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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Dominkovic, D. F., Baekovi, I., osi, B., Krajai, G., Pukšec, T., Dui, N., & Markovska, N. (2016). Zero carbon energy system of south east europe in 2050 - poster.

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Zero Carbon Energy System of South East Europe in 2050

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Abstract:

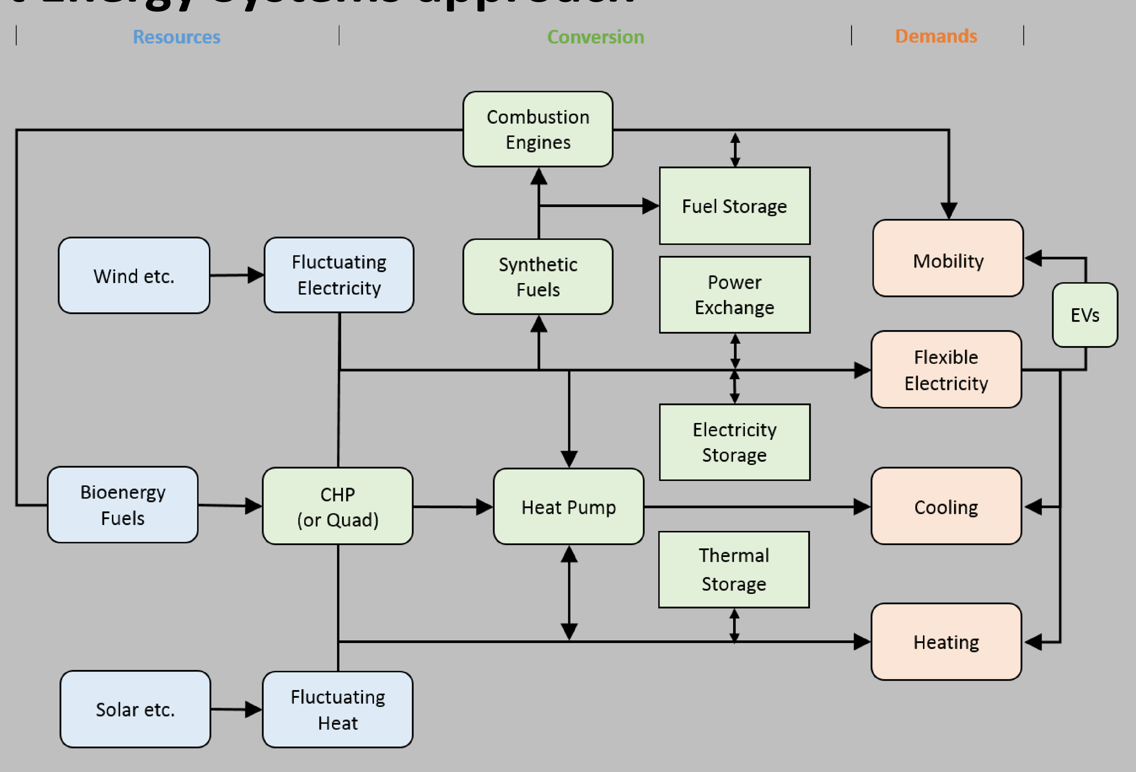
South East Europe consists of several smaller countries in terms of energy systems and thus, integrating energy systems of the whole region has significant benefits for all the countries included. However, as there are large differences between energy mixes of the countries included, careful energy planning needs to be carried out in order to satisfy energy needs of all the countries of the region.

Due to the significant differences in geography and the climate of different parts of the region, many different technologies need to be introduced in order to have optimal, low-carbon energy mix.

In this paper, steps toward the 100% renewable energy system (RES) for the year 2050 have been presented. Novelty in this paper, compared to the similar research already being carried out, is the sustainable use of biomass in 100% RES, as this is the only way in which biomass can be considered as carbon-neutral. Smart energy systems' approach has been used in planning of 100% RES, which considers significant integration of the electrical, heating and gas sectors. Many technologies have been employed in the year 2050, but the major share is put on photovoltaics and wind energy, followed by geothermal, solar thermal, CHPs driven on biomass, hydro power and synthetic fuel technologies. Finally, it was shown that the 100% RES in the year 2050 is cheaper than the reference system, developed for the year 2012.

Methodology:

❑ **Smart Energy Systems approach**



❑ Modelled in EnergyPLAN
- ❑ Used for modelling of more than ten 100% RES (EU, national and regional)
- ❑ Deterministic simulation model
- ❑ Input/output model
- ❑ Hourly resolution

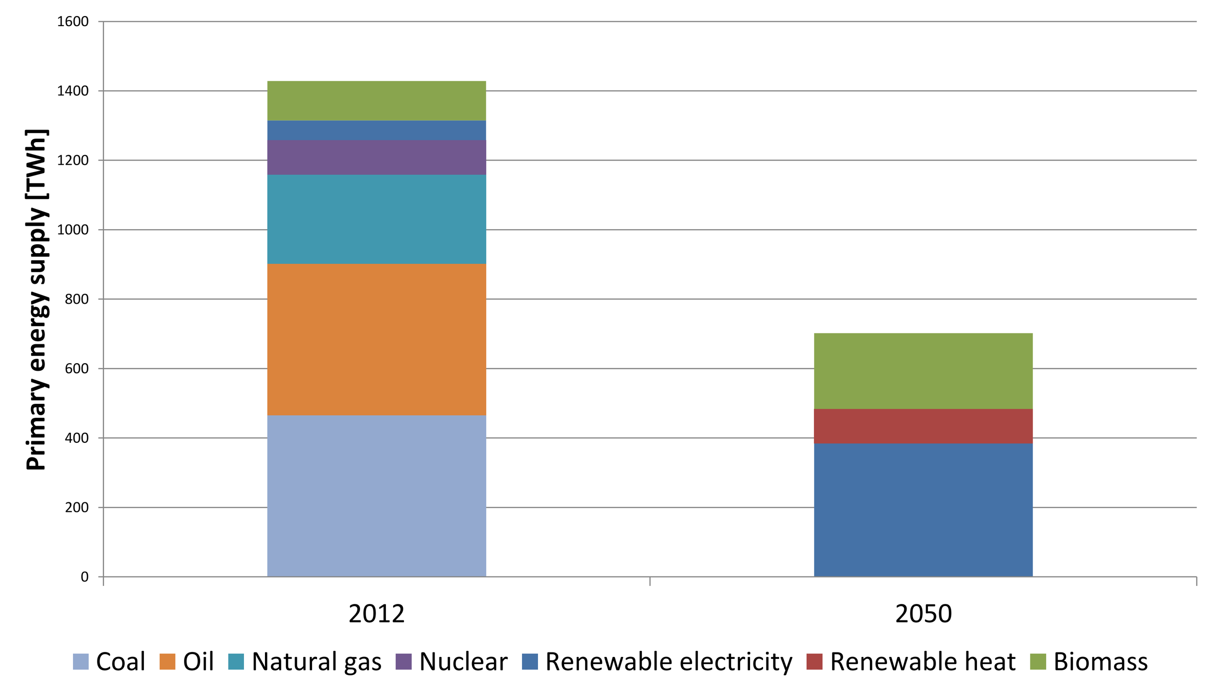
Measures to be adopted for achieving low carbon Southeast Europe:

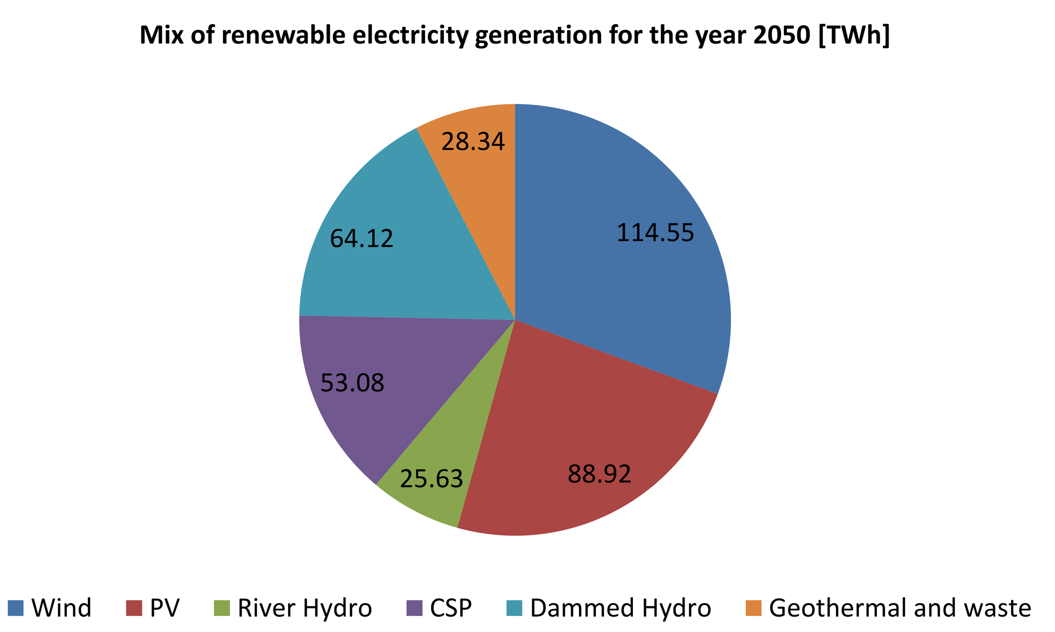
- ✓ Efficiency increase in individual houses by 40%
- ✓ DH efficiency increase of 40%
- ✓ Replacement of 52.5% of individual heating houses with small scale district heating (1.5% per year)
- ✓ 50% of final heating demand of houses not connected to the DH is met by heat pumps, 20% by solar thermal and 30% by biomass boilers
- ✓ In industry, increased efficiency of 40% is leveled out with the some increase in industrial activity, which sets the total energy demand leveled out with the reference year
- ✓ 20% of demand in industry is met by industrial CHPs
- ✓ 15% of demand is met by solar thermal energy with storages
- ✓ 45% of energy demand of fossil fuels in industry is replaced with electricity
- ✓ Remaining coal and oil consumption is replaced by biomass
- ✓ In transport sector 20% energy savings needs to be achieved by improved public transportation system and replacement of one part of individual vehicles with public transportation (mainly electrified trains)
- ✓ Total electrification of railway system
- ✓ 100% of light transport vehicles and 35% of medium transport vehicles is replaced by electrical vehicles; out of these 85% will be using smart charge system, while 15% dumb charge system
- ✓ Remaining part of transport sector demand is met by synthetic fuels produced mainly by chemical synthesis from biogas (produced at gasification plants from biomass); 25% of fuel demand is met by CO_2 hydrogenation using electricity as energy input

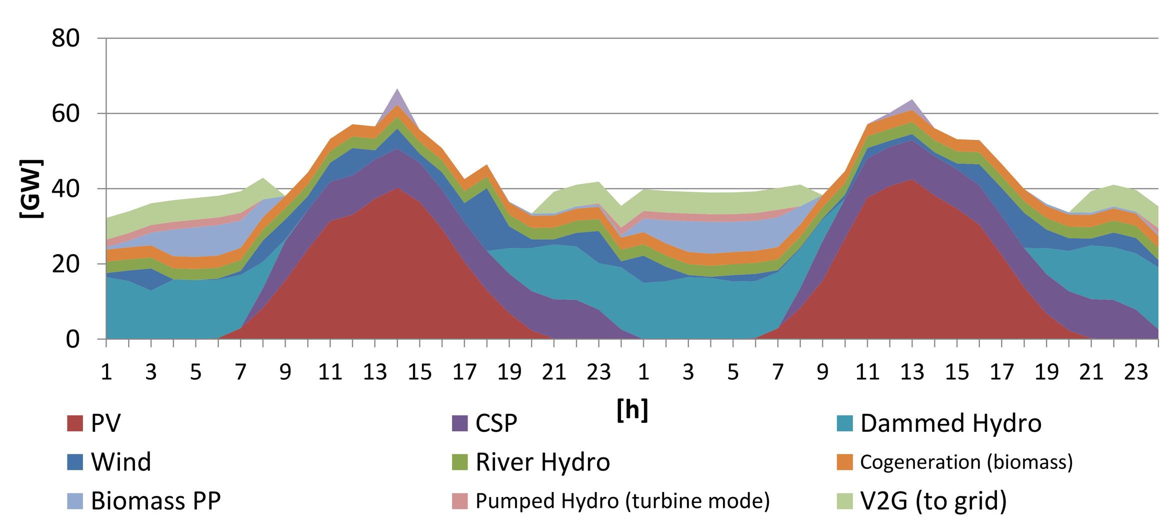
On the supply side following steps are made:

- ✓ Total capacity of wind set to 50 GW
- ✓ Total capacity of PVs set to 65 GW
- ✓ Total capacity of CSP set to 11 GW
- ✓ Increase in dammed hydro power capacity for 25%, to 23.5 GW
- ✓ Introduction of 1.5 GW_e of large scale heat pumps
- ✓ 13.3% of heat in DH system is met by solar thermal with a 75 GWh of seasonal thermal energy storage
- ✓ All newly introduced district heating goes to the small scale networks
- ✓ Installation of 230 GWh of seasonal storage in DH network
- ✓ 400 MWe of waste incineration power plants
- ✓ 400 MWe of geothermal PP
- ✓ Increase in river hydro and small hydropower plants to 6.8 GW
- ✓ Adding 300MW of geothermal heating energy yearly (in 2050 50% of heat in DH is produced by geothermal energy sources)
- ✓ Introduction of 11 power plants similar to Avča (total new storage 1067 GWh (obtained from [42], pumping capacity 1980 MW and turbine capacity 2035 MW)
- ✓ Increase in CHP capacity to 8 GW
- ✓ Reduction in thermal power plants capacity to 24.7 GW and replacing its fuel with biomass
- ✓ Decommission of all nuclear power plants

Results:







	2012	2050
PES [TWh]	1426	701.78
CO2 emissions [Mt]	332	0
CEEP [TWh]	0	20.33
Total annual system cost [MEUR]	63903	45179

Sustainable use of biomass (785 PJ in the year 2050)!

Conclusions:

- ➢ It is possible to build 100% RES of the Southeast Europe
- ➢ Significant integration of different energy subsectors is needed in order to integrate high share of intermittent RES
- ➢ Biomass consumption is sustainable
- ➢ Thermal and gas storage need to be maximally utilized, as well as V2G concept for storing the electricity
- ➢ Many coordinated steps are needed in order to reach zero carbon energy system

*Acknowledgement: Financing from the CITIES project nº DSF1305-00027B is greately appreciated.