of storage capacity is available with reservoirs that even during the driest years contain more than 60% of their nominal water volume. Additionally, the water circulated between the upper & lower reservoir is less than 1/10 of the driest content of the lower reservoir which is used for irrigation purposes i.e. safety factor in terms of water availability is extremely high.

Figure 11: Potential locations of pumping storage power plants in Cyprus.

Table 2: Ranking of potential pumped -hydro storage potential in Cyprus.

Existing Reservoirs (Dams)	Water availability (M3)			Head	Hybrid Power Station Capacity (MW)	Ranking
	Lower Reservoir -1-	Upper Reservoir -2-	Capacity % 2/7/2014	ΔH - 1-2 (m)		[0 - 7.5]
Priority projects						
Arminou	4.300.000	800.000	62,0	580	60	7,50
Asprokremmos	52.375.000	1.500.000	72,7	320	60	4,75
Kannaviou	17.168.000	700.000	63,2	400	35	5,25
Evretou	24.000.000	1.200.000	62,6	400	60	6,25
Kalopanagiotis	363.000	180.000	90,4	550	13	5,25
TOTAL					**228**	
Other projects						
Dipotamos	15.500.000	500.000	15,0	220	15	5,75
Lefkara	13.850.000	500.000	16,2	400	20	5,75
Kouris	115.000.000	1.800.000	33,1	250	60	5,75
Germasogeia	13.500.000	450.000	34,3	250	20	4,75
Kalavasos	17.100.000	750.000	10,9	350	35	5,75
Mavrokolympos	2.180.000	700.000	54,3	435	37	6,25
Argaka	990.000	300.000	26,2	400	15	2,00
Pomos	860.000	200.000	17,6	420	13	1,00
Ksiliatos	1.430.000	250.000	33,1	300	10	3,00
Lefkas	368.000	200.000	50	400	8	2,75
Klirou	2.000.000	300.000	50	280	15	5,25
Palaiochori	620.000	200.000	50	300	8	4,25
TOTALS	**183.398.000**	**6.150.000**			**256,0**	

Table 2 presents the potential of pump-hydro systems based on existing reservoirs in Cyprus. They are classified using a system of ranking which takes into account several parameters including water availability, capacity, CAPEX, proximity to the grids, environmental issues etc.

3.2 Novel hybridization concepts

As already mentioned above, solar irradiation is the RES to be used with the storage facilities in Cyprus. Currently there are two methods when turning the available solar irradiation into electricity: PVs and CSPs.

Figure 12 shows typical CAPEX data for both of them. Today the margin between PVs and CSPs increased more as PVs cost dropped considerably to less than 700 Euro/kW nominal installed, while CSP's including storage is still at the range of 4.500 Euro/kW installed (Denholm P. and Hand M., 2011).

Taking into account that PV plant efficiency -electricity output/solar irradiation input per m^2 of collector- is about 50% of a modern CSP plant efficiency the use of PVs is three times cheaper compared to CSP's. This assumption is based also on the fact that PVs can also utilise the diffused solar irradiation while CSP's only the direct one. Meteorological data show that in Cyprus total irradiation is about 10-15% higher than the direct one.

When adding the storage parameter i.e. to assign the storage cost to PVs only then the cost of PVs with pumping storage or batteries is going up to around 1.700 Euro/kW which is still a third of the hybrid CSP/storage cost. Based on the above, PV development with pumped-hydro and batteries storage is more financially sound compared to CSP development, if the goal is to increase RES penetration in Cyprus.

The combined use of PV's with pumped-hydro storage has not been used elsewhere. Typical scheme includes the use of wind as a primary RES. However, as in Cyprus wind resources are modest while solar irradiation is high, the hybridization of PVs with pumped-hydro storage creates significant benefits including lower CAPEX, local added value, water storage enhancement etc.

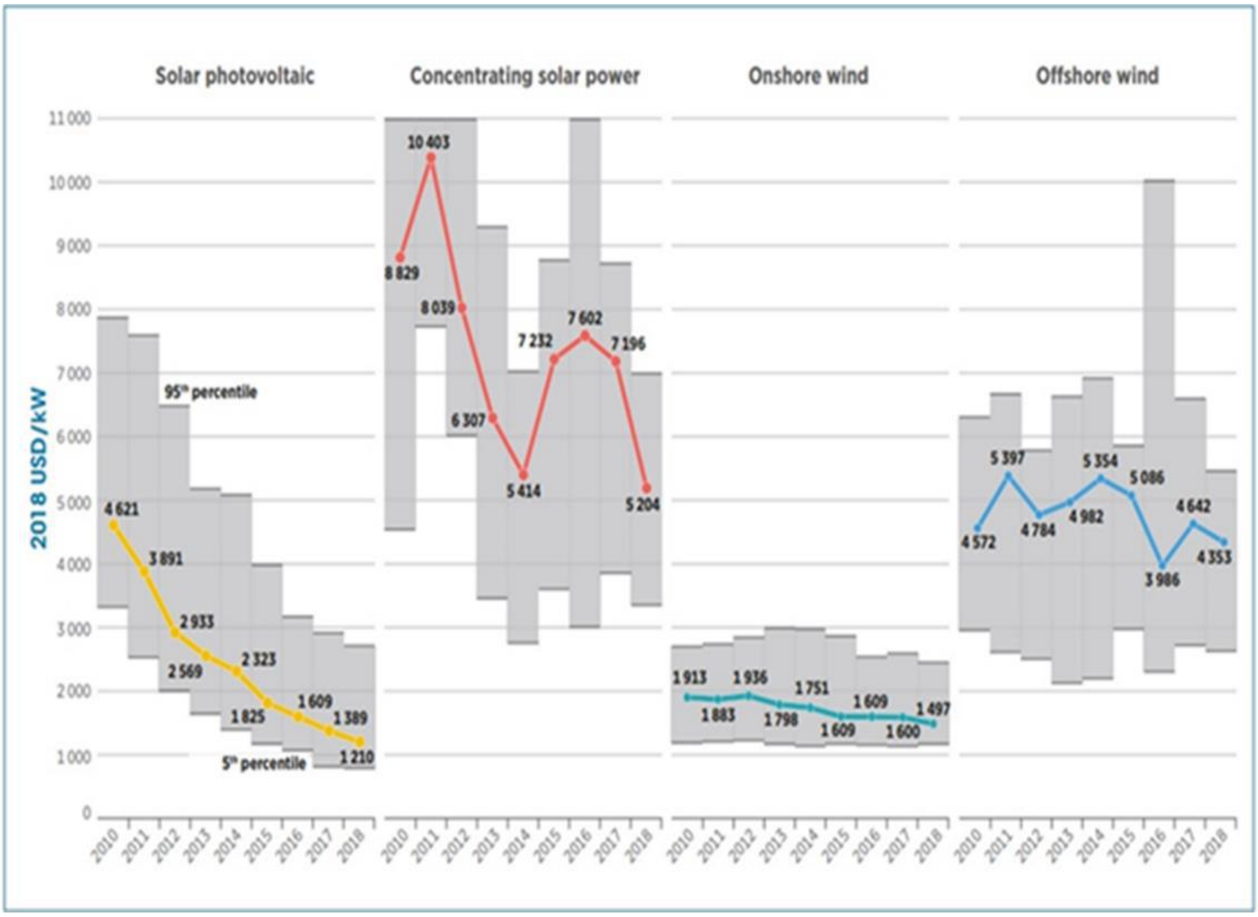

Figure 12: Comparing costs of well proven technologies until 2018.

Despite the novelty of this combination i.e. PVs with pumped-hydro, both technologies are well matured and present significant benefits compared with other approaches. One of them is the ability of the decentralization of the PV plants.

3.3 Smart Grid suggestions

The Smart Grid approach can be summarized in applying methods to smooth the demand side instead of cope generation to the demand only.

Smart Grid techniques play an important role when generation side consists of power plants having an optimum operation mode. In such cases smart grid techniques offer significant benefits if manage to transform the demand curve to cope with the most efficient generation mode.

In cases of high RES penetration which is vastly intermittent and stochastic, smart grid approaches are very useful when conserving the grid stability and power quality under conditions of "chaotic" operation of the intermittent RES generators.

As presented in the previous paragraphs the most proven smart grid technique in this case is the ability to store power and cope with short time scales - seconds or milliseconds - to the implications of generators stoppage or ramping which affect the grid stability. It has been shown in several real life cases that this can be offered with battery storage although there is ongoing research to achieve those benefits also with modern pumped-hydro storage equipment.

Other smart grid approaches include actions to develop consumer behavior that might be beneficial for the grid e.g. apply local cool storage in medium and large consumers to shift the cooling load from day time to night. In any case all those are related to incentives or variable charging of consumed power around the day because all these methods typically require more CAPEX compared to common equipment.

4. Expected implications to the Grid and sustainability

Following the previous developed approach, the implication of the selected technologies to the grid of Cyprus were examined.

An excel based code has been developed to examine the implications of storage in the operation of the conventional units taking into account RES generation through a stochastic approach related mainly with the climatic characteristics of Cyprus and able to change the installed RES capacity.

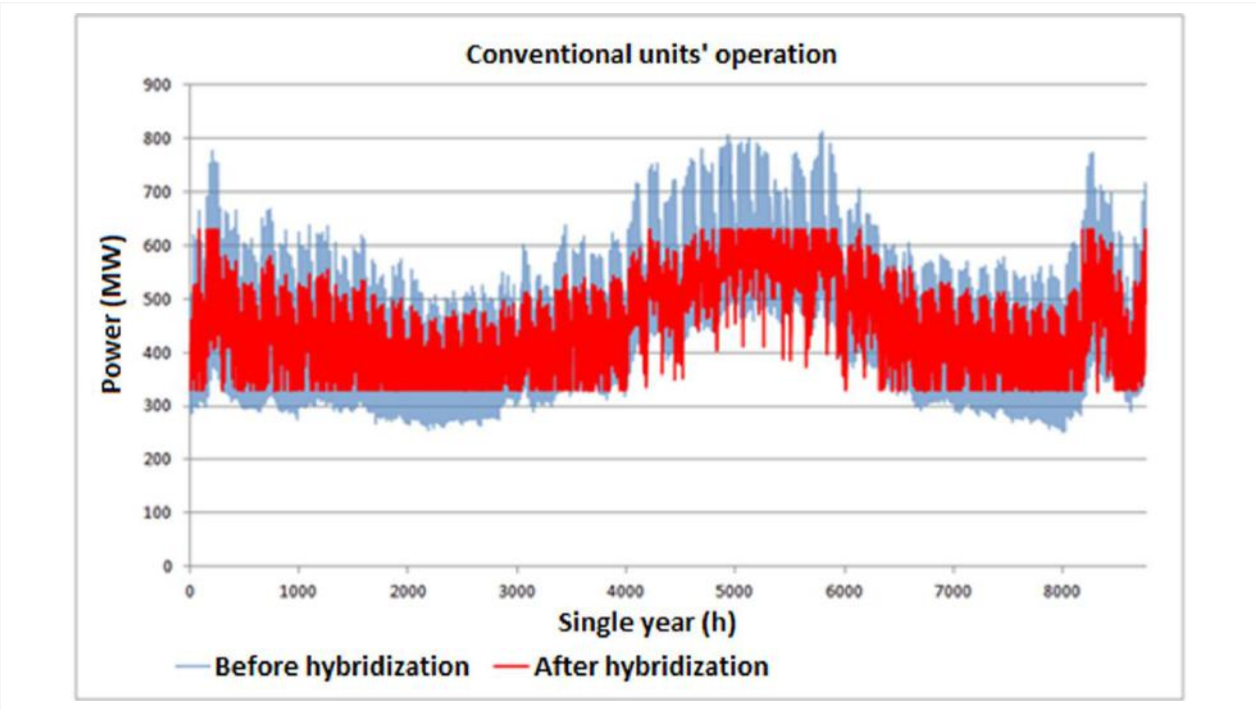

Figure 13: Results of applying storage with PVs on the typical yearly operation of the conventional units. Blue line: before hybridization - Red line: after hybridization. Peak saving and power variation is significant.

Several scenarios were examined. Figure below presents the change of the operation of the conventional units of Cyprus grid when 165 MW of storage capacity is applied, and 200 MW of additional PVs are installed.

Important peak saving occurs. Low grid demand is increased minimizing the curtailment of the RES plants as power is needed to recharge the storage units. The big variation between day and night load demands is significantly reduced. Figures show that this variation is reduced up to 50%. Additionally, the RES penetration is increase more than 100%. Power safety supply is also enhanced significantly as there is a back-up of 165 MW of power to meet emergency needs. Idle run of conventional units can be significantly reduced saving costs.

5. Conclusions

According to the present study and in order to reach the goal of increased RES penetration and grid stability in Cyprus the following steps could be followed:

- Apply storage including pumped-hydro storage of around 150 MW using the existing reservoirs and battery storage of about 60 MW to stabilize the grid.
- Based on the existence of storage capacities increase the PV installations over Cyprus thus provide RES power to charge the storage facilities and minimize the operation of the conventional units.
- CSP installations are more expensive today. If their costs drop in the future then this technology could be examined again in terms of financial competitiveness compared to PVs.
- Other storage technologies are either more expensive to apply in Cyprus - e.g. Compressed air storage or sea water hydro pumping storage - or in a non-matured stage regarding commercial applications - e.g. gravity based solutions, flying wheels etc.-.

Acknowledgement

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Mapping of the Cyprus energy storage potential. Implications in the penetration of renewables and the operational mode of the conventional units

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Abstract

It has been proven that energy storage can largely assist increased penetration of renewables into the grids. This is more important in autonomous grids as the one in Cyprus. One of the most technologically advanced and mature energy storage technologies is Pumped- Hydro (PH). PH is also considered as the most suitable storage technology to achieve high Renewable Energy Sources (RES) penetration levels in autonomous power systems, such as Cyprus', avoiding unnecessary RES energy curtailment. The existing water reservoirs in Cyprus provide an important potential for energy storage application at relatively reduced cost providing many side benefits. Sizing and siting of potential PH Storage (PHS) systems are evaluated within the present study. It is shown that existing reservoirs can cope with the energy storage demands for high renewables' penetration exceeding the current Cyprus state goals. DISPA-SET model is used in order to quantify impact and implications of the potential energy storage projects and in order to identify the optimal transmission grid behavior (in terms of re-scheduling operation of conventional units). Conventional units will be assisted to achieve more efficient operational modes with less idle loads, significantly enhancing the operational safety of the grid. Simulations for the selected scenarios were performed both for the Cypriot isolated-autonomous grid and for an interconnected grid between Cyprus, Greece and Israel.

Keywords: RES penetration, Energy Storage, Pumped hydro storage, Cyprus.

1. Introduction

Energy storage systems employed worldwide cope with the intermittent nature of distributed power generation from Renewable Energy Sources (RES) (Ziyu Z. et al., 2021, McIlwaine N. et al., 2021, Kang M. T. et al., 2021), mitigating its impact on operational practices of Transmission System Operators (TSOs). Determining the size (power rating and energy storage capacity) of the storage systems, as well as their location and connection to the grid is a fundamental problem. Multiple grid services may be provided by storage systems of different technologies coupled together, thus increasing the potential exploitation of their capacity and their feasibility (Kang M. T. et al., 2021; Bahloul M. and Shafiuzzaman K. K., 2021; Günter N. and Marinopoulos A., 2016).

One of the most technologically advanced and mature energy storage technologies is Pumped-Hydro (PH) (Shafiqur R. et al., 2015, Barbour E. et al., 2016, Mahmouda M. et al., 2020). PH is also considered as the most suitable storage technology to achieve high-RES penetration levels in autonomous power systems, such as Cyprus', avoiding unnecessary RES energy curtailment. The existing water reservoirs in Cyprus provide an important potential for energy storage application at relatively reduced cost providing many side benefits.

According to European Association for Storage of Energy (EASE) the typical characteristics (sizes) for energy storage projects having a rated maturity level (Technology readiness levels (TRL) at least 1) are shown in Table 1 (EASE, 2021). The potential services provided by each storage technology, along with their inherent development issues are in Table 2.

In order to select the appropriate size and the sitting of electrical energy storage systems, the previous constraints have to be taken into account and the potential problem storage is addressing.

Based on the above information, the present study focuses on the following:

- The sizing and the siting of storage and/or hybrid plants in Cyprus. A map-based data base is prepared including all the main technical parameters of the proposed plant.
- The possible implications of the operation of storage/hybrid plants together with smart operation algorithms for the whole Cyprus transmission grid.
- To simulate the grid's behavior and quantify the impact of various storage/RES scenarios.

2. Assessing the underlying potential of storage in Cyprus

Since the most technologically advanced and mature storage technology is Pumped-Hydro (PH), the assessment of the underlying potential in Cyprus started with this storage technology. This is considered as the most suitable storage technology to achieve high-RES penetration levels in autonomous power systems, such as Cyprus', avoiding unnecessary RES energy curtailment.

For the sitting of the PH Storage (PHS) systems the major constraint is finding suitable landscape. Furthermore, there has to be available land for the potential required project's capacity and there should be no significant environmental or grid connection issues. Potential sites considered, have to have at least one storage reservoir that is not currently used for potable water, as well as height difference for the sitting of the second water storage reservoir.

To this end, a preliminary investigation of the potential size and sitting of PHS projects in Cyprus resulted in the following map bellow (Figure 1). In Figure 1 the sitting of the upper and lower reservoirs for each potential PHS is shown, with some information on the required reservoir volume to be created.

Further investigation provided data on long term water availability of the reservoirs and their filling percentage, also in draught periods (Ministry of Agriculture Rural Development and the Environment, Water Development Department). Then, the PHS systems were sized based on worst case scenario of water availability and other design characteristics. The followed dimensioning method is described in steps below:

1. For each existing reservoir (taking as an assumption that it will be the lower water reservoir), the required volume of the upper reservoir was calculated based on water availability (% nominal) of the lower one.
2. For the calculated upper reservoir volume, the available height difference between reservoirs and the length of the penstock required were also calculated.

Table 1: Technology readiness level ranking of various storage technologies and typical main characteristics.

Technologies	Sub-technologies	Energy Capacity	Power Installed capacity	Storage duration at full power	Round-trip efficiency (%)	Response Time	Level of maturity (TRL, 3: very mature, 1: not mature)
Mechanical	Pumped Hydro Storage (PHS)	1-100 GWh	100 MW-1 GW	several hours	80	Seconds - Minutes	3
	Compressed Air Energy Storage (CAES)	10 MWh-10 GWh	10-300 MW	several hours	45-60	Minutes	2
	Flywheel	5-10 kWh	1-20 MW	5-30 minutes	85	Minutes	1.5
ElectroChemical	Lithium-ion batteries	< 10 MWh	< 50 MW	10 min to 4 hours	86	Milliseconds	2
	Redow flow batteries Zn Fe	< 100 MWh	< 10 MW	some hours		Milliseconds	2
	Redox flow batteries Vanadium	< 100 MWh	< 10 MW	some hours	70	Milliseconds	2
	Redox flow batteries Zn Br	< 100 MWh	< 10 MW	some hours	70	Milliseconds	2
Electrical	Superconducting Magnetic Energy Storage (SMES)	1-10 kWh	100kW-5MW	1-100 seconds	>90	Milliseconds	1.5
Chemical	Power to Gas (H2)	up to 100 GWh	1kW -1 GW	several hours-several months	20-40	Minutes	1

Table 2: Storage technologies services to the grids and their main constraints.

Technologies	Sub-technologies	Services provided	Major technological issues experienced
Mechanical	Pumped Hydro Storage (PHS)	Renewables integration shifting, Load levelling, Frequency regulation, Voltage support	Geographical constraint
	Compressed Air Energy Storage (CAES)	Renewables integration shifting, Load levelling, Frequency regulation, Voltage support	Low efficiency, Geographical constraint
	Flywheel	levelling	power for energising magnetic bearings
ElectroChemical	Lithium-ion batteries	Renewables integration shifting, Load levelling, Frequency regulation, Voltage support, Blackstart	Lithium ressource
	Redow flow batteries Zn Fe	Renewables integration shifting, Load levelling, Frequency regulation, Voltage support, Blackstart	Unoptimised electrolyte flow rates can increase pumping energy requirements and reduce energy efficiency
	Redox flow batteries Vanadium	Frequency regulation, Voltage support, Blackstart	membrane,designs, Unoptimised electrolyte flow rates
	Redox flow batteries Zn Br	Frequency regulation, Voltage support, Blackstart	pumping energy requirements and reduce energy
Electrical	Superconducting Magnetic Energy Storage (SMES)	Renewables integration shifting, Load levelling, Frequency regulation	Maturity of the technology, expensive, low energy density
Chemical	Power to Gas (H2)	Renewable integration shifting, fuel utilisation, energy arbitrage, chemical and petrochemical uses	Low efficiency, expensive, low energy density

3. For the calculated upper reservoir volume, the available height difference between reservoirs and the length of the penstock required were also calculated.
4. A preliminary nominal power in MW was selected for the system and the specific water energy content was further calculated (taking as assumption 15% system losses).
5. The nominal water flow and a suitable penstock diameter were then calculated.
6. Calculation of the nominal autonomy of the system (in hours) for 70% use of the upper reservoir water content followed.
7. Estimation of the cost of the proposed system based on sizes (reservoir, penstock length) was the next step.
8. Recalculation of the crucial parameters (upper reservoir volume and potential nominal power), so that the nominal autonomy will be at least 10 hours was the final step.

Further to the above design procedure, the resulting PHS systems were ranked by employing selection and ranking criteria in Table 3.

Based on the selection and ranking criteria, the potential PHS projects were ranked as first priority and second priority. Design characteristics emerged for the investigated PHS projects are shown in Table 4, whereas their ranking is presented in Table 5.

Table 3: Selection and ranking criteria for PHS systems.

CRITERIA	CASE 1	RANK 1	CASE 2	RANK 2
LOWER SESERVOIR WATER CONTENT	≥ 40%	1.75	< 40%	0
PROJECT CAPACITY	≥ 10 MW	1.00	< 10 MW	0
AUTONOMY	≥ 10 h	1.00	< 10 h	0
ENVIRONMENTAL ISSUES	NO	1.50	YES	0
GRID CONNECTION ISSUES	NO	1.00	YES	0
SOUTHERN MAIN WATER PIPELINE	NO	1.25	YES	0
PRIVATE LAND FOR THE UPPER RESERVOIR	NO	1.50	YES	0

Figure 1: Map based representation of potential HPS projects in Cyprus. Sitting and sizing of reservoir.

Table 4: Design characteristics of investigated PHS projects throughout Cyprus.

existing reservoirs	Water availability													
	lower reservoir [m3]	Upper reservoir [m3]	mean volume of lower reservoir % nominal	minimum water volume in the lower reservoir [m3]	water volume ratio - lower/upp	height difference [m]	penstock (m)	Nominal Power [MW]	specific water energy content [kJ/kg]	water flow nominal [m3/sec]	penstock diameter [m]	autonomy nominal [hours]	upper reservoir cost estimation[keuro]	upper reservoir specific cost (€/kW)
FIRST RANK PROJECTS														
Arminou	4,300,000	800,000	62.0	2,666,000	3.3	580	4,000	60	4,836	12.4	2.0	12.5	16,000	267
Asprokremos	52,375,000	1,500,000	72.7	38,076,625	25.4	320	5,500	60	2,668	22.5	2.7	13.0	30,000	500
Kanaviou	17,168,000	700,000	63.2	10,850,176	15.5	466	5,600	40	3,886	10.3	1.8	13.2	14,000	350
Evretou	24,000,000	1,200,000	62.6	15,024,000	12.5	400	4,000	60	3,335	18.0	2.4	13.0	24,000	400
Kalopanagiotis	363,000	180,000	90.4	328,152	1.8	550	2,100	15	4,586	3.3	1.0	10.7	3,600	240
Mavrokolympos	2,180,000	700,000	54.3	1,183,740	1.7	435	4,000	40	3,627	11.0	1.9	12.3	14,000	350
Partial Summary	**98,206,000**	**4,380,000**						**275**						
OTHER PROJECTS														
Dipotamos	15,500,000	500,000	15.0	2,325,000	4.7	220	3,500	15	1,834	8.2	1.6	11.9	10,000	667
Lefkara	13,850,000	500,000	16.2	2,243,700	4.5	400	3,500	30	3,335	9.0	1.7	10.8	10,000	333
Kouris	115,000,000	1,800,000	33.1	38,065,000	21.1	250	1,000	60	2,085	28.8	3.0	12.2	36,000	600
Germasogia	13,500,000	450,000	34.3	4,630,500	10.3	250	1,000	20	2,085	9.6	1.7	9.1	9,000	450
Kalavassos	17,100,000	750,000	10.9	1,863,900	2.5	350	3,800	35	2,918	12.0	2.0	12.2	15,000	429
Argaka	990,000	300,000	26.2	259,380	0.9	400	3,000	15	3,335	4.5	1.2	13.0	6,000	400
Pomos	860,000	200,000	17.6	151,360	0.8	420	1,500	13	3,502	3.7	1.1	10.5	4,000	308
Ksiliatos	1,430,000	250,000	33.1	473,330	1.9	300	1,500	10	2,502	4.0	1.1	12.2	5,000	500
Lefka	368,000	200,000	no data			400	1,500	8	3,335	2.4	0.9	16.2	4,000	500
Klirou	2,000,000	300,000	no data			280	5,500	15	2,335	6.4	1.4	9.1	6,000	400
Paleochori	620,000	200,000	no data			300	1,500	8	2,502	3.2	1.0	12.2	4,000	500
Partial Summary	**181,218,000**	**5,450,000**						**229**						
TOTAL								**504**						

Table 5: Ranking of the potential PHS projects from Table 4.

existing reservoirs	Water availability															
	lower reservoir [m3]	Upper reservoir [m3]	mean volume of lower reservoir % nominal	minimum water volume in the lower reservoir [m3]	water volume ratio - lower/upp	height difference [m]	penstock (m)	Nominal Power [MW]	water content of lower reservoir	project capacity	hours of autonomy	Environ-mental issues	Grid connection	southern main water pipeline	Private land for the upper reservoir	score [0-9]
FIRST RANK PROJECTS																
Arminou	4,300,000	800,000	62.0	2,666,000	3.3	580	4,000	60	1.75	1.0	1.0	1.5	1.0	0.00	0.00	6.25
Asprokremos	52,375,000	1,500,000	72.7	38,076,625	25.4	320	5,500	60	1.75	1.0	1.0	0.0	1.0	1.25	0.00	6.00
Kanaviou	17,168,000	700,000	63.2	10,850,176	15.5	466	5,600	40	1.75	1.0	1.0	1.5	1.0	1.25	1.50	9.00
Evretou	24,000,000	1,200,000	62.6	15,024,000	12.5	400	4,000	60	1.75	1.0	1.0	1.5	1.0	1.25	0.00	7.50
Kalopanagiotis	363,000	180,000	90.4	328,152	1.8	550	2,100	15	1.75	1.0	1.0	1.5	1.0	1.25	1.50	9.00
Mavrokolympos	2,180,000	700,000	54.3	1,183,740	1.7	435	4,000	40	1.75	1.0	1.0	1.5	1.0	1.25	1.50	9.00
Partial Summary	**98,206,000**	**4,380,000**						**275**								
OTHER PROJECTS																
Dipotamos	15,500,000	500,000	15.0	2,325,000	4.7	220	3,500	15	0.00	1.0	1.0	1.5	1.0	0.00	1.50	6.00
Lefkara	13,850,000	500,000	16.2	2,243,700	4.5	400	3,500	30	0.00	1.0	1.0	1.5	1.0	0.00	1.50	6.00
Kouris	115,000,000	1,800,000	33.1	38,065,000	21.1	250	1,000	60	0.00	1.0	1.0	1.5	1.0	0.00	1.50	6.00
Germasogia	13,500,000	450,000	34.3	4,630,500	10.3	250	1,000	20	0.00	1.0	0.0	1.5	1.0	0.00	1.50	5.00
Kalavassos	17,100,000	750,000	10.9	1,863,900	2.5	350	3,800	35	0.00	1.0	1.0	1.5	1.0	0.00	0.00	4.50
Argaka	990,000	300,000	26.2	259,380	0.9	400	3,000	15	0.00	1.0	1.0	0.0	0.0	1.25	1.50	4.75
Pomos	860,000	200,000	17.6	151,360	0.8	420	1,500	13	0.00	1.0	1.0	0.0	0.0	1.25	1.50	4.75
Ksiliatos	1,430,000	250,000	33.1	473,330	1.9	300	1,500	10	0.00	1.0	1.0	0.0	1.0	1.25	1.50	5.75
Lefka	368,000	200,000	no data			400	1,500	8	1.75	0.0	1.0	0.0	0.0	1.25	1.50	
Klirou	2,000,000	300,000	no data			280	5,500	15	1.75	1.0	0.0	1.5	1.0	1.25	1.50	
Paleochori	620,000	200,000	no data			300	1,500	8	1.75	0.0	1.0	1.5	0.0	1.25	1.50	
Partial Summary	**181,218,000**	**5,450,000**						**229**								
TOTAL								**504**								

First rank projects (having a rank over 6.00 AND water content of lower reservoir >40%) of a total of 275 MW nominal power have been identified. Other projects of ranks equal to or less than 6.00 account for another 229 MW nominal power.

It has to be stated here that the nominal power of the PHS systems may be increased by increasing each project's size (upper reservoir, penstock). Thus, in the next section, simulations were set up and run to investigate the impact of the various scenarios on the grid and in the case of high-RES penetration conditions.

3. Impact and implications of potential storage projects – Isolated grid

The DISPA-SET model has been used In order to identify the optimal transmission grid behavior (in terms of scheduling conventional generators) in the presence of high RES penetration and varying storage projects nominal capacity. For the investigation it has been assumed that by 2030:

a) RES penetration will be maximized - 1680 MW PV will be installed;
b) Cyprus grid will remain isolated;
c) 0 MW to 725MW of PHS systems may be installed, having nominal capacity for 8h;
d) A total annual demand of 6120 GWh for 2030.

The following capacity distribution for the clustered generators is envisaged in Table 6. The goal was to estimate the RES penetration potential, the curtailed energy and the energy cost, when accounting only for operation costs (and no installation costs), for the isolated grid and for an Additional Measures Scenario (AMS, without interconnection). According to National Centers for Environmental Prediction (NCEP) for the AMS (i.e. with all energy efficiency measures in place, as compared to the Current Measures Scenario (CMS) of the plan), the RES penetration in the electricity sector has been estimated in 30.3% of the total energy consumption by 2030 (National Centers for Environmental Prediction).

The configuration above has been run in DISPA-SET and the following results have been obtained, summarized in Table 7 and Figure 2 bellow. Indicative results for four weeks during the year are presented in graphical form in ANNEX. The conclusions that might be drawn from the above are that in case of maximizing RES penetration by 2030:

- In case of no PHS systems installed there exists an issue of unserved energy, even in the optimal scheduling configuration.
- RES penetration increases from 30% in the case of no storage facilities to 45%. For PHS capacity of over 500 MW the RES penetration increases only for 0.5% for over 200MW additional PHS.
- System cost and unit energy cost is only marginally decreasing for PHS systems of over 500 MW installed capacity.
- Curtailed power decreases by 60% only by the first 275MW of PHS capacity, when the RES penetration potential increases by 10%.

To investigate further the impact of the storage systems to the grid, for the 275MW and 500 MW installed nominal capacity, further scenarios of energy storage capacity from 4h to 15h of providing nominal power have been investigated.

Table 6: Capacity distribution for the clustered generators.

GENERATORS TECHNOLOGY	MODEL CLUSTER	INSTALLED CAPACITY [MW]
PV	[4] - CY_PHOT_SUN	1680
SOLAR THERMAL	[7] - CY_STUR_SUN	50
WIND	[3] - CY_WTON_WIN	198
GAS TURBINE (OIL)	[0] - CY_GTUR_OIL	128
INT. COMB. ENGINE (OIL)	[1] - CY_ICEN_OIL	102
COMB. CYCLE (OIL)	[2] - CY_COMC_OIL	836
BIOMASS	[5] - CY_STUR_BIO	58
COMB. CYCLE (GAS)	[6] - CY_COMC_GAS	432

Table 7: Cyprus' system characteristics estimated for 2030 – Isolated grid.

INSTALLED HPHS CAPACITY [MW]	TOTAL PRODUCTION [MWh]	UNSERVED [MWh]	RES PENETRATION [%]	SYSTEM COST [10MEuro]	CURTAILED ENERGY [MWh]	UNIT ENERGY COST [Euro/MWh]
0	6117744.646	1357.816838	30.02	34.55667738	1037626.039	56.49
275	6307817.917		39.38	29.41629793	405551.2321	46.63
400	6390256.111		42.22	27.70702472	202271.5633	43.36
500	6436436.939		43.86	26.70827351	92120.14999	41.50
550	6450954.263		44.43	26.36090377	56262.60473	40.86
625	6464760.788		44.99	26.03670107	23924.22901	40.27
700	6473787.295		45.26	25.87411561	8180.283681	39.97
725	6475052.327		45.31	25.84500835	5462.053193	39.91

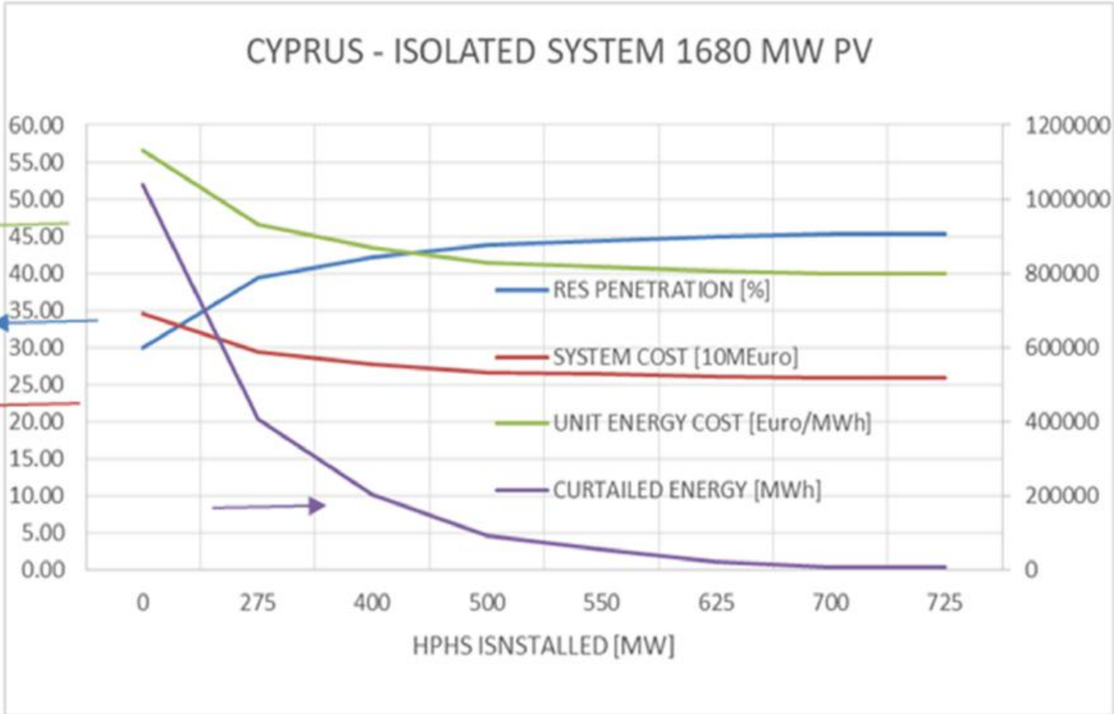

Figure 2: Effect of HPS installed capacity by 2030 to the Cypriot electricity system.

Table 8: Effect of changing the duration of nominal power of HPS.

NOMINAL POWER FOR	INSTALLED HPHS CAPACITY [MW]	TOTAL PRODUCTION [MWh]	RES PENETRATION [%]	SYSTEM COST [10MEuro]	CURTAILED ENERGY [MWh]	UNIT ENERGY COST [Euro/MWh]
4h	275	6229827.708	36.53	30.99926849	607017.6197	49.76
8h	275	6307817.917	39.38	29.41629793	405551.2321	46.63
12h	275	6322989.383	39.28	29.35478485	405516.895	46.43
15h	275	6309421.325	39.25	29.30166227	413163.2011	46.44
8h	500	6436436.939	43.86	26.70827351	92120.14999	41.50
12h	500	6424386.636	43.84	26.57181184	98366.71202	41.36

Results have been summarized in Table 8. Again, from Table 8 the following conclusions might be drawn:

- Storage capacity of 8h is considered to be optimal when compared to 4h or 12h and 15h in terms of RES penetration increase.
- System cost change to 12h from 8h is marginally decreased, while unit energy cost is decreased by 0.2 Euro/MWh.
- In the 275MW PHS case moving to 12h from 8h has no effect on curtailed energy, while for the 500MW system the case is worse.

Another implication investigated is the average daily usage/commitment span of the conventional generators for the various periods of nominal storage capacity. The results for the 275 MW PHS system are summarized in the following figure. The 0h case is for the case where no PHS system is installed.

From figure **3** above it may be stated that:

- PHS has a significant effect in decreasing the span of the daily conventional generators usage.
- PHS availability of over 8h does not provide any significant advantages.

4. Impact and implications of potential storage projects – Interconnected grid

In the case Cyprus will be interconnected with Greece and Israel by 2030 additional scenarios have been investigated. The generator capacities for each country are the followings (In Table 9):

The annual demand by 2030 has been for Israel around 95 GWh and for Greece around 62 GWh. The interconnector capacity has been taken as 2000MW to and from each country. The results are summarized for two cases of transmission cost in the table 10.

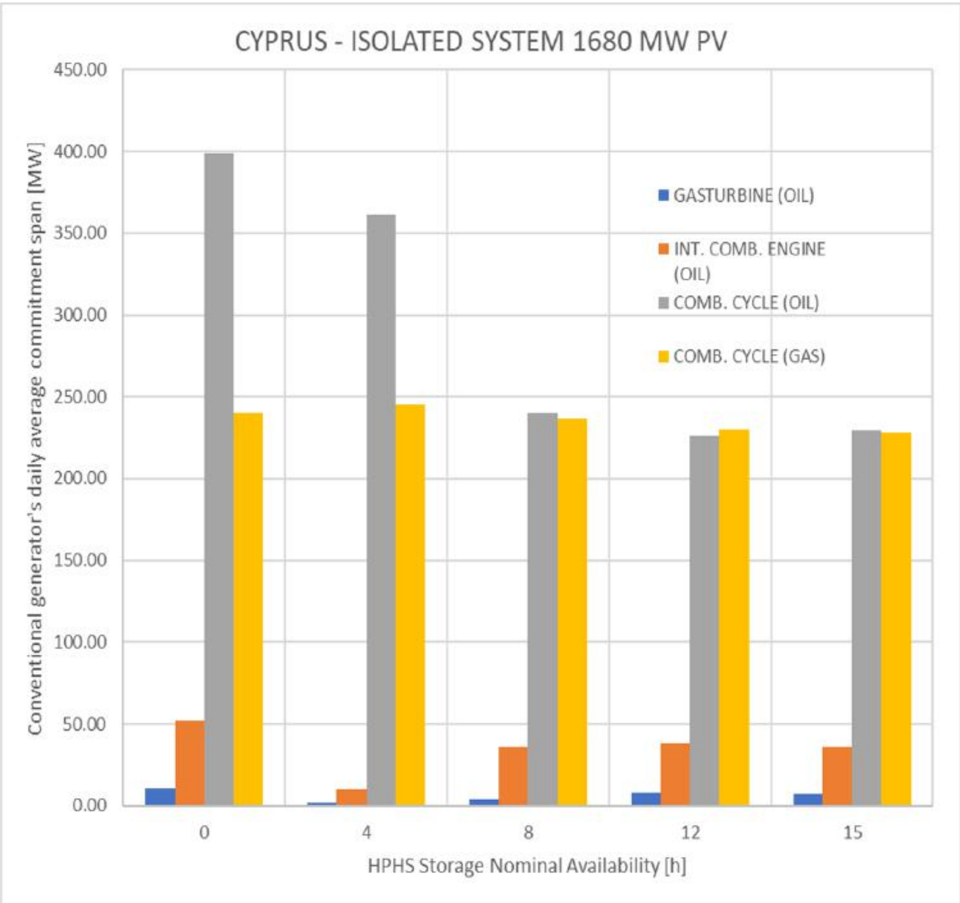

Figure 3: Overview of the effect of availability of nominal capacity to the usage of conventional generators.

Table 9: Generator capacities for each country.

COUNTRY	GENERATORS TECHNOLOGY	MODEL CLUSTER	INSTALLED CAPACITY [MW]
CYPRUS	BATTERIES	[17] - CY_BATS_OTH	41
	GAS TURBINES (OIL)	[9] - CY_GTUR_OIL	128
	SOLAR THERMAL	[16] - CY_STUR_SUN	50
	COMBINED CYCLE (GAS)	[15] - CY_COMC_GAS	432
	BIOMASS	[14] - CY_STUR_BIO	50
	PV	[13] - CY_PHOT_SUN	1680
	WIND	[12] - CY_WTON_WIN	198
	COMBINED CYCLE (OIL)	[11] - CY_COMC_OIL	836
	INTERNAL COMB. ENGINE (OIL)	[10] - CY_ICEN_OIL	102
GREECE	BATTERIES	[28] - EL_BATS_OTH	1300
	SOLAR THERMAL	[27] - EL_STUR_SUN	100
	BIOMASS	[26] - EL_STUR_BIO	300
	WIND	[25] - EL_WTON_WIN	7050
	HYDRO	[24] - EL_HPHS_WAT	3900
	PV	[23] - EL_PHOT_SUN	7660
	STEAM TURBINE (GAS)	[22] - EL_STUR_GAS	614.4347272
	INTERNAL COMB. ENGINE (GAS)	[21] - EL_ICEN_GAS	117.2028786
	GAS TURBINES (GAS)	[20] - EL_GTUR_GAS	1137.507752
	COMBINED CYCLE (GAS)	[19] - EL_COMC_GAS	5040.854642
ISRAEL	BATTERIES	[8] - IL_BATS_OTH	3000
	BIOMASS	[7] - IL_STUR_BIO	28
	HYDRO	[6] - IL_HPHS_WAT	7
	WIND	[5] - IL_WTON_WIN	27
	SOLAR THERMAL	[4] - IL_STUR_SUN	700
	PV	[3] - IL_PHOT_SUN	15000
	STEAM TURBINE (GAS)	[1] - IL_STUR_GAS	3538.23832
	COMBINED CYCLE (GAS)	[0] - IL_COMC_GAS	8739.638947
	GAS TURBINES (GAS)	[2] - IL_GTUR_GAS	592

Table 10: Cyprus' system characteristics estimated for 2030 – Interconnected grid.

VARIATION	INSTALLED HPHS CAPACITY [MW]	CY RES PENETRATION [%]	SYSTEM COST [10MEuro]	CY CURTAILED ENERGY [MWh]	UNIT ENERGY COST [Euro/MWh]	NET TRANSFER FROM CY [MWh]
TRANSMISSION COST 5 Euro/MWh	0	1.31	839.4558048	14855.15	49.04	653865.5
	275	39.14	835.4127998	1738.22	48.62	366348.5
	400	38.49	831.1620751	264.37	48.32	239038.5
	700	37.11	828.7360296	0.00	48.08	31292.2
TRANSMISSION COST 30 Euro/MWh	0	1.27	854.3155082	16735.32	49.82	1403662.6
	275	35.10	847.4484627	3750.86	49.22	1067688.4
	400	34.28	846.1323013	305.39	49.08	1034403.8
	700	32.92	843.9192049	16.02	48.85	989428.4

The following conclusions might again be drawn:

- There is extremely limited RES penetration in case of no PHS installation to accommodate the extra energy, not achieving the goals posed.
- Cyprus will be energy exporter with larger RES share in the case of 275MW PHS installed capacity.
- Curtailed energy is practically zero by employing 700MW PHS, achieving marginally better unit energy cost but also less RES penetration and energy exports.

5. Conclusions

The potential of electricity storage in Cyprus has been investigated. PHS can be coupled with batteries to provide for required energy services to the grid. There is significant room for PHS to assist in achieving maximum penetration of available RES, PVs in particular. Moreover, targeting 275MW PHS for 1680MW PV installed both in the case of isolated and interconnected Cypriot grid may assist in achieving current and future goals for the electricity system.

Acknowledgement

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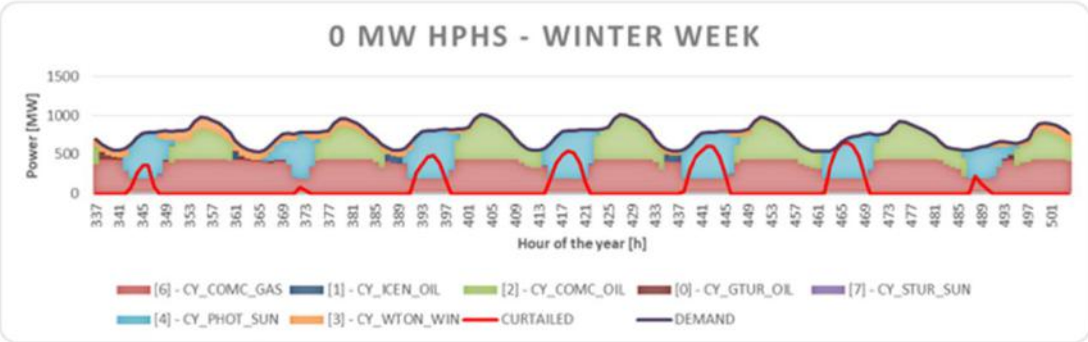
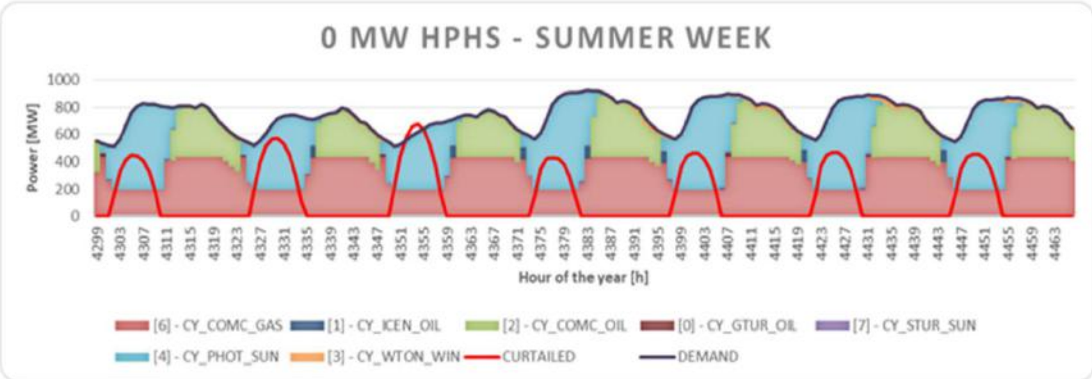
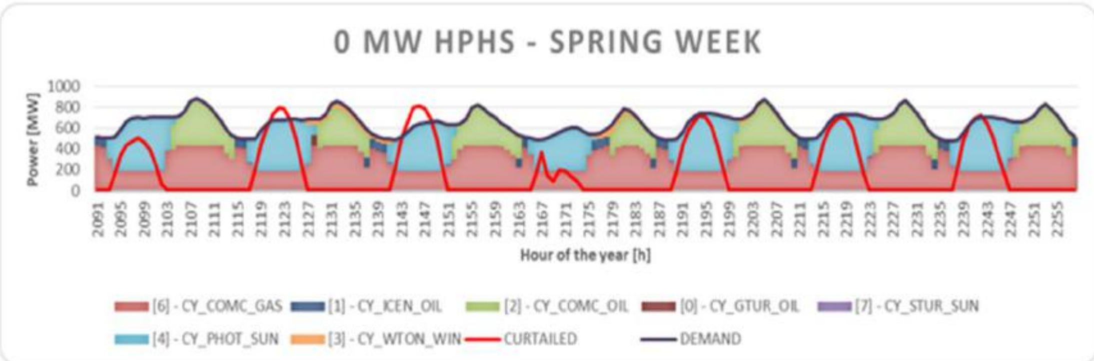
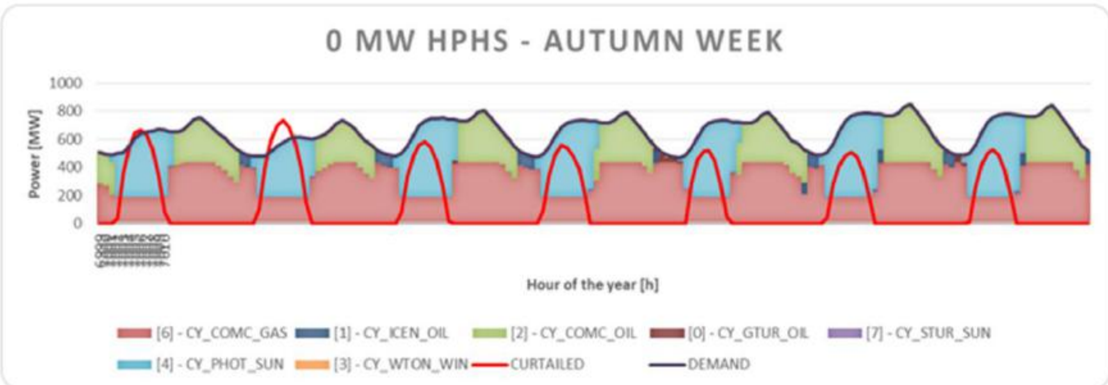
ANNEX

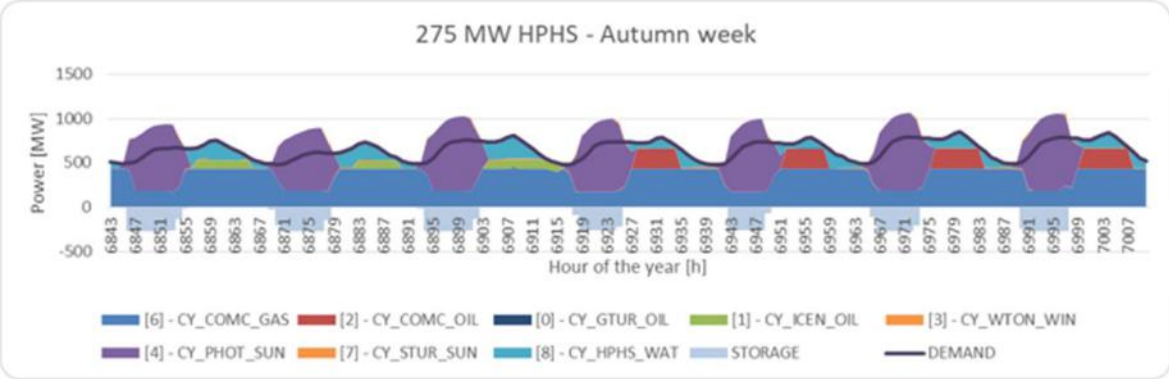
Indicative simulation results for 0MW, 275MW and 500MW PHS systems installed in the isolated grid of Cyprus

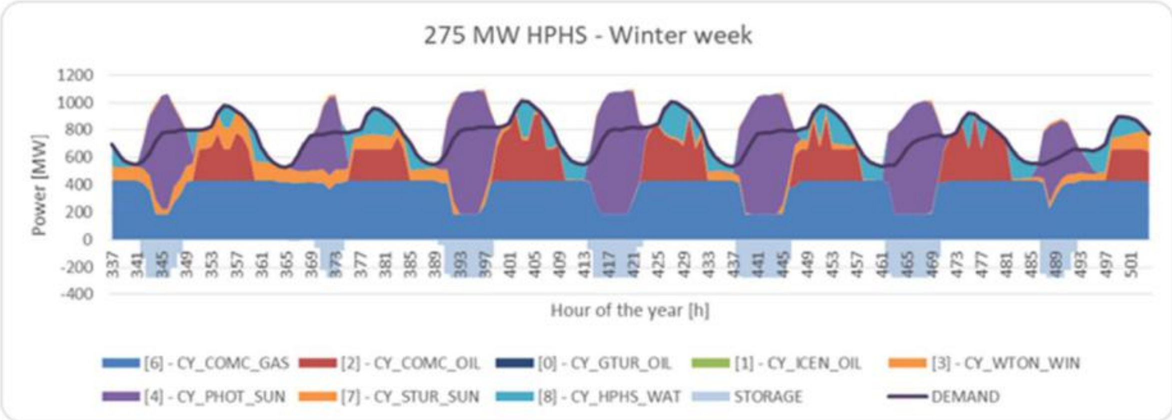









275 MW HPHS - Autumn week
Power [MW]
Hour of the year [h]
[6] - CY_COMC_GAS
[2] - CY_COMC_OIL
[0] - CY_GTUR_OIL
[1] - CY_ICEN_OIL
[3] - CY_WTON_WIN
[4] - CY_PHOT_SUN
[7] - CY_STUR_SUN
[8] - CY_HPHS_WAT
STORAGE
DEMAND


275 MW HPHS - Winter week
Power [MW]
Hour of the year [h]
[6] - CY_COMC_GAS
[2] - CY_COMC_OIL
[0] - CY_GTUR_OIL
[1] - CY_ICEN_OIL
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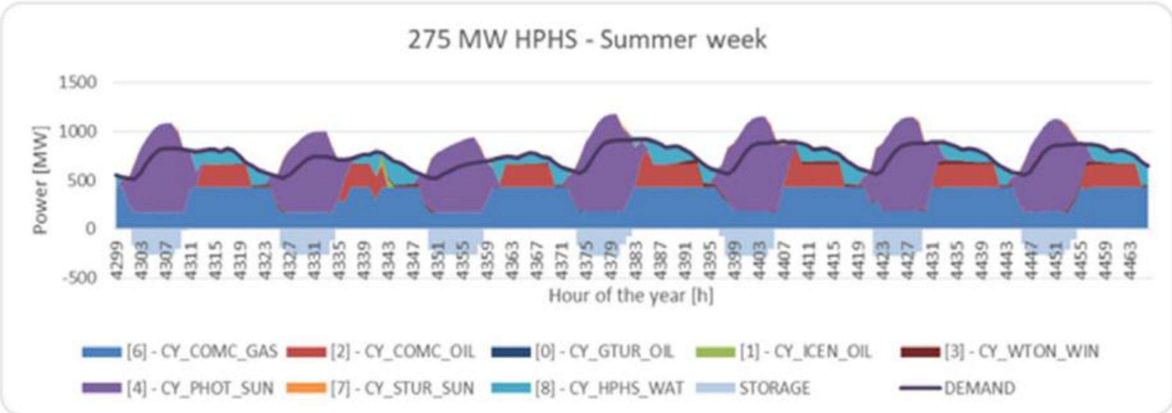
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Power [MW]
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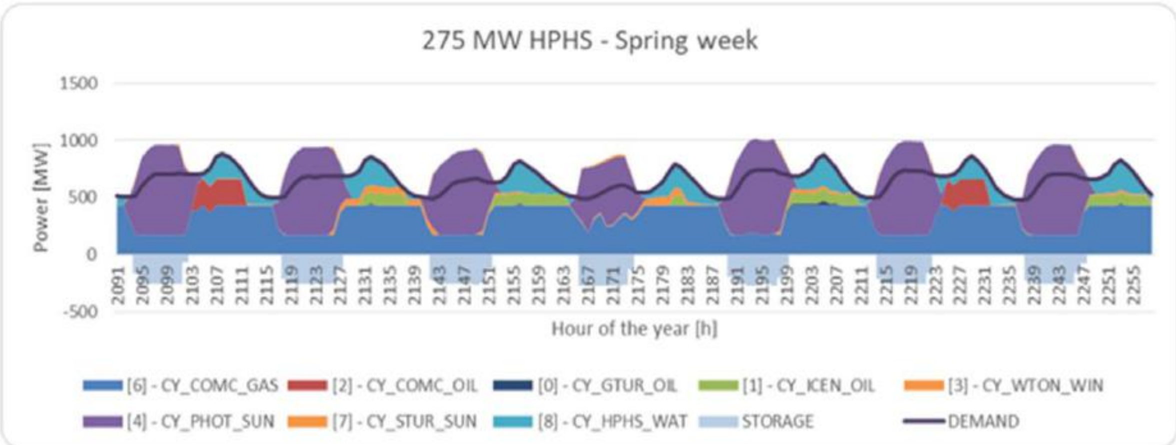
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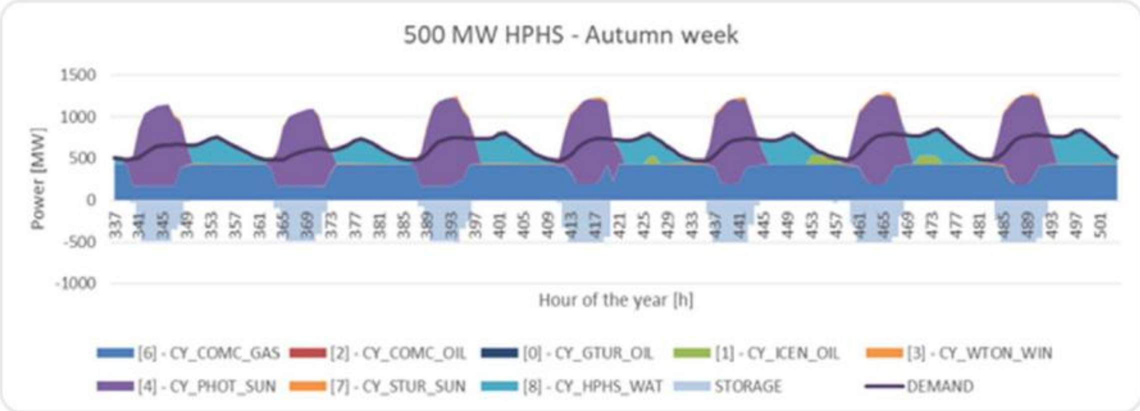
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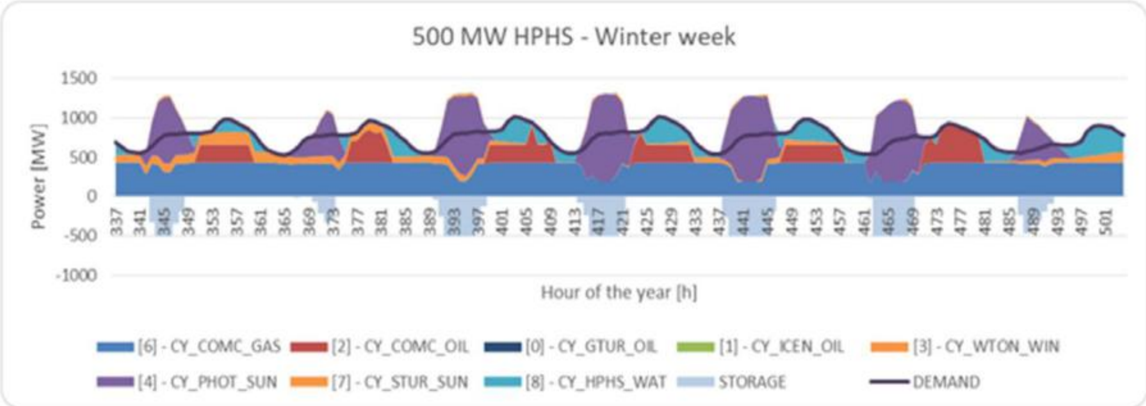
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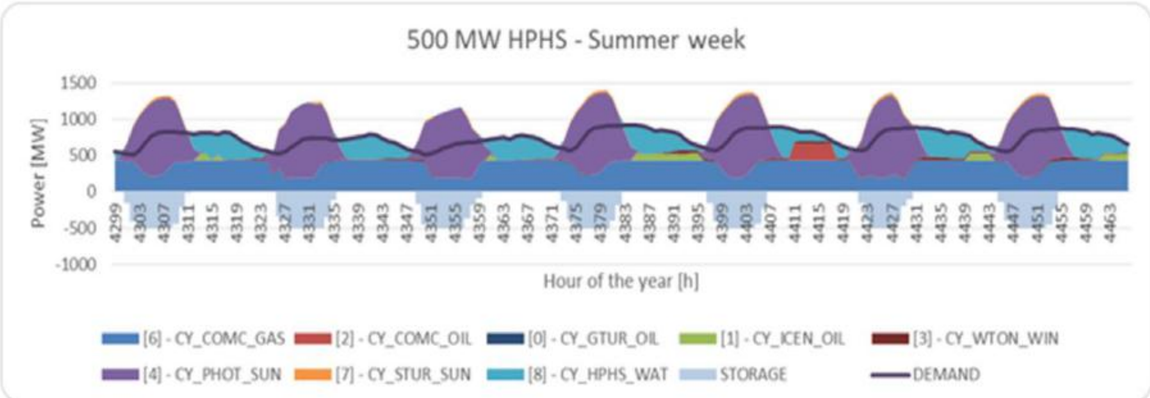
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Power [MW]
Hour of the year [h]
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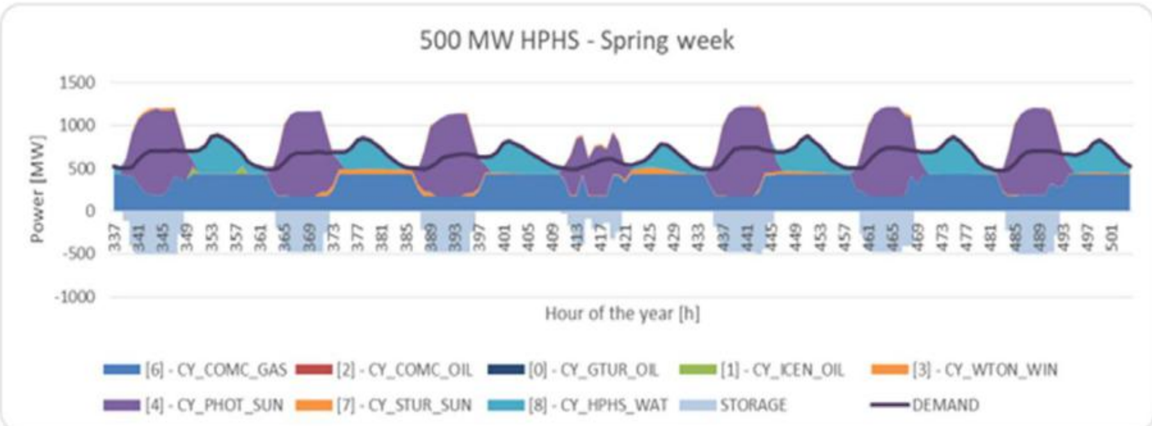
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The environmental multifunctionality of forests under the EU 2030 climate and energy framework

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Abstract

The aim of this paper is to shed light on the role of forests in mitigating the climate change according to the new Strategy of the European Union for energy and climate (The EU 2030 climate and energy Framework). It will analyze the Regulation (EU) 2018/841, which is aimed at the maintenance of the functionality of the forests as carbon storages, together with the Directive (EU) 2018/2001, which encourages the use of renewable energy sources, and specifically the use of forest biomass. The paper will examine the interaction between the two legal texts in the light of the requirement for the protection of the (environmental) multifunctionality of forests. For this purpose, special attention will be given to the analysis of the no-debit rule of the Regulation (EU) 2018/841, which serves as a sustainability criterion under the Directive (EU) 2018/2001.

Keywords: LULUCF Regulation, RED II Directive, sustainable forest management, no-debit rule, sustainability criteria.

1. Introduction

Forests have become increasingly important in mitigating the climate change since they can store carbon in the forests pools and contribute to the production of renewable energy from biomass. This article focusses on the utilization of forests in the EU's 2030 Climate and Energy Framework, which aims at the implementation of the Paris Agreement at the European level, namely at the reduction of greenhouse gas emissions to at least 40% by 2030 compared to 1990 levels (European Commission, 2015).

In particular, the article will examine the Regulation (EU) 2018/841 (Land Use, Land Use Change and Forestry (LULUCF) Regulation), which establishes the forestry sector as a carbon storage together with the Directive (EU) 2018/2001 on the promotion of use of energy from renewable sources (RED II), which encourages the use of biomass from forests. The article will shed light on the internal environmental conflict, which can arise in view of this dual function of forests, since the rising demand for biomass may cause a decrease in the carbon storage through forests (Baumgartner R., 2019). The interlinkage between the LULUCF Regulation and the RED II will be analysed in the light of the requirement of the protection of the (environmental) multifunctionality of forests. Finally, the paper will examine the proposals for the amendment of the LULUCF Regulation and the RED II in the context of the EU Green Deal and their impact on the environmental multifunctionality of forests.

2. The (environmental) multifunctionality of forests under International and European Law

Under International law and in particular the “Rio forest principles” adopted by the United Nations Conference on Environment and Development in1992 (Non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests, 1992), the principle of sustainable development for forestry requires that “*Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations*.”

At European level, the principle of the sustainable forest management aims at the functionality of the principle of sustainable development for forestry and is specified as

"*The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biological diversity, productivity, regeneration capacity, vitality and their potential to fulfill), now and in the future, relevant ecological, economic and social functions*" (Resolution H1, General Guidelines for the Sustainable Management of Forests in Europe, Second Ministerial Conference on the Protection of Forests in Europe, 1993).

It appears from the foregoing that the principle of sustainable development as applied to forestry serves the maintenance and enhancement of interrelated social, economic and multiple environmental functions of forests, such as the soil stabilisation, the erosion control, the maintenance and enhancement of biodiversity.

It should be highlighted that the need for the protection of the environmental multifunctionality of forests is also associated with their function as carbon storages: Forests are acknowledged as a stabilising force for the climate. In this context special attention should be paid to art. 5 of the Paris Agreement, which focusses on the importance of forests for the climate and calls for the conservation, sustainable management and enhancement of forest carbon storages.

Consequently, the protection and enhancement of the environmental multi-functionality of forests and therefore the maintenance of the forest carbon storages seems to be a crucial criterion for the assessment of the EU Law in the context of the EU 2030 Strategy regarding the climate protection, especially in view of the internal-environmental conflict in the field of forestry.

3. The establishment of the forestry sector as a carbon storage under the LULUCF Regulation and its limitations

The LULUCF Regulation implements art. 5 of the Paris Agreement at the EU level (Recital 3 of the Regulation) and aims at the enhancement of the utilization of six land categories (afforested land category, deforested land category, managed cropland category, managed cropland category, managed forest land and managed wetland category as greenhouse gases storages) as carbon storages. Noteworthy is that the LULUCF sector is considered as the key element of the 2030 Framework (Kulovesi K., Oberthür S., 2020). The category of managed forest land is of highest importance, since during the period 2000 to 2009 the removals by sinks from forests were 372 million tonnes of CO_2 equivalent per year for the Union as a whole (European Commission, 2016 and Böttcher H. et al. 2019).

The key target of the LULUCF Regulation is the compliance with the no-debit rule, according to which emissions should not exceed removals during the two commitment periods (2021-2025 and 2026-2030). It appears from the above, that the no-debit rule contributes to the forests' conservation and to the maintenance of their multiple functions. However, the accounting methods for the application of the no-debit rule raise concerns.

For the category of the managed forests, essential is the Forest Reference Level (FRL), which serves as a reference value for the application of the no-debit rule. Each Member State (MS) must document the balance of total emissions and total removals during the reference period of 2000-2009 and establish its FRS. The balance of emissions and removals during the two commitment periods are compared with the FRL: Thus, a decrease in forest sinks/in a sink compared with the reference level should be accounted for as emissions.

Consequently, however, not all emissions that exceed removals during the two commitment periods can create debits. Obvious is therefore a limitation in the effectivity of the LULUCF sector due to the incorporation of existing decreases in forest sinks in the no-debit rule.

Another point of criticism is the effect of the flexibilities, which are provided in the Regulation, on the forests. According to the managed forest-land flexibility, each member state can have a debit in the category of forests. The total amount of the flexibility for the Union is 360 million tonnes of CO_2 equivalent and is specified for each MS in Annex VII (art. 13 of the Regulation).

In conclusion, this flexibility limits the effectivity of the no-debit rule and therefore other interrelated environmental functions of forests.

4. The LULUCF Regulation as a sustainability criterion under RED II

RED II aims at the overall target of at least 32% share of energy from renewable energy sources by 2030 (art. 3 para. 1 of the Directive) and addresses the concerns raised about the intensification of the use of biomass (Saravesi A., Perugini L., 2019, Searchinger T. et al., 2018 and Nabuurs G.-J. et al., 2018) through the establishment of sustainability criteria.

A prerequisite for the sustainability of the forestry biomass, namely the biomass produced form forestry, is that the country of its origin has established national laws which ensure the application of the no-debit rule in the LULUCF sector (para. 7 of art. 29 of the Directive).

Regarding the agricultural biomass, i.e. the biomass produced from agriculture, the Directive excludes the examination of the no-debit rule.

5. Shortcomings of the existing framework

It appears from the above, that the examined sustainability criteria of the RED II aim at protecting the environmental multifunctionality of forests. However, their effectivity is limited. In view of the shortcomings of the LULUCF Regulation (FRL, flexibilities), which serves as a sustainability criterion under the RED II, it can be concluded that this Regulation cannot serve as an effective boundary to an overharvesting of the forests for the production of forestry biomass: This sustainability criterion does not necessarily lead to reductions of emissions or a balance between emissions and removals, whereas the RED II excludes the examination of the no-debit rule for the agricultural biomass.

The interlinkage between the two legislations and their shortcomings explain the controversy of the 2030 Framework as to its sustainability, whereas there is criticism also on its effectivity to reach the established targets (Böhling K., Todeschini M.F.M, 2021, Kulovesi K., Oberthür S., 2020 and Saravesi A., Perugini L., 2019). In view of the above, it is estimated, that the carbon sink in managed forests will have declined by 32% by the year 2030 (European Commission, 2016; G. Erbach, G., 2018).

6. The revision of the 2030 climate target and the proposals for the amendment of the relevant legislation.

However, the revision of the 2030 climate target, according to which the greenhouse gas emissions have to be decreased by at least 55% by 2030 compared with the 1990 levels, led to the proposals for the amendment of both legislations (European Commission, 2020; EU Commission, 2016; European Commission, 2020).

According to the proposal for the amendment of the RED II, the share of energy from renewable sources has to be increased by 38-40 %. Interestingly, one of the driving forces of the amendment was also the insufficient sustainability criteria (Proposal for a Directive amending Directive (EU) 2018/2001, Brussels, 17.07.2021, Com (2021) 557 final, 2021/2018 (COD), p. 12 and EU Commission, Communication form the Commission, EU Biodiversity Strategy for 2030, Bringing nature back into our loves, Brussels 20.05.2020, (COM(2020) 380). According to the Proposal, the existing sustainability criteria for agricultural biomass apply also to forestry biomass (including primary, highly diverse forests and peatlands).

Moreover, the Proposal for the amendment of the LULUCF Regulation introduces an essential change since it abolishes the no-debit rule and establishes the overall binding Union target of 310 million tonnes of CO2 equivalent greenhouse gas removals in the LULUCF sector for the period from 2026 to 2030.

Furthermore, the application of the managed forest land flexibility will be limited to the first commitment period. As a compensation, a new compensation mechanism (flexibility) is introduced, which extends the scope of the flexibility for managed forests to all categories for the second commitment period (art. 13 para.1 and 2 of the proposal).

7. Conclusions: The role of the EU Law in protecting the environmental multifunctionality of forests

Admittedly, both proposals can be regarded as a significant improvement with respect to the environmental multifunctionality of forests. More specifically, it is expected that the establishment of a binding target for removals in the LULUCF Regulation will contribute to the maintenance of the function of forests as carbon storages, while at the same time will help in maintaining their other interrelated environmental functions. In this respect, this change will lead to the revaluation of the LULUCF Regulation as a sustainability criterion under the RED. However, despite the improvements, the situation is not ideal, since the effectivity of this sustainability criterion remains questionable for biomass extracted outside the EU, i.e. outside the scope of the new LULUCF Proposal, where the FRL and the no-debit rule remain according to international law (Kyoto Protocol, IPCC) still applicable. Furthermore, according to the proposal for the new RED, the LULUCF-Regulation does not serve as a sustainability criterion for the agricultural biomass.

Besides, the new flexibility introduced in the LULUCF Regulation can still undermine the multiple environmental, economic, and social functions of forests. In conclusion, the protection of the multifunctionality of forests outside the EU is to a large extend dependent on the international law and on the reexamination of the no-debit rule. In view of the abolition of the no-debit rule, the EU is a pioneer in the environmental protection in the field of forestry and climate protection.

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The sustainability of the EU 2030 climate and energy framework regarding the environmental multifunctionality of forests

Dr Pantelitsa Sfiniadaki
14th International Conference on Energy and Climate Change

Objectives of the presentation:

1. Utilization of forests in the EU 2030 climate and energy framework (2030 Framework) aiming at the implementation of the International Paris Agreement (Paris, 2015) at EU level (reduction of greenhouse gas emissions by at least 40% by the year 2030 compared with the 1990 levels)

2. Sustainability of the 2030 Framework regarding forests in the light of the conflict between the use of biomass from forests and their function as carbon storages and their other (environmental) functions

Parts of the presentation

A. The principle of sustainable development as applied to forestry

B. Regulation (EU) 2018/841 on inclusion of greenhouse gas emissions and removals from land use land use change and forestry into the 2030 climate and energy framework **(LULUCF Regulation)**

Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources **(RED II)**

C. Proposals for a new LULUCF Regulation and a new RED in the context of the EU Green Deal

A. The principle of sustainable development for forestry

- International level: Rio Forest Principles (United Nations Conference on Environment and Development, 1992)

„Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations."

- European level: Forest Europe (Ministerial Conference on the Protection of forests in Europe, Helsinki, 1993)

"The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biological diversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological economic and social functions, at local, national and global levels, and that does not cause damage on other ecosystems."

Forests´ functions:

economic and employment functions (provision of raw materiels for a number of industries)

multiple environmental functions (soil stabilizasion, erosion control, biodiversity protection, water circulation, air purification, carbon storage)

• Art. 5 of the Paris Agreement:

„Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases including forests. “

B. The LULUCF Regulation

• Implements art. 5 of the Paris Agreement at the EU level

• Aims at the maintenance of six land categories (the afforested land category, the deforested land category, the managed cropland category, the managed cropland category, the managed forest land and the managed wetland category) as carbon storages

• The category of the managed forest lands is the category of highest importance

• **During the reference period (2000 to 2009) the removals by sinks from forests were 372 million tonnes of CO_2 equivalent per year for the EU**

• Target of the LULUCF Regulation

No debit rule: emissions should not exceed removals during the two commitment periods (2021-2025 and 2026-2030).

• Pros of the Regulation

-Establishment of the LULUCF sector and of the managed forest land category as carbon storages

-The no debit rule can contribute to the maintenance of forests as carbon storages and to the maintenance of their multiple functions

• **Cons of the Regulation**

- **The Forest Reference Level (FRL)** for the application of the no debit rule limits its effectivity

FRL: reference value for the application of the no-debit rule

FRL establishment: MS document the balance of emissions and removals during the reference period (2000-2009)

How it works: The balance of emissions and removals during the two commitment periods (2021-2015, 2026-2030) is compared with the FRL

A decrease in sinks during the two commitment periods compared with the FRL creates debits

Result: Incorporation of existing decreases in sinks in the climate target

- **Cons of the Regulation**

- **The Forest Reference Level (FRL)** for the application of the no debit rule limits its effectivity

FRL: reference value for the application of the no-debit rule

FRL establishment: MS document the balance of emissions and removals during the reference period (2000-2009)

How it works: The balance of emissions and removals during the two commitment periods (2021-2015, 2026-2030) is compared with the FRL

A decrease in sinks during the two commitment periods compared with the FRL creates debits

Result: Incorporation of existing decreases in sinks in the climate target

The RED II

- **Target:** 32% share of energy from renewable sources by the year 2030
- Sustainability criteria

Different sustainability criteria

for biomass from forestry (forestry biomass)

for biomass from agriculture (agricultural biomass)

- **Forestry biomass**

A. National legislation at the country of origin of biomass protecting the regeneration and the biodiveristy of forests

Cons: the effect of the sustainability criteria depend on the level of the national legislation and its effective implementation

B. National legilsation at the country of origin of biomass ensuring the application of the no debit rule

Cons: Can the no debit rule ensure the balance between the removals and emissions?

- Agricultural biomass

The application of the land sustainability criteria remains restricted to forests of a high biodiversity value

No examination of the no-debit rule

- The application of the sustainability criteria apply to biomass-based installations with a total rated thermal capacity exceeding or equal to 20 MW
- It is estimated that about 75 percent of the wood energy currently used in the EU would not need to comply with any RED II sustainability requirements.

Results

- Limited effectivity of the sustainability criteria of the RED II
- The LULUCF Regulation can not serve as an effective boundary to the RED II

However,

- At present, the carbon storage in managed forests (-373 Mt CO_2 eq. in 2010), is the main contributor to the LULUCF sinks.
- This contribution is estimated to decline by 32% by the year 2030
- Forest harvest appears to increase over time from 516 million m3 in 2005 to 565 million m3 in 2030 due to growing demand for wood, meant for material purposes and energy production

C. EU Green Deal, New Proposals

- New climate target: Greenhouse gas emissions have to be decreased by at least 55% by the year 2030 (the previous target was 40%)

A. Proposal for the amendment of the RED II (**new RED Proposal**)

- Target of a 38%-40% share of energy from renewable sources (existing target: 32%)
- Amendement of the sustainability criteria:

1. The sustainability criteria for agricultural biomass apply also to forestry biomass
2. The sustainability criteria apply to small scale biomass-based installations of a total rated capacity of 5 MW

- B. Proposal for the amendment of the LULUCF Regulation **(new LULUCF Proposal)**

1. Abolition of the no-debit rule

Overall binding Union target of greenhouse gas removals in the LULUCF sector of 310 million tonnes of CO2 equivalent

2. Flexibilities

- The managed forest land flexibility is restricted to the first commitment period (2021-2025)
- New flexibility for all land categories for the second commitment period (2026-2030)

(the access to the flexibility mechanism, for the period 2026-2030, is set at half of the maximum amount set out in Annex VII, i.e. 178 million tonnes of CO2 equivalent.)

Conclusion

- Important Improvements (abolition of the no-debit rule, application of the sustainability criteria to small scale installations)
- Shortcommings:

1. The restriction of the land sustainability criteria of the new RED Proposal to forests of a high biodiversity value
2. The dependance of the effect of the sustainability criteria on the level of the national legislation (in particular for biomass extracted outside the EU)
3. The no debit rule remains applicable to the forestry biomass extracted outside the EU (Kyoto Protocol, IPCC)
4. The flexibilities of the new LULUCF proposal, despite the improvements, can substitute the function of forests as carbon storages and undermine their other (environmental) functions

Building model-based optimisation of the HVAC control utilizing data from the EPC process – first results from the EPC4SES project

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Abstract

Model Predictive Control (MPC) is addressing regulation of complex systems with time delays and so-called disturbance for the thermal equilibrium (Drgona, et al., 2020). Based on building data from the Energy Performance Certification (EPC), measured status data if needed and prognosed weather and CO_2-intensity data, EPC4SES aims to deploy a software model to determine the control value for the next control step, optimising operation for the whole forecast period staying within the comfort limits.

The amount of data from the EPC process depends on the thermal building model, we compare various approaches in terms of deviations to a fully-fledged model. This paper compares the MPC approach for heating control of buildings fed from a district heating network to the actual control scheme for the Berlin pilot. We are judging Monte Carlo Optimization, and empirical algorithms which might allow low CPU-cost and high control quality and use an algorithm stemming from predictive optimisation of serial hybrid power trains (Cebrat G., 2015).

An extended "grey box" approach using a R_mC_n model for the building, discrete simulation of the floor and solar gain calculation are used to calculate the comfort for the inhabitants. The optimization target is a single value either taking the CO_{2eq} of the district heating, which is depending on the actual amount of renewable energy used and fixing the allowable comfort band or combining CO_{2eq} with the deviation from the optimal comfort, weighted higher. Variation of charging of a central solar thermal buffer and adapting the domestic hot water tank heating is adding active elements and is increasing the reduction of CO_2 but also adding complexity to the optimisation.

The paper also describes the extraction of the building model data from the XML transfer file for the asset-based energy performance certification, discusses the practical implementation for Pilots of the EPC4SES project.

Keywords: MPC, digital twins, building energy efficiency, EPC, Heating Ventilation Air Condition (HVAC).

1. Project description

The ERANET RegSys project EPC4SES has 6 partners from 4 countries and is funded by the governments of the partner countries who also receive funding from the EU HORIZON 2020 program. The management of the funds lie with PTJ for Germany and FFG in Austria.

The project which is having separated funding contracts by the national funding entities and thus started at 9/2019 to 5/2020, runs until mid-2022. More actual info is provided by the social media channels like https://twitter.com/SmartenergN or https://www.linkedin.com/showcase/epc4ses

The project contributes to the digitalisation of energy systems exploiting bidirectional information exchange in order to allow MPC on both sides – on the side of energy supply and domestic energy usage to jointly allow for decarbonisation using fluctuating renewable energy sources.

a. Pilot Description

Six partners from four country collaborate and test the approach in four pilots. One of the pilots covered here is in Berlin where a small district heating subnetwork is supplying heat to connected single homes, also including domestic hot water production. Other pilots also fall either into this category or have all electric heating and cooling, where the approach is transferred to the electric grid.

b. Status Quo Existing Control Scheme

In the current setting the room temperature is measured and forwarded to the DH Controller (DHC). The DHC also heats the DHW tank in case the water temperature drops under a certain level. Because of user complaints and limited DHW storage tank size the heating is quasi permanent.

Thus, the system is operating the thermal network over a very long period of time and thus creating huge losses.

c. Digitalisation of the energy system

The paradigm of the project is to exchange information between energy supplier and energy users, in order to allow increase of renewable energy utilisation. Figure 1 shows the bidirectional information flow.

This communication method employing the interface of the smart meter for a Controllable Local System (CLS) (PPC-AG, 2020) is not ready for application since the responsible body BSI in Germany has not yet issued the related standard for the communication interface TR-03109-5 (BSI Referat DI21, 2021), and may also be used for district heating if smart meters are installed. For Austria no such motion is visible, so the standard internet would be proposes using trusted platform modules. Also, for Germany the approach might be overshooting since there is the need of contracting with a smart meter gateway administrator.

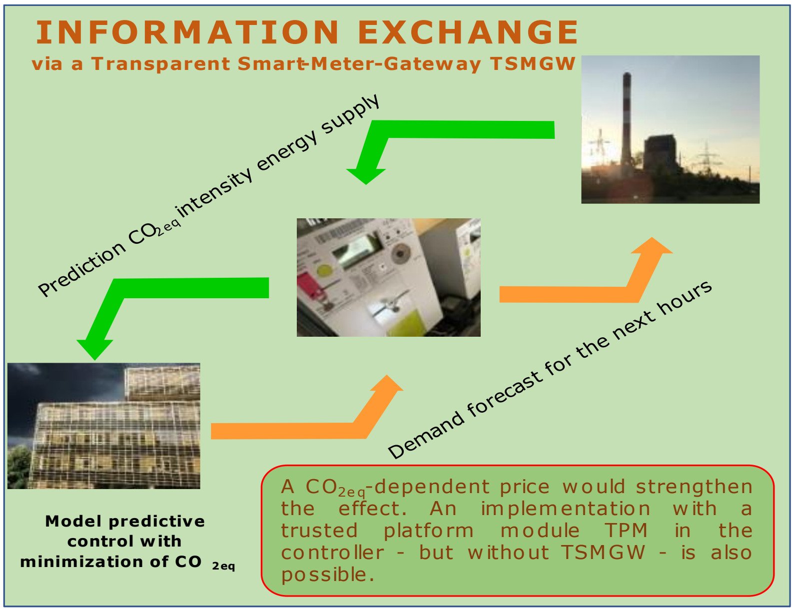

Figure 1: Information exchange via Transparent Smart Meter Gateway TSMGW.

Also, it has to be noted that we deviate from the CLS paradigm, introducing collaborating self-controlled local system, where the motivation comes from the wish to improve the CO_2 balance for an environmental statement or to save money with CO_2-based energy taxation.

d. Implementation of the MPC Model Predictive Control

For the interlinked smart energy system, the controlled variable comprises the room temperature of the model either in a single or multiple room arrangement and the DHW tank temperature on the building level and the buffer tank temperature on the network level. As such we try to include as much active components able to reduce CO_2.and other GHG, subsumed under CO_{2eq}.

The cost function is the total of the CO_{2eq}-emission as drawn from the CO_{2eq}-forecast for the MPC and the load profile resulting from the controlled variable.

e. Selection of MPC variant

The first phase of the work has seen a search for the best suited approach based on reasoning. The extrapolation using correlation with historical data was quickly discarded, also because the proposal requires MPC, and decided to use weather forecast for a period of time to determine an optimal load curve based on simulation of the future.

Figure 22 shows the time axis and locates the data to be used as input and of the output, on the one hand consisting of a 36h load forecast and on the other hand provided for the Heating Ventilation Air Condition (HVAC) control.

The weather forecast was bought from a professional service and is including global and direct solar irradiation. Figure 3 shows how the forecast changes with progressing time. On the other hand, data in the provided data stream covering past time is also changing because it is corrected with measurement data.

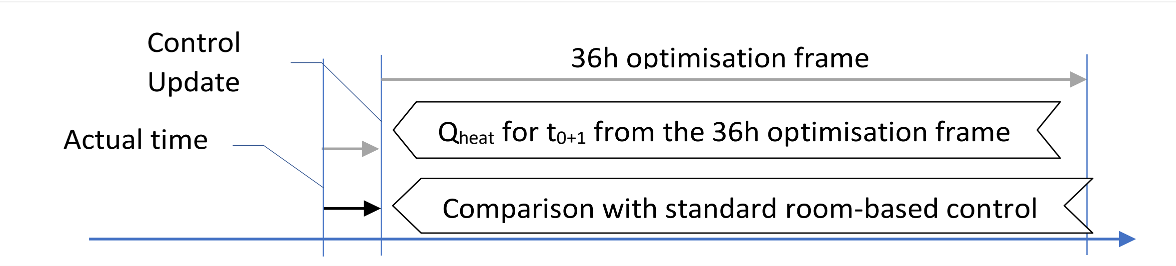

Figure 2: Time axis for the simulation using MPC based optimisation.

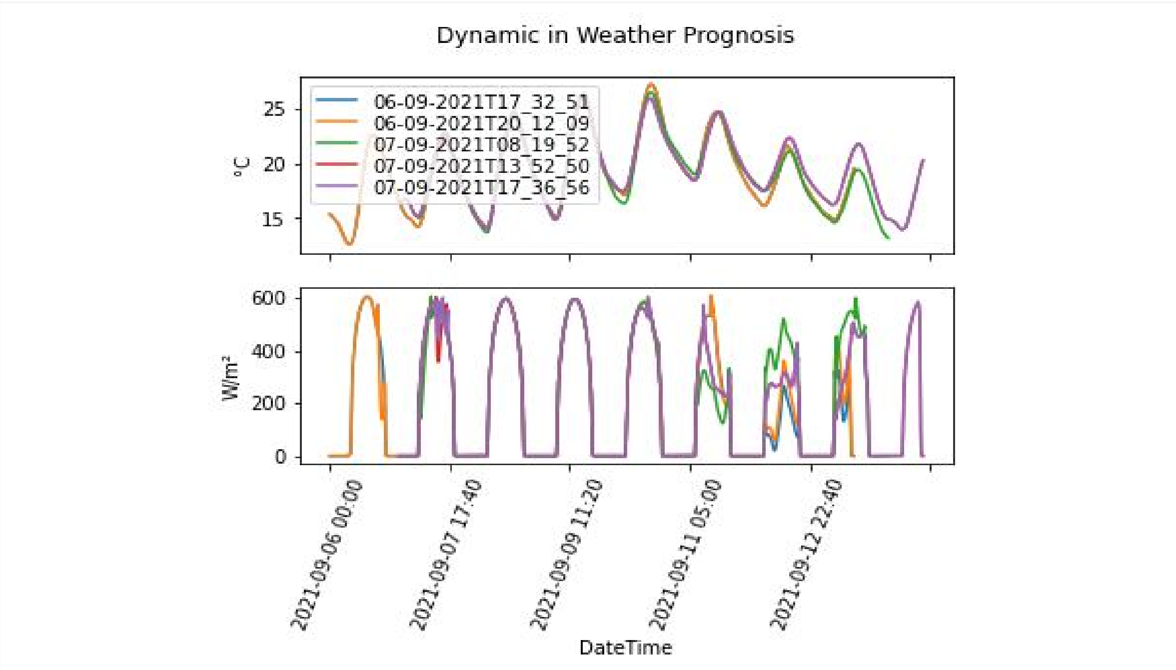

Figure 3: Dynamic in weather forecast (Temperature and solar irradiation) data source meteoblue.ch

So, this weather API could be exploited for calculating both, the forecast and the actual timestep for MPC and the base variant. Of course, since it takes time before the measurements are known the evaluation of the MPC via simulation using measured data is some hours behind actual time.

There was pre-existing experience with Monte Carlo (MC) Optimisation (Cebrat, 2015) and this would also allow to separate the calculation from the optimisation of factors. This would also allow to save CPU time in order to be able to have less performant and less costly energy management devices and to save electric energy. The variants investigated for MPC are characterized in Table 1.

The need to reduce the time step to less than 5 minutes - especially for linked more dimensional approaches - then killed the MC option, because the number of variants would have been too high if a high resolution of the load curve in the time domain is needed to avoid step answers of the system. But the outcome might be less optimal using algorithms, so the decision is taken under the reservation that the savings of the empirical approach are significant. Previous experience with MC optimisation has shown that the expected gain is small having many iterations and CPU load might be reduced if parameters linked to the influence factors are varied (Cebrat, 2015). So, the algorithm solution can be combined with MC based optimisation if there is such influence factor. The MC-Optimisation was developed with random set temperatures over the control period. This was compared to an empiric approach correlating set temperature with the prognosed CO_2-intensity. In order to have the same average temperature with the variants, the set temperature was corrected while modulating it.

The fuzzy approach was discarded since after investigating fuzzy rules, the next step with direct calculation of a solution using algorithms was successful and the search for solutions was requiring only few iterations. This includes the following active elements targeting heat consumption in times of low carbon intensity in the DH network. A buffer tank in the DH-network applying the same MPC principle and profiting from the lead forecast using the RC model and the weather prognosis also allowed to shift usage of that solar gain over a longer period of time. Table 2 presents the active approaches in MPC.

Table 1: Comparison of computational MPC approaches.

Criterium	**Monte Carlo Optimisation**	**Fuzzy (combined with NN)**	**Algorithms**
Resolution of the solution for the load curve	Low to medium	High	high
CPU load	Very high	Low (since non-iterative)	Average (if iterative)
Stability outside the learned area	n.a.	n.a.	With normalisation
Self-Explaining	no	Yes, based on the rules	Yes, but to a lesser extent
Distance to optimum	good	good	To be researched
Ability to include boundary conditions	possible	complicated	Possible

Table 2: Target for the model-based optimisation of the control.

Target	**Implementation**	**Comment**
Heat DHW tank in times of low CO_{2eq}	Sweeping line with CO_2 limit below which heating takes place	Circulation losses bring the solution to sub optimal values
Heat floor in times of low CO_{2eq}	Adapt the target comfort temperature in the comfort band and calculate the heating demand	Heating demand is then calculated iteratively from the coupled floor-room model
Decrease heating of the floor before solar gain through transparent openings is expected	Reduce the target comfort temperature the smaller the timespan to the next solar gain is	Factor from the amount of solar gain

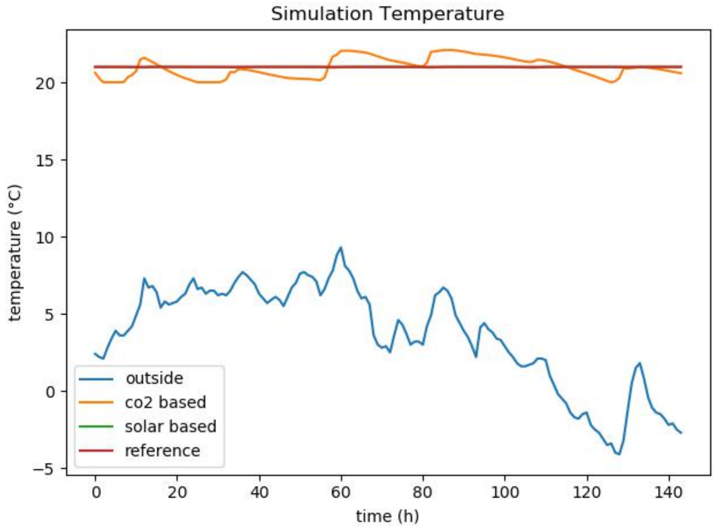

Figure 4: Modulation of the Comfort Temperature.

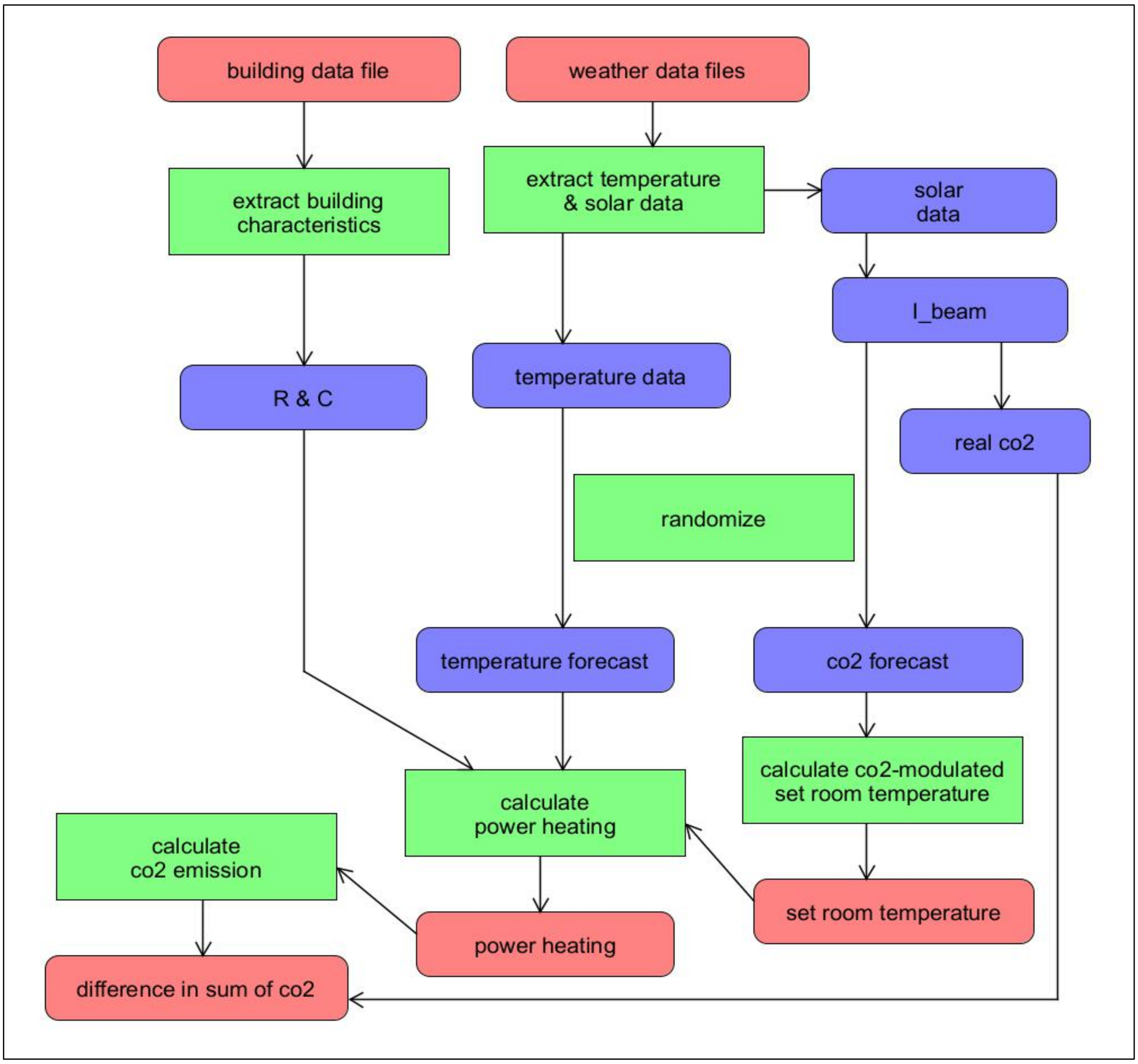

Figure 5: Flow Diagram for the MPC.

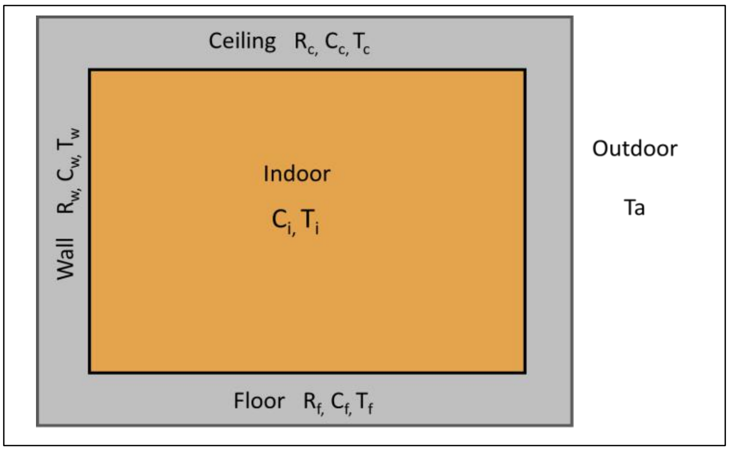

Figure 6: Room parameters.

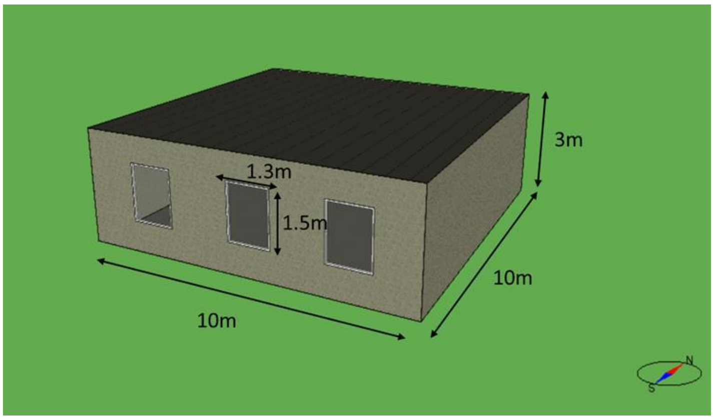

Figure 7: A single zone building model in IDA ICE.

Both influences on the set comfort temperature were combined. For the DHW a very important factor was the circulation loss. With active circulation pump the content of the water tank was cooled down swiftly.

The actors play a very important role in MPC. The set temperature was replaced by a varying comfort temperature consisting of room (air) and floor temperature. It was ensured that the average value is the same, comparing to the set-temperature in the base variant.

f. Implementation

Figure 5 shows the basic simulation tasks, the complexity is higher since hydraulic storage was also taken into MPC.

g. Selection of Building Model

One of the major components in model predictive control is a mathematical model of the system. In building energy management application, the model takes inputs of current state measurements and weather forecast to predict the future behaviour of the building.

Detailed analysis of heat transfer between different zones in a building is not the major concern of this task. As the application of model predictive control is targeted at district energy system, zoning of a building will be reduced as simple as possible in modelling while the accuracy for energy demand prediction is still maintained.

Thermal behaviour of a building can be represented by a lumped parameter RC-network model. It is a model reduction method analysing building heat transfer based on electrical analogy. The purpose of the method is to represent an intrinsically high-order system by a low-order model in order to achieve low computational effort while the dominant dynamics of the original high-order system are preserved as much as possible (Gouda, Danaher, & Underwood, 2002). In this section, the development and selection of RC building model is elaborated.

Heat transfer between buildings and surroundings is classified into 3 mechanisms: conduction through building envelope; convection through air movement through forced and natural ventilation; radiation through incident solar radiation through glazings (solar gain).

The following assumptions are used for formulating simplified RC models:

- Effect of each wall surface are uniform;
- Air in the zone is well mixed;
- Longwave radiative heat exchange between internal surfaces is neglected;
- Radiative heat exchange is dominated by solar radiation through windows;
- Direct solar radiation is absorbed by floor and diffuse solar radiation is uniformly distributed in room.

Simplified model structures for a single zone building are developed. Each consists of 2R1C opaque building component. The models were programmed in MATLAB environment. Validation of the models was performed by comparing the results of the simplified model and those of equivalent IDA ICE models under nine different test cases. Figure 8 depicts an approach with a single zone model built on 2R1C opaque building component.

Wall, ceiling and floor are represented by a 2R1C model respectively. Heat flow from outdoor to indoor through building envelope is expressed as a combination of convective and conductive heat flow.

T_a: ambient temperature

T_w: wall temperature

$R_{i\ (i=1,2,3)}$: thermal resistance of wall layer

R_{si} : thermal resistance of internal surface

R_{se} : thermal resistance of external surface

$C_{i\ (i=1,2,3)}$: thermal capacitance of wall layer

The energy balance equation for 2R1C model can be written as:

$$C_w \frac{dT_w}{dt} = \frac{1}{R_{aw}}(T_a - T_w) + \frac{1}{R_{wi}}(T_i - T_w)$$

R_{aw}, R_{wi} and C_w are calculated as follows:

$$R_{aw} = R_{se} + \frac{R_1 + R_2 + R_3}{2}$$

$$R_{wi} = R_{si} + \frac{R_1 + R_2 + R_3}{2}$$

$$C_w = C_1 + C_2 + C_3$$

Where R_{se}=0.04 and R_{si}=0.13 according to Austrian Standards EN ISO 6946.

The end use of the RC model is to create digital twins of buildings by utilising EPC XML data. Since the Austrian EPC XML file provides an aggregated U-value of a multi-layer building component only, R-value of every single layer cannot be calculated in a straightforward way from the data source. This constraint is considered in the development of RC model. Therefore, in the calculation of equivalent R-values (R_{aw}, R_{wi}) for RC model, R-value of each material layer (R_1, R_2, R_3) is first summed up to get a total R-value, which reproduces the conditions in end application. Definitions of the nine test cases are listed in Table 3.

Case 1-3 are actually not realistic but they are useful to study how the building responses to outdoor temperature change, solar radiation input and space heating input. Case 4-9 simulates an occupied family house. Case 7-9 are similar to case 4-6 but the thermal properties used in these three cases were estimated based on the building information available in Austrian EPC XML.

The simulation period was 48 hours. Prediction accuracy of the RC models was measured by the mean absolute percentage error (MAPE) method which compared the indoor temperature of a zone and required heating power in time-series calculated by the RC models and those from equivalent IDA ICE models.

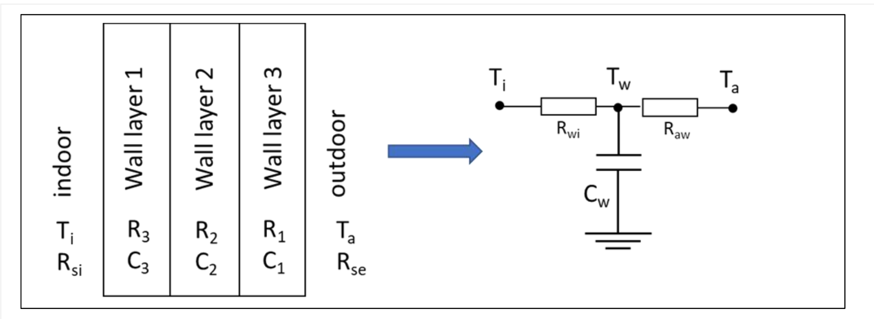

Figure 8: Conversion of a multi-layer wall to a 2R1C model.

Table 3: Description of test case 1-9.

Test case	xRyC	Construction type	Solar radiation	Heating equipment	Internal loads	Determination of model parameter
1	2R1C	heavy	×	×	×	based on exact thermal properties value
2	2R1C	heavy	✓	×	×	based on exact thermal properties value
3	2R1C	heavy	✓	✓ Set point=22°C	×	based on exact thermal properties value
4	2R1C	heavy	✓	✓ Set point=22°C	100W (between 17h-7h next day) 0W (7h-17h)	based on exact thermal properties value
5	2R1C	medium-heavy	✓	✓ Set point=22°C	100W (between 17h-7h next day) 0W (7h-17h)	based on exact thermal properties value
6	2R1C	light	✓	✓ Set point=22°C	100W (between 17h-7h next day) 0W (7h-17h)	based on exact thermal properties value
7	2R1C	heavy	✓	✓ Set point=22°C	100W (between 17h-7h next day) 0W (7h-17h)	based on thermal properties derived from EPC data
8	2R1C	medium heavy	✓	✓ Set point =22°C	100W (between 17h-7h next day) 0W (7h-17h)	based on thermal properties derived from EPC data
9	2R1C	light	✓	✓ Set point=22°C	100W (between 17h-7h next day) 0W (7h-17h)	based on thermal properties derived from EPC data

Table 4: Mean absolute percentage error of indoor temperature and required heating power for case 7-9.

Case	MAPE (Indoor air temperature)	MAPE (Required heating power)	MAPE (Total required heating power in 48 hours)
7	4.12%	48.81%	42.96%
8	2.55%	21.16%	-18.87%
9	4.88%	104%	98.73%

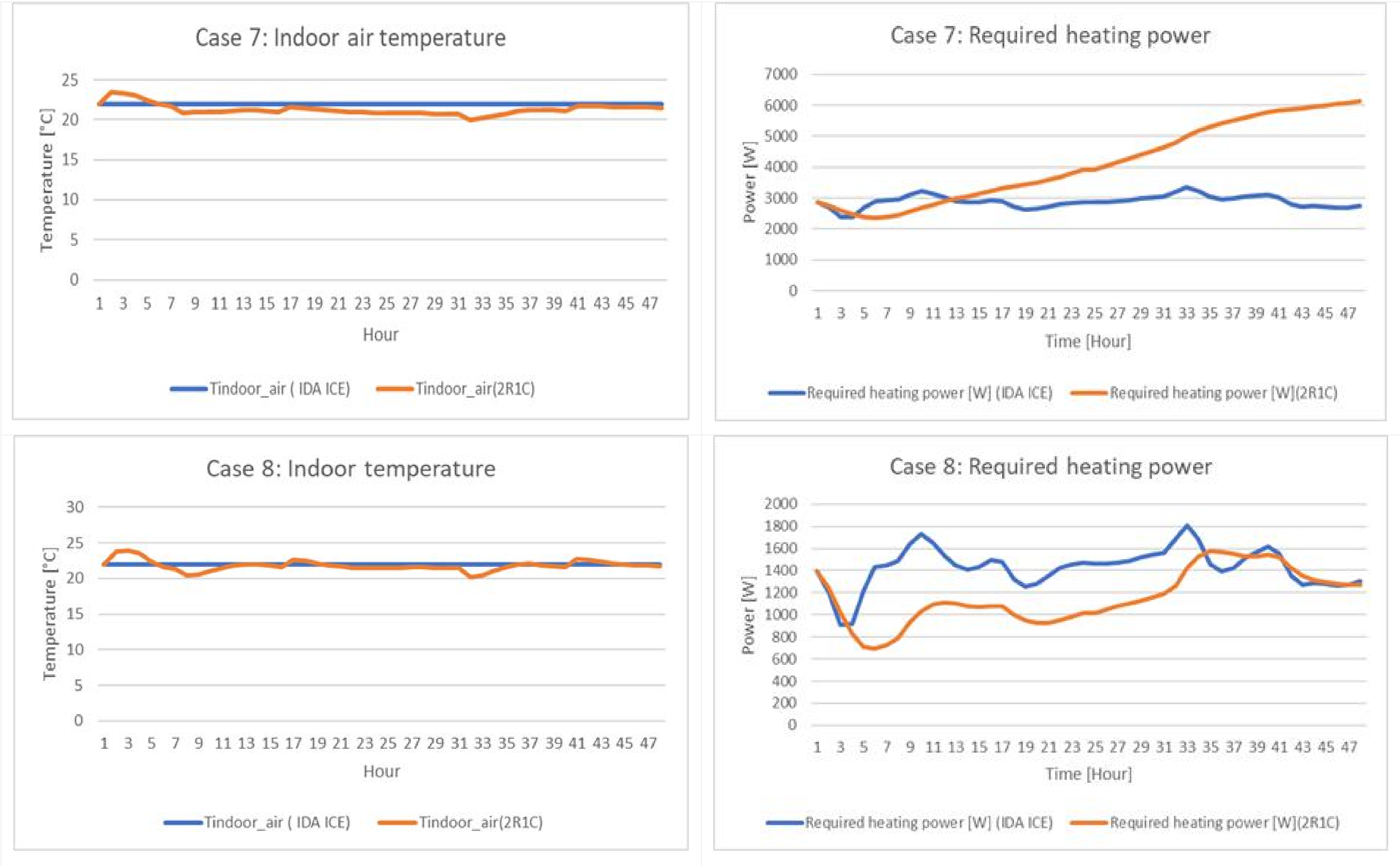

Figure 9: Indoor temperature and required heating power in time-series for case 7-9.

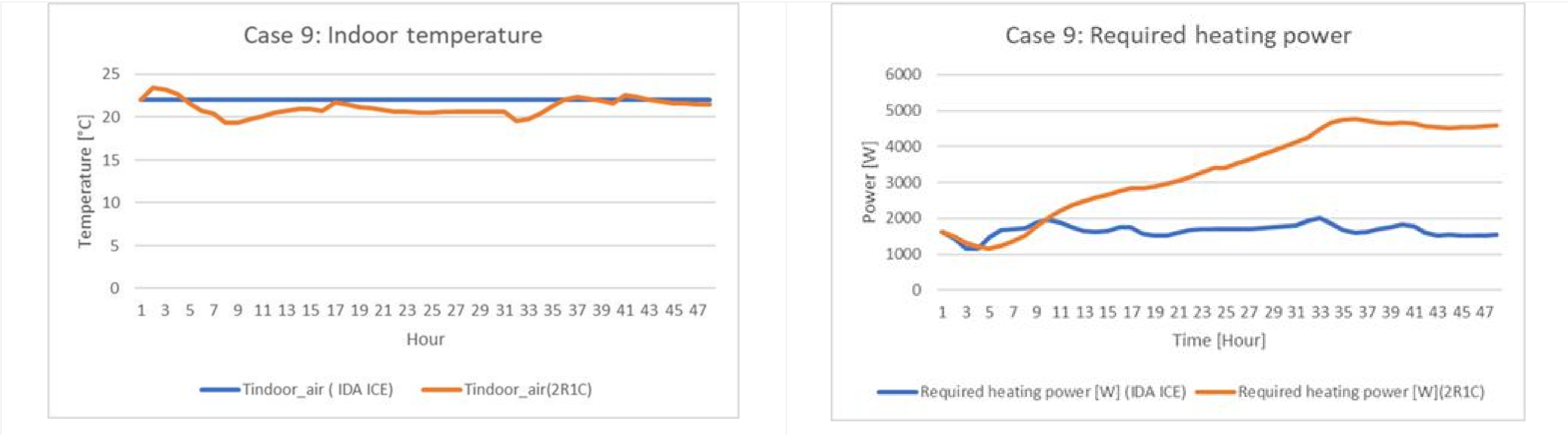

Figure 10: Indoor temperature and required heating power in time-series for case 7-9.

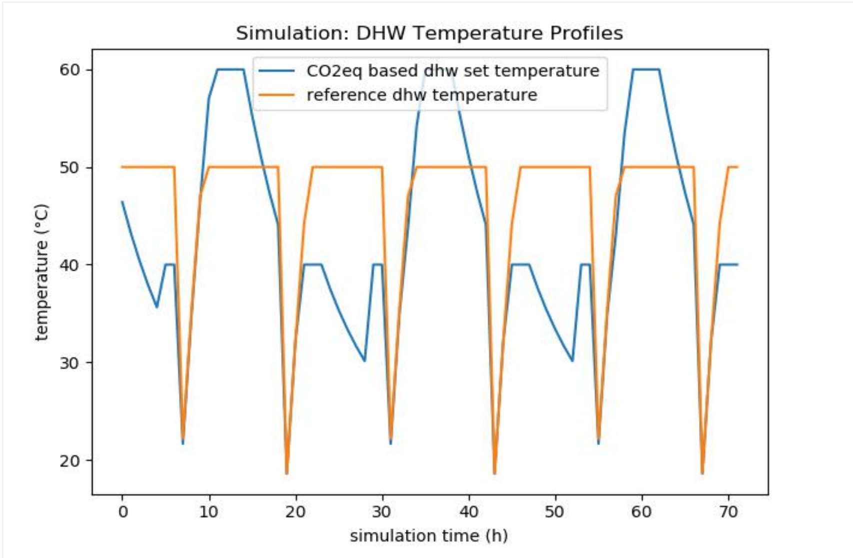

Figure 11: Modulation of the Building Set Comfort Temperature.

In case 4-9, initial values of effective thermal resistance for the single zone building model were calculated according to Ohm's law and those of effective thermal capacitance were the sum of all material layers and components. Since the focus of the project is to build a digital building model based on EPC XML data, only case 7-9 were further analysed in this paper.

Results shown in Table 6 and Figure 8 demonstrated that the EPC-based RC model in this stage performs moderately for medium-heavy building but does not perform satisfactorily for heavy and light weight building in a 48-hour horizon. The relationship between parameters of thermal properties derived from EPC XML data and effective thermal properties of a building will be further explored.

h. MPC using a simple RC model

The developments of the RC model specification and of the MPC approach went in parallel so the chapters used their own models and tools. Here a 2C first order one room building model (PTC, 2013) was used which is separating the heated floor from the room, since it may be used for thermal activation and also receiving and storing solar irradiation. Unfortunately, in the XML files so far, no such information can be found.

Figure 9 shows MPC Prognosis, evaluation and PID-regulation calculated with 5-min intervals, data given in 1-hour intervals, simulation over 3 days with a comparison of

(1) measured outside temperature,
(2) MPC with CO_{2eq} based calculated comfort set building temperature,
(3) MPC with solar based calculated comfort set building temperature and
(4) MPC with constant comfort set temperature (= reference) and
(5) PID regulator with no prognosis calculation;

Figure 10 shows MPC Prognosis, evaluation and PID-regulation calculated with 5-min intervals, data given in 1-hour intervals, simulation over 3 days with

(1) MPC with CO_{2eq} based sweeping line and
(2) reference with constant DHW temperature;

2. Findings from a multi-room simulation with regards to temperature distribution in the building

In parallel to the works in Austria on assessing the RC models and developing active MPC components, a simple multi room simulation was developed in Python with the data of the Berlin building and compared to a RC approach, which also had terms for internal and solar heat gains and air infiltration losses.

Figure 11 shows results from a multiple reem RC approach. Based on test runs, it might be stated that the more uniform the building usage is, the better the one room RC approach fits. Especially with vertical temperature differences in rooms, a more complex simulation is needed. In case of open settings and buoyancy in staircases directly connected to rooms, we would see that a one room model is applicable.

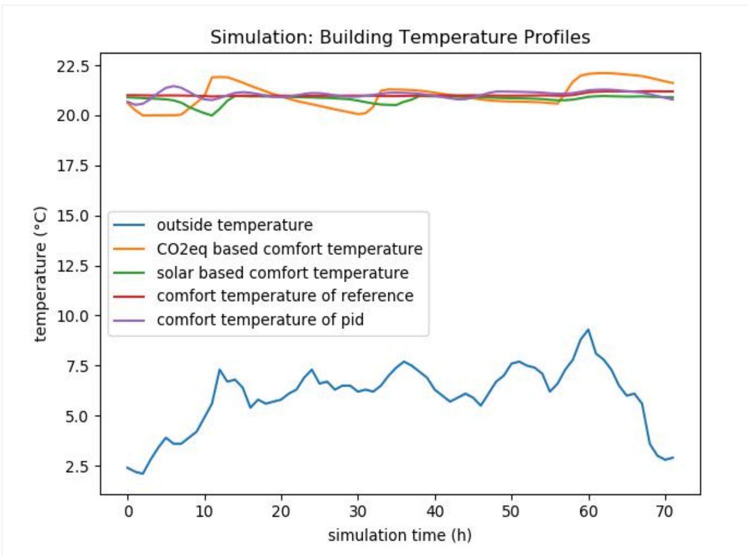

Figure 12: Modulation of DHW Set Temperature.

Non insulated outside oriented building elements shall be modelled in more detail, as well as the storage of solar gains in ceilings/floor constructions. For the pilot building in Berlin a massive floor for floor heating is certainly helpful for storing solar gains and should be modelled separately.

The solar gain through windows is to be accounted for, gain from solar irradiation on insulated enclosures depends on the effective u-value. Especially with heat bridges and high absorptance factors of the exterior, significant solar gains are expected in summer, which is relevant for the cooling load.

Figure 13 shows the difference in the heating energy demand for synthetical weather conditions. The longer the room with the lower start temperature has to adapt, the smaller the difference between the heat demand of the one room and multi room approach gets. The stability of the result depends much on the PID controller setting used in the calculation. This also influences the CPU cost, since relatively small simulation timesteps are to be used. This favours empirical MPC approaches over MC-based approaches. For the multi-room MPC, the optimisation was only possible with a few permutations per room for time difference and amplitude of the modulated load curve.

The multi room simulation finally was also used for testing a multiple room MPC. Figure 14 compares the output of both approaches. Since the permutations for multiply rooms create a huge number of cases to be calculated the granularity had to be extremely high, and it is not surprising the results were less favourable, even the time demand was 600 times higher for the multi room MPC (non-threaded).

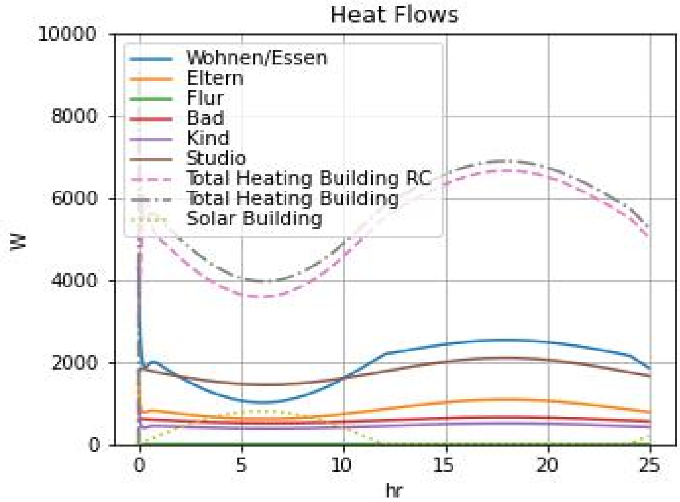

Figure 13: Dynamic Multi-Room Simulation with uniform air layers compared to on room model.

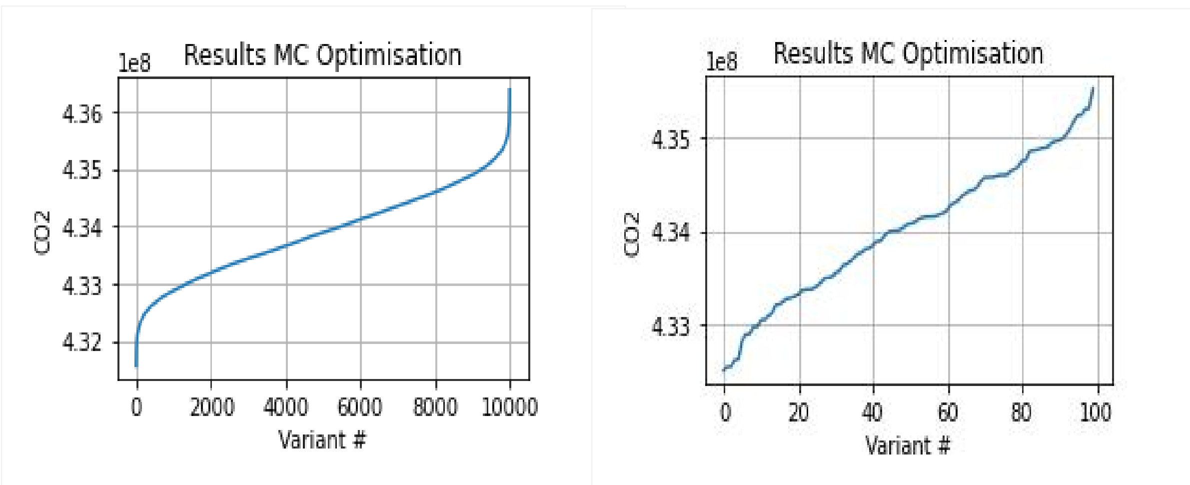

Figure 14: Comparing single room MPC with multiple room MPC with uniform temperature.

3. Data sources, extraction from XML

The core methodology to be employed in the project is to extract information from XML data produced for uploading to EPC register data bases /controlling bodies. A parser is exploiting XML files containing EPC data in Austria and Germany. In both schemes there are deficiencies to be able to have optimal dynamic building models. In Austria the orientation of the windows is lacking and no info given about the weight/type of floors/ceilings.

The definition of the scheme is negotiated by the participating federal governments and may differ from federal stat to federal state in Austria. For Germany, there is only one XML control scheme (DIBt, 2021), and it is changing less frequently. It also serves the purpose of printing EPC, while in Austria the XML only serves for quality control by the official bodies, which also check the eligibility since in some federate states EPC is mandatory when building owners apply for funding.

```xml
<xs:element name="bauteile" minOccurs="0">
    <xs:complexType>
        <xs:sequence>
            <xs:element name="bauteil" minOccurs="0" maxOccurs="unbounded">
                <xs:complexType>
                    <xs:sequence>
                        <xs:element name="bezeichnung" type="xs:string"/>
                        <xs:element name="flaeche" type="xs:double"/>
                        <xs:element name="u-wert" type="xs:double"/>
                        <xs:element name="bauteilgewicht" type="xs:double"/>
                        <xs:element name="korr-faktor" type="xs:double"/>
                    </xs:sequence>
                </xs:complexType>
            </xs:element>
        </xs:sequence>
    </xs:complexType>
</xs:element>
```

Figure 15: Extract XML Scheme ZEUS Austria.

```xml
<xs:complexType name="Bauteil-Opak-Daten">
  <xs:annotation>...</xs:annotation>
  <xs:sequence>
    <xs:element name="Flaechenbezeich" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="Flaeche" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="U-Wert" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="Ausrichtung" type="n1:Ausrichtung-enum" minOccurs="1" maxOccurs="1"/>
    <xs:element name="grenztAn" type="n1:Medium-enum" minOccurs="1" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="Bauteil-Transparent-Daten">
  <xs:annotation>...</xs:annotation>
  <xs:sequence>
    <xs:element name="Flaechenbezeich" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="Flaeche" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="U-Wert" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="g-Wert" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="Ausrichtung" type="n1:Ausrichtung-enum" minOccurs="1" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="Bauteil-Dach-Daten">
  <xs:annotation>...</xs:annotation>
  <xs:sequence>
    <xs:element name="Flaechenbezeich" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="Flaeche" minOccurs="1" maxOccurs="1">...</xs:element>
    <xs:element name="U-Wert" minOccurs="1" maxOccurs="1">...</xs:element>
  </xs:sequence>
</xs:complexType>
```

Figure 16: XSD for the German Transfer Format (2016 Version) for uploading to the QA body.

The python code for the simulation allowed to read XML and to extract the data. The utilised two mass model for the Berlin building required further data for the heat capacity of the floor and also for the heat capacity of the walls, the aperture for windows which might be depending on the g-Value as well as the heat capacity of the walls might depend on the U-value. Unfortunately, such correlation might only be used for one type of material (bricks, porous concrete…), so we propose to have such data in the EPC transfer XML. In Austrian regions applying ZEUS we see at least a value for the specific weight in kg/m². Also, the artificial horizon and eventual shading can be added to get more precises simulation results. For the artificial horizon GIS data might be exploited, in Carinthia such a service is already existing (Carinthia, 2021).

The validation of the extraction from different XML formats has to be expanded-Germany and Austria have a good basis. In Austria the slight changes in the XML DTD of the ZEUS System do not hinder much, but some federal states did not join the ZEUS system and deliver only few data. On a European level a joint minimum data model would be helpful allowing to set up digital twins of buildings.

4. Discussion of the implementation of a MPC scheme in practice

The implementation of the MPC scheme with the pilots revealed to mayor points.

1. Currently, no suitable affordable weather forecast is available for single family homes which is including solar irradiation. For free services covering only temperature during the operation, the API are not sufficiently persistent. Even if the implementation on a single board computer would load the code over the network, this poses a thread for the persistence of the services. Therefore, it is recommended that local data retailer care about the quality and uptime of the weather forecast services. Those might be energy agencies then held responsible to offer tangible services for energy saving. This of course should also comprise energy policy services like calculating potential savings for different renovations paths, utilising data from the EPC issuing. Such tasks mandated by law will also increase pressure that the federal government act on improving the XML scheme for storing EPC register data, so high fidelity digital twins may be derived automatically.
2. The main savings of a MPC scheme results from the possibility to control hydraulic storage, since the temperature amplitude might be higher than for walls and floors where comfort parameters restrict the amplitude. The thermal activation of heavy structures for exploiting MPC fully shall be mandatory for new buildings, and be part of the EPC assessment for buildings with constant use over the day. However massive heated floors can be amending with thermal activation.
3. Acceptance of MPC in the district heating network controlling the solar storage needs acceptance of communicating forecasted usage profiles for buildings. In multi-family homes aggregation of the forecasts might be implemented. Also overriding the temperature setting by users will reduce the savings, thus some bonus shall be offered by energy suppliers for keeping the optimal load curves. The more randomly the usage characteristics is, the more difficult to achieve savings.

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Cooling water flow rate impact on water vapor condensation from flue gas in a vertical tube water injection

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Abstract

During the last decades, the energy policy of most countries has been focused on the increase of energy efficiency, the reduction of greenhouse gas emissions and the use of renewable energy sources. This orientation has been caused by the climate change, the rise of fuel prices and other factors. Waste heat recovery from flue gas based on water vapor condensation is an important issue as waste heat recovery significantly increases the efficiency of thermal power units and other industrial processes. Heat recovery efficiency is controlled by using condensing heat exchangers. Although the main principles of their design are known rather well, however the investigations of the local characteristics necessary for the optimization of this type of equipment are very limited. In this work, the investigations were performed of local water vapor condensation heat transfer from biofuel flue gas in a long vertical tube as the main component of the condensing heat exchanger. The main focus was paid on the impact of cooling water flow rate in the case of water injection into the flue gas flow. The results showed that the cooling water mass flow rate is an important factor defining water vapor local condensation heat transfer as the change of cooling water flow rate drastically changes the distribution of total Nusselt number along the tube. It was also determined that at higher flue gas inlet temperatures, the effect of cooling water flow rate on the total Nusselt number is also stronger.

Keywords: Condensation, water injection, local total heat transfer, vertical tube, cooling water flow rate.

1. Introduction

Water vapor condensation phenomenon is important in many industrial applications such as chemical thermal, nuclear, and others. To increase the efficiency of thermal power and boiler stations, they are equipped with condensing heat exchangers (economizers). As the flue gas leaving the boiler are still of high temperature and humidity, especially when incinerating biofuel, there is a possibility to gain additional heat and increase the efficiency of the station by condensing water vapor from the flue gas. In condensing heat exchangers, flue gas starts to cool down and, when the dew point is reached, water vapor from flue gas starts to condensate. The condensation process generates additional amount of heat, which is usually used to heat the return water from consumers. Besides, when the condensate film is flowing down the condenser tubes, it precipitates various solid particles from the flue gas, which are the most significant source of environmental pollution, especially when incinerating biofuels

(Kasurinen S. et al., 2015; Institute for process and particle engineering, 2011).

Although the efficiency of the boilers is usually less than 100 %, but when the boilers are equipped together with condensing heat exchangers, the efficiency of the boilers can reach almost 100 % as condensing heat exchangers enable from the same amount of burned fuel to get additional amount of heat (Che D. et al., 2005; Satyavada H., Baldi S., 2016).

Despite the fact that the main principles for designing of such type of heat exchangers are known rather well, however the knowledge of the processes taking place in the condensing heat exchangers and the peculiarities of these processes in case of flue gas are rather limited.

The investigations of condensation heat transfer with the steam and non-condensable gas mass fraction from 0 % to 10 % in a vertical tube, which active length of condensation was x/d ≈ 35, demonstrated that condensation heat transfer decreases with the increase of the non-condensable gas fraction. The analysis also showed that in case of pressure decrease in the system, the obtained heat due to vapor condensation also decreases. The calculated average condensation heat transfer coefficient during various experimental conditions in the case with pure vapor (system pressure and inlet non-condensable gas mass fraction) was about 7 $kW/m^2 \cdot K$, but when the non-condensable mass fraction was increased to about 5%, the average condensation heat transfer coefficient decreased almost two times – to about 4 $kW/m^2 \cdot K$. The heat gained due to condensation was 3.5 KW and 2 kW in case of pure vapor and vapor with non-condensable mass fraction was of about 5%, respectively (Oh S., Revankar S.T., 2006).

Local heat transfer of pure steam and steam-nitrogen mixture in the vertical tube was investigated by (Lee K.Y., Kim M.H., 2008). The investigations were performed in a rather long vertical test section (x/d ≈ 230) with the measurements of the cooling water temperature, steam temperature in the centre of the tube and tube wall temperature along the test section. The steam and the cooling water were supplied in counter-current configuration. When pure steam was supplied to the test section, the bulk steam temperature was constant almost till the middle of the condenser tube, which was up to x/d ≈ 110, and this indicated that condensation is taking place in that part of the test section. The bulk steam temperature till that point was constant. When x/d was in the range from ≈110 to 160, there was observed a sudden decrease in the bulk temperature. From x/d ≈ 160 till the end of the test section, the bulk temperature was almost constant. The character of the cooling water temperature was not so evidently expressed as that of the bulk steam temperature. The obtained character of the water temperature clearly indicated when the water was gaining heat due to steam condensation. With the increase in non-condensable gas mass fraction the drop of the steam temperature measured in the centre of the tube was not so evidently expressed as in the case with pure steam. The analysis of the local heat transfer showed that the increase in the non-condensable gas mass fraction significantly decreased the local heat transfer. However, this was true till x/d ≈ 70 while further from that point the change of non-condensable gas mass fraction from 3% till 30% practically had no influence on heat transfer.

The results presented in papers (Oh S., Revankar S.T., 2006; Lee K.Y., Kim M.H., 2008) generally reflect the main aspects occurring in vertical tubes in case of pure steam or steam condensation with small amount of non-condensable gases. The main conclusions done in these works are that in case of pure steam the condensation occurs almost in the initial part of the experimental section and this results in very high heat and mass transfer rates.

So, the review of publications shows that there are many experimental and theoretical studies related to pure water vapor condensation in tubes with high condensable gas – water vapor content (90-100%, by volume) and small amount of non-condensable gases. When incinerating biofuel or other fuels, the flue gas contains a relatively small amount (≈ 5-20 % vol.) of water vapor and the remaining portion – the portion of non-condensable gases is high.

The air-vapor mixture was used for the investigation of heat and mass transfer in a vertical relatively short tube of x/d ≈ 70 (Dedalic N. et al., 2008). The volumetric water vapor fraction during the experiments with condensation was about 17 % and without condensation – about 1 %. The cooling agent in this study was air with the inlet temperature of 20 °C. Although during the experiments only ≈30 % of water vapor was condensed, the total heat transfer was almost two times higher in comparison with experiments without condensation.

Simulated flue gas condensation in a vertical annulus with test section of x/d ≈ 30 was presented by (Chantana Ch., Kumar S., 2013). At the inlet, water vapor mass fraction was in the range from 5 to 12 % and the mixture Reynolds number Re = 4600-14000. The condensation rate when the vapor mass fraction was 5% in the indicated Reynolds number range was between ≈ 0.2-0.6 kg/h. When the vapor mass fraction was increased to 12%, condensation rate was from ≈1 to ≈2.8 kg/h for the mentioned Reynolds number range. The condensation heat transfer coefficient for Re=4600 and water vapor fraction of 5% was determined to be almost the same as the sensible heat transfer coefficient. When the water vapor mass fraction was 12%, the condensation heat transfer coefficient for the same Re number was about five times higher in comparison with the sensible heat transfer coefficient.

Condensation of flue gas generated by incinerating natural gas was studied by (Jia L. et al., 2001). The experiments were performed in a vertical tube x/d ≈ 80, with inlet water vapor volume fraction of ≈15-18 %. The flue gas Reynolds number during the experiments was varied in a rather narrow range, i.e. from 2300 to 5000. The results showed that the moisture existing in the flue gas increased total average heat transfer at least by about two times in comparison with dry air. During the experiments the total Nusselt number for different cooling wall temperatures and Re numbers was in the range between 20 and 70. During the investigation it was also determined that the wall temperature was an important factor in terms of the condensing rate. It was obtained that in a certain wall temperature range (49°C–38°C), the condensing mass flow rate increases by about three times.

Other investigations show that condensation of water vapor from flue gas has a noticeable impact on heat transfer (Shi X. et al., 2011; Li J.D. et al., 2011; etc.). But most of the investigations usually deal with average characteristics in the test sections.

So, literature review shows that there is a very broad topic to study – heat transfer processes in flue gas condensers using real flue gas from the boilers in the real range of their operational parameters. There are no such investigations performed and the processes occurring in the condensers with actual flue gas are not adequately analyzed. In practice, the gas flow velocity is such that Reynolds number in industrial flue gas condensers can to reach 20000 or even more. The design of condensing heat exchangers depends on the power required. But despite of that, condensing heat exchangers usually have a housing where a few hundreds of small diameter tubes are installed, and thus the relative length x/d of these tubes is more than 150. Flue gas from the boiler is routed into these tubes and the cooling water flows around them – counter-current flow arrangement is usually applied. Despite the fact that condensing heat exchangers are widely used in boiler plants, there is not much analysis done of local distributions of temperatures and processes of condensation heat and mass transfer.

This paper is the continuation of the study related with water vapor condensation from the flue gas in a long vertical tube – model of the condensing heat exchanger. The results presented in the first paper of the series (Poškas R. et al., part 1, 2021) revealed that, under certain inlet flue gas conditions, the initial part of the condensing heat exchanger is not used efficiently for condensation heat and mass transfer due to the reason that the flue gas has to be cooled down until its temperature reaches the dew point temperature. Usually after that, a significant increase in heat transfer was determined due to condensation of water vapor from the flue gas. Therefore, in order to use such type of heat exchangers more efficiently from its beginning, certain parameters of the flue gas at the inlet to the exchanger should be reached. The results also showed that at higher Reynolds numbers, there was an increase in the length of the convection prevailing region. After that region, a sudden increase was observed in heat transfer due to water vapor condensation.

In order to have the efficient operation of the condensing heat exchanger, the flue gas temperature at the inlet to the heat exchanger should be reduced so that condensation can start from the very beginning of the exchanger. A possible way to reduce the flue gas temperature is the injection of water into the flue gas flow (Tissot J. et al., 2012). Injected water additionally increases flue gas humidity. Therefore, more favorable conditions are created for condensation heat transfer. In study by (Lee S.Y., Tankin, R.S., 1984), an analytical model was proposed for the behavior of a water spray in vapor. The spray experiments were performed in a chamber 250 mm in diameter and 300 mm in length with pure vapor. The sprayed droplet sizes used in the experiments were in the range of 0.67–1.32 mm. The water spray pattern determined was divided into several regions. The modeling results were compared with the experimental results and showed a reasonable agreement. When water was sprayed into the same chamber with air (no condensation) and into the chamber with vapor (with condensation), the structure of the flow streamlines showed a considerable difference between the two cases. Also, the droplet size was determined to be larger in vapor than in the air environment. However, the authors did not analyze heat transfer. The influence of droplet size on total heat transfer was analyzed by (Chung J. N., Chang T.H., 1984). It was determined that the larger the droplet size, the lower the total average heat transfer obtained. The droplet radius increase from ~0.3 mm to ~0.8 mm resulted in an average total heat transfer decrease by about 3 times. Heat transfer analysis in a flat tube heat exchanger showed that an optimum water spray rate should be achieved to give an increase in total heat transfer (Chen C.W. et al., 2013).

The results presented in the second paper of the series on condensation heat transfer (Poškas R. et al., part 2, 2021) indicated that water injection into the flue gas flow drastically changes the distribution of temperatures along the heat exchanger and enhances local total heat transfer. The injected water causes an increase in the local total heat transfer by at least two times in comparison with the case when no water is injected. Different temperatures of injected water mainly have a major impact on the local total heat transfer until almost the middle of the model of the condensing heat exchanger. From the middle part until the end, the heat transfer is almost the same at different injected water temperatures.

The current paper presents the investigations performed on local water vapor condensation heat transfer from biofuel flue gas focusing on the impact of cooling water flow rate in the case of water injection into the flue gas flow.

2. Experimental setup

The experimental setup used for the investigations of water vapor condensation from flue gas is presented in Figure 1. Flue gas was generated by incinerating wood pellets in a class 3 (according to EN303-5:2012) automatic boiler Kostrzewa (Poland). The boiler's power (max. 50 kW) can be adjusted in the range from 50 to 100 %. Generated flue gas with the temperature of about 180–190 °C (at the exit from the boiler) was directed to the experimental section. For flue exhaust gas temperature regulation after the boiler (i.e. before test section), the boiler's power and the economizer of the boiler were used.

The flue gas flow rate was adjusted by the dampers. Then the flue gas flew through the internal vertical calorimetric tube and was directed to the flue gas pipe (chimney) and after that it was discharged into the environment.

The whole test section was made of stainless steel. It was composed of an internal calorimetric tube (length $x \approx 5.8$ m, inner diameter $d = 0.034$ m, wall thickness $\delta = 2$ mm, $x/d \approx 170$), where condensation took place on the internal surface of the tube and of an outer tube (length $x \approx 5.9$ m, inner diameter $D=0.108$ m).

The whole experimental section as well as the flue gas pipe (chimney) was insulated using 50 mm thickness rockwool insulation.

In order to increase flue gas relative humidity up to 15-16 % due to the reasons indicated in (Poškas R. et al., part 1, 2021), the water was sprayed into the furnace by using fog nozzles with a total flow rate of ≈0.3 l/min.

More detailed description of the test setup is presented in (Poškas R. et al., part 1, 2021). A water injection chamber with one nozzle was installed just before the inlet into the calorimetric tube for increasing flue gas humidity before it enters the test section. The internal diameter of the chamber was 100 mm and the height 250 mm. The nozzle for water injection was mounted in the middle of the chamber's height at its side surface.

Therefore, the directions of flue gas flow and water injection to the gas flow were perpendicular to each other. The distilled water was supplied to the nozzle via a flexible hose from the water tank with a pump. The supply water flow rate to the nozzle was about 0.52 l/min. The hose connecting water tank and the nozzle was insulated using 6 mm thick polyethylene insulation. The injected water temperature was chosen to be about ≈ 40 °C.

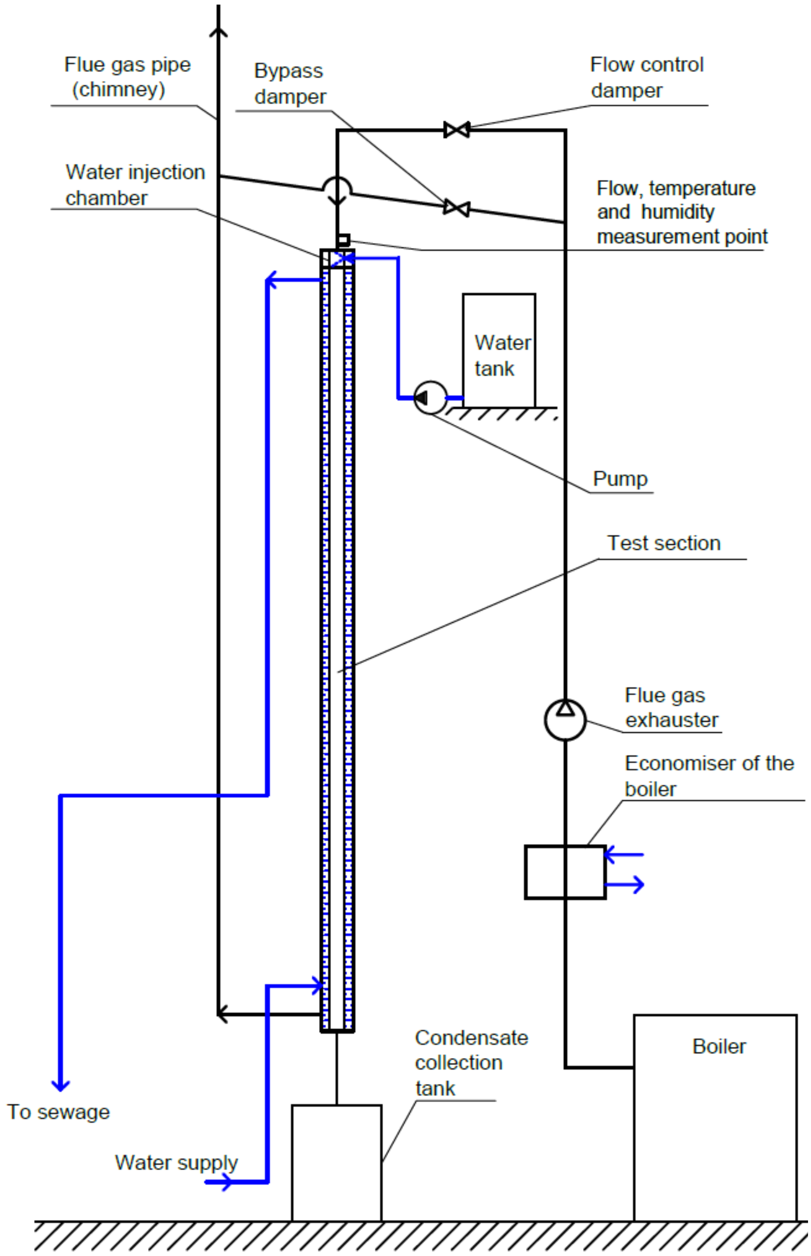

Figure 1: Experimental setup (not to scale).

For cooling of the calorimetric tube, the water from the municipal water supply network was supplied into the space between the inner and outer tubes. Water flow rate was measured at its discharge line by the weighting method and the necessary flow rate was adjusted by a corresponding valve. Before entering the experimental section at the bottom part (counter-current flow arrangement was applied), the water was mixed in a water mixer to have a uniform inlet temperature. When leaving the experimental section at the top part, the water was also mixed in the same type of a mixer. For more details see (Poškas R. et al., part 2, 2021).

The injected water and the water condensed on the calorimetric tube inner wall were drained into the condensate collection tank.

3. Methodology

The investigations were performed at a fixed Reynolds number (Re ≈ 20500) at the inlet into the calorimetric tube, different flue gas inlet temperatures and at two different cooling water flow rates.

Temperature measurements were carried out using chromel-copel thermocouples:

- 20 thermocouples were installed in the centre of the calorimetric tube to measure the flue gas temperature along the tube. The distances between the thermocouples were approx. 0.28 m.

- 20 thermocouples were installed in the inner wall of the calorimetric tube along the length of the tube. The distances between the thermocouples were approx. 0.28 m.
- 10 thermocouples were installed between the inner and the outer tubes to measure the cooling water temperature along the space between the tubes. The distances between the thermocouples were approx. 0.56 m.
- 3 thermocouples were installed in each of the water mixers.
- 2 thermocouples were installed in the water tank used for water (≈ 40 °C) injection into the injection chamber.

During the experiments, all the thermocouple readings were performed using the Keithley automatic data acquisition system.

The parameters of the boiler (flue gas temperature, supply and return water temperature, chimney draft) were automatically registered every 5 minutes using the KD7 data recording system. The flue gas temperature (t_{in}, °C) and the relative humidity (RH_{in}, %) before injection chamber were measured with a KIMO C310 (Switzerland) temperature and humidity sensor. The accuracy for RH measurement is ±0.88 % and for temperature ±0.3 %. The inlet flue gas flow rate was measured using a bellmouth with installed Pitot-Prandtl's tubes, which were connected to the micromanometer. The flow rate of cooling water during the experiments was ≈60 kg/h and ≈120 kg/h, i.e. about 1 l/min. and about 2 l/min, respectively. The flow rate was measured by the weighting method. During the experiments, the cooling water inlet temperature measured in the mixer was in the range of about 10-13 °C.

In the formulas presented further, all the properties (c_p, λ, etc.) of the gas, i.e. the mixture of flue gas and water vapor, were calculated using formulas for mixture properties calculation (Siddique M., 1992). The calculation of the properties is based on flow temperature measured in the centre of the calorimetric tube.

The local total (convection and condensation) heat transfer coefficient and the Nusselt number were calculated in 20 positions along the tube where flow temperature in the centre of the tube and inner wall temperatures were measured.

Total local heat flux was obtained as:

$$q_{t_i} = \frac{m_{H2O_i} \cdot c_{pH2O_i}}{\pi \cdot d} \cdot \left(\frac{dt_{H2O}}{dx}\right)_i \quad (1)$$

where dt_{H2O}/dx is the slope of the cooling water temperature gradient, which was determined as the least squares polynomial fit of the coolant temperature as a function of the length of the heat exchanger model.

The local total heat transfer coefficient was calculated as:

$$\alpha_{t_i} = q_{t_i}/(t_c - t_w)_i \quad (2)$$

where t_c is the temperature measured in the centre of the calorimetric tube, °C, t_w is the measured inner wall temperature of the calorimetric tube, °C.

The total Nusselt number:

$$Nu_{t_i} = \alpha_{t_i} \cdot d/\lambda_i \quad (3)$$

Flue gas Reynolds number at the inlet to the calorimetric tube was calculated based on the flue gas parameters before the water injection chamber.

The accuracy of the data was evaluated by using the methodology presented in (Barford N.C., 1985). The highest uncertainties are where the temperature difference between flue gas and tube wall is the smallest. For the Nusselt number the uncertainty was in the range of about 6–14%.

4. Results and Analysis

As it was indicated above, the experiments were carried out for two different inlet flue gas temperatures (lower and higher), the same Reynolds number (Re_{in}) at the inlet into the calorimetric tube and for two different cooling water flow rates.

4.1 Lower inlet flue gas temperature

Figure 2 presents typical temperature distributions in the case of the lower inlet flue gas temperature. The dew point temperature before the injection chamber was calculated based on t_{in}, RH_{in} and using the equations presented by (Lawrence M.G., 2005) and was determined to be in the range of ~62–64 °C. It should be noticed that for both cases presented in Figure 2, the tube wall temperature (Figure 2, curve 2) is below even the dew point temperature before the injection of water (Figure 2, curve 4).

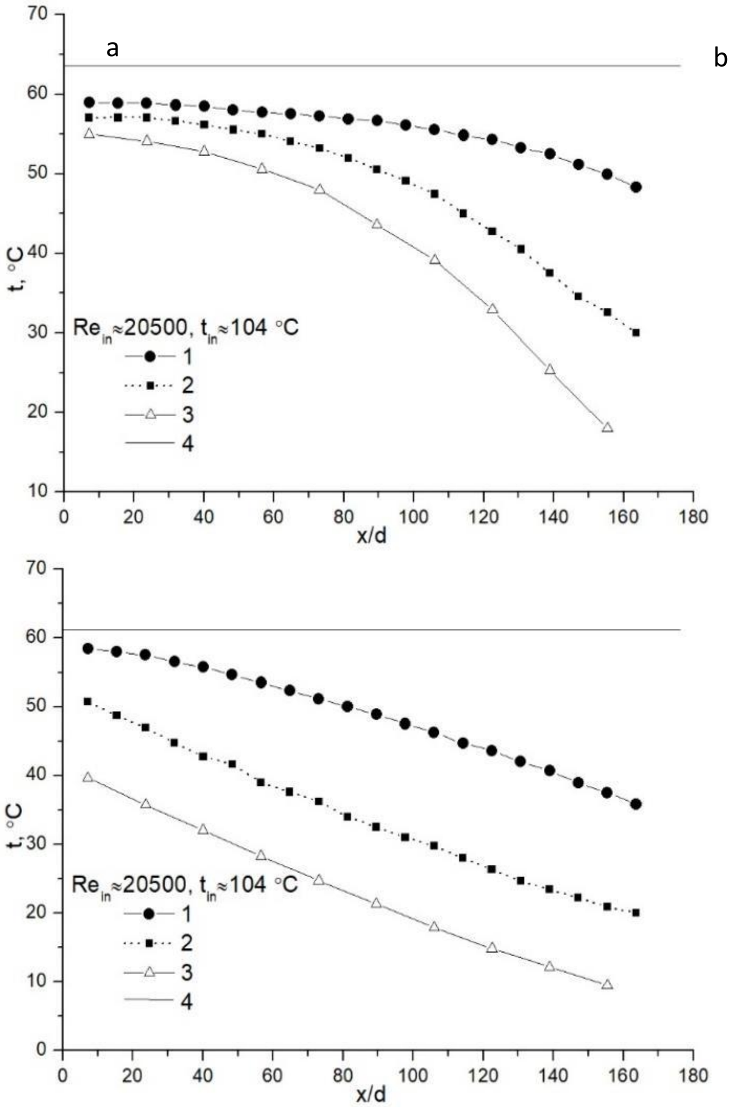

Figure 2: Temperature distribution along the tube at different cooling water flow rates: a – 60 kg/h, b – 120 kg/h. 1 – centre of the calorimetric tube, 2 – the inner wall of the calorimetric tube, 3 – cooling water in the middle between the inner and outer tubes, 4 – the dew point temperature at the inlet to the calorimetric tube (before the injection chamber).

The tube wall temperature (Figure 2, curve 2) is below the dew point temperature, and therefore condensation on the wall of the calorimetric tube should start from the beginning of the tube.

The results of temperature distribution obtained in case of cooling water flow rate of 60 kg/h (Figure 2a) indicate that flue gas temperature decreases slightly from the inlet until x/d ≈ 110 (Figure 2a, curve 1). After that, a more pronounced decrease is observed. The distribution of the cooling water temperature indicates that the water is gaining heat rather intensively from the inlet (x/d ≈ 170) until x/d ≈ 60 (Figure 2a, curve 2). In this region, the water temperature increases by about 33 °C (from 17 to 50 °C). From x/d ≈50 until the outlet, the water temperature increase is insignificant, i.e., by ~5 °C, up to ~ 55 °C. The tube wall temperature character (Figure 2a, curve 3) is similar to the cooling water temperature character.

According to the temperature distribution results presented in Figure 2a, it is evident that from x/d ≈ 50-60 until the end of the tube of the condensing heat exchanger, the differences between flue gas and tube wall as well as between flue gas and cooling water temperatures increase significantly.

Distribution of the total local Nusselt number along the tube is presented in Figure 3. The results show that at the beginning of the tube, Nu_t is relatively high and is about $Nu_t \approx 90$. This could be related to the fact that the wall temperature is below the dew point temperature, and therefore condensation takes place already at the beginning of the tube. From the beginning of the tube till x/d ≈ 60, a very intensive growth of Nu_t is observed and at x/d ≈ 60, Nu_t reaches a peak value of about 1450. This means that condensation heat transfer is very intensive in this part of the tube. After that, as some amount of water vapor has been condensed, the decrease of Nu_t till the end of the tube is obtained. Despite that fact that influence of condensation heat transfer is decreasing, at the end of the calorimetric tube Nu_t remains still high – $Nu_t \approx 800$.

When the flue gas inlet parameters were the same but cooling water flow rate was increased by two times, i.e. to 120 kg/h, the distribution of temperatures in the test section drastically changed (Figure 2b) in comparison to the temperatures presented for the case when the cooling water flow rate was 60 kg/h.

In this case (Figure 2b) the flue gas temperature (Figure 2b, curve 1) remains almost constant only for a short distance of the tube, i.e. from x/d = 0 till x/d ≈ 20. From x/d ≈ 20 till the end of the tube almost a linear decrease of temperature is observed. Flue gas temperature at the exit from the tube (at x/d = 170) was about 15 °C lower in comparison with the case for the smaller cooling water flow rate (Figure 2a).

Tube wall temperature (Figure 2b, curve 2) is almost linearly decreasing through all the length of the tube and from the beginning till the end it decreases by about 32°C – from ≈ 52°C to ≈ 20°C.

Cooling water temperature (Figure 2b, curve 3) almost linearly increases all over the length of the tube – from ≈ 10 °C (at inlet x/d ≈170) to ≈ 40 °C (at exit x/d = 0).

It can be noticed (Fig. 2b) that temperature differences between flue gas and tube wall as well as between flue gas and cooling water temperatures remain almost constant through all the length of the tube.

The change (increase) of the cooling water flow rate has also a significant impact on the distribution of the Nu_t along the tube (Fig. 3).

At the beginning of the tube and in case of cooling water flow rate of 120 kg/h, Nu_t is about 15 times ($Nu_t \approx 1400$) higher in comparison to the case when the cooling water flow rate was 60 kg/h ($Nu_t \approx 90$).

Then a rather steep decrease of $Nu_t \approx 1400$ till x/d ≈ 20-30 is observed. This means that water vapor is being condensed intensively and later, as the amount of water vapor is decreased, Nu_t also decreases till the end of the tube, but not so sharply as before. At the end of the tube Nu_t remains high – $Nu_t \approx 600$, but it is less than in case of cooling water flow rate of 60 kg/h.

4.2 Higher inlet flue gas temperature

The results of temperature distributions along the tube in the case of the higher inlet flue gas temperature and two different cooling water flow rates are presented in Figure 4. In this case the tube wall temperature (Figure 4, curve 1) is also below the dew point temperature (curve 4). Thus, condensation heat transfer should start from the beginning of the tube (Figure 5). The flue gas temperature in this case (Fig. 4a, curve 1) is also almost constant till x/d ≈ 60. Then a small decrease of temperature occurs and continues till the end of the tube. Cooling water (Fig. 4a, curve 3) is intensively heated from inlet (x/d ≈ 170) to x/d ≈ 60. The characteristics of the tube wall temperature (Fig. 4a, curve 2) are very similar to the characteristics of the cooling water temperature.

In general, the characteristics of the temperatures presented in Figure 4a are very similar to those presented in Figure 2a for the lower inlet flue gas temperature.

The main difference is that in the case of the higher inlet flue gas temperature, the values of temperatures along the tube are only higher by about 2-3 °C in comparison to those presented in Figure 2a.

Distribution of the total local Nusselt number along the tube presented in Figure 5 similarly to the results presented in Figure 3 shows that at the beginning of the tube, Nu_t is relatively high – $Nu_t \approx 100$. This means that condensation takes place already at the beginning of the tube. From the beginning of the tube till x/d ≈ 60, also as in Figure 3, a very intensive growth of Nu_t is observed where at x/d ≈ 60 Nu_t has a peak value of about 1650. This means that condensation heat transfer is very intensive in this part of the tube. Then as some amount of water vapor was condensed, the decrease of Nu_t till the end of the tube was obtained.

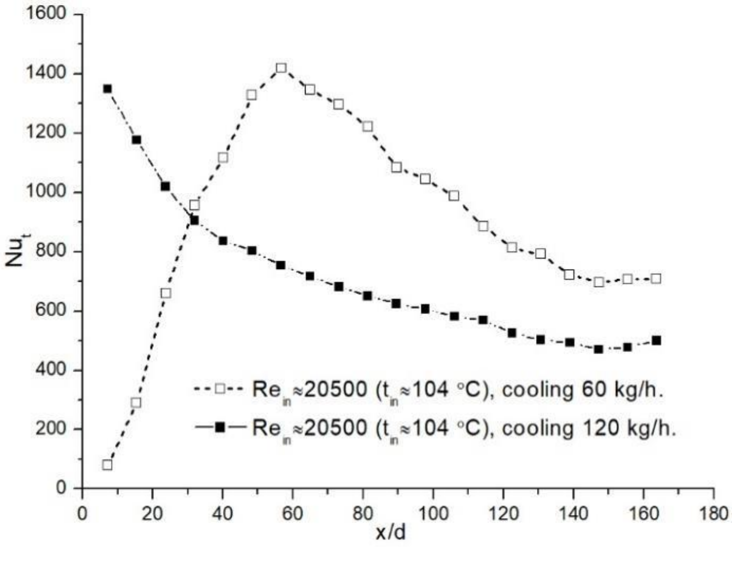

Figure 3: Distribution of the total local Nusselt number along the tube at different cooling water flow rates and the same inlet flue gas temperature.

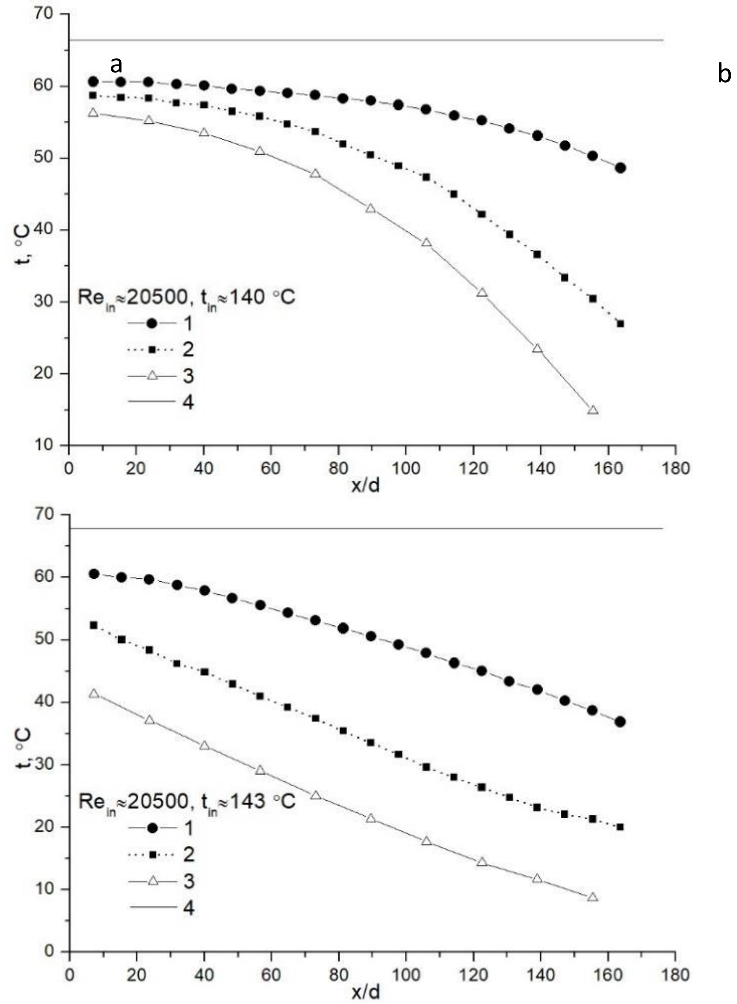

Figure 4: Temperature distribution along the tube at different cooling water flow rates: a – 60 kg/h, b – 120 kg/h. 1 – centre of the calorimetric tube, 2 – the inner wall of the calorimetric tube, 3 – cooling water in the middle between the inner and outer tubes, 4 – the dew point temperature at the inlet to the calorimetric tube (before the injection chamber).

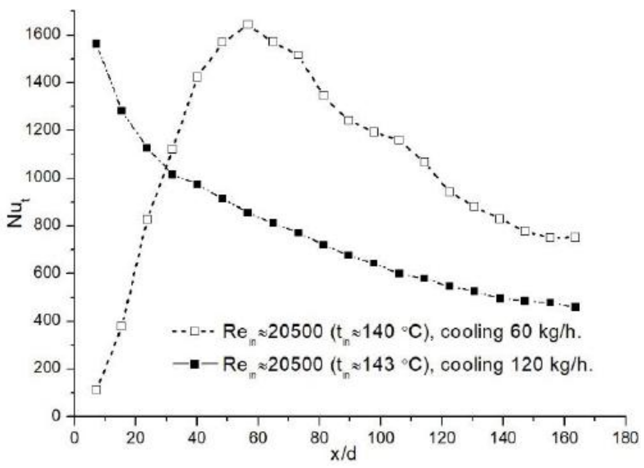

Figure 5: Distribution of the total local Nusselt number along the tube at different cooling water flow rates and the same inlet flue gas temperature.

Despite that fact that the influence of condensation heat transfer is decreasing, at the end of the calorimetric tube $Nu_t \approx 780$ (i.e. very similar to that presented in Figure 3 for the lower inlet flue gas temperature).

In the case of the cooling water flow rate of 120 kg/h, the drastic change in temperature distribution was also obtained (Figire 4b). In this case also, the characteristics of the temperatures measured were very similar to those presented in Figure 2b for the lower inlet flue gas temperature. The difference is that in the case of the higher inlet flue gas temperature, the values of temperatures are also higher by about 2-3 °C in comparison with the lower inlet flue gas temperature.

Distributions of temperatures along the test section are similar for both inlet flue gas temperatures, and therefore the characteristics of the total Nusselt number are also very similar (Figure 5 and Figure 3).

For the cooling water flow rate of 120 kg/h (Fig. 5) at the beginning of the tube, Nu_t remained higher by about 15 times ($Nu_t \approx 1580$) in comparison to the case when the cooling water flow rate was 60 kg/h ($Nu_t \approx 100$).

Then, a rather steep decrease in Nu_t till x/d ≈ 20-30 is observed. This means that water vapor is being intensively condensed and later, as the amount of water vapor is decreased, Nu_t also decreases till the end of the tube. At the end of the tube Nu_t remains high – $Nu_t \approx 500$ and is less than in the case of the cooling water flow rate of 60 kg/h.

4. Conclusions

After performing the analysis of the local water vapor condensation from biofuel flue gas along the model of the condensing heat exchanger at the same flue gas Re_{in} number, different flue gas inlet temperatures and two different cooling water flow rates, the following conclusions have been drawn:

1. The performed investigations revealed the peculiarities of the local total Nusselt number at different cooling water flow rates in a vertical tube with water injection.
2. The change in cooling water flow rate drastically changes the distribution of the total Nusselt number along the tube.
3. At higher flue gas inlet temperatures, the effect of cooling water flow rate on Nu_t is also stronger. For the lower cooling water flow rate, the effect is more pronounced in the middle part of the tube (x/d ≈ 20-150) and for the higher cooling water flow rate, it is in the x/d range between 0 and 100.

Funding

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Συνεδρία 2η: Κλιματική Αλλαγή

Περιβαλλοντική δράση της «ΕΡΓΟΣΕ Α.Ε.»

Βασίλειος ΞΟΥΡΑΦΑΣ

Αγρονόμος-Τοπογράφος Μηχανικός Ε.Μ.Π.
Προϊστάμενος Τμήματος Τοπογραφικών Μελετών,
Απαλλοτριώσεων και Γεωγραφικών Συστημάτων Πληροφοριών (G.I.S.). ΕΡΓΟΣΕ Α.Ε.

Σύντομη περιγραφή έργου

Η Ergose S.A., στο πλαίσιο της #ΕΚΕ, υλοποιεί μια καινοτόμα πρωτοβουλία διάσωσης ελαιόδεντρων που εκριζώνονται από περιοχές στις οποίες πραγματοποιούνται σιδηροδρομικά έργα και τα οποία μεταφέρονται, ακολουθώντας αυστηρά πρωτόκολλα και μεταφυτεύονται σε κομβικά σημεία σε Δήμους όλης της χώρας, σε συνεργασία με το Πράσινο Ταμείο. Πολλά από αυτά τα δέντρα είναι υπεραιωνόβια με ηλικία από 500 έως 1.500 έτη, δημιουργώντας έτσι κατά τόπους, μικρά, ανοικτά "μουσεία" φυσικής ιστορίας.

Πληροφορίες: https://www.ergose.gr/programma-metafyteysis-yperaionovion-elaiodentron-apo-tin-ergose/

Περιβαλλοντική δράση της «ΕΡΓΟΣΕ Α.Ε.»

Διάσωση, μέσω της μεταφύτευσης των ελαιόδεντρων, που βρίσκονται εντός των απαλλοτριούμενων εκτάσεων, που απαιτούνται για την ανάπτυξη των σιδηροδρομικών έργων.

ΕΡΓΟΣΕ

- Σύντομη παρουσίαση της «ΕΡΓΟΣΕ Α.Ε.»

Η «ΕΡΓΟΣΕ Α.Ε.» είναι θυγατρική εταιρεία του ΟΣΕ και έχει ως αντικείμενο την κατασκευή και τον εκσυγχρονισμό του σιδ. δικτύου στη χώρα. Για το λόγο αυτό μεταξύ των άλλων προβαίνει και σε όλες τις απαραίτητες ενέργειες, που προβλέπονται από τη νομοθεσία, για την εξασφάλιση μέσω της αναγκαστικής απαλλοτρίωσης των εκτάσεων, που απαιτούνται για την ανάπτυξη των σιδηροδρομικώνέργων.

ΕΡΓΟΣΕ 2

Απεικόνιση της απαλλοτριούμενης έκτασης στηνπεριοχή του ΕλαιώναΑιγιαλείας.
ΧΘ από 75 έως 80 της νέας σιδ. γραμμής
(1.847 ελαιόδεντρα)

Πριν την κατασκευή

Μετά την κατασκευή

ΕΡΓΟΣΕ 3

Οργανωμένοι ελαιώνες με δέντρα μεγάλης ηλικίας

ΕΡΓΟΣΕ

- <u>Έναρξη της δράσης – καθορισμός αντικειμένου</u>

Η επίσημη έναρξη της δράσης τοποθετείται αρχικά το 2013 και στη συνέχεια το 2014 με τη διενέργεια 2 διαγωνισμών για την ανάθεση της σύμβασης διαχείρισης του φυτικού κεφαλαίου εντός των απαλλοτριωμένων εκτάσεων. Το αντικείμενο της σύμβασης ήταν η διάσωση και η μεταφύτευση όσο το δυνατόν περισσότερων ελαιόδεντρων.

ΕΡΓΟΣΕ

5

- <u>Βήματα για την υλοποίηση της διαδικασίας</u>

- Σύνταξη μελέτης κτηματολογίου
- Καταγραφή αριθμού ελαιόδεντρων ως επικείμενων
- Κήρυξη απαλλοτρίωσης
- Συντέλεση απαλλοτρίωσης
- Παρακολούθηση και φύλαξη των ελαιόδεντρων για την αποφυγή παράνομης υλοτόμησης
- Κατάληψη εκτάσεων - συνεργασία με ανάδοχο κατασκευής του σιδ. Έργου
- Απομάκρυνση των ελαιόδεντρων από το εύρος κατάληψης των έργων
- Αποθήκευση – φύλαξη και συντήρηση τους σε κατάλληλους χώρους
- Διαχείριση και καταμερισμός τους ανά κατηγορία μεγέθους και ηλικίας

ΕΡΓΟΣΕ

6

- <u>Κύρια χαρακτηριστικά της δράσης</u>

1) Καινοτόμα ιδέα με υψηλό ρίσκο

- Η «ΕΡΓΟΣΕ Α.Ε.» προχώρησε στη υλοποίησή της γνωρίζοντας το μεγάλο ποσοστό ρίσκου που έπαιρνε, δεδομένου ότι δεν διέθετε ούτε την εμπειρία αλλά ούτε και την πολυτέλεια διάθεσης εξειδικευμένου ανθρώπινου δυναμικού για την επιτυχή έκβαση αυτής της πρωτότυπης ιδέας.

ΕΡΓΟΣΕ

7

- <u>Κύρια χαρακτηριστικά της δράσης</u>

2) Μη ύπαρξη νομικού πλαισίου

- Δεν προβλέπεται στην κείμενη νομοθεσία η διαχείριση των επικειμένων συστατικών εντός των απαλλοτριούμενων εκτάσεων συμπεριλαμβανομένου και του φυτικού κεφαλαίου και επομένως και των ελαιόδεντρων.

ΕΡΓΟΣΕ

8

- Κύρια χαρακτηριστικά της δράσης

3) Διαχείριση Δημόσιας περιουσίας

- Τα ελαιόδεντρα όπως και οι εδαφικές εκτάσεις αποζημιώνονται με χρήματα του Ελληνικού Δημοσίου και ως εκ τούτου αποτελούν περιουσιακό του στοιχεία

ΕΡΓΟΣΕ

9

- Κύρια χαρακτηριστικά της δράσης

4) Ανάσχεση παράνομης υλοτομίας (επικρατούσα κατάσταση)

- Στο φυσικό αντικείμενο της υπογραφείσας σύμβασης, προβλέπεται η φύλαξη και η συντήρηση των ελαιόδεντρων σύμφωνα με τους κανόνες της γεωπονικής επιστήμης για όσο διάστημα απαιτείται, σε κατάλληλα διαμορφωμένους ασφαλείς χώρους, καθώς και η διαρκής τους παρακολούθηση – εποπτεία, έτσι ώστε να αποφευχθούν παράνομες δραστηριότητες υλοτομίας.

ΕΡΓΟΣΕ

10

Διαχείριση και προσωρινή αποθήκευση ελαιόδεντρων

ΕΡΓΟΣΕ

11

Ελαιόδεντρα παράνομα υλοτομημένα πριν την κατάληψη της έκτασης

ΕΡΓΟΣΕ

12

Ελαιόδεντρα παράνομα υλοτομημένα πριν την κατάληψη της έκτασης

13

- Κύρια χαρακτηριστικά της δράσης

5) Χρηματοδότηση

- Για την υλοποίηση της δράσης πρέπει να γίνουν μια σειρά από εργασίες από την πλευρά του αναδόχου για τις οποίες πρέπει να αμειφθεί.
- Σημαντική χρηματοδότηση από το Πράσινο Ταμείο

14

- Κύρια χαρακτηριστικά της δράσης

6) Υποχρεώσεις εμπλεκόμενων φορέων

- Η «ΕΡΓΟΣΕ Α.Ε.» έχει την υποχρέωση να μεταφέρει τα ελαιόδεντρα δωρεάν έως την περιοχή που θα γίνει η μεταφύτευση (200 χλμ. από το έργο)
- Ο ενδιαφερόμενος φορέας έχει την υποχρέωση να τα παραλάβει και να τα φυτέψει με δικά του μέσα αλλά κυρίως να τα συντηρήσει για όσο διάστημα απαιτείται για την επιτυχή έκβαση της διαδικασίας.

15

- Τι έχει γίνει έως σήμερα

➢ Έχουν διατεθεί για μεταφύτευση 650 ελαιόδεντρα σε 50 Δήμους και δημόσιους φορείς εκ των οποίων τα 60 είναι υπεραιωνόβια

➢ Το μεγαλύτερο μέρος αυτών έχει διατεθεί στο Λεκανοπέδιο Αττικής ενώ πρόσφατα έχουν διατεθεί και σε άλλες περιοχές

➢ Έχουν ξεκινήσει πρόδρομες ενέργειες για τη διάθεση ελαιόδεντρων στις πυρόπληκτες περιοχές

Ενδεικτικές θέσεις μεταφύτευσης ελαιόδεντρων στο Λεκανοπέδιο Αττικής

- Τι περιμένουμε ;

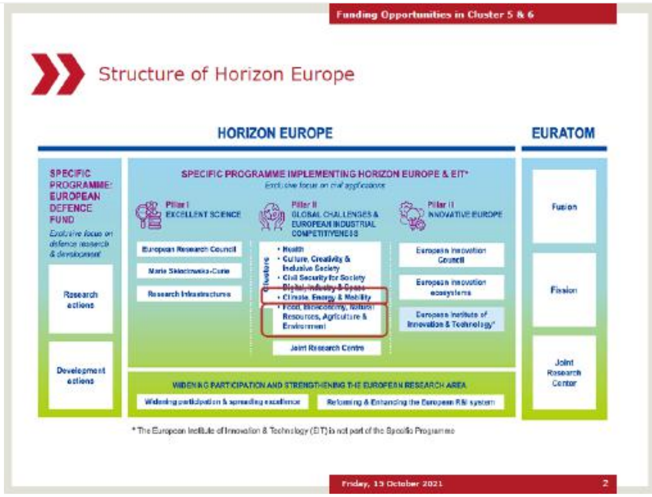
- Σχέδιο έξυπνης «πράσινης» διαχείρισης των ελαιόδεντρων
- Να θεσμοθετηθεί ένα εξειδικευμένο νομικό πλαίσιο διαχείρισης του φυτικού κεφαλαίου και ιδιαίτερα των ελαιόδεντρων, που απαλλοτριώνεται για τις ανάγκες κατασκευής μεγάλων έργων
- Να εξασφαλιστεί η κατάλληλη χρηματοδότηση για την κάλυψη των εξόδων μεταφύτευσης
- Το παράδειγμα της «ΕΡΓΟΣΕ Α.Ε.» να το ακολουθήσουν και άλλοι φορείς στο μέλλον που έχουν παρόμοιο αντικείμενο

ΕΡΓΟΣΕ 19

DAY 3: Brokerage event

Horizon Europe open calls

Mrs. Katerina PAPADOULI
Head of Unit, National Contact Point in Horizon Europe, PRAXI Network, Hellas



Pillar 2: Global Challenges and European Industrial Competitiveness

Pillar II

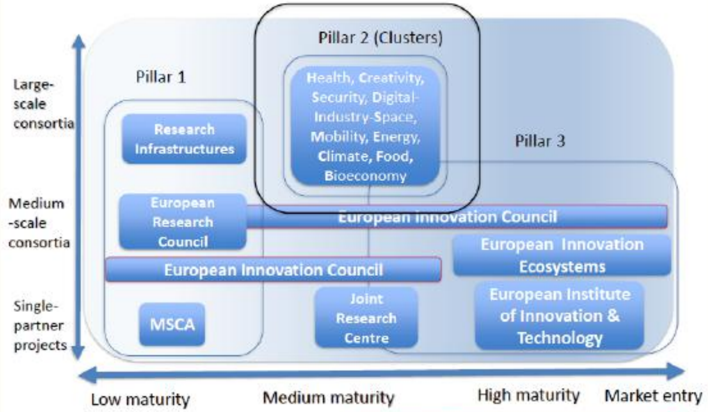
Budget for clusters & for JRC

in current prices

Cluster 1	Health	€8.246 billion (including €1.35 billion from NGEU)
Cluster 2	Culture, Creativity & Inclusive Societies	€2.280 billion
Cluster 3	Civil Security for Society	€1.596 billion
Cluster 4	Digital, Industry & Space	€15.349 billion (including €1.35 billion from NGEU)
Cluster 5	Climate, Energy & Mobility	€15.123 billion (including €1.35 billion from NGEU)
Cluster 6	Food, Bioeconomy, Natural Resources, Agriculture & Environment	€8.952 billion
	JRC (non-nuclear direct actions)	€1.970 billion

Clusters are including a budget for Partnerships and Missions
NGEU is Next Generation EU programme – Recovery Fund

R&I Orientation



Research and Innovation Missions

EU Missions

R&I Missions — **Relating EU's research and innovation better to society and citizens' needs; with strong visibility and impact**

A mission is a portfolio of actions across disciplines intended to achieve a **bold and inspirational and measurable goal** within a set timeframe, with **impact** for society and policy making as well as relevance for a significant part of the European population and wide range of European citizens.

Horizon Europe defines mission characteristics and elements of governance, and **5 missions areas**. Specific missions will be programmed within the Global Challenges and European Industrial Competitiveness pillar, but may also benefit from actions carried out within other parts of the Programme as well as complementary actions carried out under other Union programmes.

Research and Innovation Missions

European Partnerships

New approach to European Partnerships

New generation of objective-driven and more ambitious partnerships in support of agreed EU policy objectives

Key Features

- Strategic orientation
- Systemic approach
- Simple architecture and toolbox
- Common set of criteria for the life-cycle

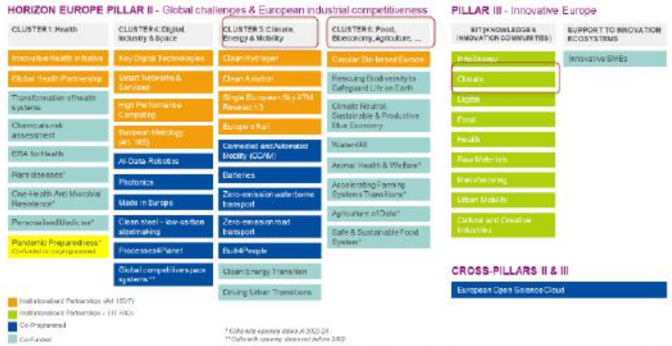
CO-PROGRAMMED
Based on Memoranda of Understanding/contractual arrangements; implemented independently by the partners and by Horizon Europe

CO-FUNDED
Based on a joint programme agreed and implemented by partners; commitment of partners for financial and in-kind contributions

INSTITUTIONALISED
Based on long-term dimension and need for high integration; partnerships based on Art 185/187 of TFEU and the EIT legal acts for 2021-2027

European Partnerships - Candidates

Overview of 49 candidate European Partnerships



Cluster 5: Climate, Energy and Mobility

Aim

- This clusters aims to fight climate change by better understanding its causes, evolution, risks, impacts and opportunities, and by making the energy and transport sectors more climate and environment-friendly, more efficient and competitive, smarter, safer and more resilient.

Areas of Intervention

1. Climate science and solutions
2. Energy supply
3. Energy systems and grids
4. Buildings and industrial facilities in energy transition
5. Communities and cities
6. Industrial competitiveness in transport
7. Clean, safe and accessible transport and mobility
8. Smart mobility
9. Energy storage

Cluster 5: Climate, Energy and Mobility

Destinations

- Climate sciences and responses for the transformation towards climate neutrality
- Cross-sectoral solutions for the climate transition
- Sustainable, secure and competitive energy supply
- Efficient, sustainable and inclusive energy use
- Clean and competitive solutions for all transport modes
- Safe, Resilient Transport and Smart Mobility services for passengers and goods

Funding Opportunities in Cluster 5 & 6

Mission area: Adaptation to Climate Change including Societal Transformation

Mission: A Climate Resilient Europe

The Goal: Prepare Europe for climate disruptions and accelerate the transformation to a climate resilient and just Europe by 2030.

21 Sep. 2021

Mission Call: HORIZON-MISS-2021-CLIMA-01-01: Better prepared regional and local authorities to adapt to climate change

Friday, 15 October 2021 13

Funding Opportunities in Cluster 5 & 6

Mission area: Climate-neutral and Smart Cities

Mission: 100 Climate Neutral and Smart Cities

The Goal: Support, promote and showcase **100 European cities** in their systemic transformation towards climate neutrality by 2030 and make these cities into experimentation and innovation hubs for all cities.

14 Sep. 2021

Mission Call: HORIZON-MISS-2021-CIT-01-01: Supporting national, regional and local authorities across Europe to prepare for the transition towards climate neutrality within cities

Friday, 15 October 2021 14

Funding Opportunities in Cluster 5 & 6

Indicative Calls for Cluster 5

HORIZON-CL5-2022-D4-01-03: Smarter buildings for better energy performance

Scope: Improvement and cost-reduction of technologies to predict, assess, monitor and control in real time the energy performance of buildings, including energy efficiency, renewables, storage and their optimisation.

Type of Action: Innovation Action
Budget per proposal: 4-6 million
Budget of topic: 12 million
Opening date: 28 April 2022
Deadline: 06 September 2022

Friday, 15 October 2021 15

Funding Opportunities in Cluster 5 & 6

Indicative Calls for Cluster 5

HORIZON-CL5-2022-D3-01-01: Demonstration of cost-effective advanced biofuel technologies utilizing existing industrial plants

Scope: Proposals should demonstrate cost-efficient advanced biofuel technologies which improve the economic viability of the advanced biofuel production. This should be done through innovative transformation of existing plants to incorporate production of advanced biofuels from non-food/feed sustainable biomass feedstock into existing processes, e.g., first generation biofuel plants, paper mill industry, waste treatment plants, oil-refineries, petrochemical industry, etc.

Type of Action: Innovation Action
Budget per proposal: 10 million
Budget of topic: 20 million
Opening date: 14 October 2021
Deadline: 26 April 2022

Friday, 15 October 2021 16

Cluster 5: Climate, Energy and Mobility

Call deadlines

Call 2022
Different Opening Dates: 14 October 2021, 24 April 2022, 26 May 2022, 06 September 2022

Different Deadlines: 26 April 2022 , 6 September 2022, 27 October 2022, 10 Jan 2023

Work Programme 2021-2022: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-8-climate-energy-and-mobility_horizon-2021-2022_en.pdf

Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment

Aim

This cluster aims at reducing environmental degradation, halting and reversing the decline of biodiversity on land, inland waters and sea and better managing natural resources through transformative changes of the economy and society in both urban and rural areas.

Areas of Intervention

1. Environmental observation
2. Biodiversity and natural resources
3. Agriculture, forestry and rural areas
4. Seas, oceans and inland waters
5. Food systems
6. Bio-based innovation systems in the EU
7. Circular systems

Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment

Destinations

- Biodiversity and ecosystem services
- Fair, healthy and environment-friendly food systems from primary production to consumption
- Circular economy and bioeconomy sectors
- Clean environment and zero pollution
- Land, ocean and water for climate action
- Resilient, inclusive, healthy and green rural, coastal and urban communities
- Innovative governance, environmental observations and digital solutions in support of the Green Deal

Mission Area: Soil Health and Food

Mission: Caring for Soil is Caring for Life

The Goal: Ensure 75% of soils are healthy by 2030 for food, people, nature and climate.

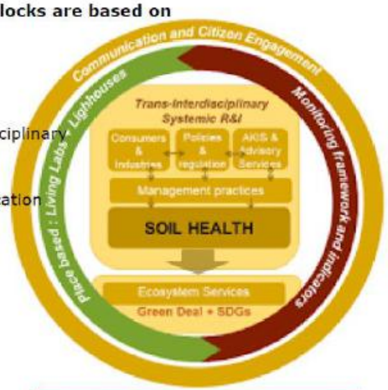
20 Oct. 2021

Mission Call: HORIZON-MISS-2021-SOIL-01-01: Preparing the ground for healthy soils: building capacities for engagement, outreach and knowledge

Caring for soil is caring for life

The mission's building blocks are based on

- co-creation and sharing
- soil monitoring programme
- cross-scale, inter and transdisciplinary R&I programme
- training, education, communication and citizen engagement



Mission Area: Healthy Oceans, Seas, Coastland and Inland Waters

Mission Starfish 2030: Restore our oceans and Water

The Goal: Know, restore and protect our ocean and waters by 2030, by reducing human pressures on marine and freshwater environments, restoring degraded ecosystems and sustainably harnessing the essential goods and services they provide.

14 Sep. 2021

Mission Call: HORIZON-MISS-2021-SOIL-01-01: Preparing the ground for healthy soils: building capacities for engagement, outreach and knowledge

Indicative Calls for Cluster 6

HORIZON-CL6-2022-CIRCBIO-01-02: Marginal lands and climate-resilient and biodiversity-friendly crops for sustainable industrial feedstocks and related value chains

Scope: Sustainable biomass provision by primary land sectors (agriculture and forestry), supporting climate change mitigation and adaptation. This will require finding a balance between productivity and ecosystem services, notably biodiversity and social sustainability goals.

Type of Action: Innovation Action
Budget per proposal: around 7 million
Budget of topic: 14 million
Opening date: 28 October 2021
Deadline: 15 February 2022

Indicative Calls for Cluster 6

HORIZON-CL6-2022-CIRCBIO-02-01-two-stage: Integrated solutions for circularity in buildings and the construction sector

Scope: Measures should strive for the use of more climate-neutral circular materials with low environmental footprint and tackle material recovery, upcycling, recycled content in products, durability and adaptability of buildings, and they should have a strong life cycle and digitalisation focus. They should also focus on circular design that facilitates reuse and recycling beforehand.

Type of Action: Innovation Action
Budget per proposal: 6-8 million
Budget of topic: 21 million
Opening date: 28 October 2021
Deadline (first stage): 15 February 2022
Deadline (second stage): 01 September 2022

Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment

Call deadlines

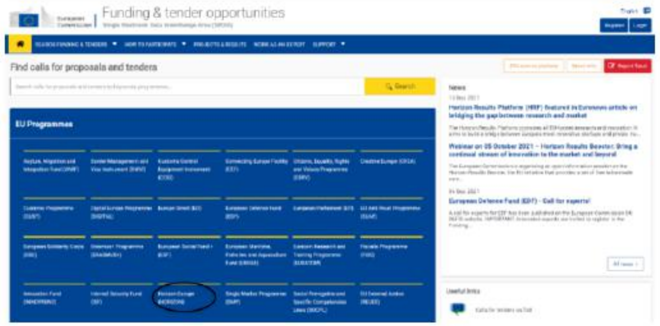
Call 2022
Opening Date: 28 October 2021

Deadlines: 15 February 2022 (First Stage),
01 September 2022 (Second Stage)

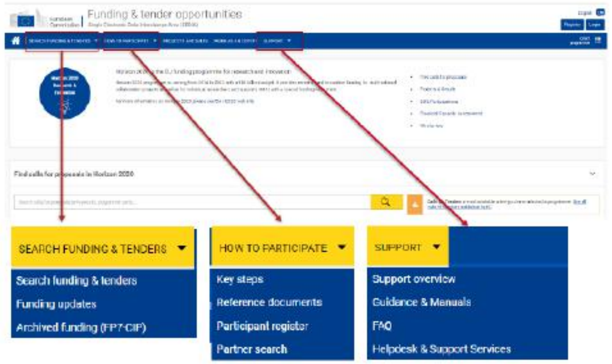
Work Programme 2021-2022: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-9-food-bioeconomy-natural-resources-agriculture-and-environment_horizon-2021-2022_en.pdf

Funding and Tender Opportunities Portal

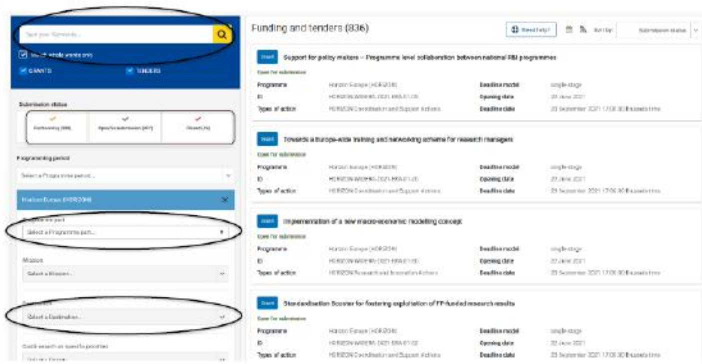
https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home



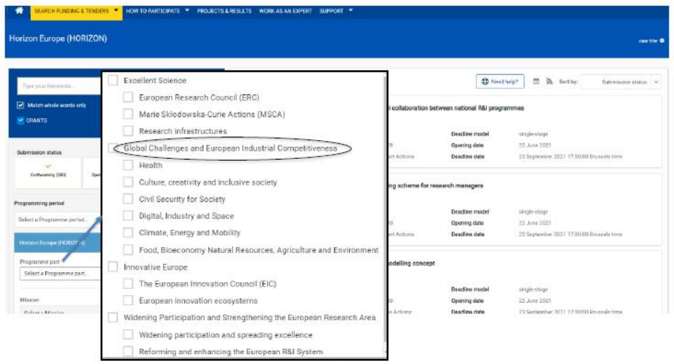
Funding and Tender Opportunities Portal: Search for Calls



Funding and Tender Opportunities Portal: Topic search



Funding and Tender Opportunities portal: Search in different programme parts



Type of actions for funding

Eligibility Conditions in Horizon Europe

Eligibility

Consortium composition (collaborative projects)

- at least one independent legal entity established in a Member State, and
- at least two other independent legal entities each established either in a different Member State or an Associated Country.

Gender Equality Plan (applicable only from 2022 on)

Participants that are public bodies, research organisations or higher education establishments from Members States and Associated countries **must have a gender equality plan**, covering minimum process-related requirements.

- A self-declaration will be requested at proposal stage (for all types of participants).
- Included in the entity validation process (based on self-declaration)

Admissibility Conditions in Horizon Europe

Admissibility

Same general admissibility conditions

- Applications must be submitted before the call deadline, **electronically** via the Funding & Tenders Portal
- Applications must be **complete, readable, accessible and printable**, and include a **plan for the exploitation and dissemination of results**, unless provided otherwise in the specific call conditions.

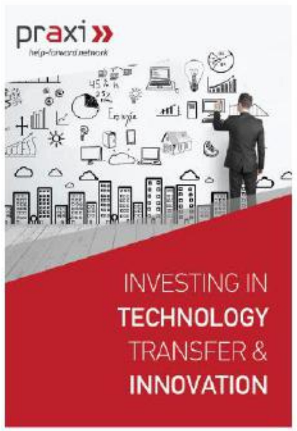
Proposal page limit

Substantial reduction in maximum length:

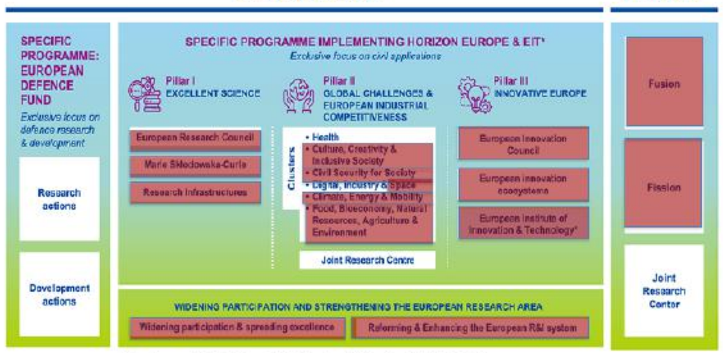
- RIAs and IAs type of actions: limit for a full application is **45 pages**
- CSAs: limit is **30 pages**
- First stage proposals: limit is **10 pages**
- EIC Pathfinder: limit is **17 pages**
- Exceptions, if any, would be specified in the call text.

PRAXI Network: Services towards enterprises and research organisations

- Information
- Consultation support
- Mediation



PRAXI Network: National Contact Point for **Horizon Europe**



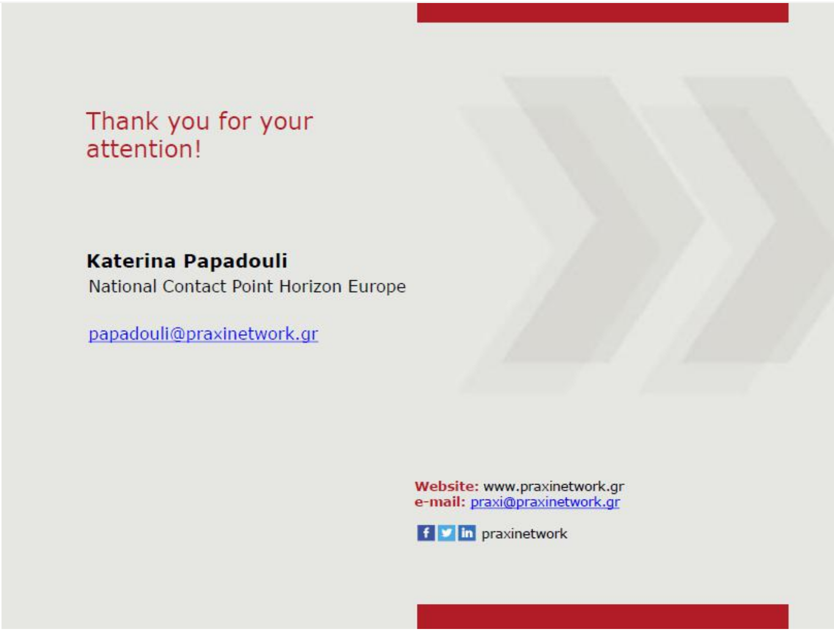
* The European Institute of Innovation & Technology (EIT) is not part of the Specific Programme

Horizon Europe Portal for Greek participants

http://horizoneurope.gr/

Useful Links

- Horizon Europe: https://ec.europa.eu/info/horizon-europe_en
- R&I Missions (incl. reports): https://ec.europa.eu/info/horizon-europe/missions-horizon-europe_en
- Work Programme Missions: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-12-missions_horizon-2021-2022_en.pdf
- Partnerships for R&I: https://ec.europa.eu/info/horizon-europe/european-partnerships-horizon-europe_en
- Open science policy: https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/open-science_en
- Work Programme Cluster 5: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-8-climate-energy-and-mobility_horizon-2021-2022_en.pdf
- Work Programme Cluster 6: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-9-food-bioeconomy-natural-resources-agriculture-and-environment_horizon-2021-2022_en.pdf


Thank you for your attention!
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praxinetwork

Innovation Fund

Mr. Georgios ZISIS – TEGOS

Head, Section for Market Mechanisms and GHG Emission Registry, Directorate of Climate Change and Air Quality, Ministry of Environment and Energy, Hellas

Ministry of Environment & Energy

Department of Market Mechanisms & GHG Emission Registry

14th "International Conference on Energy and Climate Change"
15 October 2021

Funding opportunities under
the Innovation Fund
on energy and climate change issues

Georgios Zisis - Tegos
National Contact Point for Innovation Fund
Head of department
Market Mechanisms & GHG Emission Registry

LEGISLATION

Regulation (EU) 2019/856 on the operation of the Innovation Fund (IF) was adopted pursuant to the fourth subparagraph of Article 10a (8) of Directive 2003/87 / EC the Commission Delegated.

- the forms of support;
- the application procedure;
- the procedure and criteria for project selection;
- the disbursement;
- the governance;
- the reporting, monitoring, evaluation, control, and publicity concerning the operation of the IF.

2

Implementation

➢ For the management of the IF by :

- The European Climate, Infrastructure and Environment Executive Agency (CINEA);
- The European Investment Bank (EIB).

➢ For the development of the IF by :

- The Innovation Fund Expert group.

3

Objectives

- Innovative low-carbon technologies and processes in energy intensive industries, including alternatives to carbon intensive products;
- Carbon capture and utilisation (CCU);
- Construction and operation of carbon capture and storage (CCS);
- Innovative renewable energy generation;
- Energy storage.

4

Target sectors

- Activities listed in Annex I of Directive 2003/87/EC;
- Renewable sources;
- Carbon capture and storage / use;
- Circular economy.

5

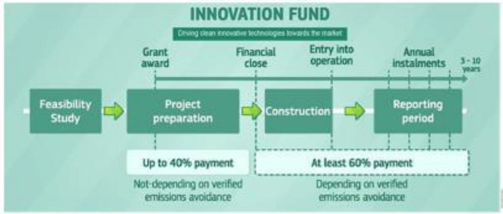
Financing

For the period 2021 – 2030 the IF is endowed:

- with at least 450 million allowances, which can amount to around €10 billion depending on the carbon price;
- undisbursed revenues from the NER300 programme.

6

Forms of the Innovation Fund support



- grants;
- contributions to blending operations under the Union investment support instrument;
- where necessary to achieve the objectives of Directive 2003/87/EC.

7

Selection Criteria (1)

Regulation (EU) 2019/856, Article 11

(a) effectiveness in terms of greenhouse gas emission avoidance potential, where applicable, compared to the benchmarks referred to in Article 10a(2) of Directive 2003/87/EC;

(b) degree of innovation of the projects compared to the state of the art;

(c) project maturity in terms of planning, business model, financial and legal structure as well as prospect of reaching the financial close within a pre-defined period of time not exceeding four years after the award decision;

8

Selection Criteria (2)

Regulation (EU) 2019/856, Article 11

(d) technical and market potential for widespread application or replication, or for future cost reductions;

(e) efficiency in terms of the relevant costs of the project minus any contribution to those costs from the project proponent, divided by the total projected amount of greenhouse gas emissions to be avoided or energy to be produced or stored or CO_2 to be stored in the first 10 years of operation.

9

Selection Procedure (1)

Regulation (EU) 2019/856, Article 12

The pre-selected projects shall be communicated to the Commission with at least the following:

(a) a confirmation of the compliance with the eligibility and selection criteria;

(b) details on project evaluation and ranking;

(c) total project costs and relevant costs referred to in Article 5, in euro;

(d) the request for the total Innovation Fund support in euro;

11

Role of the Member States (1)

Regulation (EU) 2019/856, Article 21

The Member States shall be consulted on:

(a) the list of the pre-selected projects, including the reserve list, and the list of projects proposed for project development assistance in accordance with Article 12(2), prior to the award of the support;

(b) the draft Commission decisions referred to in Article 9(1), Article 14(2) and Article 15(1);

(c) the maximum amount of the Innovation Fund support to be made available for the project development assistance;

13

Role of the Member States (2)

Regulation (EU) 2019/856, Article 21

The Member States shall, if requested by the Commission, advise and assist the Commission in:

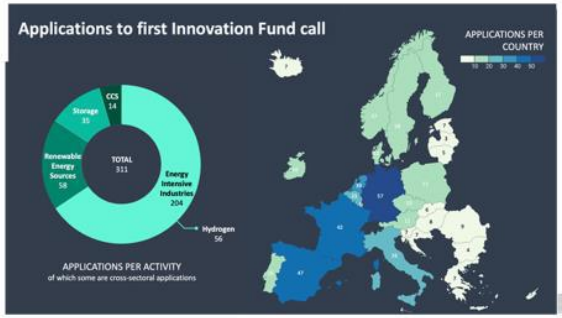
(a) setting general orientations for the IF;

(b) addressing existing or emerging project implementation problems;

(c) dealing with any other issue relating to the project implementation.

14

First call (1)



15

First call (2)

16

First call (3)

17

Second call (1)

For the year 2021
the estimated maximum budgetary is set
at EUR 1.721 millions

(a) EUR 1.500 millions for grants under the call for proposals for large-scale projects (Q4 2021) implemented under direct management;

(b) EUR 100 millions for grants under the call for proposals for small-scale projects (Q1 2022) implemented under direct management;

19

Second call (2)

(c) EUR 4 millions expenditure related to the provision of project development assistance, out of which, respectively, EUR 2 millions and EUR 2 millions will be reserved for grants in the form of project development assistance services to the project proponents under the call for proposals for large-scale projects, and under the call for proposals for small-scale projects;

(d) EUR 100 millions for contributions to blending operations under the Union investment support instrument InvestEU;

(e) EUR 21 millions for other administrative expenditure, including complementary actions under direct management.

20

Second call (1)

Types of solicited projects or sectors :

- environmentally-safe carbon capture and utilization;
- products substituting carbon intensive ones produced in sectors listed in Annex I to the Directive 2003/87/EC;
- construction and operation of projects that aim at the environmentally-safe capture and geological storage of CO_2;
- innovative renewable energy and energy storage technologies.

Type of applicants targeted by the call for proposals :

- legal entities established in the Member States, Iceland and Norway, as well as third countries (provided that the requirements as to the project implementation territory are complied with) whose activities and technologies fall into one of the sectors covered by the IF are eligible to participate.

21

Second call (2)

Maximum possible rate of co-financing of the eligible costs and the form of the IF support :

- The maximum co-financing rate is 60 % of the relevant costs of projects, out of which up to 40% need not be dependent on verified avoidance of greenhouse gas emissions, provided that pre-determined milestones, taking into account the technology deployed, are attained;
- The IF support to projects, except for the project development assistance, shall be disbursed as grants in the form of lump sums.

22

Second call for large-scale projects (3)

Description of the application procedure and a detailed list of information and documentation to be submitted at the application procedure:

- Only projects above EUR 7.5 millions of capital expenditure (large-scale projects) shall be eligible for the Innovation Fund grants under the call for proposals for large-scale projects;
- The grants shall be awarded following a competitive selection process via the call for proposals;
- The applicants shall submit, within a specific deadline, the application forms using the Union's Electronic Submission Service.

23

Second call for small-scale projects (4)

Description of the application procedure and a detailed list of information and documentation to be submitted at the application procedure:

- Only projects between EUR 2.5 millions and EUR 7.5 millions of capital expenditure (small-scale projects) shall be eligible for the IF grants under the call for proposals for small-scale projects;
- The grants shall be awarded following a competitive selection process via the call for proposals;
- During the application procedure, applicants shall submit, within a specific deadline, the application forms using the Union's Electronic Submission Service.

24

The provision of project development assistance

- The financial and technical experts of the EIB shall provide extensive and specific technical and financial support to the projects selected for project development assistance with a view to improving the projects' maturity;
- The EIB shall provide support depending on the project's needs.

25

Contributions to blending operations under the Union investment support instrument InvestEU.

- The objective is to develop and bring to market innovative products, processes, services and business models in eligible sectors that could help pre-commercial innovations develop into revenue-generating activities that provide sustainable growth in Europe's economy.

26

Other administrative expenditure

- Evaluation of projects by external experts during the application procedure;
- IT costs related to the on-boarding of the Innovation Fund to the eGrants system of the Commission;
- Communication, studies and other relevant public procurement costs;
- Fees for monetisation and asset management.

27

Department of Market Mechanisms
& GHG Emission Registry

Thank you

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National Contact Point for Innovation Fund

Head of department
Market Mechanisms & GHG Emission Registry

Envena

Dr. Stavros MAVROUDEAS, Envena, Hellas

envena
Environmental & Energy Advisors

COMPANY PRESENTATION
October 2021

ENVENA Ltd

ENVENA Environmental and Energy Advisors LTD is a consulting company specialised in the sectors of environment and energy.

The company was founded in Athens in 2007 by scientists from the fields of environmental and energy engineering, management and economics, and has cooperative partners in Greece and abroad.

Services

- Environmental Impact Assessments
- Individual/Collective Systems of Alternative Management of Waste
- Planning and Optimisation of Waste Treatment Plants
- Planning and Optimisation for the Installations of Disposal of Waste
- Remediation of Polluted Areas
- Environmental Management of Enterprises (ISO - EMAS)
- Carbon Footprint and Climate Change Studies
- Studies on the Collection and Transportation of Waste

Sectors

- Waste Management
- Smelters
- Hotels
- Sports
- Industry (steel works, plastic films)
- Chemical (fertilisers, pesticides)
- Health

Studies - Examples

Environmental Impact Assessments
- EIA for lead accumulators recycling plant in the industrial zone of Patra - AMEKON SA

Studies - Examples

Environmental Impact Assessments
- EIA for plant for the recycling of WEEE in the Municipality of Agioi Theodoroi, Prefecture Korinthia - EKAN SA

Studies - Examples

Environmental Impact Assessments
- EIA for plant for the depollution and recycling of refrigerators at 'Palaio Horio' in the Municipality of Agioi Theodoroi, Prefecture Korinthia - Hellenic Fridge Recycling SA

Studies - Examples

Environmental Impact Assessments
- EIA for hospital in Athens - Bioclinic Athens SA

Studies - Examples

Environmental Impact Assessments

- EIA for sports training centre – Sportcamp SA

Studies - Examples

Remediation of Landfill Sites / Polluted Areas

- Remediation of a landfill for household waste in the area of Thinalion, Corfu Island - Environmental Association of Prefecture Corfu
- Remediation of a landfill for household waste in the area of Kalamata - Municipality of Kalamata
- Remediation of the area of a former lead (Pb) production plant in the area of Lavrio, Prefecture Attica - Inheritors

Studies - Examples

Zero Emissions Assessments

- Assessment for the creation of a zero-emissions community at Arachneo of Municipality of Nafplio - Municipality of Nafplio

Sustainable Energy (and Climate) Action Plan

- Municipality of Agia Paraskevi
- Municipality of Korydallos
- Municipality of Nafplio

Local Waste Management Plan

- Municipality of Agios Dimitrios
- Municipality of Papagos-Holargos
- Municipality of Vyronas

Cooperation with universities

Greek universities

- National and Kapodistrian University of Athens
- Agricultural University of Athens
- Harokopio University of Athens
- Aristotle University of Thessaloniki

Foreign universities

- T.U. Dresden (Germany)

Other interests

Public consultation - Legislation
- Participation in waste management issues
- Participation in energy issues
- Participation in climate change issues

Conferences
- Participation
- Attendance
-

Contact information

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Thank you

An SRI based approach to increase building smartness

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Abstract

The EU has committed to reduce by at least 40% greenhouse gas emission by 2030 through the so called "Clean energy for all Europeans package" (European Commission, 2019a0) which set the necessary legal framework and financial infrastructure to achieve this ambitious goal. On the other hand, the most recent Green Deal aim to transform the EU into a modern, resource-efficient and competitive economy, ensuring no net emissions of greenhouse gases by 2050. Towards this direction, the EU commission has promoted the establishment of a Smart Readiness Indicator (SRI) (European Commission, 2019b; European Commission, 2020) for buildings to provide information on the technological readiness of buildings for interacting with their occupants and the energy grids, and their capabilities for more efficient operation and better performance through ICT technologies in the form of services.

In this paper we present a holistic building energy management framework targeting to increase the SRI (Directive 2018/844; VITO, 2018) level of the buildings by introducing different types of services targeting SRI uptake and thus changing the role of buildings from unorganised energy consumers to active agents orchestrating and optimising their energy consumption, production and storage, with the goal of increasing energy performance, maximising occupants' benefit, and facilitating grid operation. Such smart capabilities can effectively assist in creating healthier and more comfortable buildings with lower energy consumption and lower carbon footprint. The technological framework is complemented by suitable business models and exploitation strategies to target the broad market of smart building. In section 2, the overall architecture of the proposed SRI based framework is presented. Then, in Section 3, the focus is about the delivery of non-energy services as a core parameter of the SRI methodology. Last but not least, the business model's definition is complementing the work in Section 4 in order to pave the way for further exploitation of the different services.

Keywords: Smart Readiness Indicator (SRI), Building energy management framework.

1. A Holistic SRI Based Building Energy Management Framework

At first, the details of the innovative building management framework which brings together a wide range of SRI oriented technologies and integrates them in a holistic and interoperable framework are presented with the focus on the different operational layers that consist of the holistic solution. The analysis of the architecture remains at a functional level, specifying the detailed functionalities to be served by the different software components as depicted in Figure 1.

The different layers that comprise the integrated framework are briefly described below considering also the different modules of functionality as defined in the schema. As depicted above there are the core layers of the architecture and the additional business and asset layer that complement the overall picture. Starting with the latter:

The **Business layer** represents the point of views and the interactions with the end-users (e.g., building users/managers) and stakeholders (e.g., Energy Service Company (ESCO), Aggregators, etc).

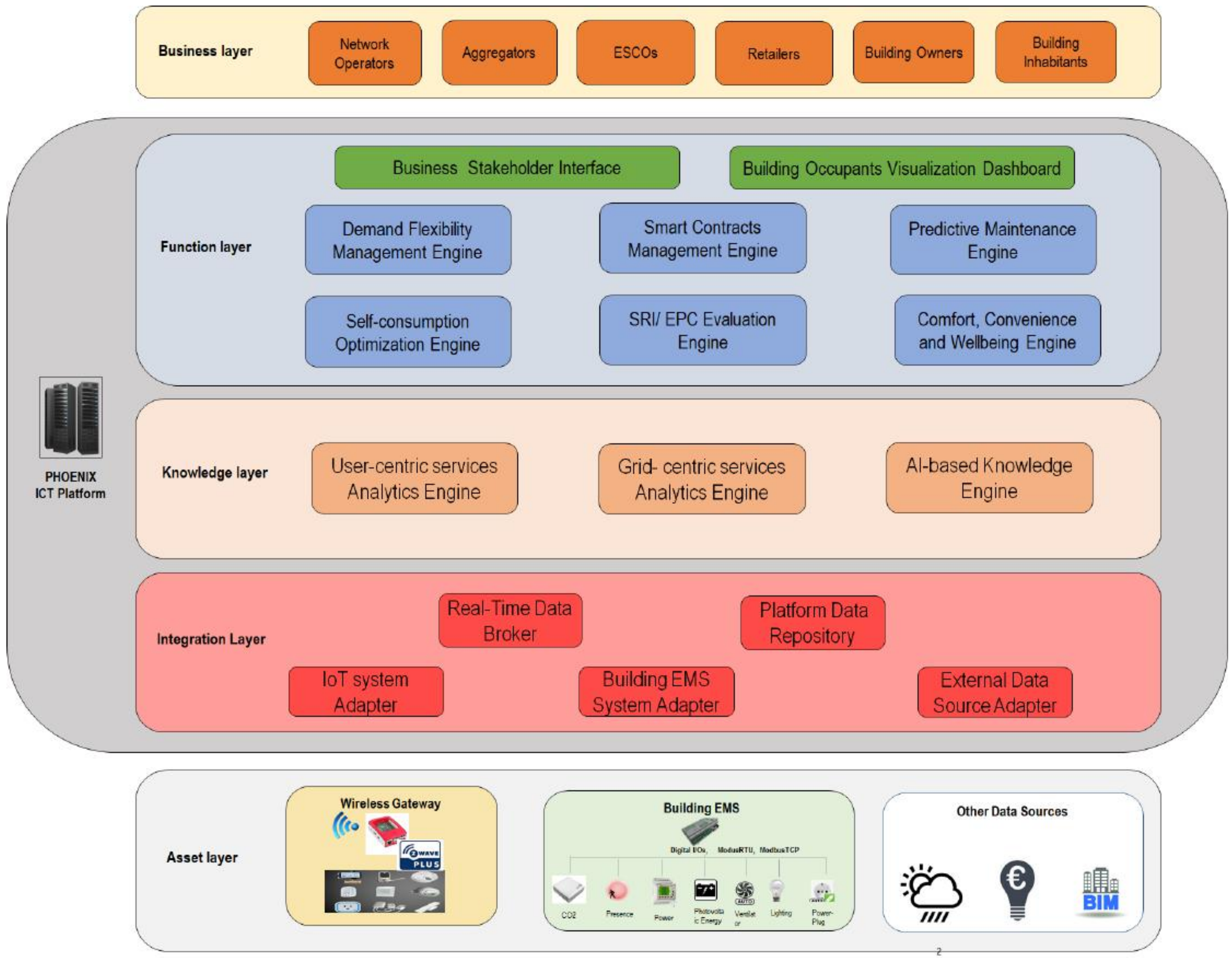

Figure 1: Conceptual architecture for the SRI oriented building management framework.

This layer provides the technical and business aspects of the large-scale pilots and associated requirements, with a specific focus on the “reference” nature of the envisaged architecture. This layer also enables to create also holistic links among different business models.

On the other hand, the **Asset layer** consists of heterogeneous legacy equipment and systems already deployed in the buildings that must be integrated and managed intelligently by the proposed framework. Namely:

- Short-life appliances (e.g., fridges, ovens, washing machines, microwaves, etc).
- Long-life appliances (e.g., Heating Ventilation Air Condition (HVAC), boilers, radiators, Domestic Hot Water (DHW) devices, ventilation, lighting, etc.).
- Energy building equipment (e.g., renewable sources, energy storage, e-vehicle recharging points, energy demanding points, smart meters, smart actuators, etc).
- Management systems (e.g., Energy Management Systems (EMSs) already deployed in existing buildings to monitor and control legacy equipment. These devices that exist in building can be categorised in four families: Envelope Adaptation systems (e.g., windows automatic opening and shading), Technical Building Systems (HVAC, DHW, built-in lighting, building automation and control, on-site electricity generation), Indoor and Outdoor Information Systems (i.e., sensors) and Entertainment Systems (e.g., television, radio, etc.).

It is evident from the schema above, that there are three key layers (Integration, Knowledge, Function) that define the Information Communication Technologies (ICT) software details of the solution with the other two layers (Asset & Business Layer) to complement the overall picture for the end-to-end demonstration of the proposed framework. The details of these technical layers are provided following a bottom-up approach.

The **Integration layer** stand on top of the asset layer and provides the mechanisms for the remote control and data monitoring from different building equipment, systems and external data sources (i.e., weather predictions) with heterogeneous protocols and technologies. This counts for (a) **Internet of Things (IoT) Gateways and Smart Controllers** to bridge the gap between smart home devices and the core data brokering by translating legacy protocols (e.g. Modbus, Zigbee, etc) of digital equipment to standardised Internet protocol in order to monitor and control their operations, (b) **building management systems integrators** to handle the same functionality in commercial buildings where BMS systems are available (c) **external data source wrappers** to incorporate energy (e.g. energy tariffs) and weather related data from national or international organizations into the common management framework.

This layer will be also responsible for the homogenisation of the communication protocols trough a real time broker and further storage to different data formats to enable the easy link between the physical assets and the layers of knowledge and function that follow. More specifically, the role of the **Real-Time Data Broker** is to receive continuous updates about the building’s state and to make sure that updated information reaches the intended parties. It does so by providing querying capabilities as well as subscription mechanisms by which interested parties will receive notifications according to their data requirements. The Real-Time Data Broker, follows the NGSI-LD standard, based in the JSON-LD data format, to allow representing semantic information, further enhancing the context representation. Related to the latter, all SRI principles are incorporated in the common information model in order to further enable the provision of added value SRI oriented services.

Last but not least, the **Platform Data Repository** is defined to is to act as the mid-term data storage for temporal series of data. Its mission is to record context information changes (for example building sensor readings) as they happen. It does so by leveraging the subscription mechanism of the Real-Time Data Broker, which will result in a stream of notifications of data entity changes from the broker, which the Platform Data Repository will store in its internal database.

On top of the Integration layer, the **Knowledge Layer** enables the provision of modular tools for creating building knowledge, based on homogenised data through data processing and analytics to upgrade the smartness of the buildings. At a first level, annotations to the integrated data are defined in order to build a background **Knowledge Graph (KG)** that facilitates the extraction of the SRI information along with relevant information about preferences related to user behaviours. A state-of-the-art ontological based module is defined to serve the SRI calculation on the basis of the data coming from different sources (sensors, appliances descriptions, user profiles, etc) by means of mapping and modelling tools.

In addition, we incorporate in the proposed framework artificial intelligence data algorithms (e.g., machine learning and deep learning) to enable self-learning capacities and automatic decisions to improve energy savings and the overall performance of buildings. Moreover, the data algorithms will generate valuable knowledge to feed the upper layer of smart services. More specifically, the **User-centric services Analytics Engine** will actively contribute to the extraction of user-centric profiles and comfort-profile preferences. Additionally, energy descriptive and predictive analytics will be provided, in order to deliver useful behavioural insights to the building occupant, regarding his indoor environment for better awareness and assurance of optimal indoor conditions. Complementary to this, a **Grid- centric services Analytics Engine** is incorporated in the platform in order to provide energy related analytics to serve mainly grid related functionalities. State of the art generation and demand forecasting analytics will be extracted that will be further complemented by flexibility related analytics in order to provide added value information to the different services that will serve the grid related functionalities of the building.

On top of the proposed ICT framework is the **Function layer** which includes multiple smart cost-effective services offered to the end users in order to optimize the energy saving, the occupants' satisfaction, the overall performance of the buildings and the grid operations as the three interlinked principles of SRI. More specifically, the proposed framework is focusing at the provision of different layers of services to the building occupants:

- Starting with the energy efficiency related services, the **Self-Consumption Optimization Engine** is responsible to provide energy savings optimization (towards the energy utility operators as well as the building occupants) through the day-ahead forecasting of energy generation, energy storage and energy consumption at building level. It is evident that this module is able to address the savings needs of the simplest demand only case while also incorporating additional Distributed Energy Resources (DERs) (Photovoltaic (PV), Electric Vehicle (EV), battery) in the energy savings optimization process.
- Complementary to this, the role of the **Predictive Maintenance Engine** is to enable the provision of equipment maintenance related services, also a key aspect highlighted in the Smart Readiness Indicator methodology. By applying state of the art machine learning techniques over the data streams, the scope of this module is to enable the extraction of useful outlier insights related to the performance of the equipment in building premises.
- At the 2md layer of SRI, the role of the **Comfort, Convenience and Wellbeing Engine** is to enable the provision of non-energy services to the building occupants as a key aspect highlighted in the Smart Readiness Indicator methodology. On the basis of user and social driven requirements defined through the analysis at the building premises, the scope of this component is to first enable identification of poor indoor conditions in buildings that may cause comfort or health issues to the building occupants. Furthermore, the component incorporates smart services that will enable either automated control of the building devices to ensure comfort, health and well-being conditions or context based personalized notifications and messages to building occupants related to the comfort and well-being conditions in premises.
- The **Demand Flexibility Management Engine** covers the needs of the 3rd layer of the SRI towards the provision of flexibility related services to the grid. The role of this module is to enable flexibility calculation and further the delivery of the appropriate interfaces in order to ensure the prompt exploitation of the available flexibility by 3rd party business entities.
- Complementary to the aforementioned SRI business-oriented services, there are additional modules defined in order to address the list of 7 impact criteria of the SRI. Information to building occupants is a very important parameter of the SRI and

thus the **Building Occupants Visualization Dashboard** is defined to serve as the user-centric reporting tool of the proposed framework. As a basis, this tool will incorporate the visualization of the historic, aggregated and real-time data context from metering and sensing of smart devices across the entire topology landscape. All the descriptive and predictive analytics results mentioned in previous sections will also be visualized in the dashboard. On top of these features, new innovations will be added in the overall functionality such as the real time visualization of EPC/SRI certificate, information that is extracted through calculation performed by the **SRI/ EPC Evaluation Engine**. This is actually one of the most innovative aspects as the SRI performance will not be extracted through the static methodology defined by the guidelines; rather actual premises data will be considered for the actual calculation of the smartness of the building.

- Last but not least and in order to server the business validation of the proposed framework, an extra module is defined, named as **Smart Contracts Management Engine.** The role of this module is to enable handling contractual process in real time, and thus delivering the dynamic pricing framework required for the applicability of innovative business models that envisioned in energy sector.

We have to point out that there exists an extra layer, the Protection Layer, which provides the techniques and protocols to ensure the security, privacy and trust of the data exchange in all the horizontal layers. Due to the interoperable and connected nature of the proposed framework, security, privacy and trust mechanisms are required to protect the data exchange among physical assets, integration agents, knowledge processing techniques, smart services and user interfaces in all abovementioned layers. The details of these security/privacy mechanisms, to be developed based on FIWARE Security Enablers to allow devices/systems authentication, privacy preserving & data protection, services access control and user management are not part of this paper.

The different layers of the proposed building management framework were presented above. While there are many functionalities provided by the different components, the focus of the paper is on the details of the Comfort, Convenience and Wellbeing services which is a critical and important aspect of the Smart Readiness Indicator methodology.

2. Smart Confort, Convenience and Wellbeing Services to support Building Smartness

The scope of this section is to provide the details for the proposed Comfort, Convenience and Wellbeing services delivered as part of the holistic building management framework. As stated above the role of this service bundle is to first enable identification of poor indoor conditions in buildings that may cause comfort or health issues to the building occupants. Furthermore, the module incorporates smart services that will enable either automated control of the building devices to ensure comfort, health and well-being conditions or context based personalized notifications and messages to building occupants related to the comfort and well-being conditions in premises (while keeping the energy usage as low as possible to meet the requirements). In order to properly design well fitted services, the review of the most recent regulation in the field is required.

Starting with thermal comfort evaluation, ASHRAE Standard 55 (ASHRAE, 2021) is the document that defines the KPIs with focus on PMV and PPD. In addition to these KPIs, adaptive comfort models are incorporated in the standard. At EU level the most recent standard is the EN 16789-1 (which updated the well know EN 15251) where thermal comfort KPIs are defined. We have to point out that relevant KPIs (Paone and Bacher, 2018) are imported also in the certification bodies such LEED, WELL etc… to address thermal comfort evaluating needs. Considering visual comfort evaluation, it encompasses a variety of aspects, such as aesthetic quality, lighting ambiance and view: Light quality, Luminosity, Absence of glare. As stated in (Holopainen R. et al., 2014) and the EN 16789-1 standard, specific metrics are related to health aspects, as also highlighted in the SRI methodology.

In addition to comfort related parameters, health related parameters need to be considered in the analysis. Focusing on specific IAQ values that are monitored from smart systems, there is the existing regulation that clearly specifies the calculation methodology and the boundary values. An overview of this information is available in (EPA, 2021). The threshold values as specified in the EPA regulation for the most common IAQ values monitored in the residential building environment along with the calculation formulas are:

- PM2.5: PM2.5, in particular, are particles which are 2.5 μm or less in diameter. Their threshold limit value is 25 μg/m^3, based on 24-hour data.
- CO_2: Human health effects can be observed at levels over 7,000 ppm. Therefore, the occupational limits set are 5,000 ppm TLV-TWA* and 30,000 ppm TLV-STEL**.
- NO_2: Due to the adverse effects associated with nitrogen dioxide (NO_2), the EPA strengthened its health guidelines and set a 1-hour standard at the level of 100 ppb.
- tVOC: As it combines the values from different VOCs. Note that its threshold limit value is 0.1 ppm TLV-TWA* and 0.3 ppm TLV-STEL**.

**TLV-TWA: Threshold Limit Value - Time Weighted Average (usually 8 hours)*

***TLV-STEL: Threshold Limit Value - Short Term Exposure Limit (usually 15 minutes)*

Related to health and IAQ conditions, there is a high interest especially in the COVID-19 era. This is clearly depicted also in EU reporting where there is a clear linkage of air quality conditions with COVID-19 (Brunekreef B. et al., 2021). Also, all major health bodies define IAQ related measures and processes in order to reduce the potential for airborne transmission of COVID-19 in building environment (European Commission, 2020; ASHRAE, 2021; Holopainen R. et al., 2014; Paone A. and Bacher J-P, 2018; Brunekreef B. et al., 2021). In (Agarwal et al., 2021) the positive connection between air pollutants (PM2.5 and NO_2) and COVID-19 contagion urges to level the air quality index. From the viewpoint of engineering controls, ventilation can help dilute contaminants and reduce infection risk. As suggested, air should not be recirculated, and thus hygiene ventilation can be done using 100% fresh air with efficient energy consumption for sustainability (World Green Building Council, 2021). Even at commercial level, there are solutions that combine metrics from sensors in order to identify the risk of potential for airborne transmission of COVID-19 (Saini J. et al. 2021). It is evident from aforementioned analysis that employing preventive measures to mitigate air pollution can reduce exposure rate of COVID-19 and thus the design of non-energy services should target also this new situation.

Considering long term impact there exist some literature that estimates the impact of smart building systems and services in non-energy related aspects. While this long-term impact analysis is out of the scope of this paper and the proposed framework, the review of the work is provided as reference. JRC (Shnapp S. et al., 2020) reports a synthesis of co-benefit impacts from many studies but the most significant is the so-called COMBI study (Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe), which compiled an assessment of health and wellbeing impacts from all 28 EU countries and derived monetized benefits for: asthma (Disability Adjusted Life Years (DALY)), excess winter mortality, indoor air pollution, mortality - ozone, mortality -PM2.5, reduced congestion amongst others. The JRC study compiles and synthesizes the data on the impacts and monetised values of the following:

- reduced winter mortality attributable to lower ozone and PM2.5
- reduced winter morbidity attributable to lower indoor air pollution (units of 1000 Years of Life Lost (YOLL)), lower asthma (units of DALY), lower PM2.5 (units of YOLL)
- reduced diseases arising from thermal discomfort
- learning and productivity benefits due to better concentration, savings/higher productivity due to avoided “sick building syndrome” whose value can then be assessed in terms of active days gained (indoor exposure) and workforce performance (mn workdays).

Furthermore, a survey from 2015 and 2016 examined several characteristics of a healthy home and the importance for healthy living. In this context, participants were asked to score health categories from 1 to 7 (1 being “not important” and 7 being “very important”). The results of this survey indicate:

- sleeping well received a score of 6.4
- ventilation for fresh air scored 6.1
- plenty of daylight received a score of 5.9.

In this context, smart building technologies can help occupants to achieve the characteristics of healthy homes, by increasing the level of controllability/automatization with the use of indoor environmental quality sensors (to regulate temperature, humidity, ventilation, lighting and CO_2) and maintain healthy indoor climate conditions and thermal comfort level. This is the approach adopted for the services envisioned at the proposed framework, presented in the figure 2.
More specifically there are 3 layers that comprise the data driven service framework, namely:

- **Comfort, Health and Well Being Interface Layer**: The role of this module is to act as the wrapper of the application in order to ensure information exchange with external components. The role of this bundle is twofold: (a) to ensure integration with external systems in order to retrieve data from the building environment (as specified above) required for the provision of the non-energy services and (b) to perform a real-time evaluation of comfort, health and well-being aspects considering also the KPI values as specified in the state-of-the-art analysis presented above.
- **Comfort, Health and Wellbeing Recommendation Engine**: The role of this DSS module is to correlate building contextual conditions along with the extracted comfort profiles and user settings in order to generate the appropriate notifications associated with the indoor conditions in premises. More specifically, the features of the recommendation approach (via a tailor-made and personalized recommendation engine) should include:
    - Timely and Context-Aware: triggers and meaningful feedback for timely need-to-act will be offered close to relevant events and necessary actions, taking into account real-time conditions like environmental conditions from sensors (luminance, temperature & humidity)
    - Non-intrusive: feedback modality, frequency and context will be configurable to ensure discreteness
    - Personalized: feedback will be customized to occupant characteristics and relevant energy behaviours, comfort preferences and contextual requirements. Feedback from the end users is also considered in order to ensure personalization at the different notifications triggered to the users.

The high-level overview of the recommendation engine is presented in the Figure 3. Comfort, Health and Well Being Automation Engine: The role of this DSS module is to correlate building contextual conditions along with the extracted comfort profiles and user settings in order to automatize the operation of controllable devices (focus on HVAC, Lights etc.) on the way to ensure the establishment of a comfortable, health and well-conditioned environment.

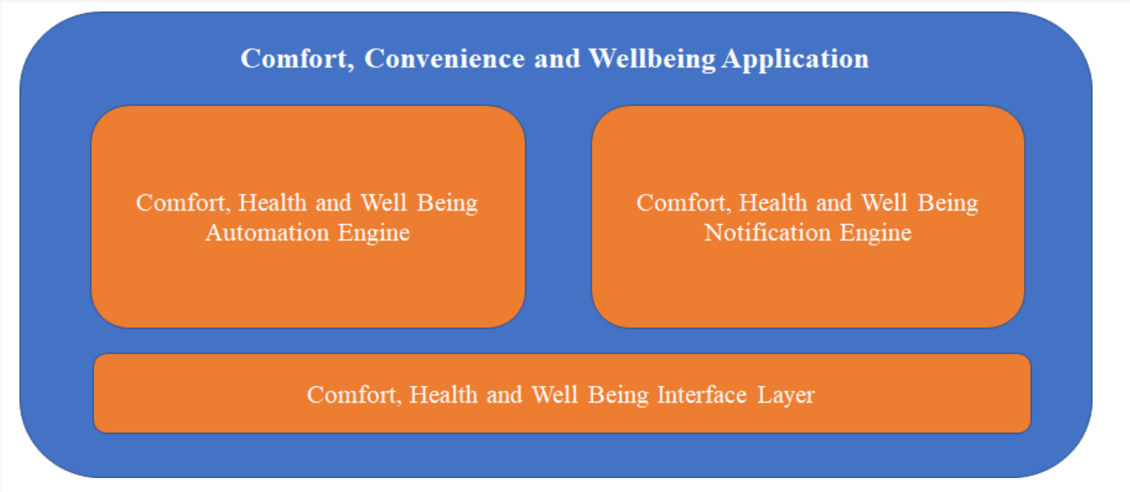

Figure 2: Non-Energy Services for the building environment.

By taking into account impact criteria such as the goal objective (comfort vs health), the level of automation (frequency of triggers) and the feedback from the end users (by rating the automation actions performed by the system), the Decision Support System (DSS) system adapts its operation in order to perform the appropriate control strategies. A high-level overview of the DSS system is presented in Figures 3 – 4.

3. Test activities & Business Models

The overall solution and integrated optimization framework will be demonstrated and validated until 2023 in four different regions around Europe. In Spain, the pilot site is located at Region de Murcia and includes two different types of building, an office building and a residential building. The demonstration activities for the office building will take place at CEEIC in Cartagena. This business incubator building focus on start-up and early-stage innovative companies. 20 spaces between company's offices and lecture rooms will participate in the validation activities for the proposed framework. The residential building selected is located at the city centre of Murcia. Four apartments will be involved in the pilot site. Each apartment is approximately 125 square meters and they are equipped with common domestic appliances. In Greece, a residential building complex at the region of Thessaloniki is considered as part of the demonstration activities. Similar to the previous case, typical domestic appliances are placed in the region and the only smart devices already installed are smart thermostats that control the refrigerant flow that serve the fan coils to perform the conditioning of the apartments. The Swedish pilot site is located in Skellefteå, a city in northern Sweden. The pilot site includes a building which is both residential and commercial. It has 12 apartments and a commercial space at the front of the building on the ground floor. The total area including the commercial space is 1920 square meters of heated area and 1278 square meters of living area. The occupant age group ranges between 20-76 years with average age of 50 years approximately. Last but not least the Irish demo site is formed by commercial and residential buildings, having a large wealth of data which is locked at the moment on closed systems that need to be integrated. The commercial pilot building is the National Centre for the Circular Economy in Ireland, the Rediscovery Centre. The building is a repurposed boiler house and includes solar PV, CHP, heat pump and solar thermal. The sensors and actuators are connected to a Building Management System that allows control of services It is an ideal demonstration site for optimisation in a building with a BEMS and a range of energy using and conversion technologies. In addition, two privately owned residential buildings located within a Sustainable Energy Community located to the south east of Dublin City have been chosen as good exemplars of smart upgrades for energy and related services.

- In all these demo sites different types of services as presented above will be tested taking into account the data gathered from the installations in premises. Based on pilot business needs the focus should be on the delivery of SRI oriented services spanning from energy savings and self-consumption optimization, comfort and health maximization while also considering the potential integration of the buildings to the grid towards the provision of flexibility related services.
- The demonstration activities should be accompanied by the definition of profitable business models as the main interest for the consumers and business stakeholders is to ensure financial profit along with any other social impact. The future of EEB (Energy Efficiency Building) sector involves engaged all relevant stakeholders becoming active producer of data, rather than passive consumers of data provided by other parties.
- which in addition ensure the provision of new services to occupants, managers and the grid. The deregulation of the energy market and furthermore the incorporation of buildings in market-based frameworks as defined in the electricity sector will enable the definition of innovative fine grained business schemas that will fully remunerate the smartness potential of the buildings.

4. Conclusions

At present, about 45% of the EU's buildings are over 50 years old and almost 75% of the building stock can be considered as energy inefficient. This issue is even more worrying when seeing that 75–90% of the existing buildings are expected to be standing by 2050.

Figure 3: Non-Energy Services Recommendation Engine.

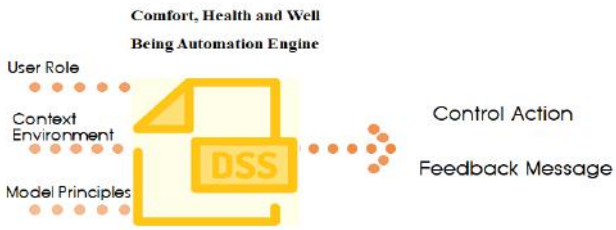

Figure 4: Non-Energy Services Automation Engine.

Figure 5: Demonstration Sites for framework evaluation.

In order to address this emerging need for building increased energy efficiency the EU in the 2018 revision of the EPBD, aims to further promote smart building technologies, in particular through the establishment of a Smart Readiness Indicator (SRI) for buildings. The SRI aim to provide information on the technological readiness of buildings for interacting with their occupants and the energy grids, and their capabilities for more efficient operation and better performance through ICT technologies in the form of services. Therefore, the SRI should accelerate the transformation of the European Building Stock from standard and manually managed buildings to smart buildings. Smart buildings integrate cutting edge ICT-based solutions for energy efficiency and energy flexibility for their daily operation. Such smart capabilities can effectively assist in creating healthier and more comfortable buildings with lower energy consumption and lower carbon footprint.

This digital transformation of the existing European building stock requires an ICT-based solution, which covers from the technological improvements of equipment until the business exploitation of the innovations born in this project. The overall framework presented in this paper aims to increase the smartness of existing buildings, covering all aspects of a building – from assets and their integration to creation of knowledge, functions/services and business opportunities – all while keeping strict security and privacy levels. Overall, the mission is to provide an approach that changes the role of buildings from unorganised energy consumers to active agents orchestrating and optimising their energy consumption, production and storage, with the goal of increasing energy performance, maximising occupants' benefit, and facilitating grid operation.

Acknowledgment

The work presented in this paper is co-funded by the EU HORIZON 2020 Program (topic: "LC-SC3-EE-4-2019-2020 - Upgrading smartness of existing buildings through innovations for legacy equipment") under grant agreement no. 893079 (project title: "PHOENIX - Adapt-&-Play Holistic cost-effective and user-friendly Innovations with high replicability to upgrade smartness of existing buildings with legacy equipment", https://eu-phoenix.eu/).

Abbreviations

API	Application Programming Interface
CHP	Combined Heat Power
DALY	Disability Adjusted Life Years
DER	Distributed Energy Resources
DSS	Decision Support System
DHW	domestic hot water
EEB	Energy Efficiency Building
EPBD	Energy Performance Building Directive
EPA	Environmental Protection Agency
EPC	Energy Performance Certificate
EVs	Electric Vehicles
EU	European Union
ESCO	Energy Service Company
HVAC	Heating Ventilation Air Condition
EMS	Energy Management System
ICT	Information Communication Technologies
IoT	Internet of things
KG	Knowledge Graph
JRC	Joint Research Centre
IAQ	Indoor Air Quality
KPIs	Key Performance Indicators
NGSI-LD	Next Generation Service Interfaces- Linked Data
PMV	Predicted Mean Vote
PPD	Predicted Percentage Dissatisfied
PM	Particle Material
PV	Photovoltaic
SRI	Smart Readiness Indicator
VOC	Volatile Organic Compounds
YOLL	Years of Life Lost

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R & D Manager

Short CV

Kostas TSATSAKIS (male) is an Electrical and Computer Engineer, holding an MSc in the field of Energy and Environmental Management, both from the National Technical University of Athens. He has considerable experience in energy saving related topics through the use of IT applications, data and systems interoperability, standardization of automated operation of energy systems and active network management. Through his participation in the FP7 and H2020 projects MERGE , BESOS, NOBEL GRID, ORBEET, MOEEBIUS, WiseGRID, Heat4Cool, INERTIA, FLEXCoop , UTILITEE, MERLON, BIM4EEB, BIMERR he has specialized in developing techniques for user modelling and profiling for understanding energy behaviors of consumers and shaping optimal control strategies and energy management to ensure the smooth operation of power networks and its undisturbed and uninterrupted power supply.

An SRI based approach to increase building smartness

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- Energy savings on site
- Maintenance & fault prediction
- Comfort
- Convenience
- Health & wellbeing
- Information to occupants
- Grid flexibility & storage

Rationale & Motivation

- The amount of buildings that need to be upgraded is really large in Europe, if the technologies are properly designed.
- All EU countries establish a long-term renovation strategy to support the renovation of their national building stock into a highly energy efficient and decarbonised building stock by 2050.
- Green Deal → A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives
- Smart readiness indicator as a common EU scheme for rating the smart readiness of buildings.
- EPBD update to apply for Fit for 55 package

A holistic SRI Framework – Key Objectives

Key Objectives of the framework

KO1: Allow Adapt-&-Play seamless integration of domestic appliances, legacy equipment and building systems

KO2: Create building knowledge with innovative techniques to upgrade the smartness of existing buildings

KO3: Enable real-time communication with energy stakeholders to optimise the grid operation.

KO4: Provide cost-effective services for building end-users to maximize the energy efficiency and overall performance.

KO5: Allow security and privacy of building data regarding the revised EPBD and the GDPR law

KO6: Create suitable business models and exploitation strategies to target the broad market of smart building

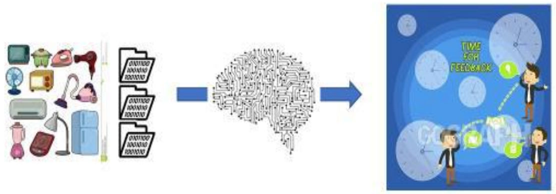
A holistic SRI Framework – Key Objectives

Framework in a nutshell

Objective 1: The concept of Adapt&Play

KO1: Allow Adapt-&-Play seamless integration of domestic appliances, legacy equipment and building systems

Objective 2: The concept of The Building Smartness-Hub



KO2: Create building knowledge with innovative techniques to upgrade the smartness of existing buildings

A holistic SRI Framework – Key Objectives

Framework in a nutshell

Objective 3: Creating a lingua franca

KO3: Enable real-time communication with energy stakeholders to optimise the grid operation.

Objective 4: Developing the tools for people that will help us using less energy and improve wellbeing

KO4: Provide cost-effective services for building end-users to maximize the energy efficiency and overall performance.

A holistic SRI Framework – Key Objectives

Framework in a nutshell

Objective 5: Ensuring that more connectivity does not imply more vulnerability

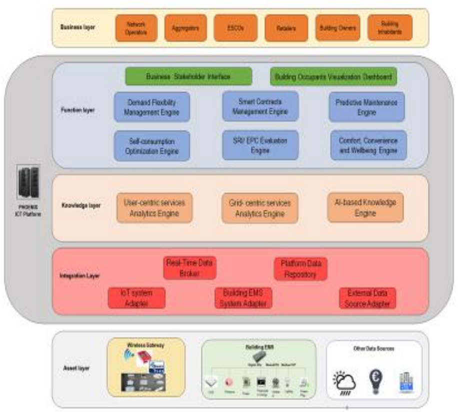
KO5: Allow security and privacy of building data regarding the revised EPBD and the GDPR law

Objective 6: The best way of elongating the solution in the future is teaching it how to fly solo

KO6: Create suitable business models and exploitation strategies to target the broad market of smart building

The holistic SRI Framework solution

- **Business layer** represents the interactions with the end-users (e.g., building users/managers) and business stakeholders (e.g., ESCO, Aggregators, etc).
- **Function layer** includes multiple smart cost-effective services offered to the end users
- **Knowledge layer** consist of modular tools that create knowledge through data processing and analytic techniques
- **Integration layer** provides the mechanisms for the remote control and data monitoring of different equipment with heterogeneous protocols and technologies.
- **Asset layer** consists of heterogeneous legacy equipment and systems already deployed in the buildings that must be integrated and managed intelligently



The holistic SRI Framework solution

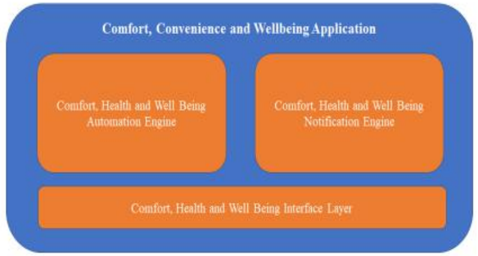
ID	Software Component	Architecture Layer
1	PHOENIX External Data Source Adapter	Integration Layer
2	PHOENIX Building System Adapter	
3	PHOENIX IoT System Adapter	
4	PHOENIX Real-Time Data Broker	
5	PHOENIX Platform Data Repository	
6	AI-based Knowledge Engine	Knowledge Layer
7	User - centric Services Analytics Engine	
8	Grid - centric Services Analytics Engine	
9	Comfort, Convenience and Wellbeing Engine	Function Layer
10	Predictive Maintenance Engine	
11	SRI/ EPC Evaluation Engine	
12	Building Occupants Visualization Dashboard	
13	Smart Contracts Management Engine	
14	Demand Flexibility Management Engine	
15	Self-consumption Optimization Engine	
16	Business Stakeholder Interface Engine	

Non Energy Services in SRI

- ASHRAE Standard 55 is the document that defines the KPIs with focus on PMV and PPD. In addition to these KPIs, adaptive comfort models are incorporated in the standard. At EU level the most recent standard is the EN 16789-1
- Certification bodies such LEED, WELL focus on health and comfort conditions in building premises
- EPA regulation for the most common IAQ values monitored in the residential building environment - PM2.5, CO2, NO2, tVOC → IAQ at post COVID era
- Long term impact: COMBI study → Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe

Comfort, Convenience and Wellbeing Services

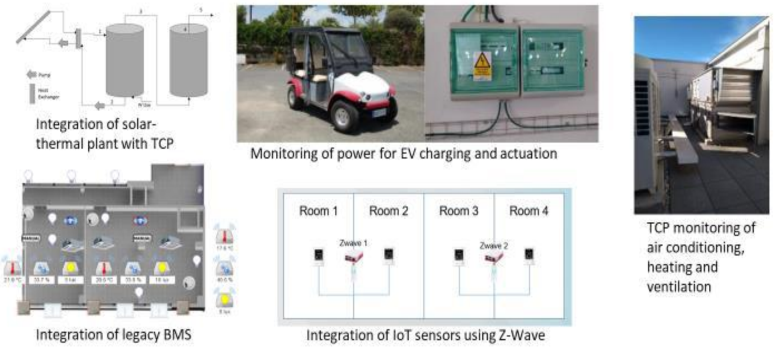
- **Comfort, Health and Well Being Interface Layer**: to act as the wrapper to ensure information exchange with external components.
- **Comfort, Health and Wellbeing Recommendation Engine**: to generate the appropriate notifications associated with the indoor conditions in premises.
- **Comfort, Health and Well Being Automation Engine**: to automatize the operation of controllable devices (focus on HVAC, Lights etc.) on the way to ensure the establishment of a comfortable, health and well-conditioned environment



Demonstration Activities

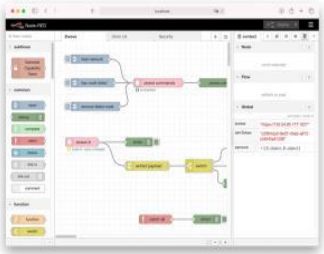
Demonstration Activities

- Integration of legacy system where an intervention has been done to upgrade the smartness of the building



Demonstration Activities

- We are achieving the connectivity of a variety of devices that were legacy before
- This has included for example the creation of low-cost secured gateways based on R-Pi, that we are testing in the Proof of Concept



Questions

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PHOENIX

https://eu-phoenix.eu/

A holistic flexibility management framework for energy aggregators

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Abstract

Since 2014, the strategy of the European Union has been clear: "we need to drive a clean, secure and efficient energy transition to face climate and energy challenges". This strategy has been reinforced by the strong commitment of the European Union towards the signature of the landmark 2015 Paris Agreement as well as the ambitious "Clean Energy for All Europeans" package (European Commission, 2019). In addition, the EU is now in the process of updating its energy policy framework in a way that will facilitate the clean energy transition and make it fit for the 21st century. The new policy framework brings regulatory certainty and empowers European consumers to become fully active players in the energy transition and fixes two new targets for the EU for 2030: a **binding renewable energy target of at least 32% and an energy efficiency target of at least 32.5% -** with a possible upward revision with the new EU Green Deal (European Commission, 2021).

In the context of these key targets for the year 2030, the increasing share of Distributed Renewable Energy Sources has **become key to improve the carbon footprint of the European electricity system and achieve energy and climate change policy goals.** While these distributed ecosystems are posing serious challenges to the stability and security of the European grids, there are at the same time new opportunities for new types of power assets such as batteries, power to heat/cold solutions, vehicle to grid services etc. offering a large flexibility potential. There is an evident need for a set of efficient, cost-effective, integrated solutions, to facilitate the optimum combination of decentralised flexibility assets, both on the generation Distributed Energy Resources (DER) side and on the demand side (V2G - Vehicle to Grid, power-to-heat/cold/gas, batteries, demand response), enabling all parties, including final prosumers, to offer their flexibility in the recently established markets creating benefits in the smart grid value chain. Towards this direction, a tool for flexibility managers is designed and developed to: (a) provide analysis and forecasting of flexibility potential from different energy sources with focus on Power-to-X (P2X) solutions incorporated in the electricity grid, (b) segmentation, classification and clustering of flexibility sources based on their location, response time, flexibility capacity and suitability to offer different types of services (c) Dynamic Virtual Power Plant (VPP) creation tools for the deployment of distribution grid optimization strategies (e.g. peak demand reduction/ increase of Renewable Energy Sources (RES) penetration/ ancillary services based on DSOs/TSOs (Distribution/Transmission System Operators), (d) Dynamic Configuration of flexibility-based Virtual Power Plants (VPPs) (execution of what-if scenarios and selection of optimal VPPs to increase the profits obtained by means of new market options and mechanisms). In section 2 of the paper, an overview of the holistic approach along with the modelling details for the P2X framework are provided. In section 3, the business layer of the proposed framework is specified. In section 4, some words about the demonstration activities for the innovative framework are reported along with the conclusions and key remarks.

Keywords: Energy Aggregators, Distributed Energy Resources, Virtual Power Plants.

1. A Holistic Flexibility Management Framework for Energy Aggregators

Up to now, most of the research activities and commercial solutions in the area of DER flexibility management have focused mostly on specific energy sources, technologies and actors, considering only a very limited and isolated part of the whole network, missing the vast flexibility opportunities that a holistic, integrated approach to the overall energy value chain can bring. In this context, we propose a framework that aim to create and integrate synergies across all energy flexibility sources and technologies, to create the optimal combination of decentralized flexibility assets located along the whole energy value chain, providing benefits to all the actors of the smart grid, energy retail and wholesale market, offering an all-win scenario.

At first, the details of the innovative flexibility management framework which brings together a wide range of DER types and technologies and integrates them in a holistic framework are presented in figure 1. The different layers that comprise the integrated framework are briefly described below.

The **Application layer** represents the point of analysis of raw data coming from the different DERs in order to further model and forecast the operation of these DERs towards the extraction of the available flexibility. The different modelling approaches are incorporated into software bundles, setting that way the different microservices for the management of the different flexible assets' technologies in place, namely:

- DER profiling layer covering generation, battery and EV charging point assets
- P2X profiling layer covering P2G and P2H solutions
- Demand Side Flexibility profiling layer covering demand side assets

In association with the different micro-modules, a unified common semantic layer is defined to ensure that the output of each modelling approach can be easily integrated into the proposed framework. On top of this layer is the (business) flexibility aggregation & clustering component responsible to aggregate the available flexibility from the different flexible sources, further making it available to the Aggregator or 3rd party business entities (marketplace). This layer is split into different functions namely:

- Flexibility Aggregation & Filtering analytics layer where the focus is at providing simple analytics over flexibility timeseries
- Flexibility Clustering layer where the focus is at providing more complex analytics over flexibility timeseries
- A flexibility management component responsible to optimize the utilization of the different flexible sources taking into account the business and operational requirements and constrains
- The User Interface provided as the front end of the application, on the way to provide an intuitive visualization for the system stakeholders, the aggregators.

As stated at the introduction, a main innovation of the proposed framework is the incorporation of a P2X framework for the exploitation of the available flexibility. More specifically, this task aims at properly modelling P2G (power-to-gas) systems (electrolysers together with hydrogen storage in fuel cells) as well as different types (both at industrial and residential level) of boilers as P2H solutions. Regarding the Power-to-Gas, the concept uses renewable or excess electricity to produce hydrogen (Power-to-Hydrogen) via water electrolysis (Wulf C. et al., 2018).

By using a P2G system the sur-plus electricity production from the local generation system is used to generate and store gas. The stored gas can be exploited afterwards in a variety of applications such as power generation, chemical industry, district heating, transportation and gas storage (Xing X. et al., 2018). The above-mentioned characteristics make P2G systems able to be coupled with multi-energy systems adding also more flexibility to the electrical system. For these reasons P2G is considered as a key technology that may enable the realization of large-scale integration of renewable energy. In the concept considered, we envision the exploitation through fuel cells in order to generate electricity when needed. Regarding the modelling of the electrolyser several models are available in the literature.

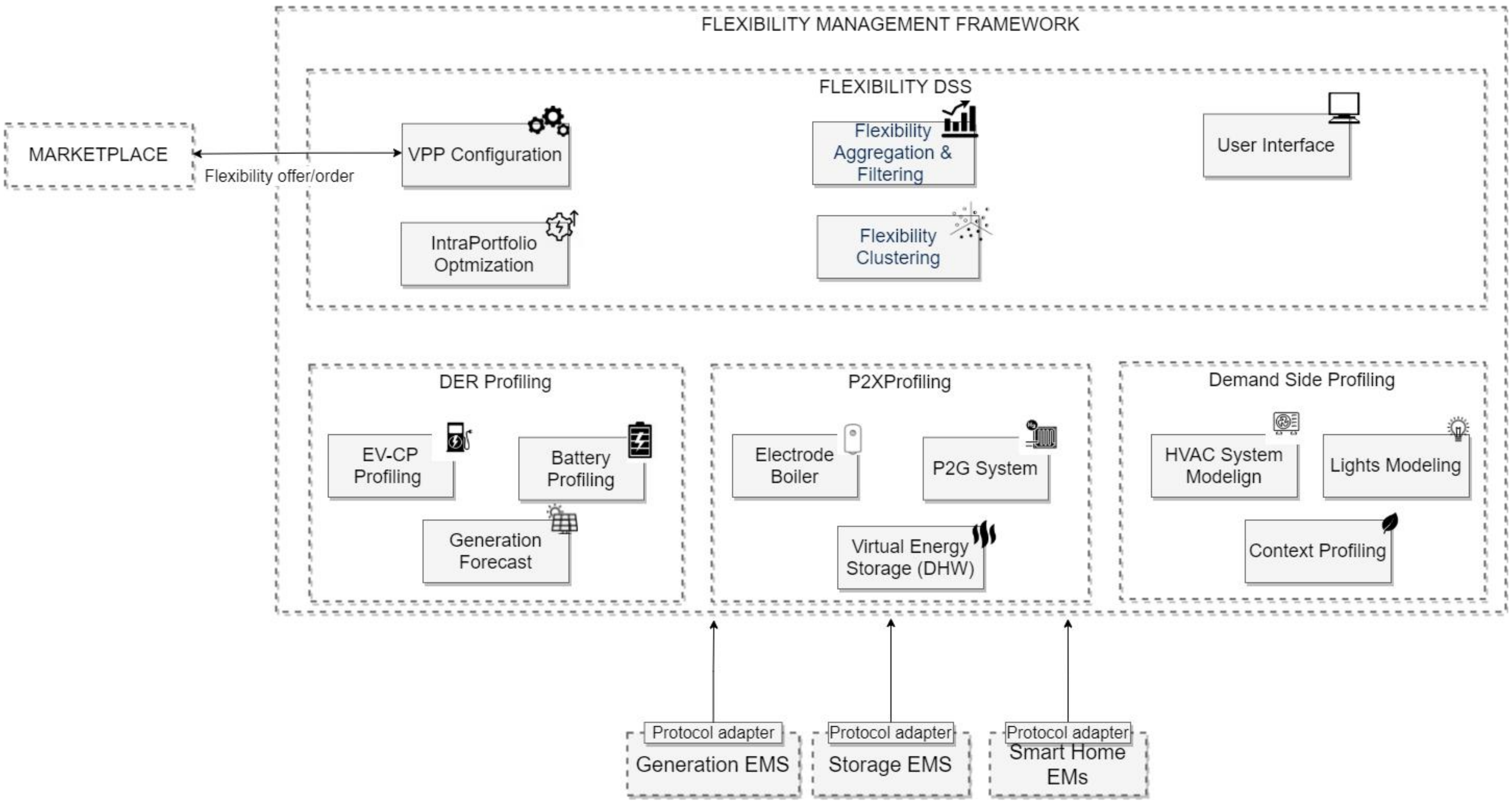

Figure 1: Conceptual architecture for the holistic flexibility management framework.

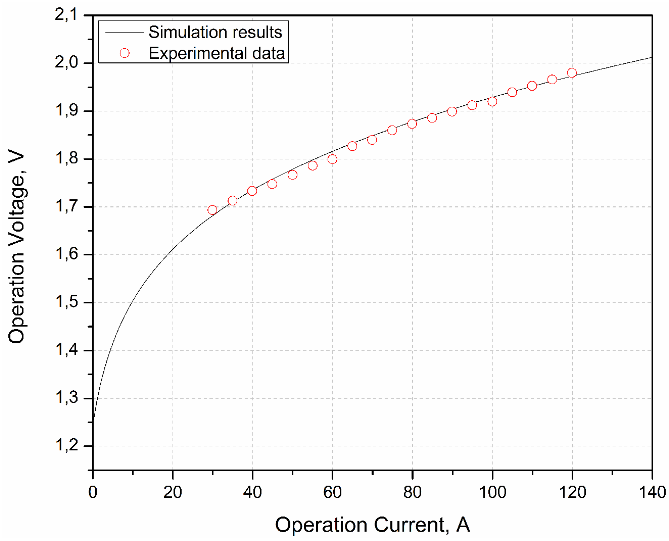

Figure 2: Operation curve of electrolyser.

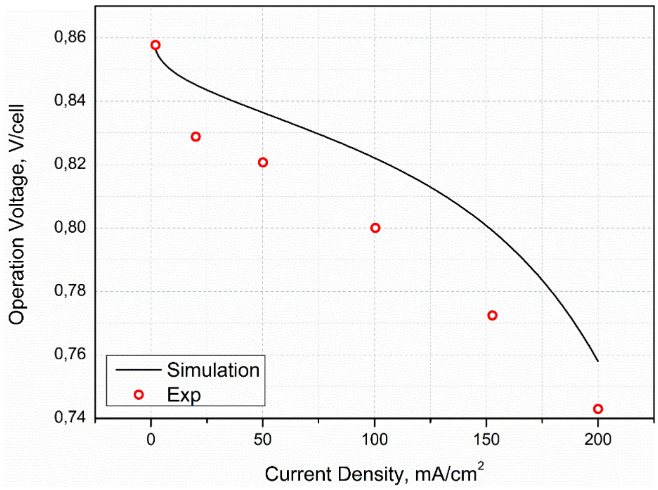

Figure 3: Operation curve of fuel cell.

In (Mazza E., Bompard G., 2018; Schiebahn S., et al., 2015) the authors used a model to estimate the hydrogen production rate of a Unipolar Stuart cell by assuming 100% current efficiency. Empirical models have also been developed using experimental data to describe the current-voltage characteristics of the electrolyser. The experimental measurements show that the I-V characteristics are mainly depend on the temperature and pressure. There are empirical models that use the "log" term to describe the non-linearities between the voltage and the current and others that use the "ln" term.

Regarding the fuel cell modelling, polarization curve fitting equations can be found in the (Priya K. et al., 2018; Laurencelle F. et al., 2001; Francois B. Et al., 2005) to express the relation between the cell voltage and the current density. These equations model the I-V characteristics of the fuel cell and are a good indicator of the performance of the fuel cell stack A typical polarization curve of a Polymer Electrolyte Membrane (PEM) fuel cell is characterized by three distinct regions (Barbir F., Gomez T., 1997; Kim J. et al., 1995; Liangyu M. et al., 2018), namely: activation polarization, ohmic polarization, and concentration polarization. The activation polarization region is represented by the first part of the curve which is strongly non-linear and steep indicating the nature of the reactions. The ohmic polarization region corresponds to the second part of the curve where the ohmic losses caused by the membrane electrical and contact resistance are depicted. Concentration polarization is reflected in the last section of the curve indicating the concentration gradient caused by electrochemical reaction.

On the other hand, the P2H technology (Bloess A. et al., 2018) is also examined with focus on boiler systems, both industrial and residential. Starting with industrial applications, electrode boiler is a type of boiler that uses electricity flowing through streams of water to create steam or hot water. Circulating water is injected into the outer bucket by the feedwater pump, while the variable frequency pump (inner circulating pump) injects the circulating water into the inner bucket (mounted on ceramic insulators which in turn are attached to the outer vessel) to adjust the water level. Three electrodes are symmetrically arranged on the top of electric boiler, which are directly pulled into the inner bucket and are immersed in the circulating water. The electrodes and the circulating water of inner bucket form a closed loop to transform electrical energy (coming in between 1-35 kV) into heat or hot water when the electric boiler is working, making molecules of circulating in boiler's upper part water move faster. The steam or hot water is sent to the heat exchanger through pipe and exchanges the heat with heat users, then the main steam or water is cooled down to cooling water. After removing salt in desalting device, the circulating water is sent back to the outer bucket again.

Water conductivity and temperature are the non-controllable parameters that affect the operation of the system. Therefore, as part of the modelling work, the appropriate fitting curve must apply in order to extract the operational curve that fit to the nominal curve of the electrode boiler system (Francois B. et al., 2005; Zhi X. et al., 2017).

A similar approach is adopted for residential boiler systems. The main differentiation is that there is no SCADA system available for monitoring the operational parameters and thus context-based models have to be considered. The same physics principles are considered for the residential level boiler systems and the monitored parameters are: water and air temperature, water flow in and out along with the operational status considering also hot water demand as presented in the following schema (Vanthournout K. et al., 2012; D'hulst R. et al., 2015).

A one-node lumped-parameter model is selected for the closed-loop DHW model operation. The equation that expresses the operation of the DHW is presented:

$$E_{tank}(t) = P_{elec(t)} - P_{draw(t)} - P_{loss(t)} \quad (1)$$

Where at each given state t:

- $E_{tank}(t)$ is the thermal energy of the water inside the DHW at each state (t)
- $P_{elec(t)}$ is the power input delivered to the heating element at each state (t)
- $P_{draw(t)}$ is the power output due to hot water draw (hot water leaving the DHW and being replaced by cold water) at each state (t)
- $P_{loss(t)}$ is the power output due to thermal losses to the environment at each state (t)

The details of each of the aforementioned parameter is provided as part of the modeling work. Starting with power input modeling, the heating element is either OFF or ON, which means that the power input $P_{elec(t)}$ delivered by the element is either zero or its rated power P_{rate}. This operation is evident from the load curve of the DHW system.

The power output due to hot water draw $P_{draw(t)}$ is given by the following equation:

$$P\_draw(t) = \rho * Qdraw(t) * [\, h\_outlet(t) - h\_inlet(t)] \quad (2)$$

Where:

- ρ is the density of the water,
- $Qdraw(t)$ is the hot water outlet volumetric flow rate
- and $h\_inlet(t)\, h\_outlet(t)$, are the specific enthalpy entering and leaving the water heater, respectively.

Under conditions of constant pressure and constant specific heat capacity, this can be approximated by the following:

$$P\_draw(t) = cp * Qdraw(t) * [T\_outlet(t) - T\_inlet(t)] \quad (3)$$

Where:

- cp is the constant pressure-specific heat capacity of the water
- $T\_outlet(t)$ is the hot water outlet temperature
- $T\_inlet(t)]$ is the cold-water inlet temperature.

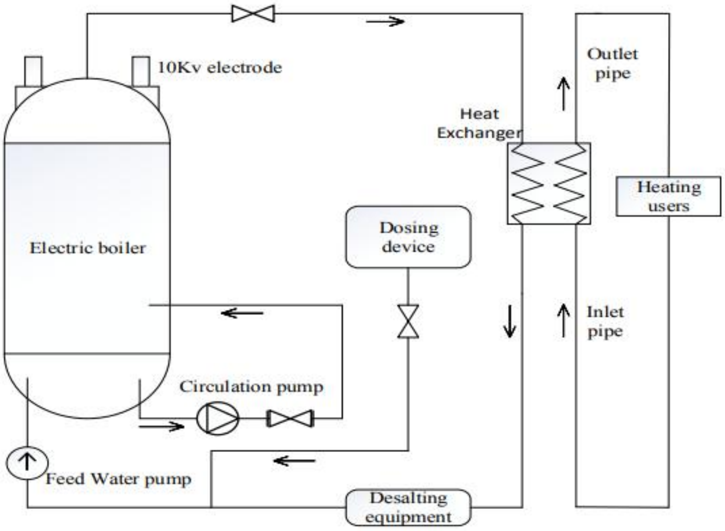

Figure 4: Technical characteristics of electrode boiler.

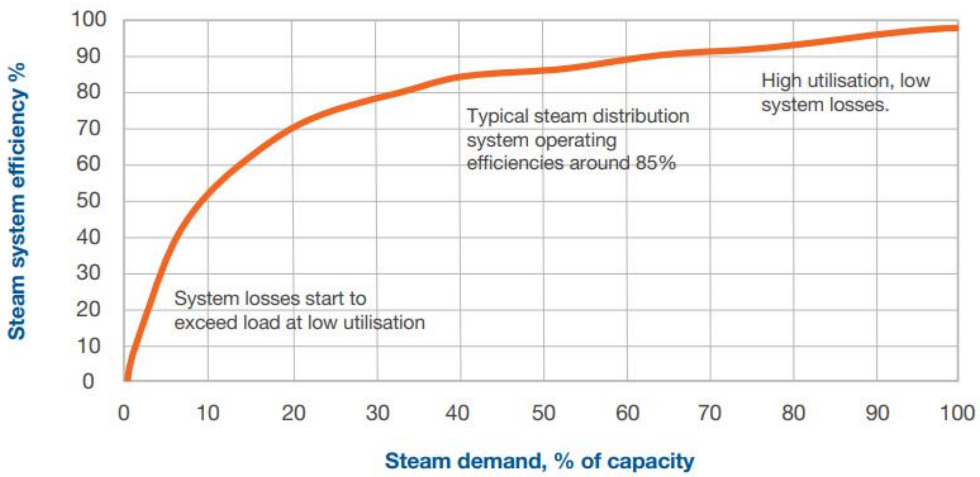

Figure 5: Operation curve of electrode boiler.

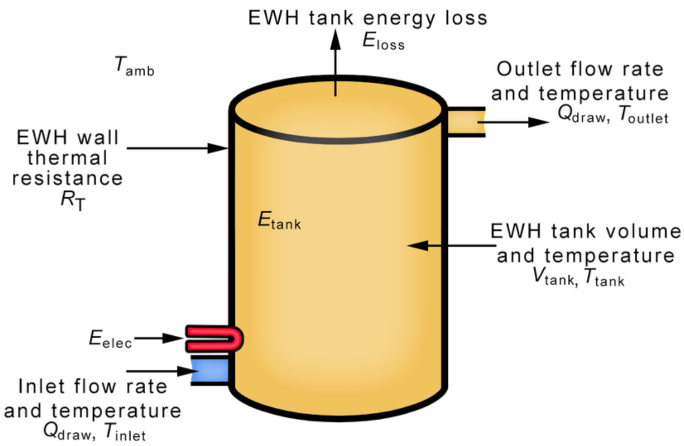

Figure 6: Operation curve of a domestic hot water boiler.

Last but not least, the power output due to hot water losses is expressed by the following equation:

$$P\_loss(t) = \frac{1}{R_{TH}}[Ttank(t) - Tamb(t)] \quad (4)$$

Where:

- RTH is the thermal resistance (1/conductance) of the DHW wall,
- $Ttank(t)$ is the water temperature inside the DHW,
- $Tamb(t)$ is the ambient temperature.

Overall, the modelling approach for the DHW (Hledik R. et al., 2021; Somer O. Et al., 2017) takes into account the operational characteristics of the device, the water and air temperature conditions as well as the water flow from the system to the actual use.

The modeling details are presented above for the P2X technologies examined in the proposed framework. In the next section, the technical details about the integration of the different models into the holistic flexibility management framework are provided.

2. Flexibility Forecasting & Management Layer Detailed Specifications

In this section, the detailed specifications of the business layer of the proposed framework responsible for Flexibility Forecasting, Clustering and Management are provided. As presented above, the analysis is split into two key components that consist of the overall layer.

The Flexibility Aggregation & Clustering Component is the component in charge of facilitating aggregators to get an overview picture and management of their portfolio assets flexibility potential (e.g., duration of flexibility, flexibility amount that can be provided, response time for flexibility activation, location of flexibility etc), in order to be able to deliver the available flexibility to 3rd party entities (e.g. flexibility marketplace). The detailed overview of the Flexibility Aggregation & Clustering component is presented. Starting with the flexibility aggregation & filtering functionality, a multi-dimensional characterization of the flexible. Each flexible asset is characterized by its metadata (both technical and business-related aspects of the asset), namely:

- Device Class: generation, storage, demand
- Device Type: HVAC, Lights, etc…
- Device Category: Inflexible, Shiftable, Storage, Adjustable / Shift, Shed, Shimmy
- Device Location: the spatial characteristics of the portfolio (or network location related characteristics)
- Device Nominal Power and Energy statistics
- Device Flexibility Potential (over time) as derived from the flexibility profiling agents
- Device Business Parameters taking into account market flexibility services (asset ownership, time to response, how often to call etc…)

By applying the respective filters, a look up on the database is performed to extract the assets with the search characteristics as defined by the user. Then, the user is prompted to store the configuration parameters for further use.

On the other hand, the details of the flexibility clustering component are considered. The potential list of input data of the Flexibility Clustering component is the same as to the filtering component. The main differentiation is the algorithmic process applied to extract clusters with common characteristics. ML clustering techniques (k-means) apply to serve the business needs of the stakeholders. Therefore, the output of the analytics process will extract, DER clusters that best fit to:

- Different flexibility markets that emerge in the electricity value chain
- Timeframes for the provision of flexibility
- Location based parameters that affect the usability of the available flexibility

Apart from the Flexibility Aggregation & Clustering functionality as presented in previous section, an optimization layer is incorporated in the proposed framework in order to enable the active participation of the flexible DERs at different business objectives. Overall, there are two different business processes examined as part of the proposed approach:

- The objective of the 1st case is the exploitation of the available flexibility by 3rd party entities when required. Upon request from the grid or the market and by taking into account the results from flexibility sources clustering, the system/platform should be able to trigger commands to the flexibility assets. The role of this use case is to incorporate the logic/functionality in order to assure optimization of flexible sources at local level taking into ac-count the requests from the external business/grid environment.

- An intra portfolio optimization process is incorporated in order to maximize the profit of the entities at district/region/portfolio level. By combining RES profiling, the analysis of the storage entities (Batteries, P2H/P2G, EVs), and load flexibility profiling, the aim is to establish a coordinated flexibility management framework for balancing of generation/ flex consumption/ storage based on internal (e.g., excess of RES and requirement to ensure maximum self-consumption, retailer prices) parameters.

By taking into account the aforementioned business objectives, the details of the algorithmic process are provided. Starting with VPP formation to serve 3rd party needs, the main objective is to ensure maximum flexibility offering by aggregating the flexibility available from different flexible sources (and considering the demonstration scenarios at the different demo sites that pose limitations on the use of flexible assets). Criteria for the selection of the assets are the contractual terms (specifying financial and non-financial – level of controllability, duration of controllability, reliability level- in the proposed framework).

On the other hand, intra-portfolio management focus on baseline profile optimization (through demand and generation shifting) by exploiting the available flexibility of the different flexible sources. A modular approach is adopted in order to ensure the incorporation of different business objectives (self-consumption maximization vs price-based optimization) or types of assets available in each demonstration scenario. The main differentiation from VPP is that while the timeframe for VPP is short term (2 -3 hours ahead), this is not the case for intra-portfolio where optimization is performed at a continuous manner (and with a long day ahead horizon).

The design details are presented above of the business analytics layer of the proposed framework tool. As stated above, a UI is considered as part of the tool to facilitate the business actors on decision making. The details of this feature are out of the scope of this paper.

3. Demonstration activities & Performance Assessment

The overall solution is about to be tested for a long period of time (18 months) in real conditions in 4 pilot sites in 3 EU Member states (Bulgaria, Slovenia and Greece), with different needs and socioeconomic and technological boundaries, involving multiple existing flexibility assets (batteries, power to heat/cold, vehicle to grid and other storage solutions) and all complementary actors of the energy network (DSO, microgrid operator, utilities, flexibility providers, local communities).

In the following figure, the key assets at the different demo sites are presented. Special focus at the integration of P2X technologies and further incorporation in the proposed innovative management framework.

With this global and holistic approach, the proposed framework aims to demonstrate the technological, economic and social benefits generated by the flexible sources in existing energy systems, ensuring major impact and replicability, as well as the exploitation potential of the project solutions. In all these demo sites different types of services will be tested taking into account the data gathered from the installations in premises. More specifically, the different demonstration cases are presented:

- *Demo Case 1:* Local/Demo site optimization ensuring maximum self-consumption. In this case, the focus of the local system operator is to optimize the operation of the local DERs in order to ensure maximum level of self-consumption and thus reduce the dependency from the upstream network.
- *Demo Case 2:* Participation in energy markets (DA, ID, ancillary services) by fully exploiting the flexibility potential. In this case, the focus of the local system operator is to optimize the operation of the local DERs in the existing energy markets, considering also the role of the emerging marketplaces.
- *Demo Case 3:* Provision of the services to the DSOs, considering different types of ancillary services required by the local system operator through the innovative market schemas and local size marketplaces.
- *Demo Case 4:* Grid resilience against extreme weather event. In this case, if severe weather conditions are predicted to hit a line

Table 1: Performance Assessment Indicators.

Category	KPI Name	Description
TECH	Self-sufficiency ratio	The ratio between on-site production and consumption of all loads.
TECH	Active power deviation from flexible units	The divergence of the active power flows of each flexible unit from their realized average values over a comparable time period. The aim is to analyse each flexible unit separately and to verify whether their activation follows a stable pattern over the time or whether DSM actions affect their use.
TECH	Flexibility availability forecasting accuracy	The accuracy of the forecast of flexibility modelled
TECH	Amount of flexibility	The ratio of capacity that can be managed with flexibility over the total installed capacity in the pilot site.
TECH	Dispatchability	The system capability for providing power when required by 3rd party entities
TECH	Generation forecast accuracy	The accuracy of the forecast of electricity generation from RES modelled
TECH	Consumption forecast accuracy	The accuracy of the forecast of electricity consumption in the network
TECH	Pilot site model accuracy	The global accuracy of each pilot site by measuring the deviation between forecasted and measured flexibility availability, RES generation and electricity consumption.
TECH	EV demand flexibility availability	The amount of energy that the smart charging strategies in EVs enable to shift compared to the total amount of power required for charging.
TECH	Peak-to-average ratio improvement	The peak-to-average ratio provides information regarding the shape of the load curve indicating how extreme the peak consumption is relative to the consumption at off-peak hours.
TECH	Amount of reduced or shifted load	The amount of load shift or the reduction from one time period to another. The aim is to evaluate the effectiveness of DSM actions.
ENV	Change in GHG emissions	Greenhouse gas (GHG) emissions are reduced by means of increasing the penetration of local renewable production and/or load shifting to the hours with higher production from renewables.
ENV	Change in total cumulative energy demand	Total (including fossil, renewable and other sources) cumulative energy demand of the pilot site or at a certain UC of the pilot site in comparison to a reference case.
ENV	Change in total renewable cumulated energy demand	Renewable cumulated energy demand of the site pilot site or a certain UC of the pilot site in comparison to a reference case.
SOC	User satisfaction	Overall user satisfaction regarding the proposed framework
SOC	Ease of use of tools	Ease of use of the tools that are defined in the proposed framework
SOC	Economic Benefit for Aggregators	The economic profit for aggregators as derived through participation in innovative business schemas
SOC	Economic Benefit for Asset Owners	The economic profit for asset owners as derived through the enrolment of their assets in innovative flexibility strategies

Figure 7: Demonstration Assets for framework evaluation.

of the local network, flexibility from assets may be asked in order to support the feeding of this loads (incl. reduction of the load injection of RES energy to the network etc).

The demonstration activities should be accompanied by the performance assessment of the different use cases as the main interest for the consumers and business stakeholders in order to ensure tangible profit along with any other social impact. A non exhaustive list of KPIs is defined for the proposed framework and are briefly presented in Table 1.

All in all, a holistic assessment process applies in order to ensure that economical and non-economical parameters are considered at the decision-making process and assessment of the flexibility management framework.

4. Conclusions

Up to now, projects and research activities in this area of DER flexibility have focused mostly on specific energy sources, technologies and actors, considering only a very limited and isolated part of the whole network, missing the vast flexibility opportunities that a holistic, integrated approach to the overall energy value chain can bring. In this context, we propose an innovative framework to facilitate the optimum combination of decentralised flexibility assets, both on the generation (DER) side and on the demand side (V2G, power-to-heat/cold/gas, batteries, demand response), enabling all parties, including final prosumers, to offer their flexibility in the market creating benefits to all the actors in the smart grid value chain. The proposed approach is unique in its multi-technology, multi-actor approach which, in an increasingly RES-powered grid, will ensure security, resilience and stability for all, even under grid-stressing scenarios such as extreme climate events, offering an all-win scenario.

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Abbreviations

DA	Day Ahead
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DSM	Demand Side Management
DSO	Distribution System Operator
EVs	Electric Vehicles
EU	European Union
HVAC	heating Ventilation Air Condition
ID	Intra Day
GHG	Greenhouse gas
KPIs	Key Performance Indicators
P2X	Power-to-X
P2G	Power-to-Gas
P2H	Power-to-Heat
PEM	Polymer Electrolyte Membrane
RES	Renewable Energy Source
SCADA	Supervisory Control and Data Acquisition
UI	User Interface
UC	Use Case
V2G	Vehicle to Grid
VPP	Virtual Power Plant

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A holistic flexibility management framework for energy aggregators

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1

Rationale and Motivation

- **Current Status and E.U. Energy Goals :**
  - ✓ Since 2014, the strategy of the European Union has been clear: "we need to drive a clean, secure and efficient energy transition to face climate and energy challenges". This is also why the European Commission proposed in November 2016 an ambitious "Clean Energy for All Europeans" package.
  - ✓ The new policy framework brings regulatory certainty and fixes two new targets for the EU for 2030: a binding renewable energy target of at least 32% and an energy efficiency target of at least 32.5%.
  - ✓ The European Green Deal, presented by the Commission on 11 December 2019, sets the goal of making Europe the first climate-neutral continent by 2050. The European Climate Law, which entered into force last month, enshrines in binding legislation the EU's commitment to climate neutrality and the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.
  - ✓ **A most recent regulation is under discussion. Fit for 55% package to promote to set an increased target to produce 40% of our energy from renewable sources by 2030.**

2

How to reach the market objectives

INTEGRATE VARIOUS EXISTING FLEXIBILITY UNITS

(batteries, electricity into heat / cold, EV into the grid and other energy storage technologies)

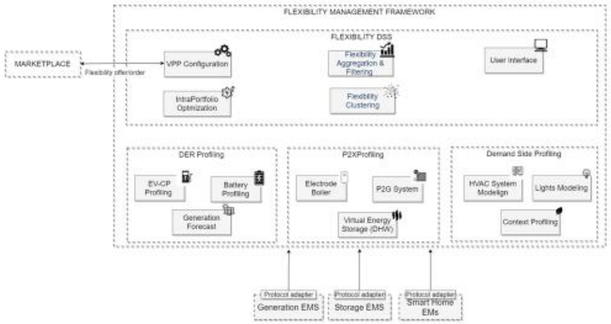
A DER- oriented Flexible and scalable integrated platform

A unified framework incorporating complementary products that will offer services to all the energy stakeholders:

- SERVIFLEX tool: Flexibility management tool for aggregators and flexibility providers.
- GRIDFLEX tool: Advanced tool for automatic control and observability of the grid for the operators.
- MARKETFLEX tool: The tool to facilitate the participation in the energy market for market operators.

A Holistic Flexibility Management Framework

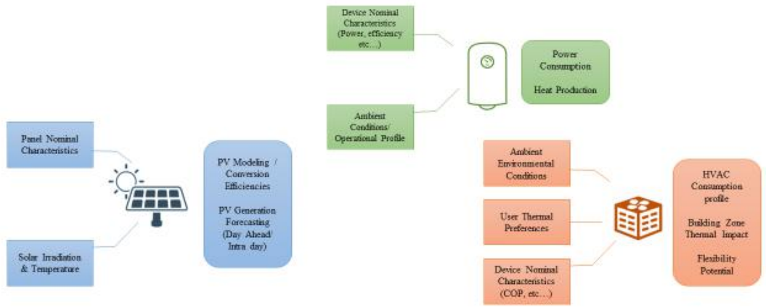
It is the tool for flexibility managers to take advantage of the value of energy storage along with other demand flexibility resources towards the establishment of a holistic framework for flexibility extraction, profiling, forecasting, classification, clustering and management to serve different market and grid needs



5

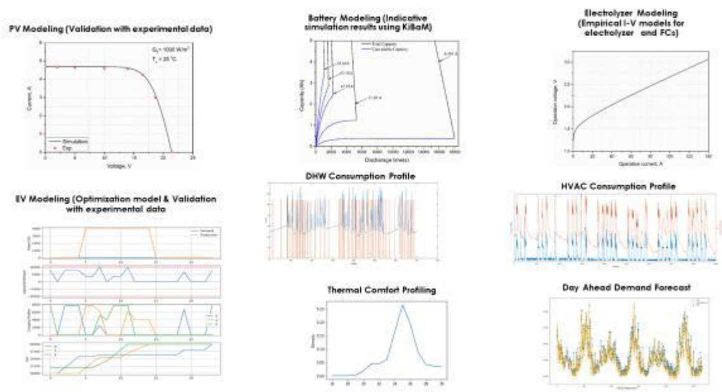
A data driven Flexibility Profiling Framework

Following a bottom up, data driven approach to define flexibility models for the different types of flexible DERs to be considered with focus on P2X systems incorporation.



6

Flexibility Profiling Framework- Prelim Results



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Demonstration Activities & Evaluation

4 PILOT LOCATIONS

- RAVNE NA KOROŠKEM, Slovenia
- LUČE, Slovenia
- ALBENA, Bulgaria
- XHANTI, Greece

Greek Demo Site Overview

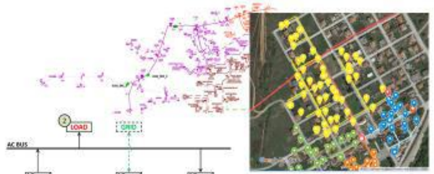
Green flexibility for network resilience

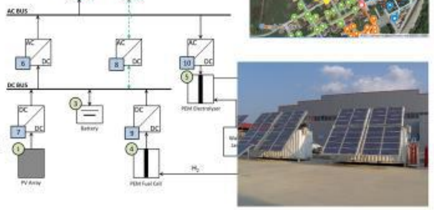
- The city of Xanthi, that has a population of more than 60,000, experiences **harsh winters and extreme weather events**, mainly including snowfall and strong rain storms.
- The goals are to facilitate the **optimal operation of Power2Gas** and **storage devices** at the microgrid, to contribute to the increased **resilience of the system under extreme weather events**, to achieve power losses reduction and to increase voltage stability.

Greek Demo Site Overview

Green flexibility pilot set up

- A state of the art Power2Gas solution combined with local RES and storage devices at the SLS microgrid
- Real time network management from HEDNO





RAVNE NA KOROŠKEM, Slovenia

State of the Art heat demand management

- To provide flexibility on the elec grid.
- To lower the imbalances in the network.
- To improve the reliability of electricity and heat supply.
- To demonstrate cooperation among key actors.

LUČE, Slovenia

Local Community in practice

- To provide flexibility to the local energy community through the use of DER (community and home batteries, PV, wind systems and EV-charging units)
- To improve the network operation costs and operational reliability

ALBENA, Bulgaria

Local Community in practice

- Battery and boiler stations control and optimization for DAM and IDM self-optimizations
- Ancillary services to TSO

Questions

The work detailed in this presentation was carried out within the XFLEX project.
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http://xflexproject.eu/

Initiative «75UN – 75 Trees UNAI SDG7»

Dr. Popi KONIDARI

Head of Climate Change Policy Unit of KEPA

14th International Conference on "Energy and Climate Change"
13-15 October 2021, Athens - Greece

Initiative "75UN-75Trees UNAI SDG7"

Dr. Popi KONIDARI
Research Fellow
KEPA of NKUA

1

Structure

- Initiative
- Actions
- Perspectives

2

Initiative -1

Invites **governments, municipalities, academic institutions, young people and all types of legal entities** to **undertake to plant, care and register**

75 trees dedicated to the 75th anniversary of UN

and to the efforts to reinforce the biodiversity of the planet

3

Initiative - 2

linked to the appeal of the UN Secretary General to governments and simple people of the planet to increase their "ambition" in the combat against Climate Change and the protection of the environment

4

UNAI

6

BSEC

Results in 2020

- Participation of 9 countries (Azerbaijan, Armenia, Bulgaria, Greece, Canada, Moldova, Romania, Ukraine and Turkey).
- Participation of 29 Hellenic municipalities
- Dynamics of the initiative is the planting of 10,077,625 trees.

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Results in 2021

- Plantation and treatment of 75 plants on the islet of Thodorou (or Theodorou) (autumn planting season)
- Preservation of historical olive trees
  - Region: Kastelli Pediadas on Crete, Greece where new airport of Heraklion is being constructed
  - Agreement between local Municipality of Minoa Pediadas and the administration of the New International Airport of Heraklion, under the coordination of the Decentralized Administration of Crete, the state organization for the Forest and Environmental Authorities on the island of Crete
- Participation of almost 60 Hellenic municipalities
  - Small scale funding from the Hellenic Green Fund

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Perspectives

Decision to continue and upgrade the Initiative for the coming years (based on results and especially willingness of participants)

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Thank you

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