Sustainability of energy systems for efficient clean energy transition

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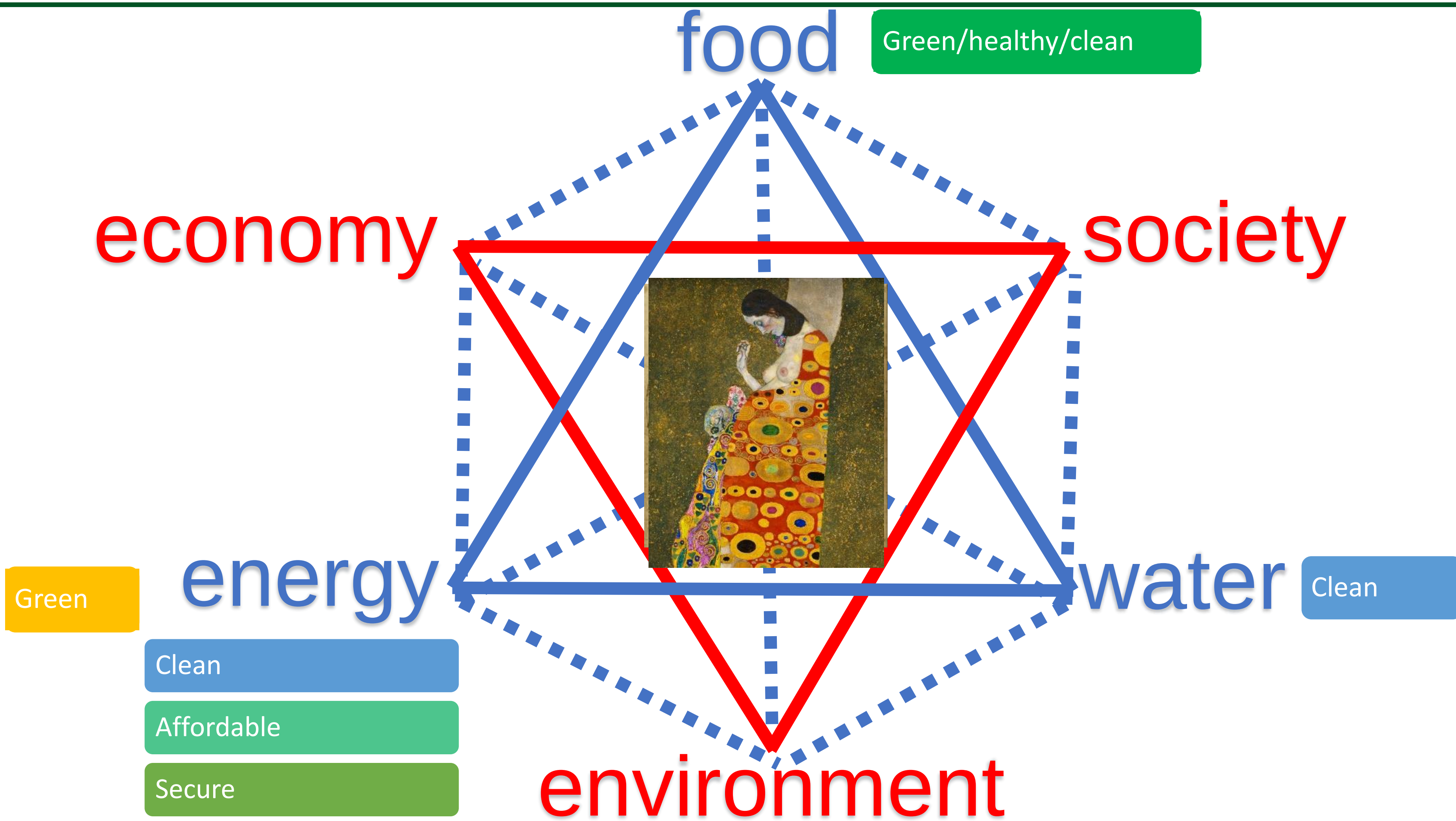
THE 17th CONFERENCE ON SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS

Paphos, Cyprus, 10/11/2022

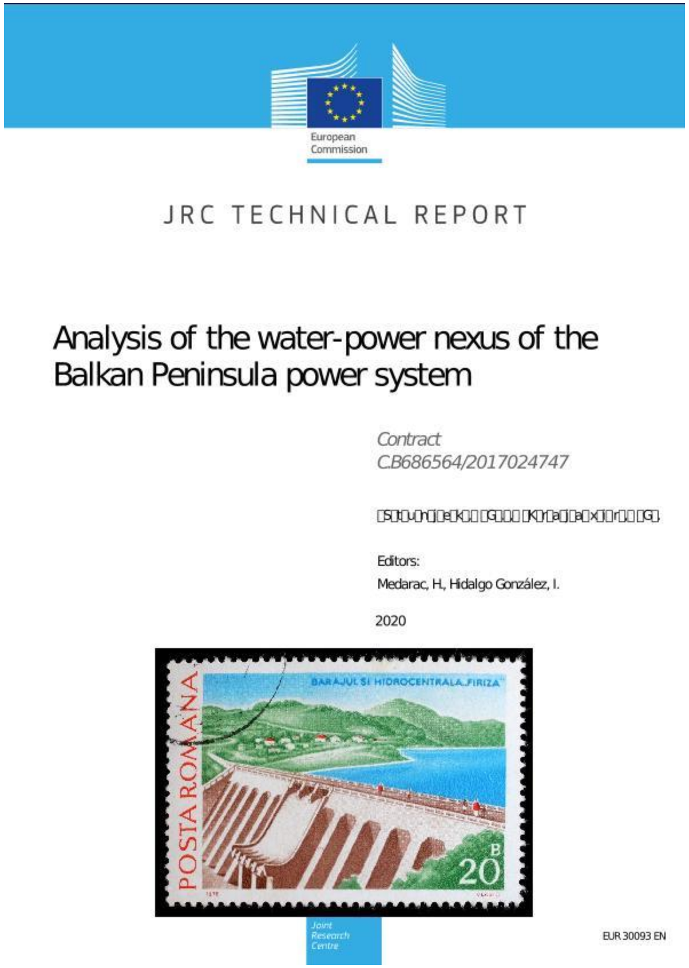
Content

- Water-Energy-Food nexus
- Renewables for Sustainability
- Re-Thinking 2050 EU → RE-Power EU
- RenewIslands → Smart Islands
- 6D for efficient energy transition
- Technology Value Chains

Water-Energy-Food nexus



Water-power nexus of the Balkan Peninsula power system


European Commission

JRC TECHNICAL REPORT

Analysis of the water-power nexus of the Balkan Peninsula power system

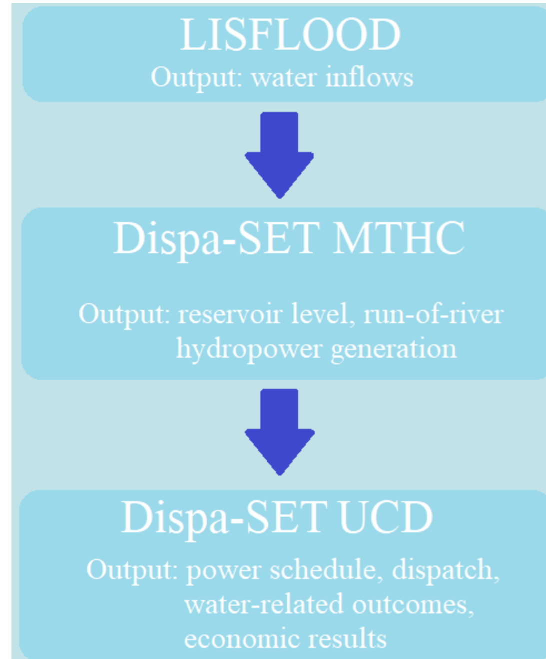
Contract CB686564/2017024747

Editors:
Medarac, H., Hidalgo González, I.

2020

Joint Research Centre

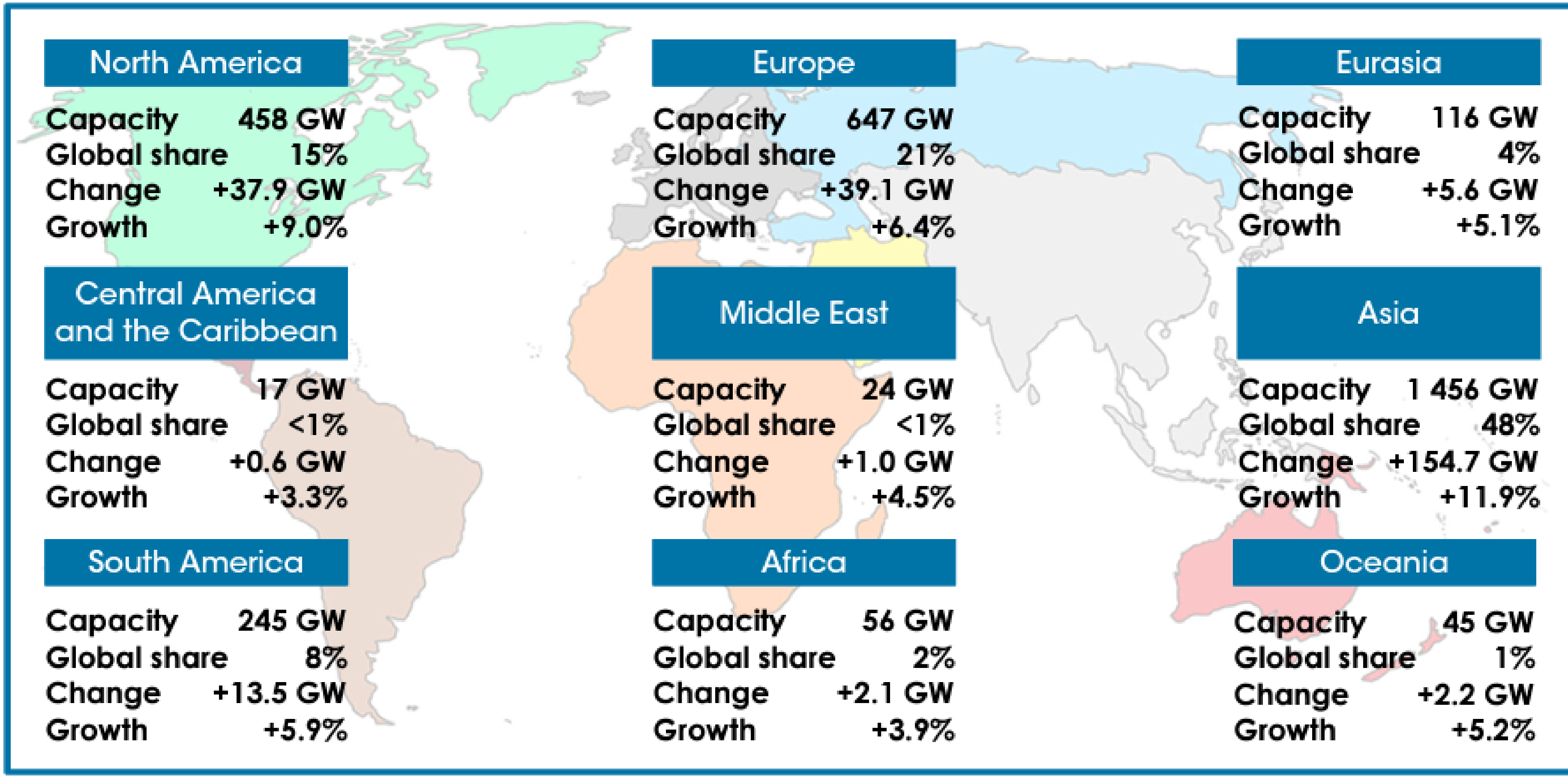
EUR 30093 EN



- Hydrological rainfall-runoff model LISFLOOD
- Dispa-SET Medium-Term Hydrothermal Coordination model
- Dispa-SET Unit Commitment and Dispatch model

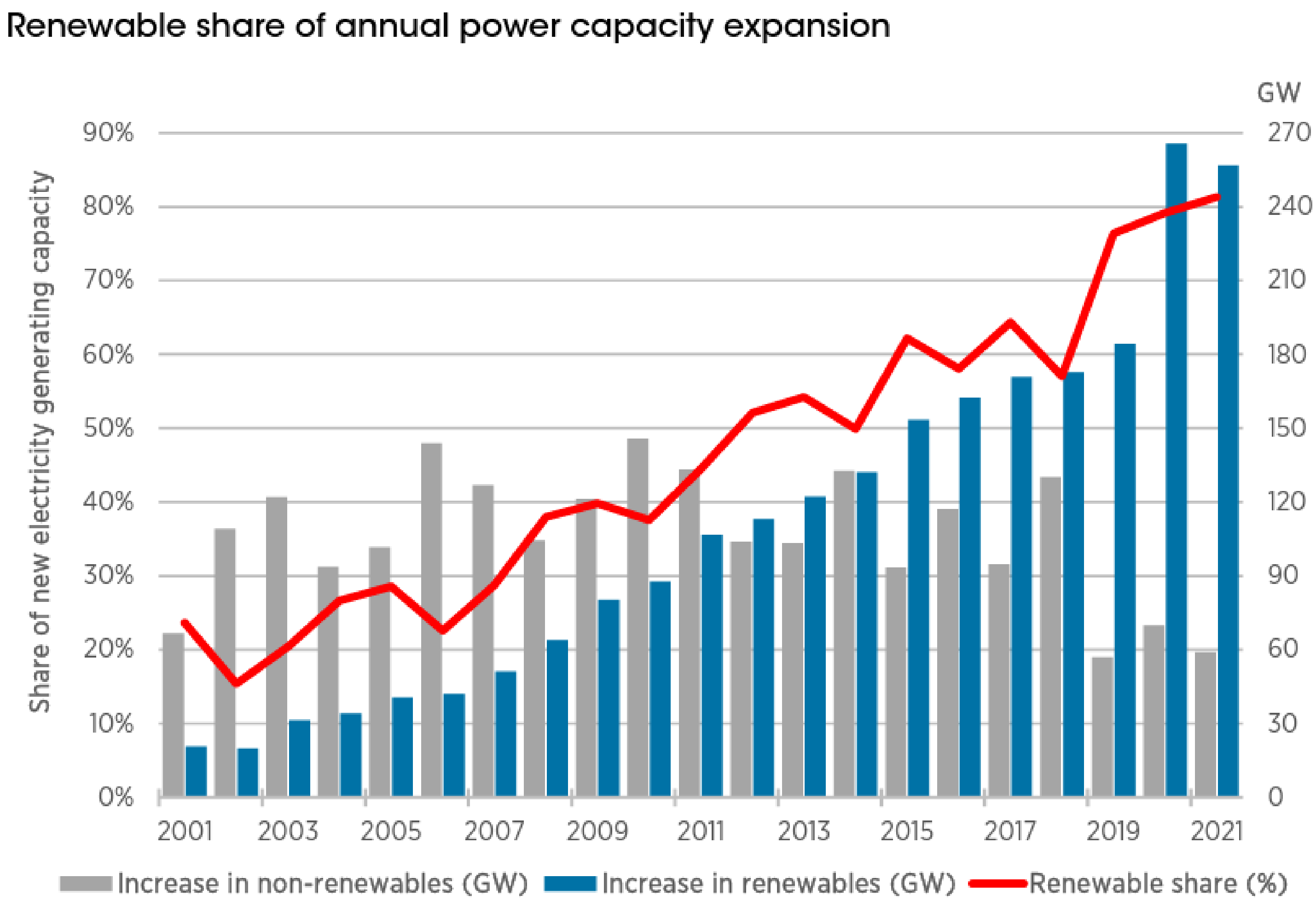
https://publications.jrc.ec.europa.eu/repository/handle/JRC119436
10.2760/781058 (online)

RES in the World



For the complete dataset see: IRENA (2022), Renewable capacity statistics 2022, available at: www.irena.org/publications.

RES in the World



Is a Vision, our hope?

Applied Energy 88 (2011) 508–517
Contents lists available at ScienceDirect
Applied Energy
journal homepage: www.elsevier.com/locate/apenergy

How to achieve a 100% RES electricity supply for Portugal?

Goran Krajačić [a,*], Neven Duić [a,b], Maria da Graça Carvalho [b,1]
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Sustainable energy planning
Energy storage
100% Renewable systems
Portugal

Applied Thermal Engineering 31 (2011) 2073–2083
Contents lists available at ScienceDirect
Applied Thermal Engineering
journal homepage: www.elsevier.com/locate/apthermeng

Planning for a 100% independent energy system based on smart energy storage for integration of renewables and CO_2 emissions reduction

Goran Krajačić [a,*], Neven Duić [a,b], Zlatko Zmijarević [c], Brian Vad Mathiesen [d], Aleksandra Anić Vučinić [a], Maria da Graça Carvalho [b,1]
[a] Department of Energy, Power Engineering and Environment, University of Zagreb, Ivana Lučića 5, 10002 Zagreb, Croatia
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Energy planning
Post carbon society
Croatian energy system

Energy
Volume 73, 14 August 2014, Pages 875-889

A roadmap for repowering California for all purposes with wind, water, and sunlight

Mark Z. Jacobson [a], Mark A. Delucchi [b], Anthony R. Ingraffea [c, d], Robert W. Howarth [e], Guillaume Bazouin [a], Brett Bridgeland [a], Karl Burkart [f], Martin Chang [a], Navid Chowdhury [a], Roy Cook [a], Giulia Escher [a], Mike Galka [a], Liyang Han [a], Christa Heavey [a], Angelica Hernandez [a], Daniel F. Jacobson [g], Dionna S. Jacobson [g], Brian Miranda [a], Gavin Novotny [a], Marie Pellat [a], Patrick Quach [a], Andrea Romano [a], Daniel Stewart [a], Laura Vogel [a], Sherry Wang [a], Hara Wang [a], Lindsay Willman [a], Tim Yeskoo [a]

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ived 16 December 2013, Revised 21 June 2014, Accepted 26 June 2014, Available online 22 July 2014.

Energy 48 (2012) 80–87
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Energy
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A 100% renewable energy system in the year 2050: The case of Macedonia

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Economic evaluation

ABSTRACT

The most important problems the energy sector faces in Macedonia are an unfavourable energy mix with a high prevalence of lignite, a strong dependence on energy import, poor condition of the energy system and inefficiency in energy production and use. This paper investigates the prospects for realization of the 100% renewable energy system in Macedonia by making use of the EnergyPLAN model. Analysis was conducted for two renewable scenarios designed for the years 2030 and 2050. First scenario, the 50% renewable energy system, has been created for the year 2030 and represents the first step towards the 100% renewable energy future of Macedonia. The second scenario has been designed for the 100% renewable energy system based only on the renewable energy sources (RES) in the year 2050. Special attention in the design of these systems has been given to intermittent RES and to storage technologies. The analysis reveals that at the moment the 50% renewable energy system seems much more likely than the 100% renewable energy system, but with additional energy efficiency measures, which will lead to a decrease of consumption and with installation of new generation capacities this goal can be easily achieved.

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TJEDNIK OD RIJEČI

Pretraga
Nema senzacionalizma. | Bez tračeva. | Bez šutila. | Činjenice

Energija

Čovjek s vizijom Hrvatske 2050. koju pokreću samo vjetar, sunce i voda

Piše
Sergej Županić
fotografija
Jurica Galoić/Pixsell
Četvrtak 12.Travanj 2012.

Model koji je već primijenjen u Danskoj, pokazuje da naftno doba neće nestati tek kad nestane nafte

The bigger vision, the bigger hope?

Contents lists available at ScienceDirect
Applied Energy
journal homepage: www.elsevier.com/locate/apenergy

Zero carbon energy system of South East Europe in 2050

D.F. Dominković [a,*], I. Bačeković [b], B. Ćosić [c], G. Krajačić [c], T. Pukšec [c], N. Duić [c], N. Markovska [d]

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[d] Macedonian Academy of Sciences and Arts, Skopje, Macedonia

HIGHLIGHTS

- 100% renewable energy system of the South East Europe has been achieved.
- Sector integration makes the zero carbon system cheaper compared to the base year.
- Numerous renewable technologies needed to achieve zero carbon in the year 2050.
- Energy efficiency is a crucial part in a transition to the zero carbon energy system.
- No technology has a larger share than 30%; increased security of energy supply.

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Zero carbon
South East Europe
Sustainable biomass
Energy efficiency

ABSTRACT

South East Europe is the region in a part of Europe with approximately 65.5 million inhabitants, making up 8.9% of Europe's total population. The countries concerned have distinct geographical features, various climates and significant differences in gross domestic product per capita, so the integration of their energy systems is considered to be a challenging task. Large differences between energy mixes, still largely dominated by fossil-fuel consumption, make this task even more demanding.

This paper presents the transition steps to a 100% renewable energy system which need to be carried out until the year 2050 in order to achieve zero carbon energy society. Novelty of this paper compared to other papers with similar research goals is the assumed sustainable use of biomass in the 100% renewable energy system of the region considered. It is important to emphasize here that only the sustainable use of biomass can be considered carbon-neutral. The resulting biomass consumption of the model was 725.94 PJ for the entire region, which is in line with the biomass potential of the region. Modelling the zero-carbon energy system was carried out using the smart energy system concept, together with its main integration pillars, i.e. power-to-heat and power-to-gas technologies. The resulting power generation mix shows that a wide variety of energy sources need to be utilized and no single energy source has more than a 30% share, which also increases the security of supply. Wind turbines and photovoltaics are the main technologies with shares of 28.9% and 22.5%, followed by hydro power, concentrated solar power, biomass (mainly used in cogeneration units) and geothermal energy sources. To keep the biomass consumption within the sustainability limits, there is a need for some type of synthetic fuel in the transportation sector. Nevertheless, achieving 100% renewable energy system also promises to be financially beneficial, as the total calculated annual socio-economic cost of the region is approximately 20 billion euros lower in the year 2050 than in the base year. Finally, energy efficiency measures will play an important role in the transition to the zero-carbon energy society: the model shows that primary energy supply will be 50.9% lower than in the base year.

PV: 65 GW
Wind: 50 GW
CSP: 11 GW
Dammed hydro: from 18.8 to 23.5 GW

Joule
Volume 1, Issue 1, 6 September 2017, Pages 108-121

Article

100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World

Mark Z. Jacobson [1,5], Mark A. Delucchi [2], Zack A.F. Bauer [1], Savannah C. Goodman [1], William E. Chapman [1], Mary A. Cameron [1], Cedric Bozonnat [1], Liat Chobadi [3], Hailey A. Clonts [1], Peter Enevoldsen [4], Jenny R. Erwin [1], Simone N. Fobi [1], Owen K. Goldstrom [1], Eleanor M. Hennessy [1], Jingyi Liu [1], Jonathan Lo [1], Clayton B. Meyer [1], Sean B. Morris [1], Kevin R. Moy [1], Patrick L. O'Neill [1], Ivalin Petkov [1], Stephanie Redfern [1], Robin Schucker [1], Michael A. Sontag [1], Jingfan Wang [1], Eric Weiner [1], Alexander S. Yachanin [1]

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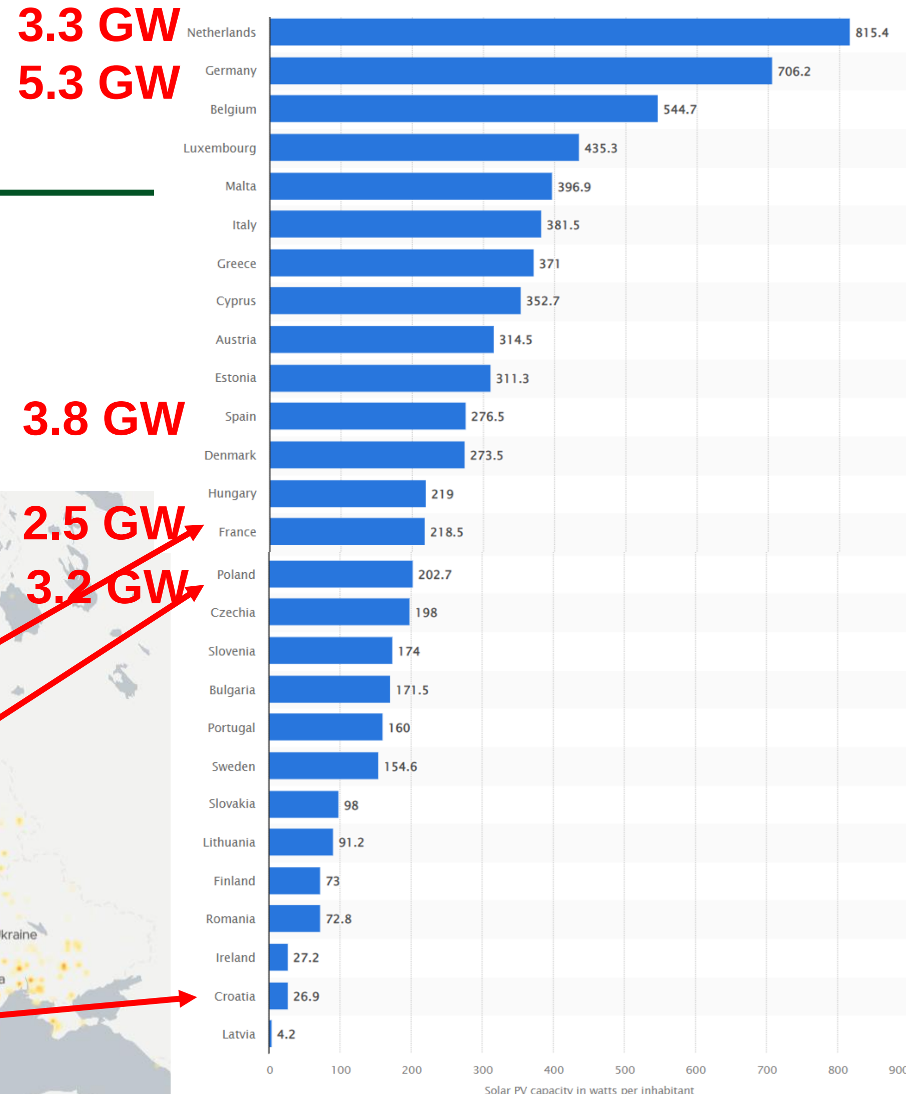
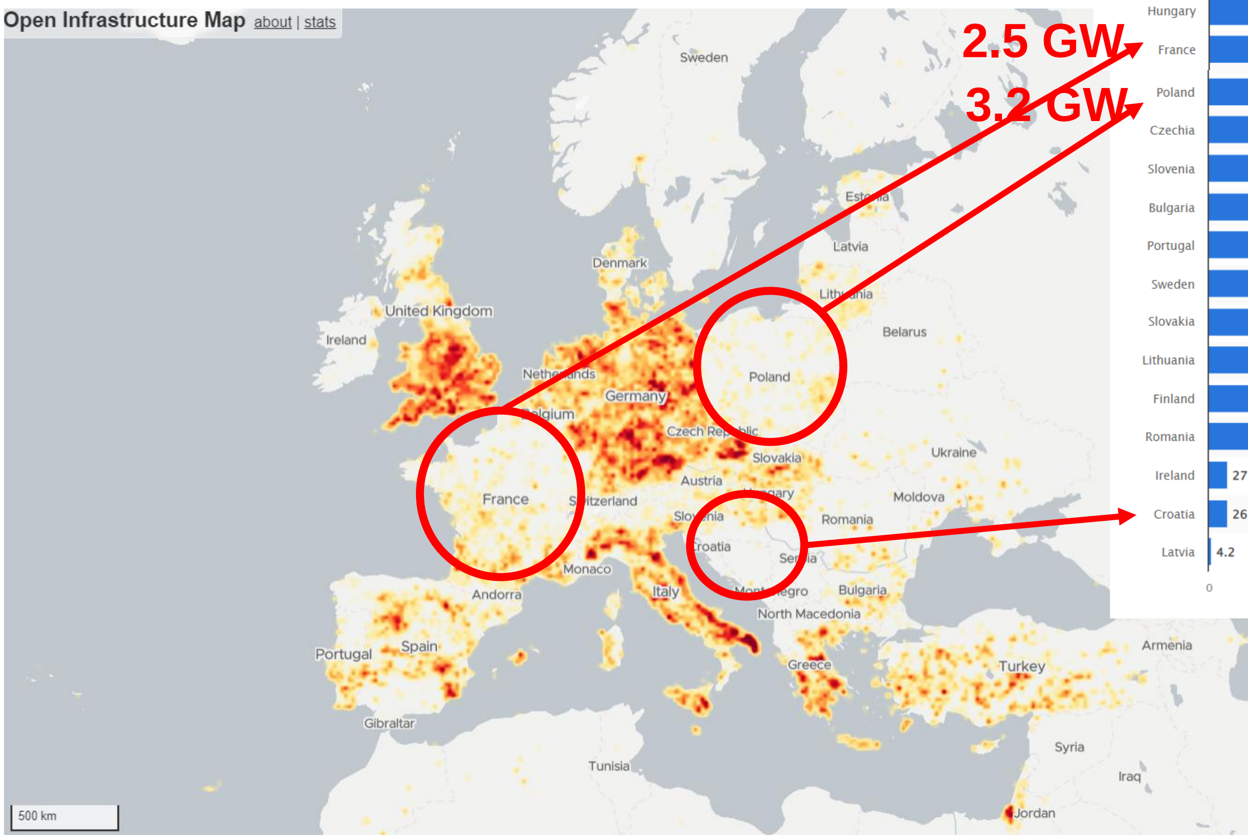
Published: August 23, 2017

No vision, no hope?





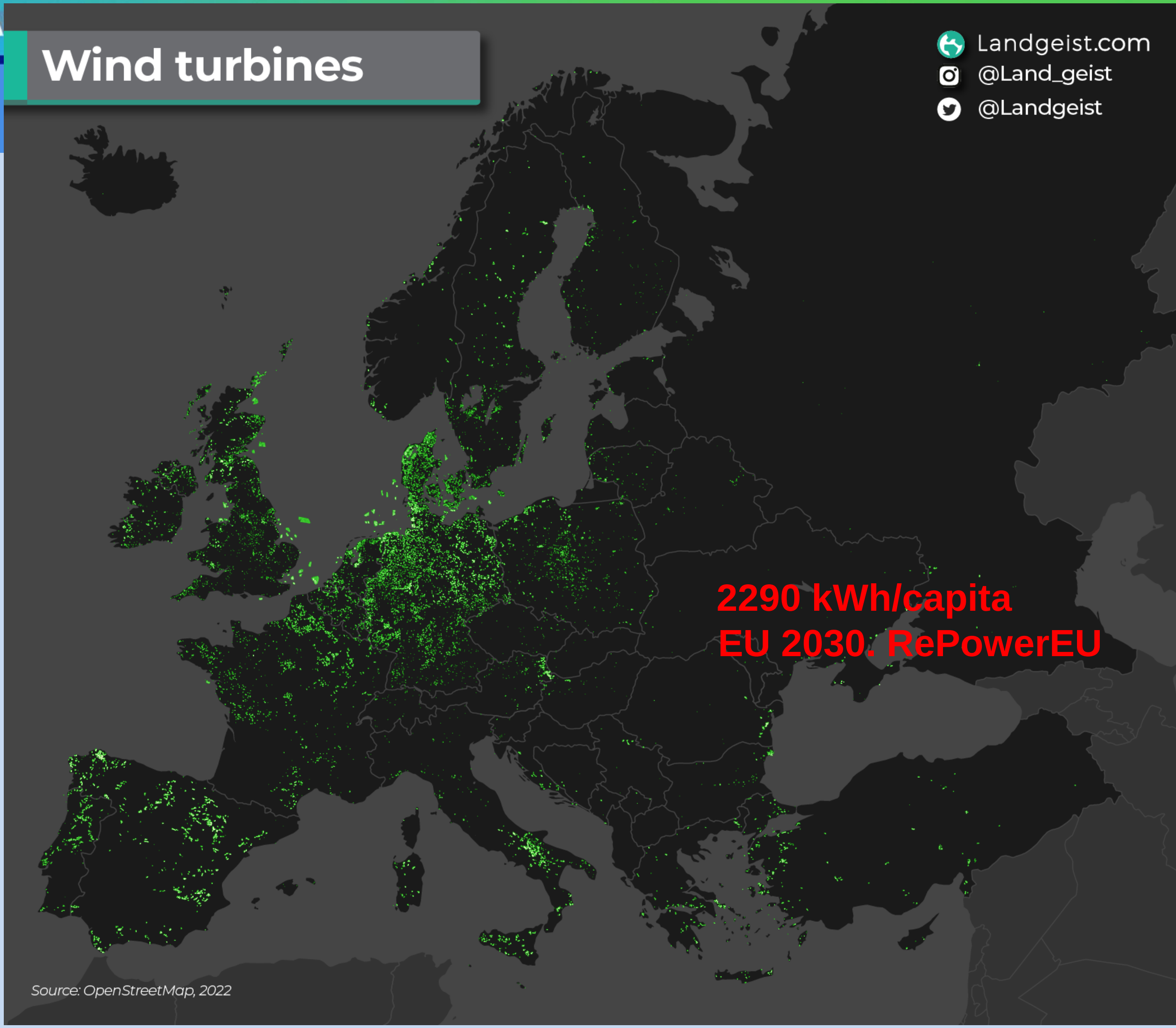
https://www.statista.com/statistics/612412/installed-solar-photovoltaics-capacity-eu/

Some vision, some hope?

Wind power plants 2021

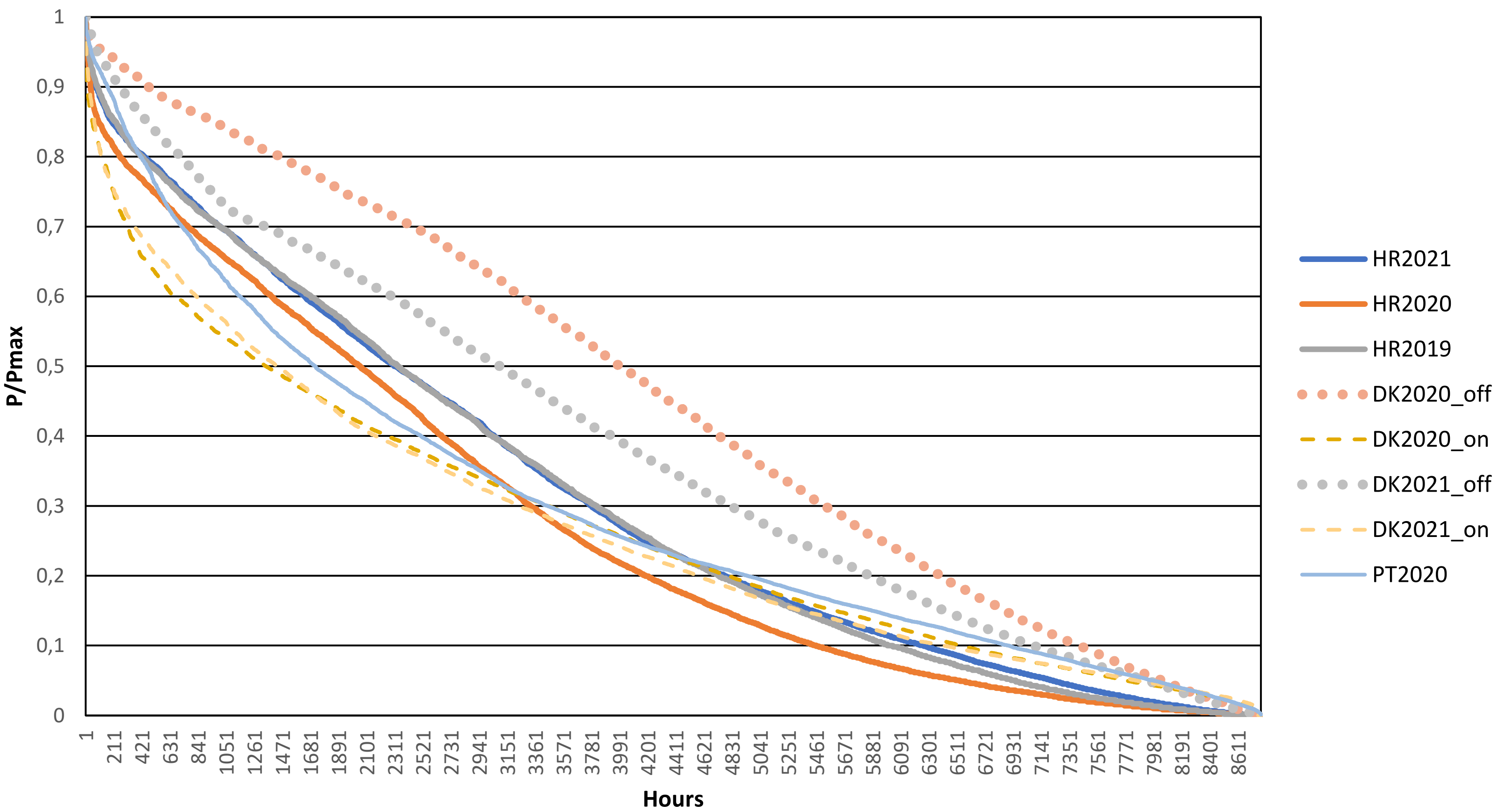
Statistically wind turbines generated in 2021:

Denmark 2749 kWh/capita,
Ireland 2019 kWh/capita,
Germany 1381kWh/capita
Portugal 1295 kWh /capita,
Austria 719 kWh/capita.
Croatia 514 kWh/capita,
Hungary 70 kWh / capita
Slovenia 5 kWh / capita

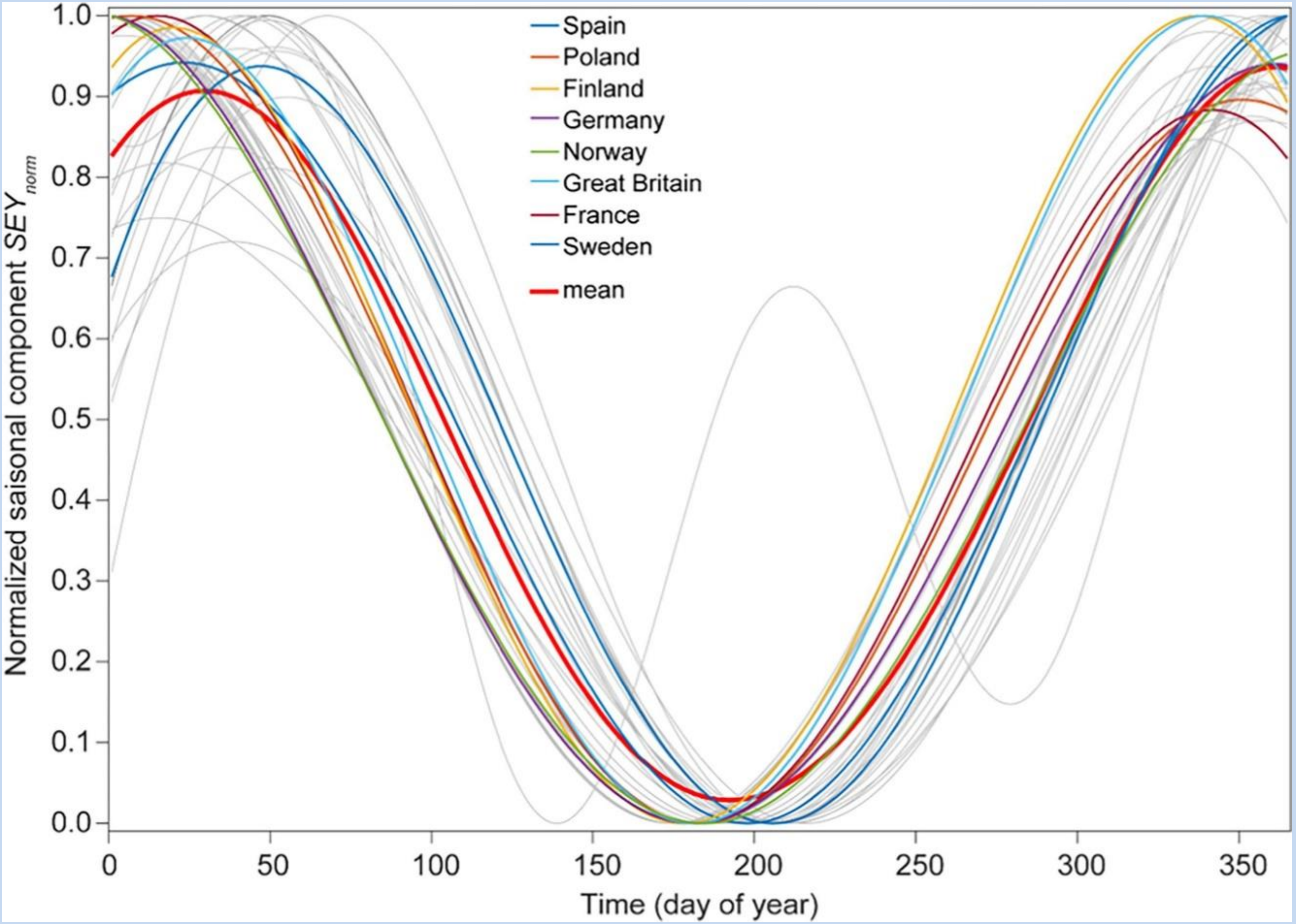


17TH CONFERENCE ON SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS
NOVEMBER 6-10 2022, PAPHOS, CYPRUS

Wind power production Croatia, Portugal and Denmark



Sessional distribution of wind power production



Dirk Schindler, Sophia Schmidt-Rohr, Christopher Jung,
On the spatiotemporal complementarity of the European onshore wind resource,
Energy Conversion and Management, Volume 237, 2021, 114098, ISSN 0196-8904,

https://doi.org/10.1016/j.enconman.2021.114098.

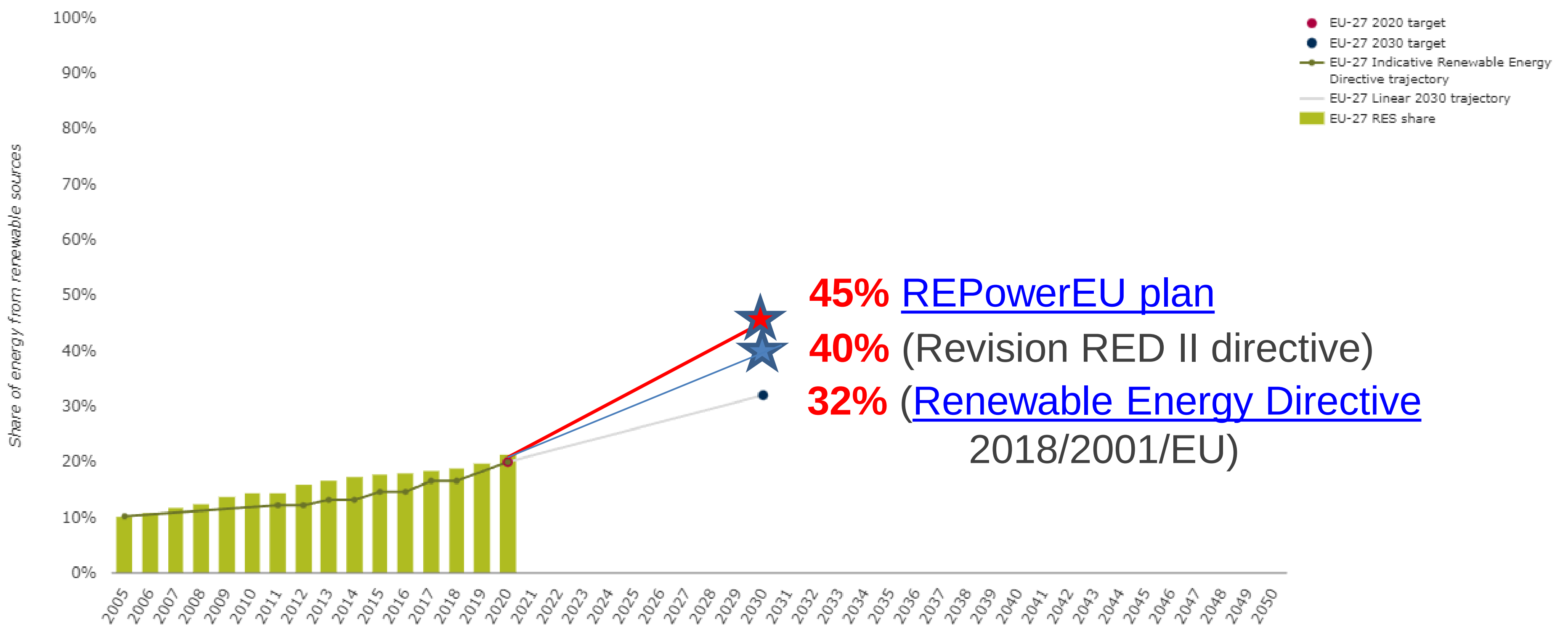
RE-thinking 2050 - EU

- “Post Carbon Society" vision (Carvalho et al., 2009):
  - Renewable energy sources
  - Buildings as "Positive Power Plants“
  - Energy Storage
  - Smart grids and electric and plug-in hybrid-electric vehicles

- "RE-thinking 2050" initiative (Zervos et al. 2010)
  - A 100% Renewable Energy Vision for the European Union"
  - Prof. Maria da Graça Carvalho underlines: “Studies of this kind are of outmost importance for policy-makers. The study RE-thinking 2050 gives an outlook of our society by 2050 if fully sustainable energy supply is adopted. The distributed nature of renewable forms of energy represents an opportunity to reshape our economic and social system towards a wealthier and more equitable model.”

REPOWER-EU

Figure 1. Progress towards renewable energy source targets since 2005



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ScienceDirect
Renewable and Sustainable Energy Reviews
12 (2008) 1032–1062
RENEWABLE & SUSTAINABLE ENERGY REVIEWS
www.elsevier.com/locate/rser
ELSEVIER

RenewIslands methodology for sustainable energy and resource planning for islands

Neven Duić[a,*], Goran Krajačić[a], Maria da Graça Carvalho[b,1]

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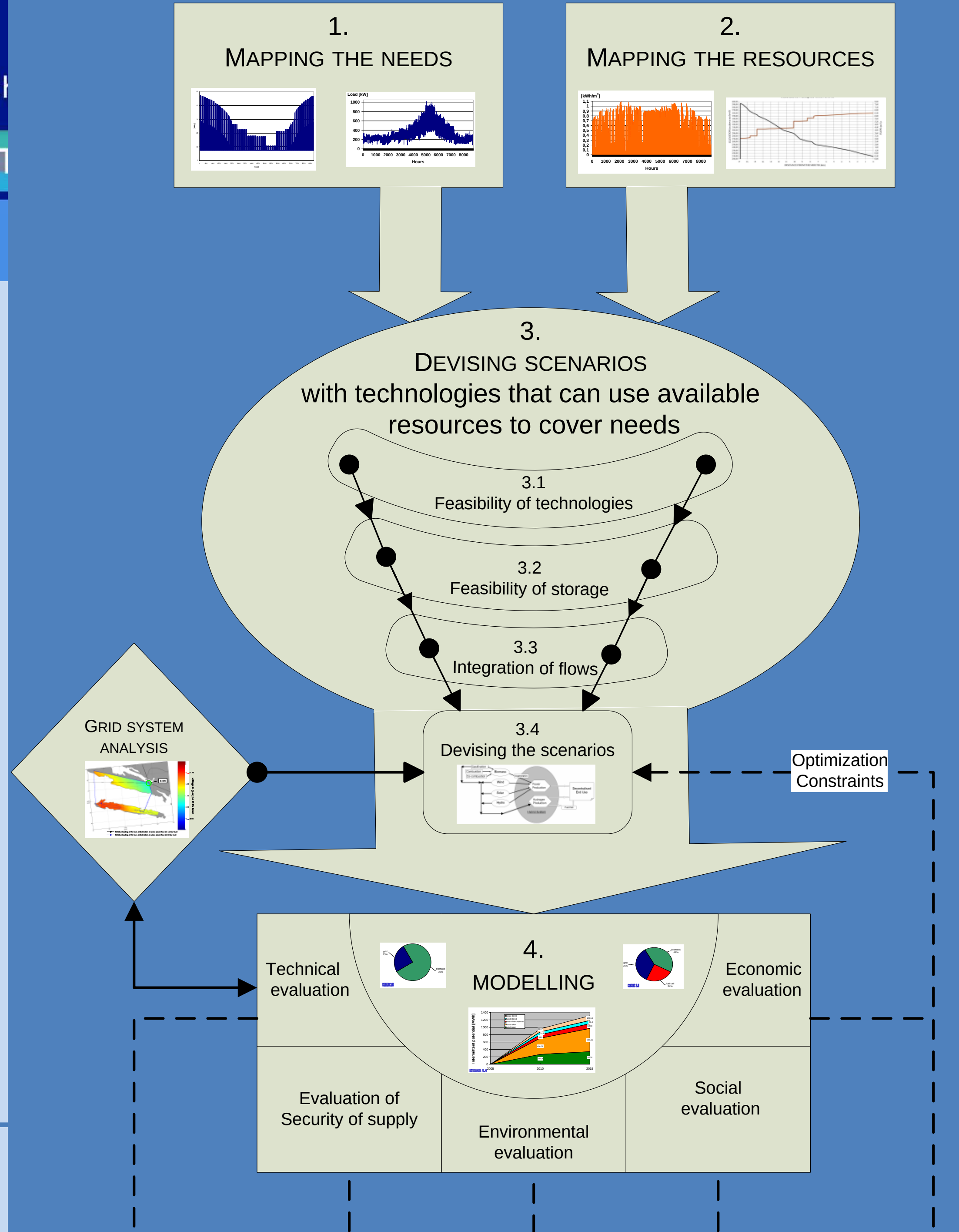
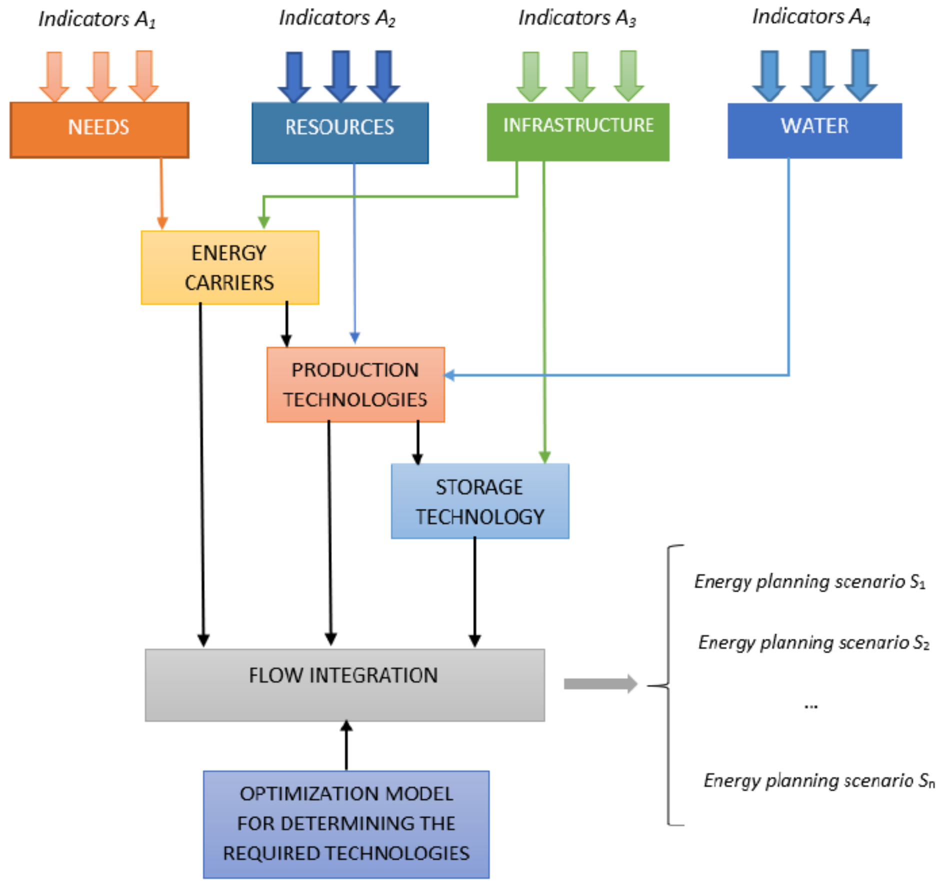
RenewIslands/ADEG METHODOLOGY

1. Mapping the needs
2. Mapping the resources
3. Devising scenaria with technologies that can use available resources to cover needs
4. Modelling the scenaria



INSULAE project http://insulae-h2020.eu/



Selected results on the Smart islands

1) **M. Mimica,** G. Krajačić, The Smart Islands method for defining energy planning scenarios on islands, ***Energy***, 237, 121653, 2021. DOI: 10.1016/j.energy.2021.121653
2) **M. Mimica**, L.G. De Urtasun, G. Krajačić, A robust risk assessment method for energy planning scenarios on smart islands under the demand uncertainty, ***Energy***, 240, 122769, 2022. DOI: 10.1016/j.energy.2021.122769
3) **M. Mimica**, D.F. Dominković, V. Kirinčić, G. Krajačić, Soft-linking of improved spatiotemporal capacity expansion model with a power flow analysis for increased integration of renewable energy sources into interconnected archipelago, ***Applied Energy***, 305, 117855, 2022. DOI: 10.1016/j.apenergy.2021.117855
4) **M. Mimica**, D.F. Dominković, T. Capuder, G. Krajačić, On the value and potential of demand response in the Smart island archipelago, ***Renewable Energy***, 176, 153-168, 2021. DOI: 10.1016/j.renene.2021.05.043
5) **M. Mimica**, Z. Sinovčić, A. Jokić, G. Krajačić, The role of the energy storage and the demand response in the robust reserve and network-constrained joint electricity and reserve market, ***Electric Power Systems Research***, 204, 107716, 2022. DOI: 10.1016/j.epsr.2021.107716
6) **M. Mimica,** M. Perčić, N. Vladimir, G. Krajačić, Cross-sectoral integration for increased penetration of renewable energy sources in the energy system – unlocking the flexibility potential of maritime transport electrification, ***Smart Energy***, 2022

Selected results on the Smart islands

Energy planning methods for islands

- **Paper 1** – **developed** Smart Island method, alternative **energy scenarios** for meeting island needs with resources
- **Paper 2** – **risk assessment** method for island energy scenarios based on outage probability and UC model of island system

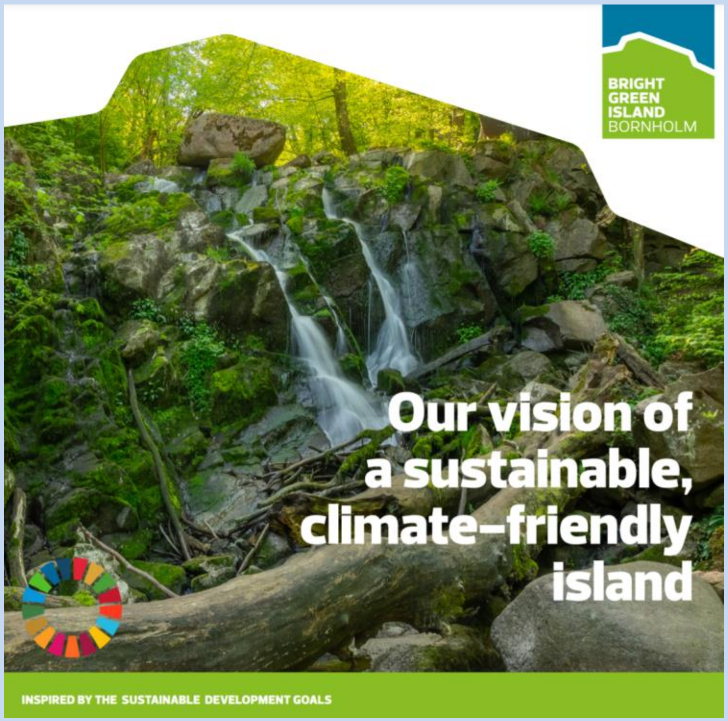
Soft-linking approach

- **Paper 3** – **capacity expansion soft-linking** approach of energy planning model and power flow model

Advanced planning approaches tested on island systems

- **Paper 4** – **demand response model** for smart archipelago; investigating the impact of different **incentive values**
- **Paper 5** – **flexibility options** through demand response and storage in joint network constrained energy and reserve market
- **Paper 6** – impact of the **maritime transport electrification** on decarbonisation of energy systems on islands

Bornholm, Bright Green Island



Welcome to Bornholm, Bright Green Island

01-07-2019

We the people of Bornholm want to be a sustainable, climate-friendly island community by 2035. We believe that a sustainable future for our island requires us to use and protect our common resources wisely and sustainably.

We call this approach Bright Green Island.

In order for our island to have a future for both residents and guests, it is important to find a sustainable and durable way to be an island community – a way that embraces Bornholmers, businesses, infrastructure and our many visitors.

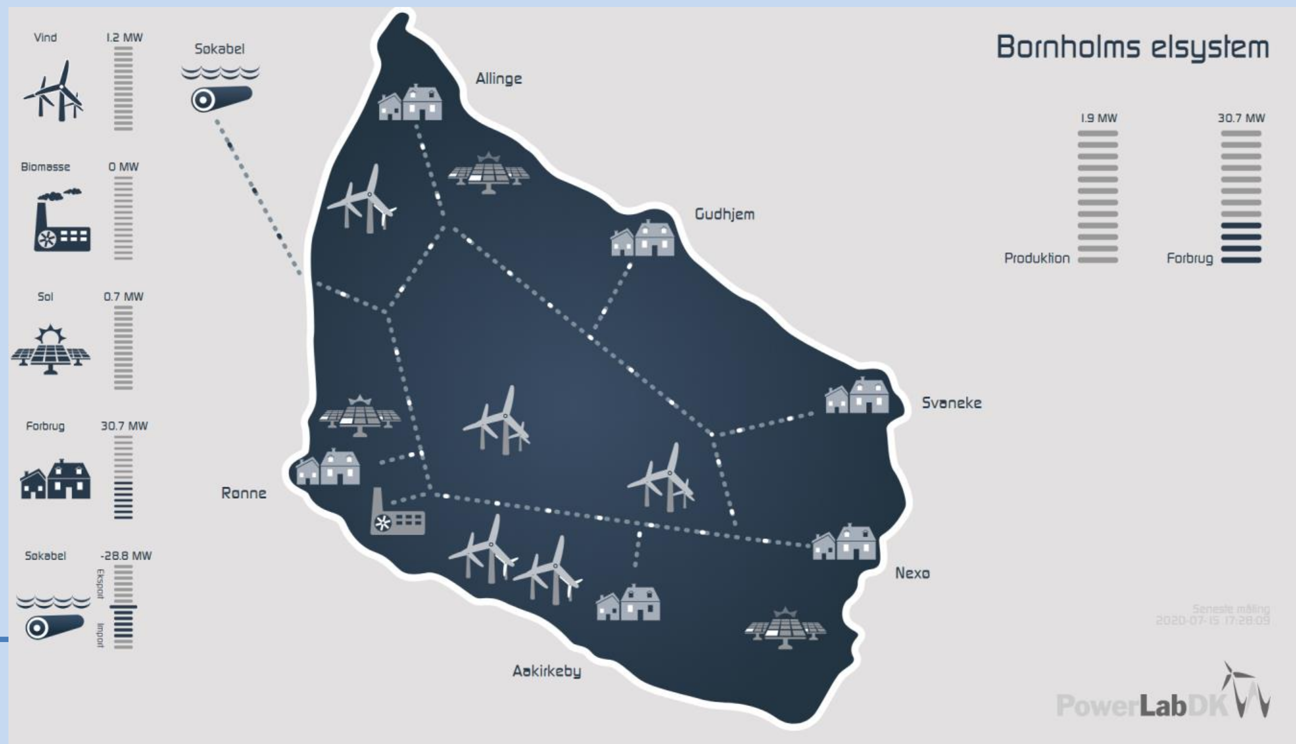
And we are already well on our way.

http://www.brightgreenisland.dk/Sider/In-English.aspx

1ST PRIZE WINNER
THE ISLAND OF BORNHOLM DENMARK

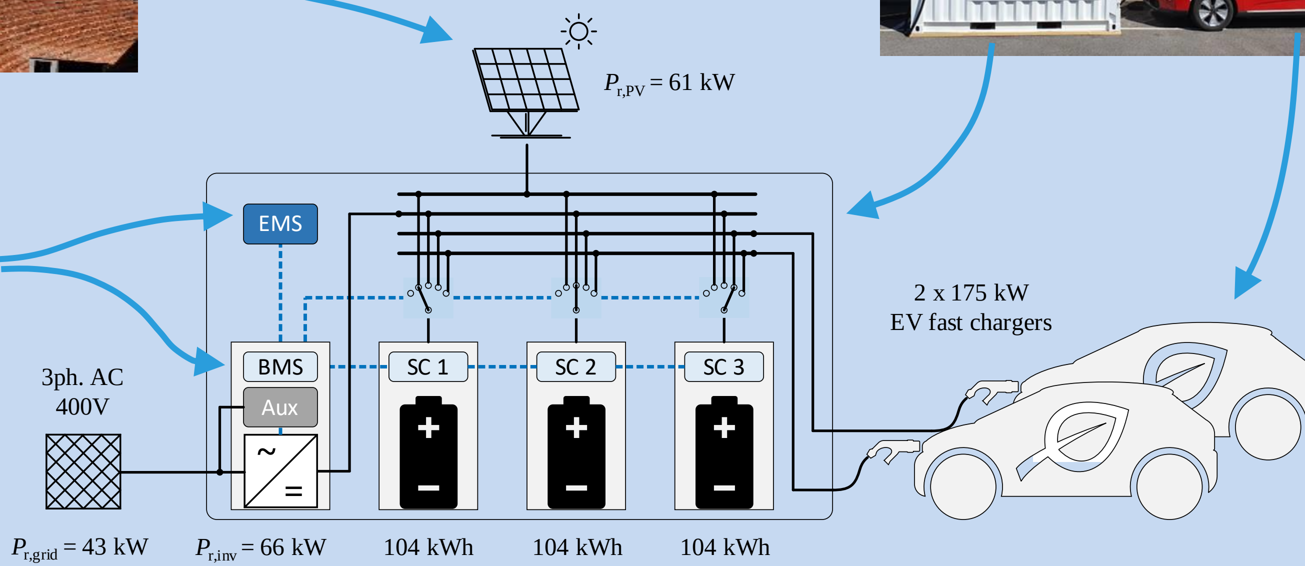
Island of Bornholm

Winner of the 2019 RESponsible Island Prize



INSULAE project http://insulae-h2020.eu/ activity at the Bornholm island - Use Case 4

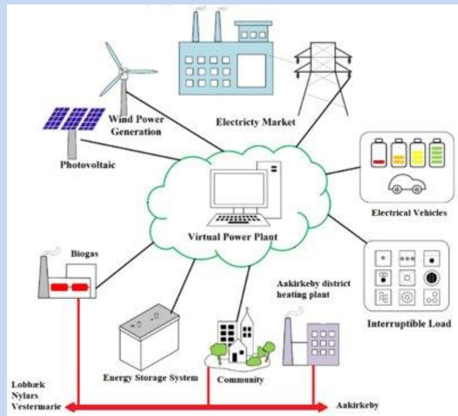
Two control levels

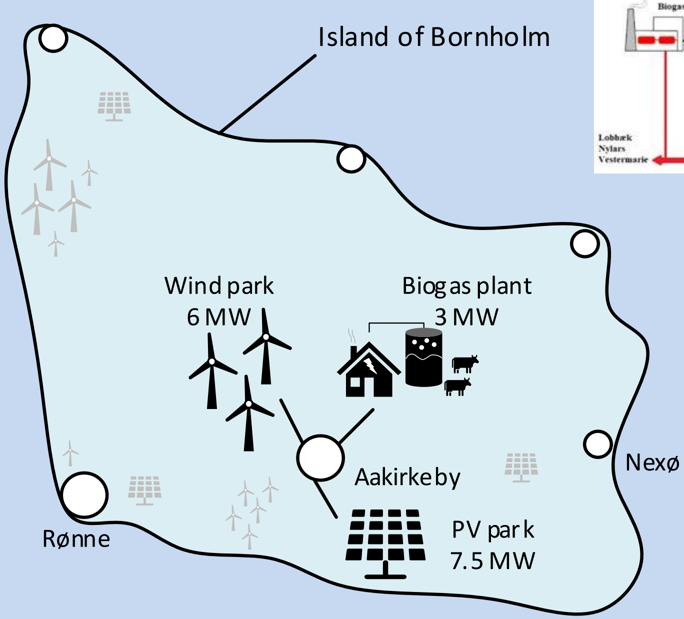


insulae
Maximizing the impact of innovative energy approaches in the EU islands

INSULAE project http://insulae-h2020.eu/
activity at the Bornholm island - Use Case 4

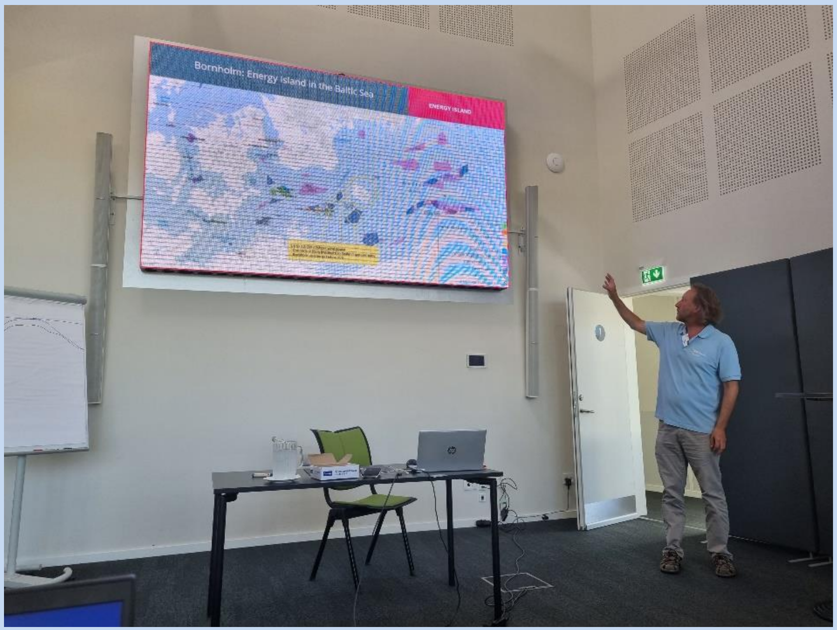
insulae
Maximizing the impact of innovative energy approaches in the EU islands





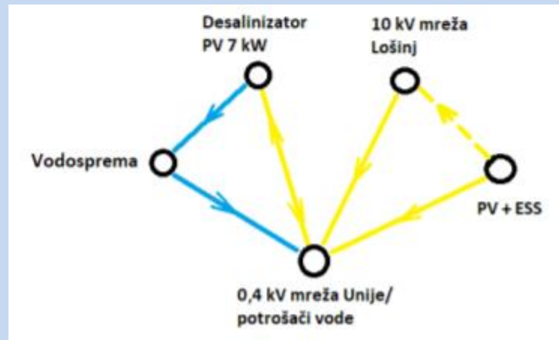
VPP Aakirkeby →
- Biogas plant modelling and flexibility assessment
- Characterize units for flexibility provision and grid support
- Investigate possible extensions of the VPP for further sector integration

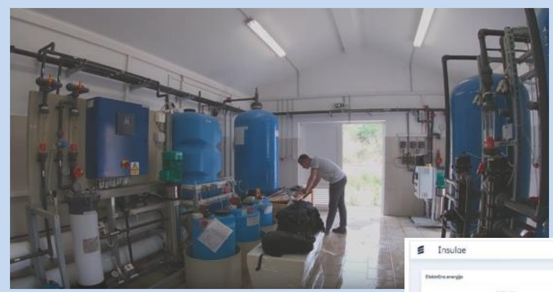
Offshore wind – new momentum in development of Bornholm

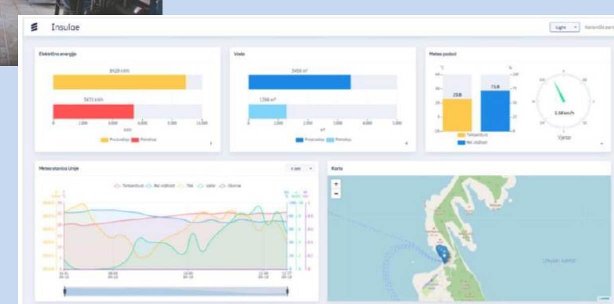


Smart Island Unije – INSULAE

- Smart management of the water and energy system
- Connecting the 7 kW solar power plant and the 27 kW desalinizer to an external system
- Controlling the pumps in the desalination plant
- Installing a smaller battery and tank







IoT platform and Blockchain

D. Kovačević, Water-energy nexus analysis of the Unije Island, 2020.
https://repozitorij.fsb.unizg.hr/islandora/object/fsb:6106

insulae
Maximizing the impact of innovative energy approaches in the EU islands

http://insulae-h2020.eu/ https://insulae.wp.fsb.hr/

2ND PRIZE WINNER
THE ISLAND OF SAMSØ DENMARK

Island of Samsø

2nd Winner of the 2019 RESponsible Island Prize

Version 1.0

Utopia is possible

Wind, solar and biomass were crucial

Samso has as a community invested in sustainable energy systems that today are owned partly by the locals. The investment total is app 62 .000.000 EUR – it makes Samso 100% self supplied by renewables – it makes Samso inhabitants CO2 negative – emission is minus 3,7 tons pr. Inhabitant.

Version 2.0

This is difficult

Independency from oil, gasoline and diesel by 2030

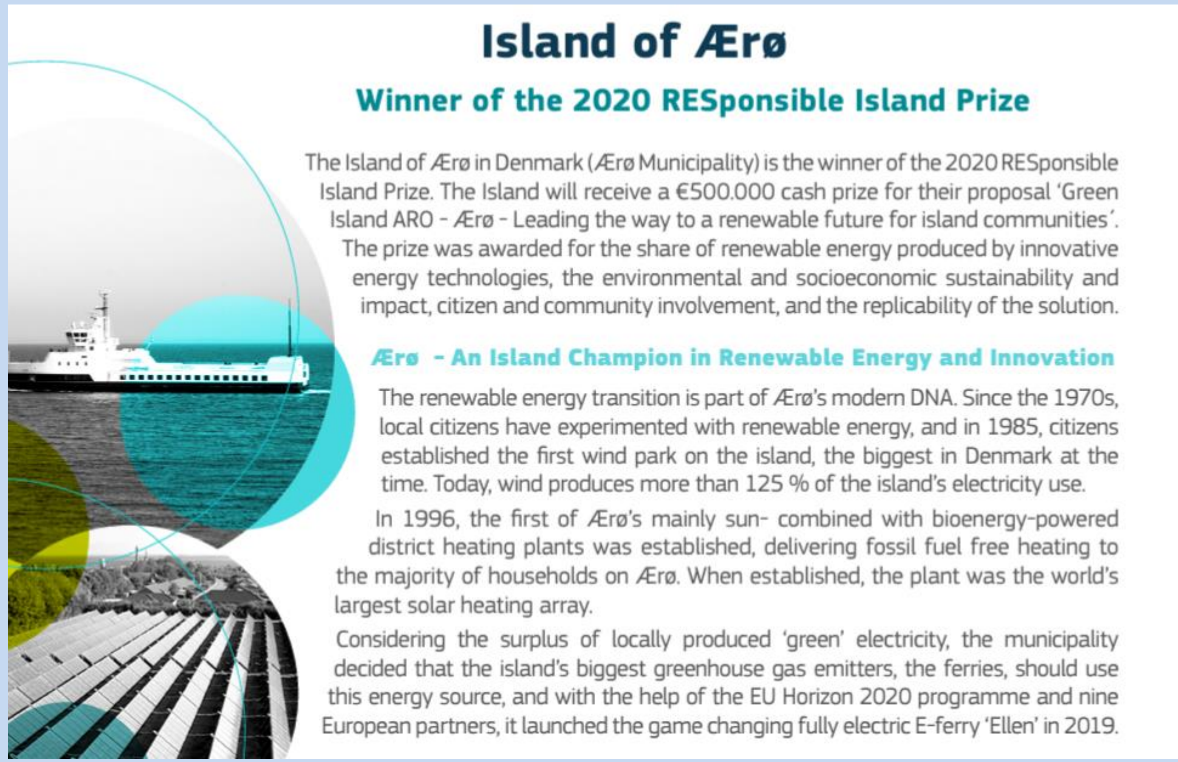
Samso´s present goal is to face out fossil fuel by 2030. It happens via thorough planning and theme meetings. The exchange of existing wind turbines and oil burners with heat pumps. Generally advising about savings and efficiency in electricity and space heating.

Version 3.0

Common sense

Recycling resources

The Energy Academy has after 20 years of activity become a meetinghouse for knowledge and solutions. What it takes to make things happen! " From Best to Next" is a way to explain what the local catalog of development initiatives anchored in existing resources and possible technical solutions



Island of Ærø

Winner of the 2020 RESponsible Island Prize

The Island of Ærø in Denmark (Ærø Municipality) is the winner of the 2020 RESponsible Island Prize. The Island will receive a €500.000 cash prize for their proposal 'Green Island ARO - Ærø - Leading the way to a renewable future for island communities'. The prize was awarded for the share of renewable energy produced by innovative energy technologies, the environmental and socioeconomic sustainability and impact, citizen and community involvement, and the replicability of the solution.

Ærø - An Island Champion in Renewable Energy and Innovation

The renewable energy transition is part of Ærø's modern DNA. Since the 1970s, local citizens have experimented with renewable energy, and in 1985, citizens established the first wind park on the island, the biggest in Denmark at the time. Today, wind produces more than 125 % of the island's electricity use.

In 1996, the first of Ærø's mainly sun- combined with bioenergy-powered district heating plants was established, delivering fossil fuel free heating to the majority of households on Ærø. When established, the plant was the world's largest solar heating array.

Considering the surplus of locally produced 'green' electricity, the municipality decided that the island's biggest greenhouse gas emitters, the ferries, should use this energy source, and with the help of the EU Horizon 2020 programme and nine European partners, it launched the game changing fully electric E-ferry 'Ellen' in 2019.

http://co2mmunity.eu/wp-content/uploads/2019/03/Factsheet-Aer%C3%B6-Marstal.pdf

Electric Ferry - ELLEN

- https://www.facebook.com/aeroe
- https://www.el-færgeprojekt.dk/
- https://batteryindustry.tech/fully-electric-e-ferry-ellen-fulfills-important-goal/
- http://e-ferryproject.eu/

Transport electrification?

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The future of transportation in sustainable energy systems: Opportunities and barriers in a clean energy transition

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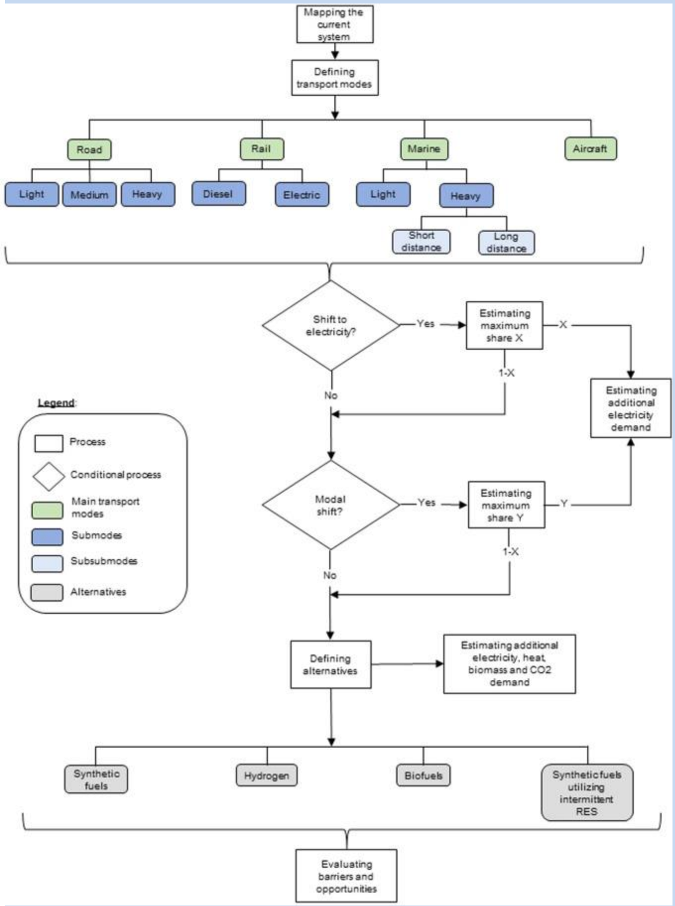
ABSTRACT

Energy demand of a transport sector has constantly been increasing in the recent years, consuming one third of the total final energy demand in the European Union (EU) over the last decade. A transition of this sector towards sustainable one is facing many challenges in terms of suitable technology and energy resources. Especially challenging transition is envisaged for heavy-weight, long-range vehicles and airplanes. A detailed literature review was carried out in order to detect the current state of the research on clean transport sector, as well as to point out the gaps in the research. In order to calculate the resources needed for the transition towards completely renewable transport sector, four main alternatives to the current fossil fuel systems were assessed and their potential was quantified, i.e. biofuels, hydrogen, synthetic fuels (electrofuels) and electricity. Results showed that electric modes of transport have the largest benefits and should be the main aim of the transport transition. It was calculated that 72.3% of the transport energy demand on the EU level could be directly electrified by the technology existing today. For the remaining part of the transport sector a significant demand for energy resources exists, i.e. 3069 TWh of additional biomass was needed in the case of biofuels utilization scenario while 2775 TWh of electricity and 925 TWh of heat were needed in the case of renewable electrofuels produced using solid oxide electrolysis scenario.



2ND PRIZE WINNER 2020
THE ISLAND OF EL HIERRO SPAIN

Island of El Hierro

2nd Winner of the 2020 RESponsible Island Prize

The Island of El Hierro in Spain is the 2nd winner of the 2020 RESponsible Island Prize. The Island will receive a €250.000 cash prize for their proposal 'El Hierro 100 RES - El Hierro: Towards a 100% Renewable Energy Island ´. The prize was awarded for the share of renewable energy produced by innovative energy technologies, the environmental and socioeconomic sustainability and impact, citizen and community involvement, and the replicability of the solution.

El Hierro - An Island Champion in Renewable Energy and Innovation

With the start-up of El Hierro's combined Wind-Pumped Hydro Power Station, the renewable energy levels have increased progressively, reaching an average level of almost 60% of electricity from renewable sources. The island has also achieved the record of 100% renewable electricity supply for 25 consecutive days in connection with significant economic and environmental benefits. This is a pioneering achievement for an off-grid energy system, which is not connected to the European electricity grid.

As a result of these achievements, the island of El Hierro has stopped consuming an average of 7,000 tons of diesel per year, and has stopped emitting around 18,700 tons of CO_2 annually into the atmosphere.

Excellence in Sustainability, community and citizen involvement

The innovative energy facilities are in majority owned by the island government Gorona del Viento, which promotes their positive impact on community and citizens. Actions are also targeting the younger generation by showing them how to save energy. They are examples of the island´s sustainable energy awareness that highlight El Hierro's potential as a perfect living-lab for the deployment of decarbonisation initiatives.

Gorona del Viento provides free electricity for electric vehicles through several charging points spread across the Island. As part of its sustainable mobility plan, the Island intends to stop consuming fossil fuel to generate electricity for the mobility of its inhabitants.

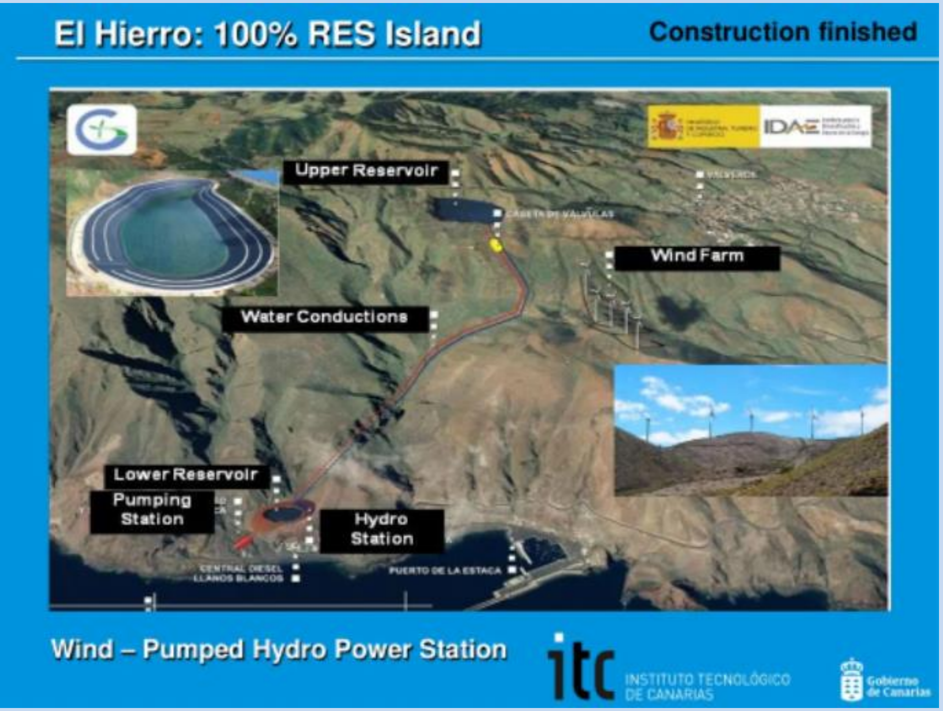
How can the example inspire other islands and communities?

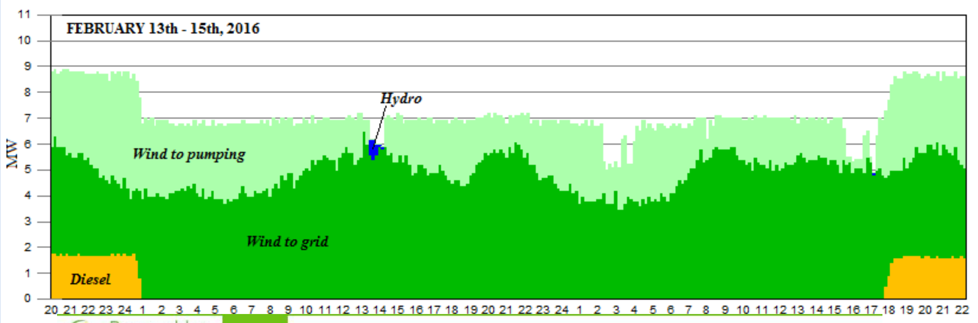
El Hierro's example is a combination of a successful social movement, energised under the umbrella of sustainability and respect of the Island´s specificities, natural resources and values, and of a highly innovative technological solution based on renewable energies (wind-pumped hydro power station). Other islands should pay attention to both aspects for inspiration.

Regarding citizen involvement, most of the actions developed in El Hierro can be easily replicated on other Islands. The Wind-pumped hydro storage solution is fully replicable in many isolated and non-isolated territories worldwide (customising the solution to the local characteristics). Years ago, more than 100 island territories were thoroughly analysed in view of a potential replication. One of these islands was Ikaria (Greece), which has recently commissioned a similar system.

Furthermore, the island of Gran Canaria, one of the most populated islands of the Canary Archipelago, will soon start the construction of a 200 MW pumped storage plant, which will store excess renewable energies that the insular grid is not able to absorb in order to bring back renewable electricity to the island system at peak hours.

HOPE – 100% RES & SMART Islands





Renewables Now

Wind

Spain's El Hierro island finishes 2019 with 54% renewables share

January 14 (Renewables Now) - Renewables met 54% of the total electricity demand on the Spanish island of El Hierro in 2019, thanks in part to the Gorona del Viento wind power-based pumped-hydro system which pushed the figure close to 100% in July.

The power station on the smallest of the Canary Islands succeeded in covering 100% of the local demand for almost 25 days in a row between July 13 and August 7, beating its own 18-day record achieved in 2018.


Source: Twitter, @GoronadelViento

Island of Tilos

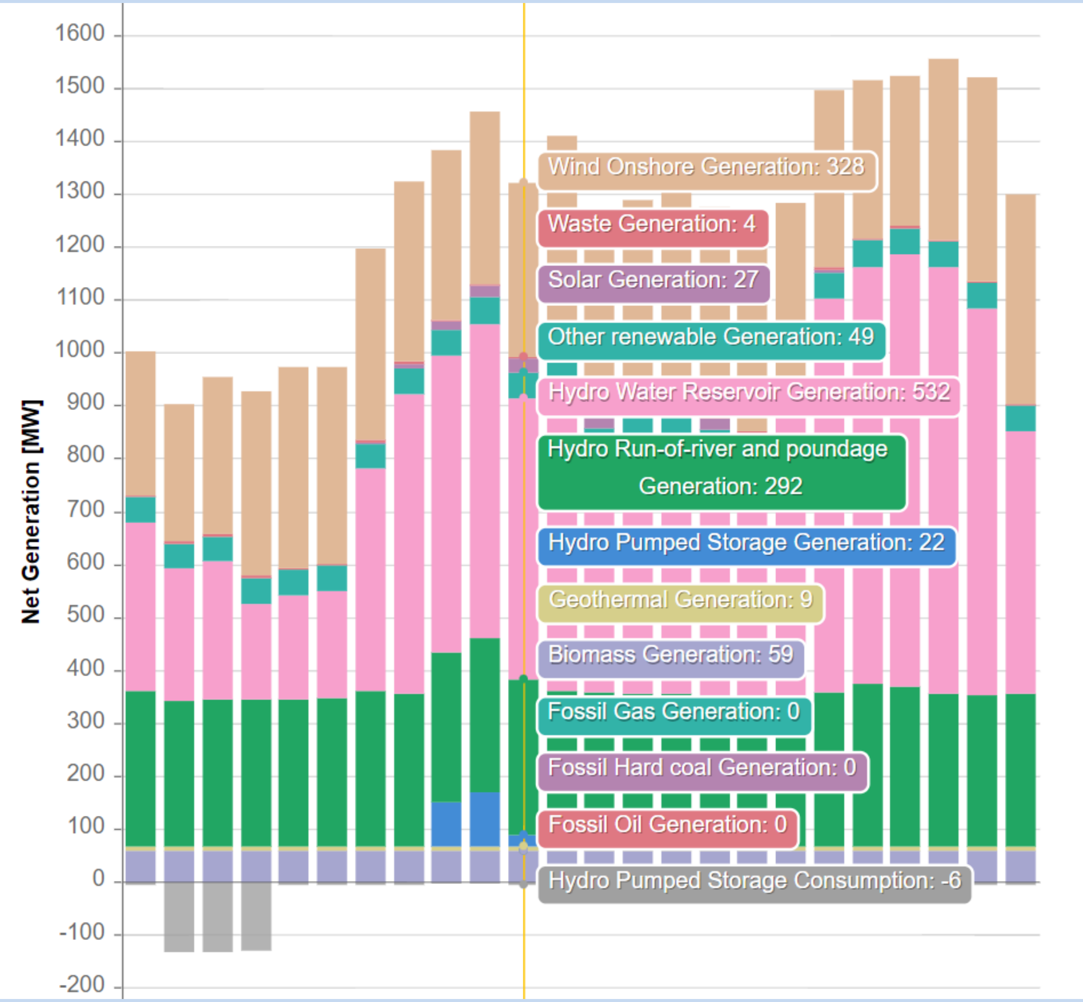
3rd Winner of the 2020 RESponsible Island Prize

The Island of Tilos in Greece is the 3rd winner of the 2020 RESponsible Island Prize. The Island will receive a €100.000 cash prize for their proposal 'TILOS- Towards the Deeper Integration of Local Renewables and a Carbon-Free Island Energy System'. The prize was awarded for the share of renewable energy produced by innovative energy technologies, the environmental and socioeconomic sustainability and impact, citizen and community involvement, and the replicability of the solution.

Tilos - An Island Champion in Renewable Energy and Innovation

Over the recent years Tilos accelerated its clean energy transition in a remarkable pace, enabled by the strong commitment of the local Municipality, the pro-environmental culture and the mindset of Tilos citizens, and the implementation of innovative demonstration projects, such as the Horizon 2020 TILOS project. By embracing community-scale wind and solar, battery energy storage and advanced energy management and metering, Tilos achieves high shares of renewables in the local electricity sector. At the same time, the island extends its efforts to the directions of e-mobility and renewable-driven EV charging infrastructure, sustainable water management and energy efficiency in the local public lighting sector.

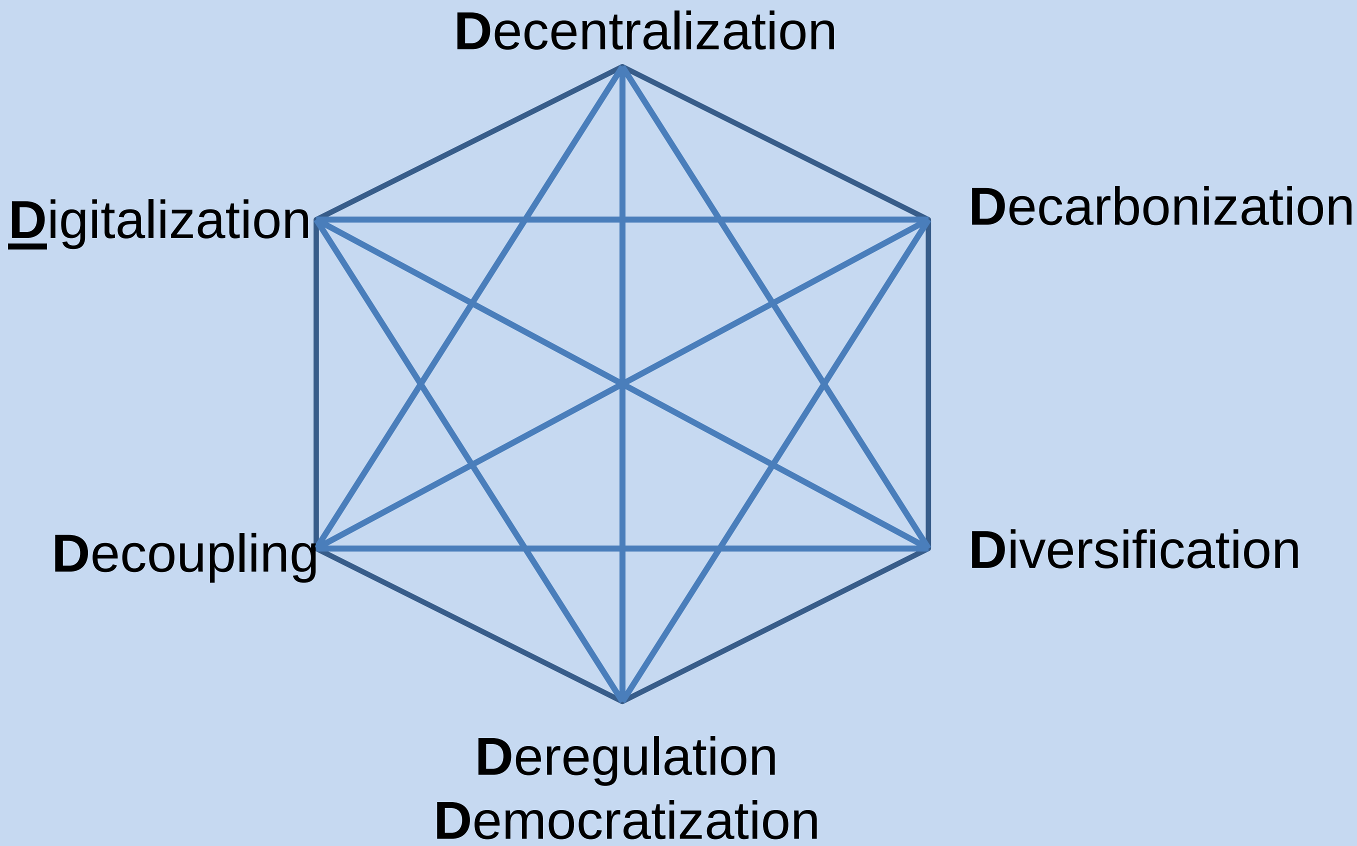
Hope II: Electricity production in Croatia 22/05/2021?



Decarbonization of the cities?

Cities occupy only 2% of the planet's surface and yet concentrate 50% of the population, consume 75% of energy and are responsible for 80% of CO_2 emissions.

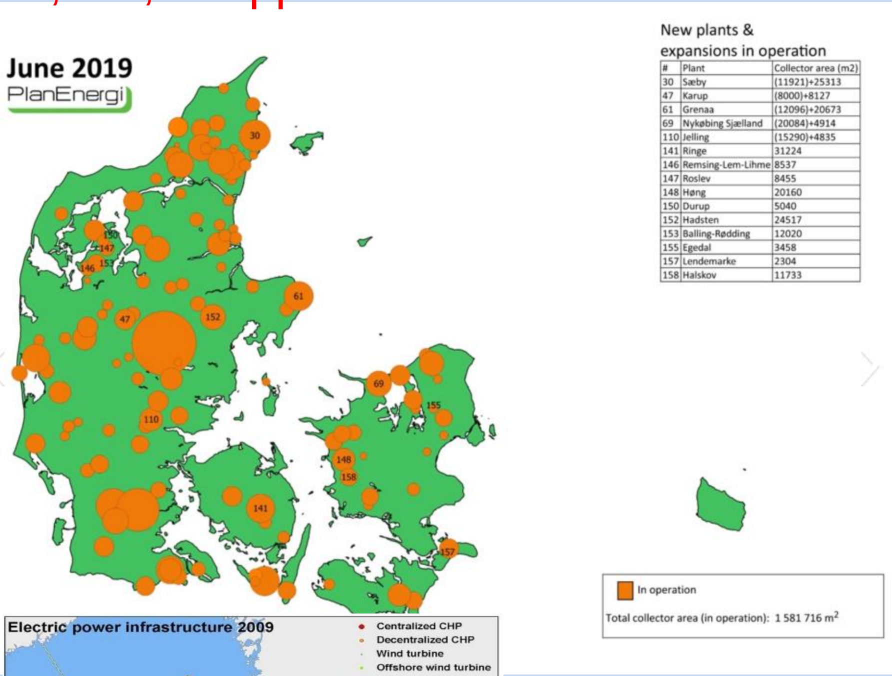
Smart cities support ENERGY TRANSITION



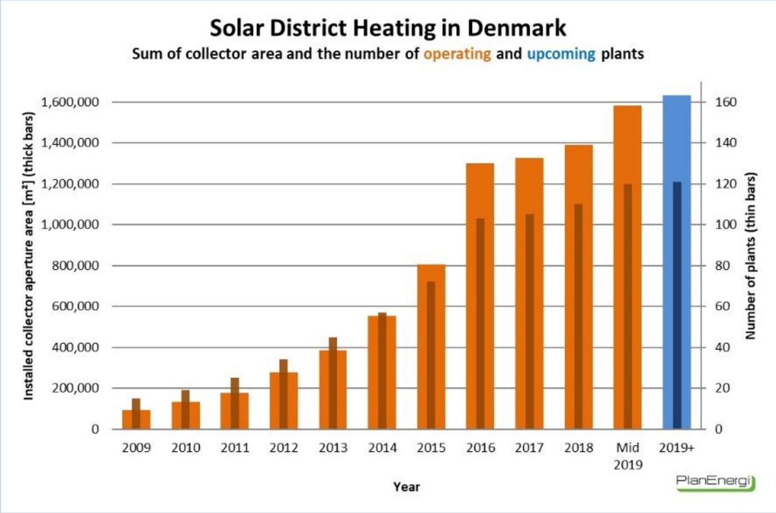
Decentralization in Denmark and Austria

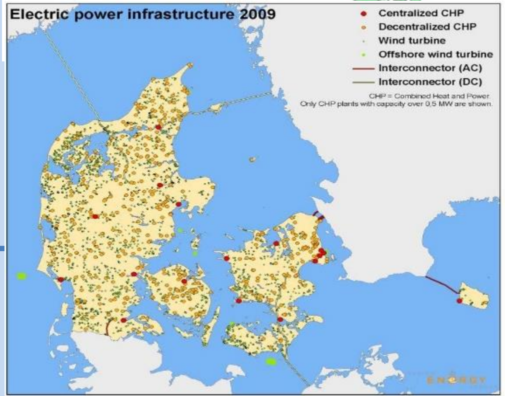
~ 1100 MW solar thermal ~ 1600000 m^2

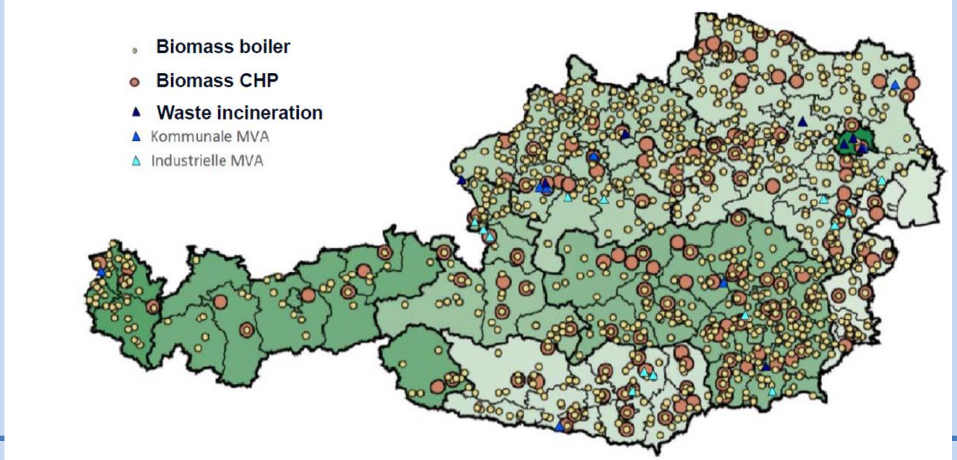
5,792,202 ppl → 0.276 m^2 per capita



#	Plant	Collector area (m2)
30	Sæby	(11921)+25313
47	Karup	(8000)+8127
61	Grenaa	(12096)+20673
69	Nykøbing Sjælland	(20084)+4914
110	Jelling	(15290)+4835
141	Ringe	31224
146	Remsing-Lem-Lihme	8537
147	Roslev	8455
148	Høng	20160
150	Durup	5040
152	Hadsten	24517
153	Balling-Rødding	12020
155	Egedal	3458
157	Lendemarke	2304
158	Halskov	11733





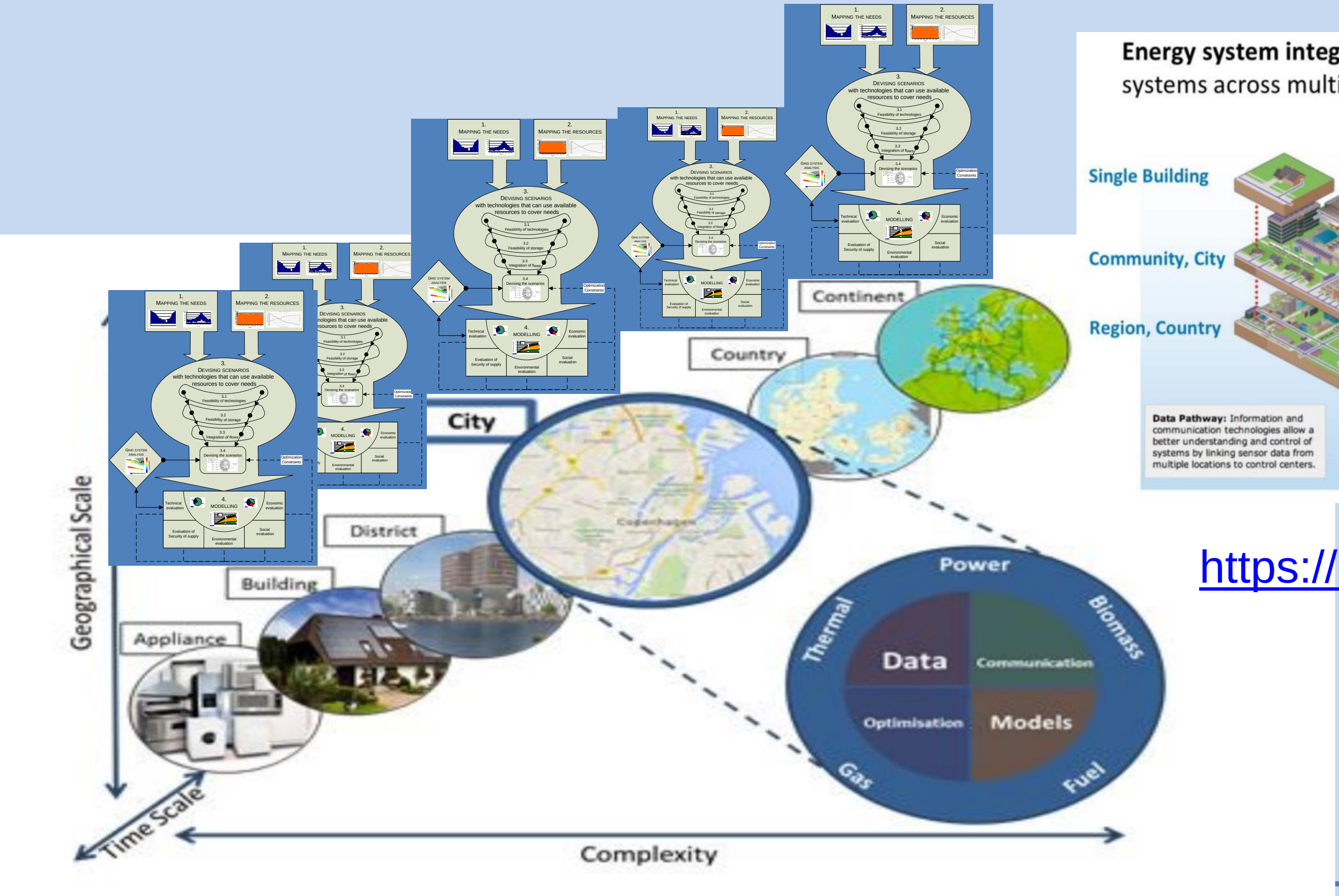


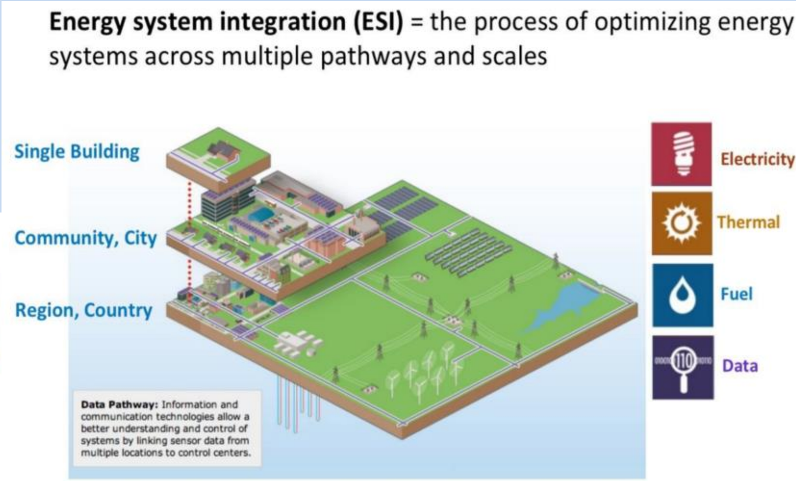
Stratego

In Austria, more that 2.400 heat networks are existing (among them a large number of small biomass networks). DH market share is about 24%. District cooling has only a minor role limited to some cities.

Everything is going to be digital …

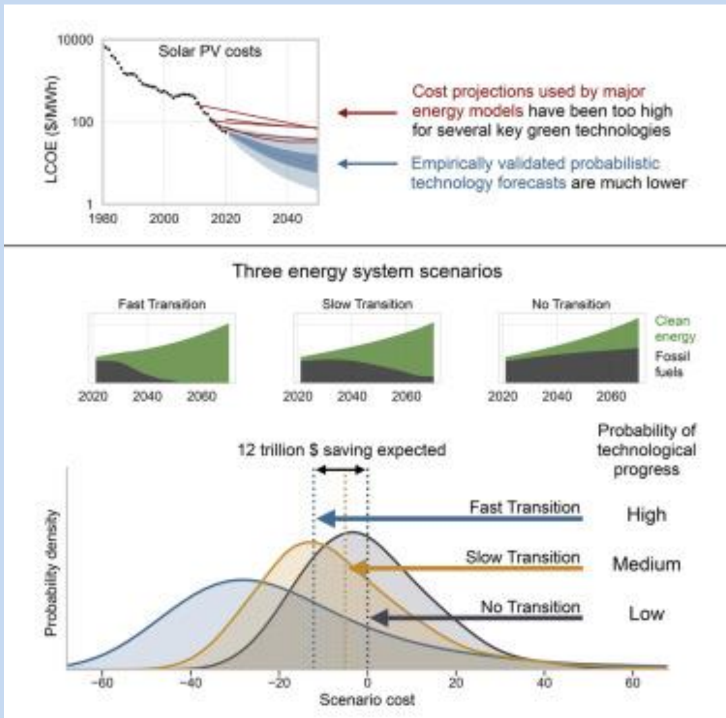
Digitalization for smart energy system integration





https://smart-cities-centre.org/

Technology Value Chains



Conclusions

- the way we are going is **unsustainable**, that's why energy systems need to be transformed from the foundations, and adequate energy planning is the key to success
- current progress towards sustainable systems is too slow
- politicians must have a clear vision of the energy systems of the future, based on reliable costs and achievable and reasonable targets
- the prices of energy and fuels must reflect real and complete costs and transparent markets must be ensured for all forms of energy and fuels
- it is necessary to speed up innovation and development of new technologies and apply the best existing ones
- it is necessary to consider the flexibility of the power system and build flexible plants
- digitalization is key to success in the planning and implementation of 100% renewable energy systems
- technology value chains will determine the future development of energy systems
- Smart islands, energy communities and cooperatives may play the key role in the decarbonization

Thank you for your attention!

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