



European Forum  
for Renewable Energy Sources

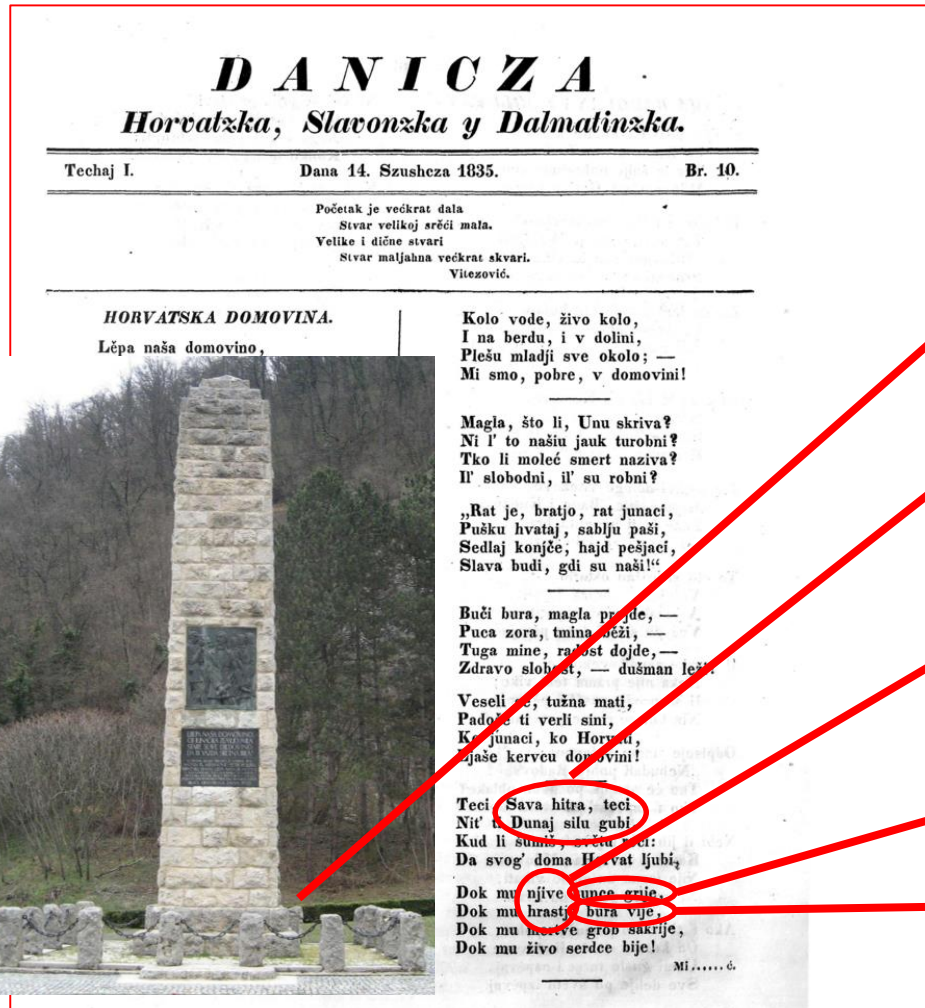


ENERGY EFFICIENCY WATCH

## REGIONAL COOPERATION IN THE WESTERN BALKANS: BENEFITS OF A TRANSNATIONAL APPROACH

**Asst.prof.dr.sc. Goran Krajačić, FSB, University of Zagreb**  
*Opportunities and challenges of the European Energy Union –  
Energy Efficiency and Renewable Energy in Croatia*  
Meeting Room Ivan Mažuranić, Croatian Parliament, Zagreb  
31 March 2017, 09:30 – 12:30

# HOW TO MAKE NEW CROATIAN ENERGY STRATEGY?



**GEOHERMAL**  
 125 MWt, 295 GWh, 2014

**HYDROPOWER**  
 2200 MW, 9000 GWh, 2014

**BIOMASS**  
 (agriculture and forests)  
 56 MWe, 388 GWh, 2016  
 515 MWt, 12600 GWh, 2014

**SOLAR ENERGY**  
 50 MWe, 61 GWh, 2016  
 113 MWt, 107 GWh, 2014

**WIND ENERGY**  
 412 MW, 1018 GWh, 2016

# HOW TO MAKE NEW CROATIAN ENERGY STRATEGY?

- 5D approach
- **D**ecentralization
- **D**iversification
- **D**ecarbonization
- **D**ecoupling
- **D**eregulation

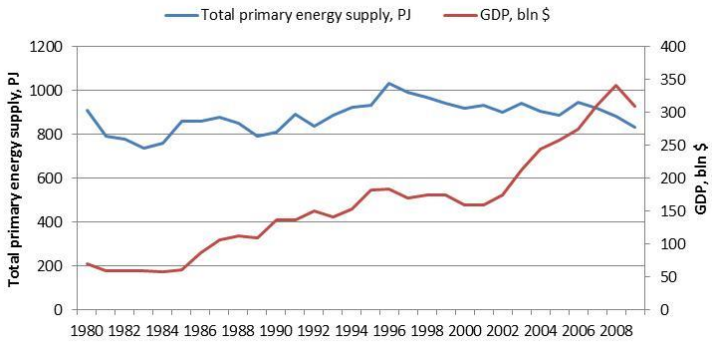
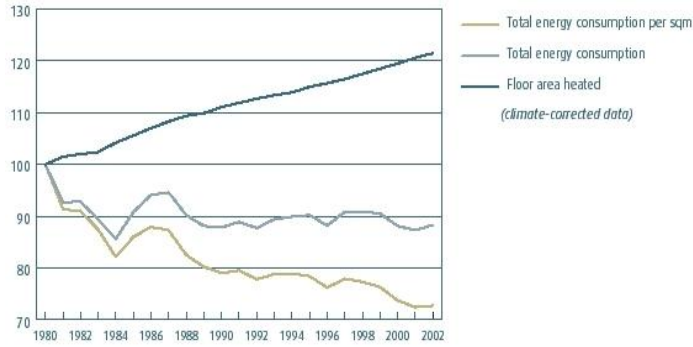
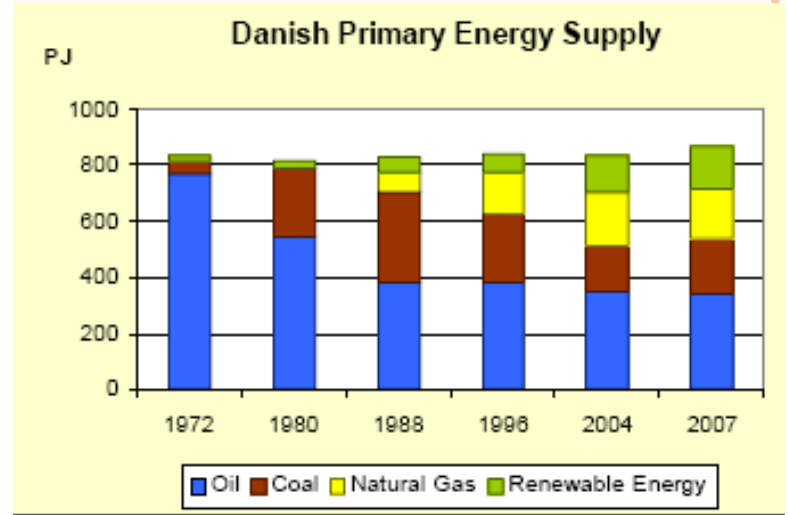
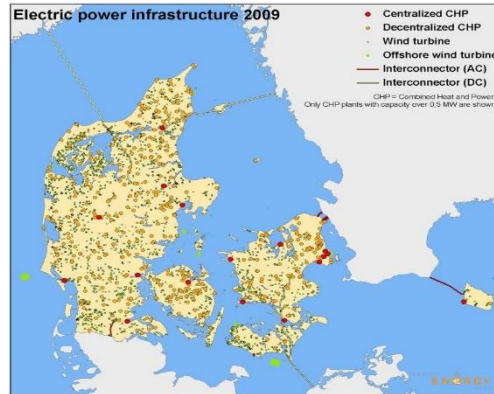
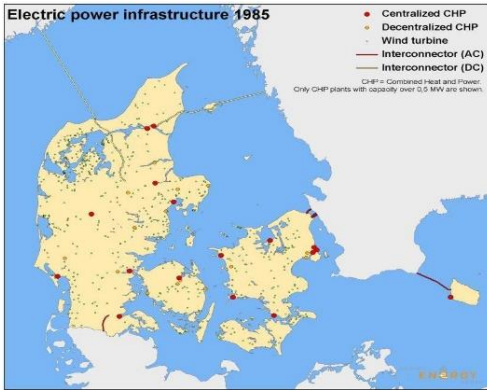


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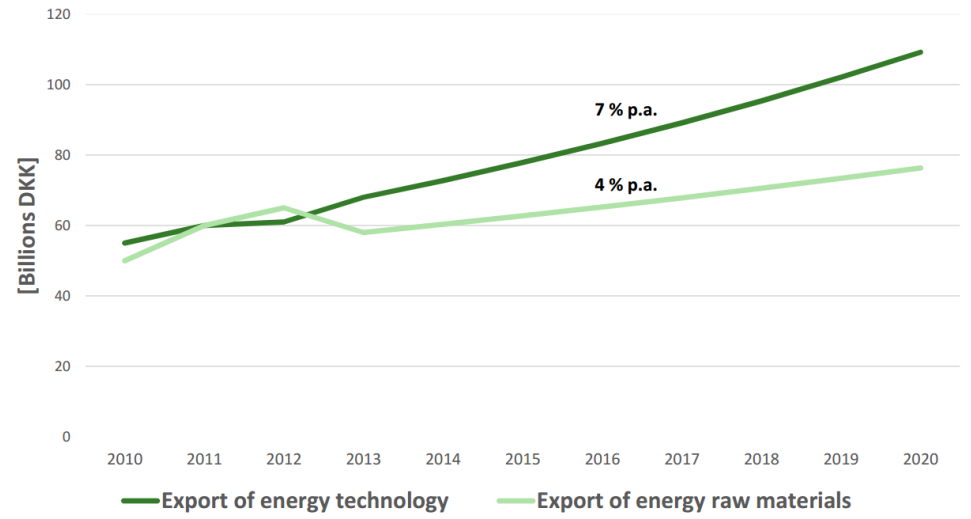
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# 5D IN THE DANISH ENERGY TRANSITION?

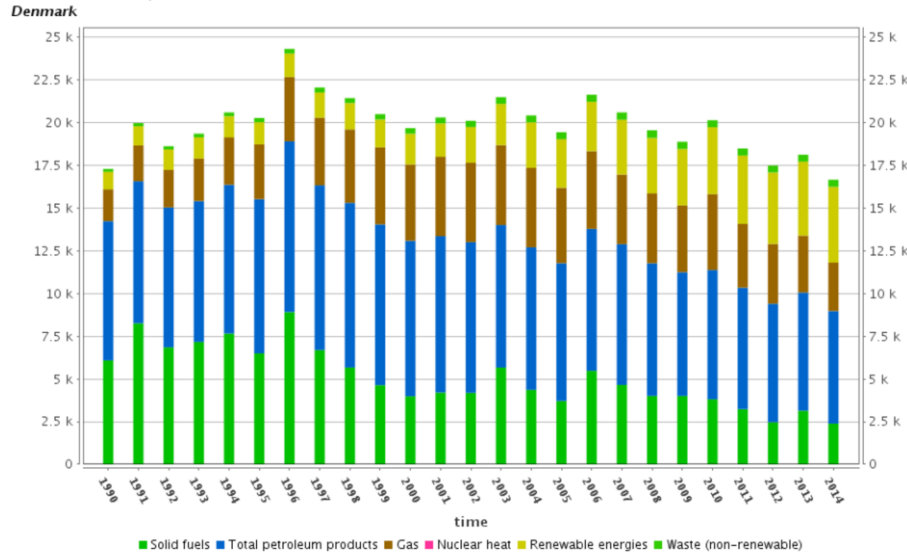


## Export prognoses based on current growth rates



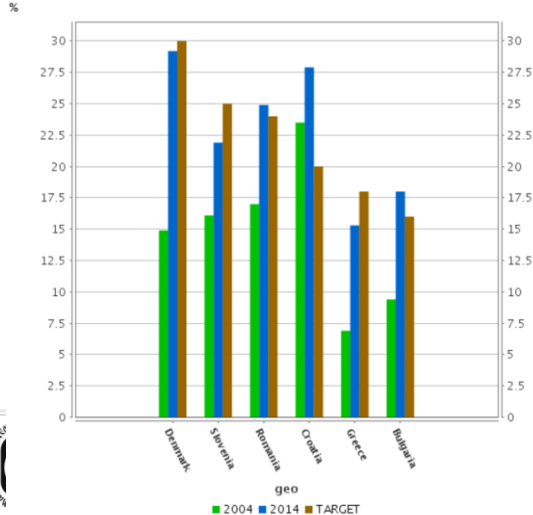
# DENMARK → SEE → THE WESTERN BALKANS

Gross inland energy consumption by fuel type  
1 000 tonnes of oil equivalent

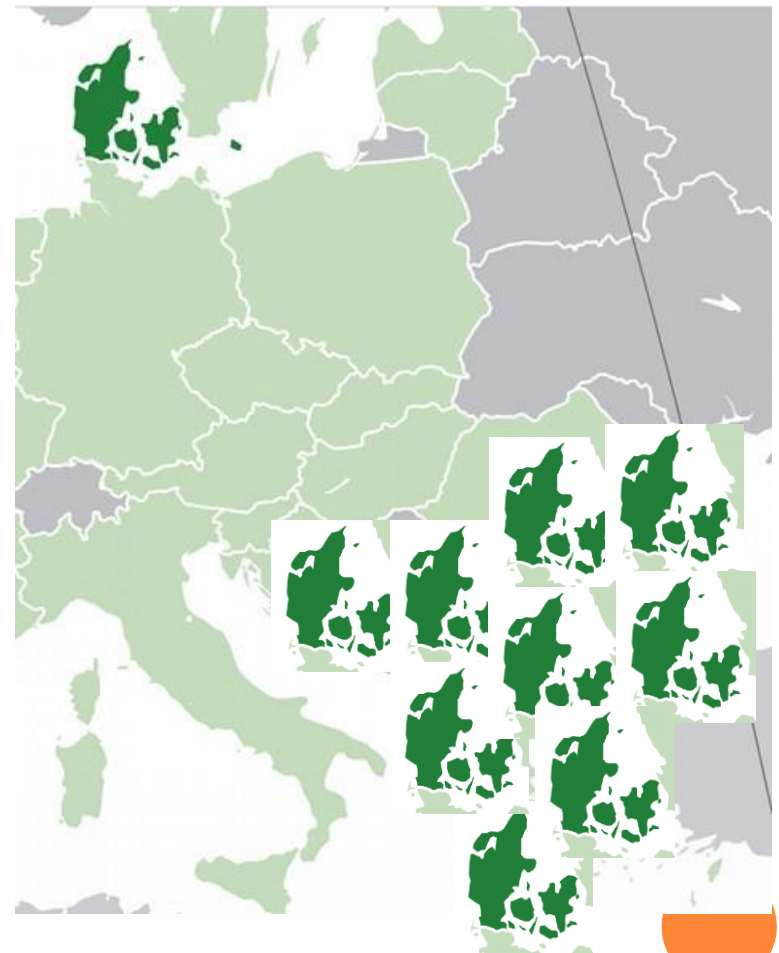


Source of Data Eurostat

Share of renewable energy in gross final energy consumption

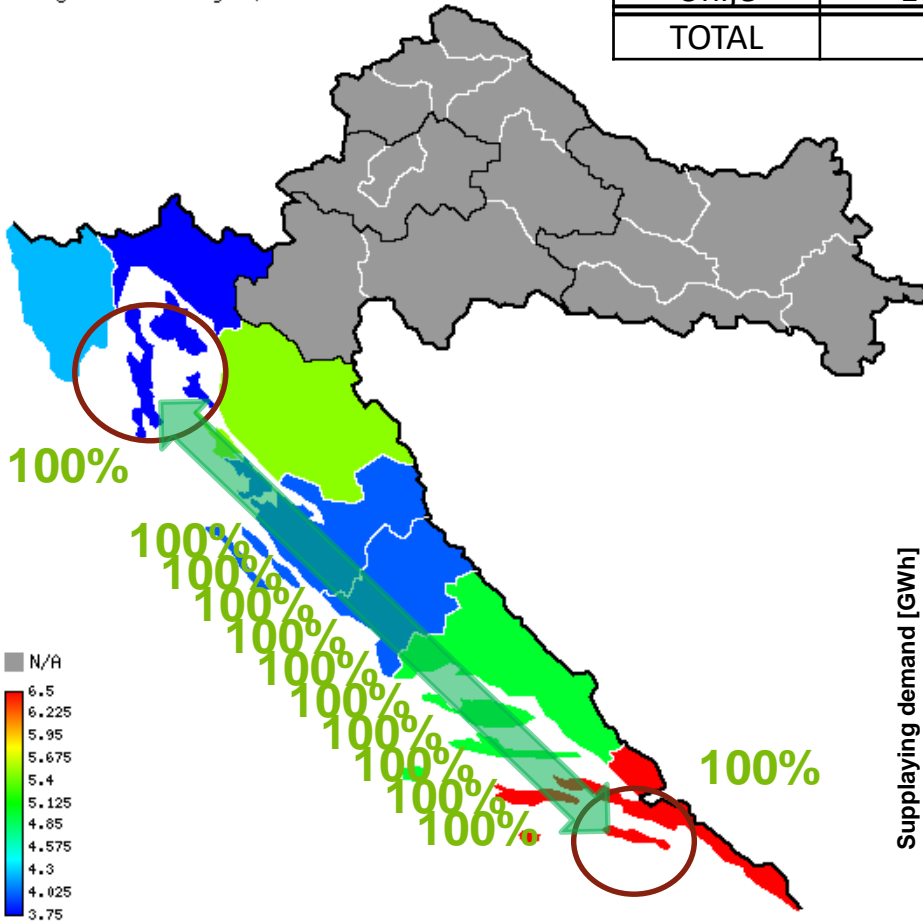


Source of Data European environment agency (EEA)

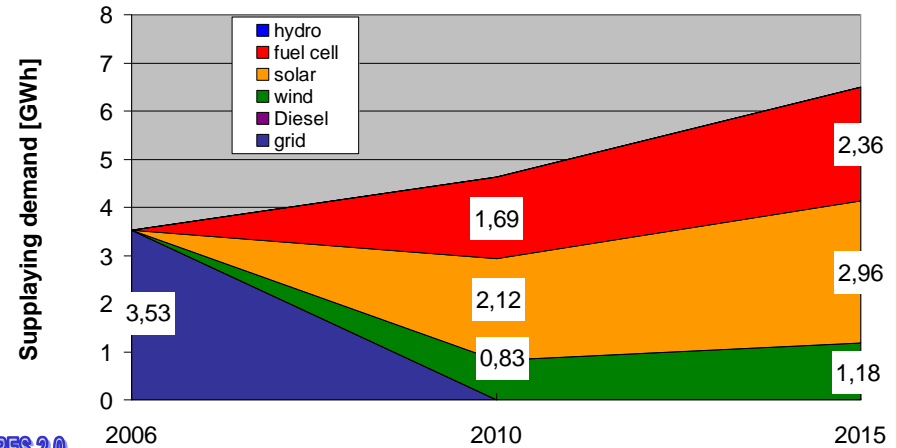


# 100% RES ISLANDS

Average wind velocity [m/s]



Island	Scenario/year	Manufacturing and Installation (person years)	O&M and Service (Jobs)
Mljet	100% RES 2015	216	11
Losinj	100% RES (80% RES PTV) 2025	3987	520
Unije	100% RES 2030	95	6
<b>TOTAL</b>		<b>4299</b>	<b>537</b>



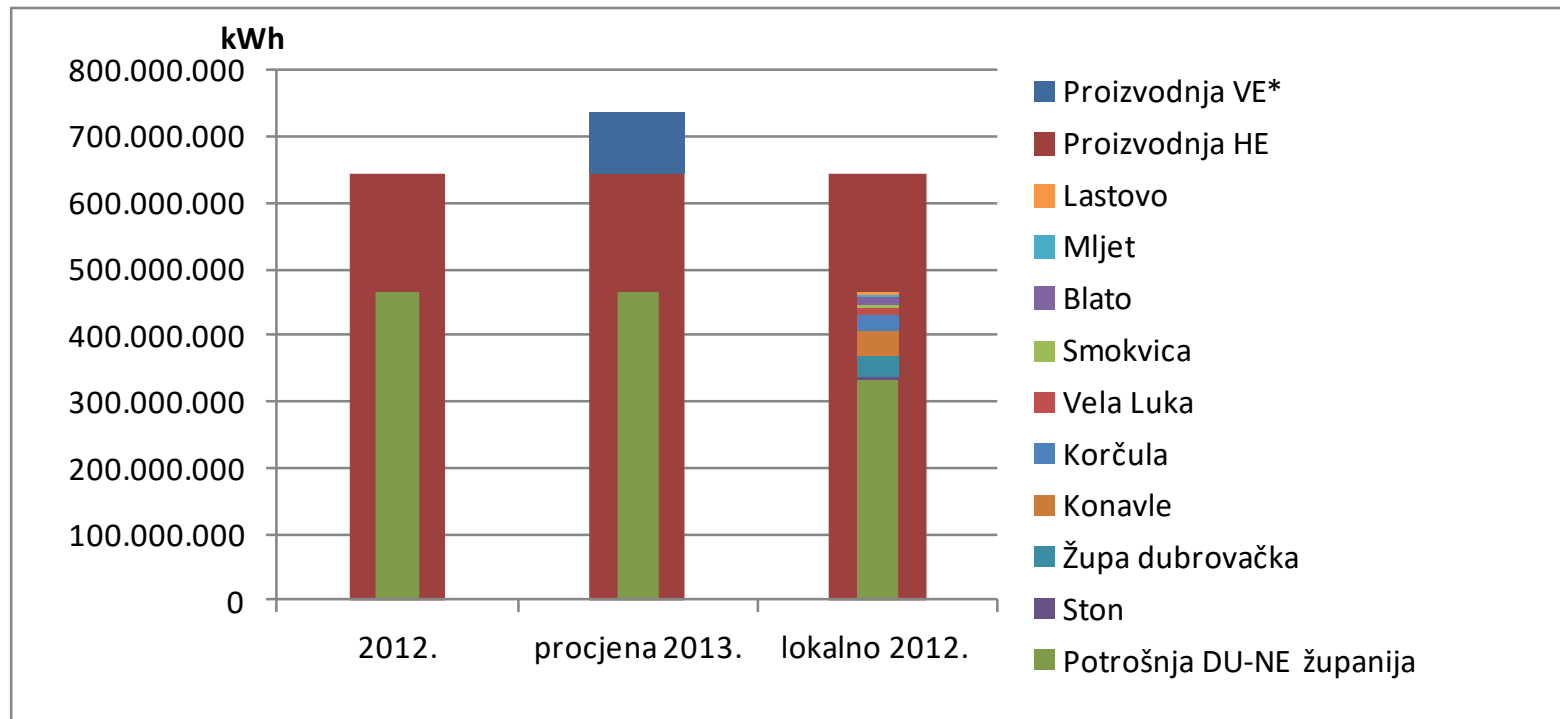
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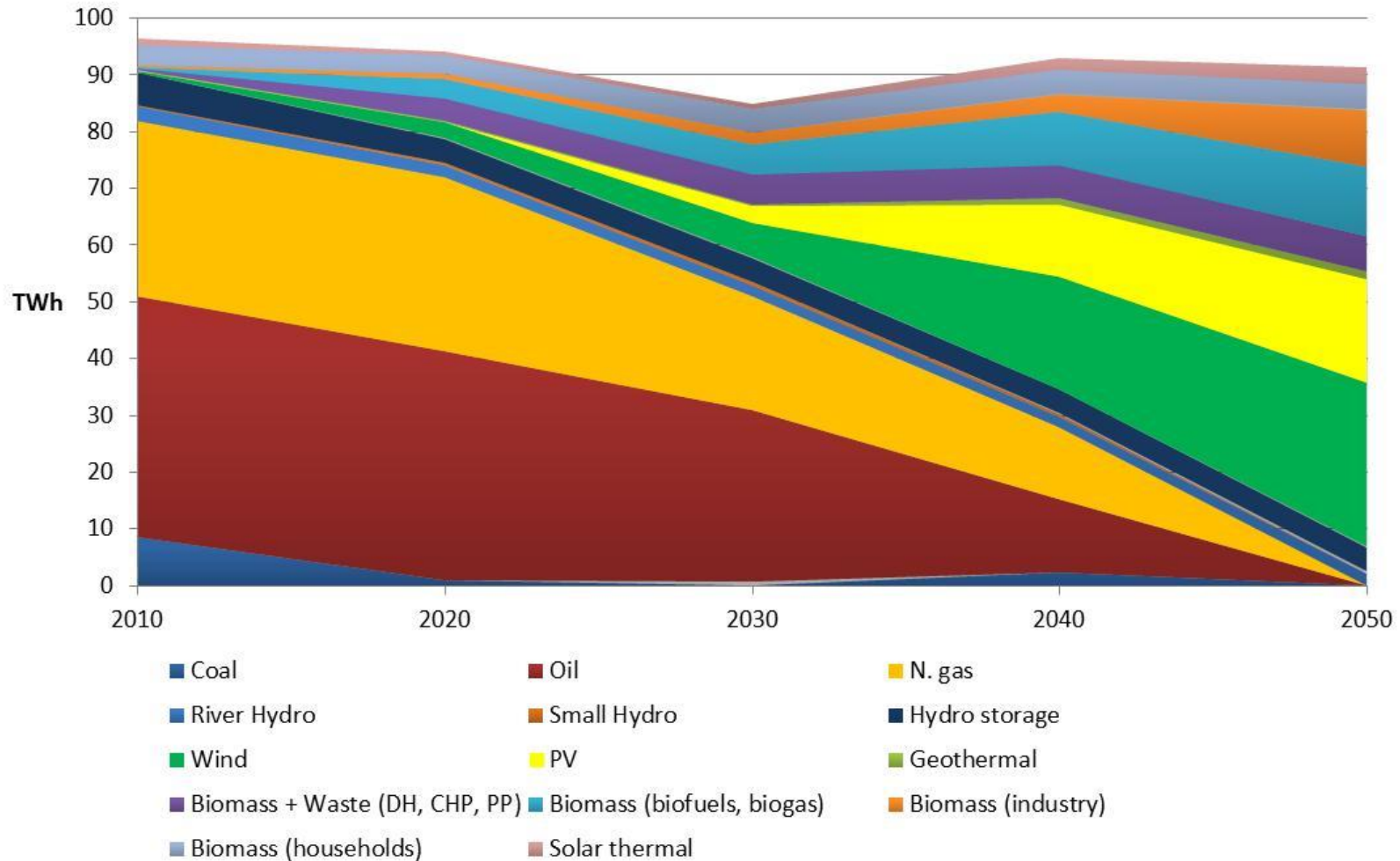
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# 100% RES CITIES AND COUNTIES



# 100% RES CROATIA!



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# Energy

Volume 48, Issue 1, December 2012, Pages 80–87



## A 100% renewable energy system in the year 2050: The case of Macedonia

Boris Ćosić <sup>1</sup>, , Goran Krajačić<sup>2, 3</sup>, , Neven Duić<sup>2, 3</sup>, 

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<http://dx.doi.org/10.1016/j.energy.2012.06.078>

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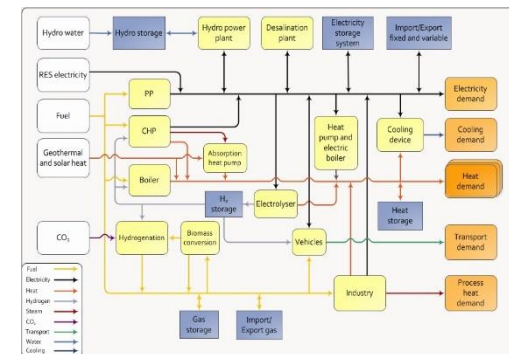
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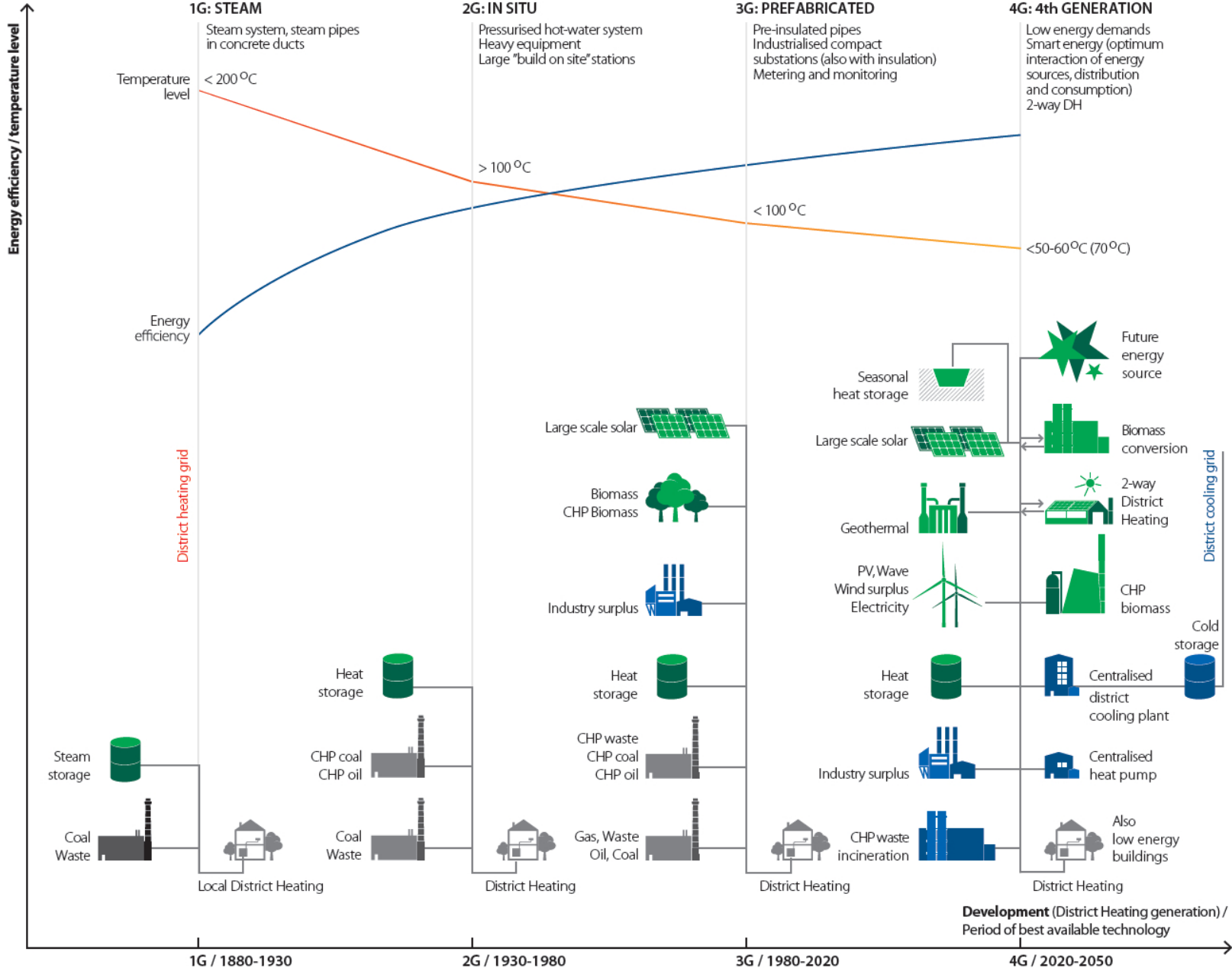
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# 100% RES ENERGY SYSTEM IN THE SOUTH EAST EUROPE (BALKANS)?

- 11 countries (65.5 mil. ppl)
- 765,884 km<sup>2</sup> (17% EU)
- 85.5 people/km<sup>2</sup> (113 ppl/km<sup>2</sup> EU)
- 8.9% of Europe's total population
- Average age: 39.8 (42.2 EU-28)
- Urban population: 59 % (72.4% EU-28)
- GDP per capita: 9,922 \$ (Slovenia: 23,962; Kosovo: 3,877 \$)





**1G: STEAM**

Steam system, steam pipes in concrete ducts

Temperature level <math>< 200^{\circ}\text{C}</math>

Energy efficiency

District heating grid

1G / 1880-1930

**2G: IN SITU**

Pressurised hot-water system Heavy equipment Large "build on site" stations

> 100°C

2G / 1930-1980

**3G: PREFABRICATED**

Pre-insulated pipes Industrialised compact substations (also with insulation) Metering and monitoring

<math>< 100^{\circ}\text{C}</math>

3G / 1980-2020

**4G: 4th GENERATION**

Low energy demands Smart energy (optimum interaction of energy sources, distribution and consumption) 2-way DH

<math>< 50-60^{\circ}\text{C}</math> (<math>70^{\circ}\text{C}</math>)

4G / 2020-2050

Development (District Heating generation) / Period of best available technology



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# SUPPLY SIDE

- PV: 65 GW
- Wind: 50 GW
- CSP: 11 GW
- Dammed hydro: from 18.8 to 23.5 GW
- Large-scale HPs: 1.5 GW
- Solar thermal with energy storage in DH: 13.3 %
- Seasonal thermal energy storage: 230 GWh
- Waste incineration plants: 0.96 GWe
- Geothermal plants: 1.25 GWe
- Geothermal heating plants: 7.5 GW
- River hydro, pumped-hydro 2 GW, 1000 GWh
- Decommission of nuclear PPs
- Reduction in thermal power plants capacity to 24.7 GW



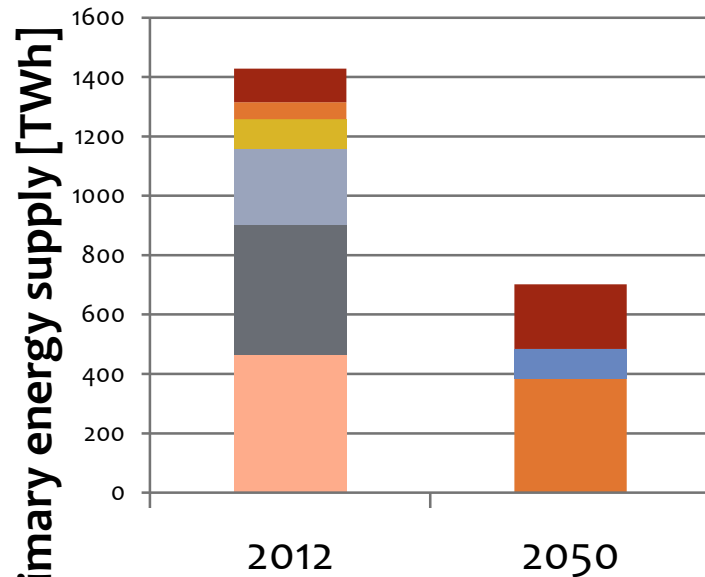
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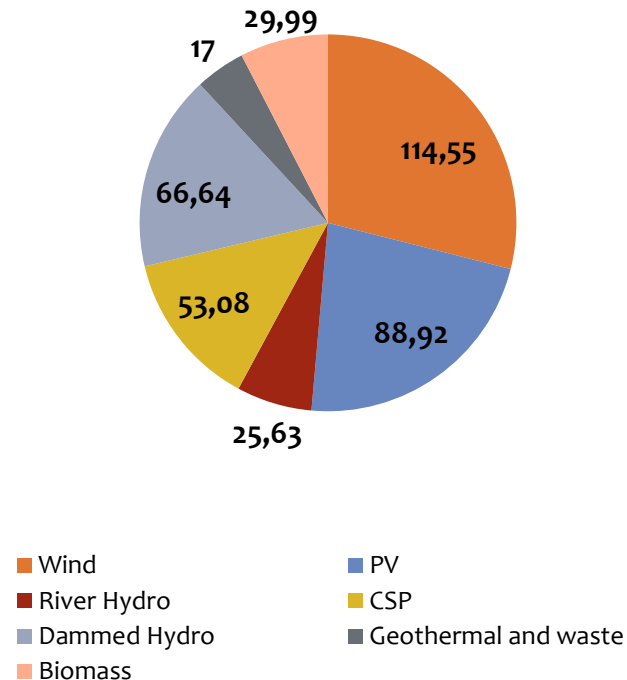
# ENERGY SYSTEMS SEE 2012 – 2050?

## Energy systems: 2012 vs. 2050



- Coal
- Natural gas
- Renewable electricity
- Biomass
- Oil
- Nuclear
- Renewable heat

## Electricity generation mix in 2050 [TWh]



- Wind
- River Hydro
- Dammed Hydro
- Biomass
- PV
- CSP
- Geothermal and waste



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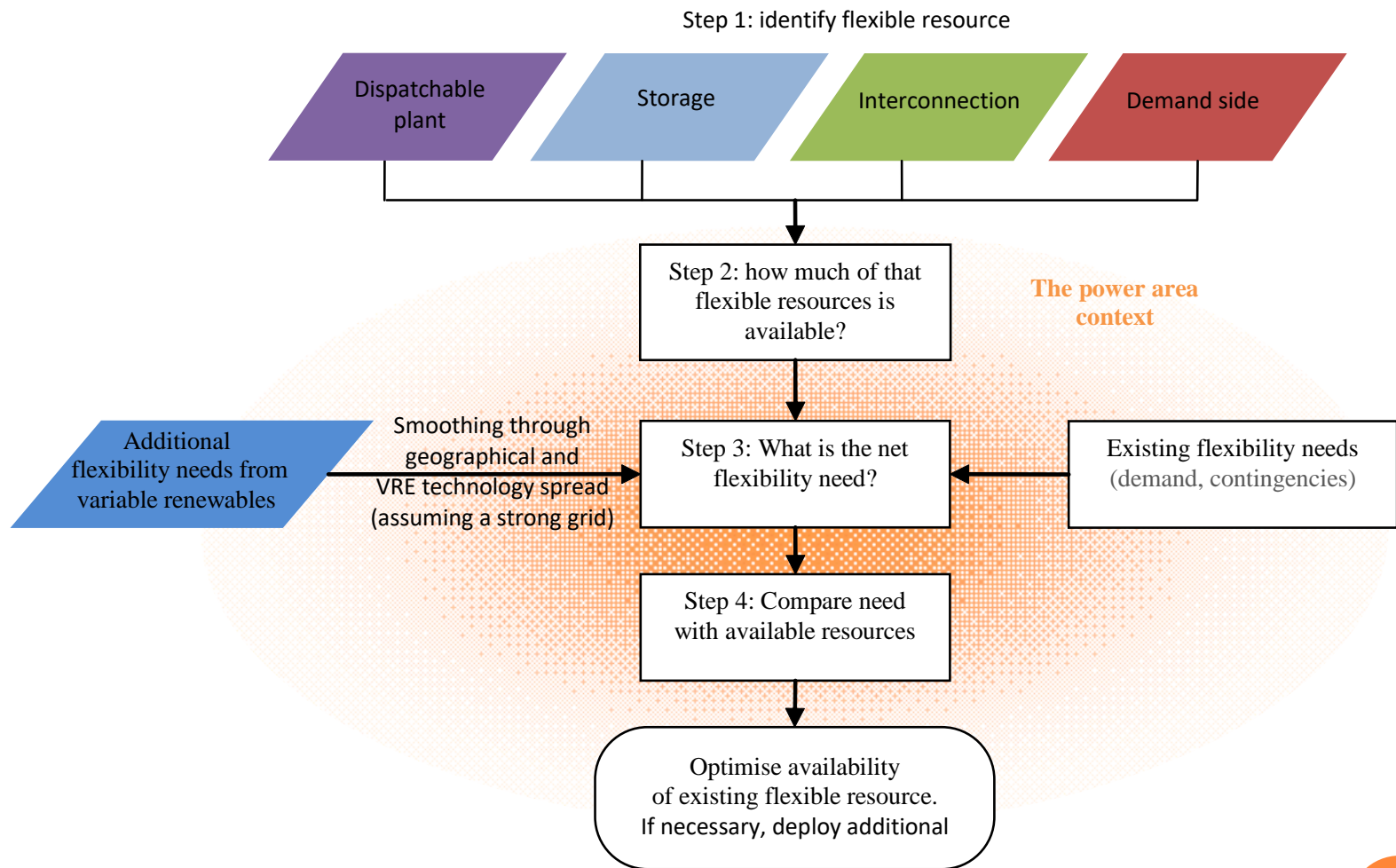
# ECONOMIC AND TECHNICAL INDICATORS

	2012	2050
PES [TWh]	1,426	702.86
CO <sub>2</sub> emissions [Mt]	332	0
CEEP [TWh]	0	15.64
Total annual socio-economic cost [MEUR]	63,903	44,415

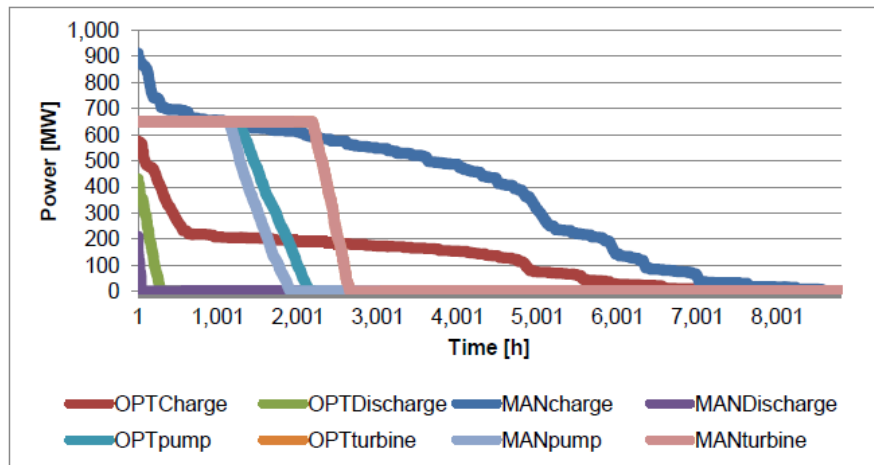
Sustainable use of biomass  
(785 PJ in the year 2050)!



# FAST – METHOD FOR FLEXIBILITY ASSESMENT



# FLEXIBILITY GAP



Energy

Volume 115, Part 3, 15 November 2016, Pages 1701–1709



## Two methods for decreasing the flexibility gap in national energy systems

Ilija Batas Bjelić<sup>a</sup>, Nikola Rajaković<sup>a</sup>, Goran Krajačić<sup>b</sup>, Neven Duić<sup>b</sup>

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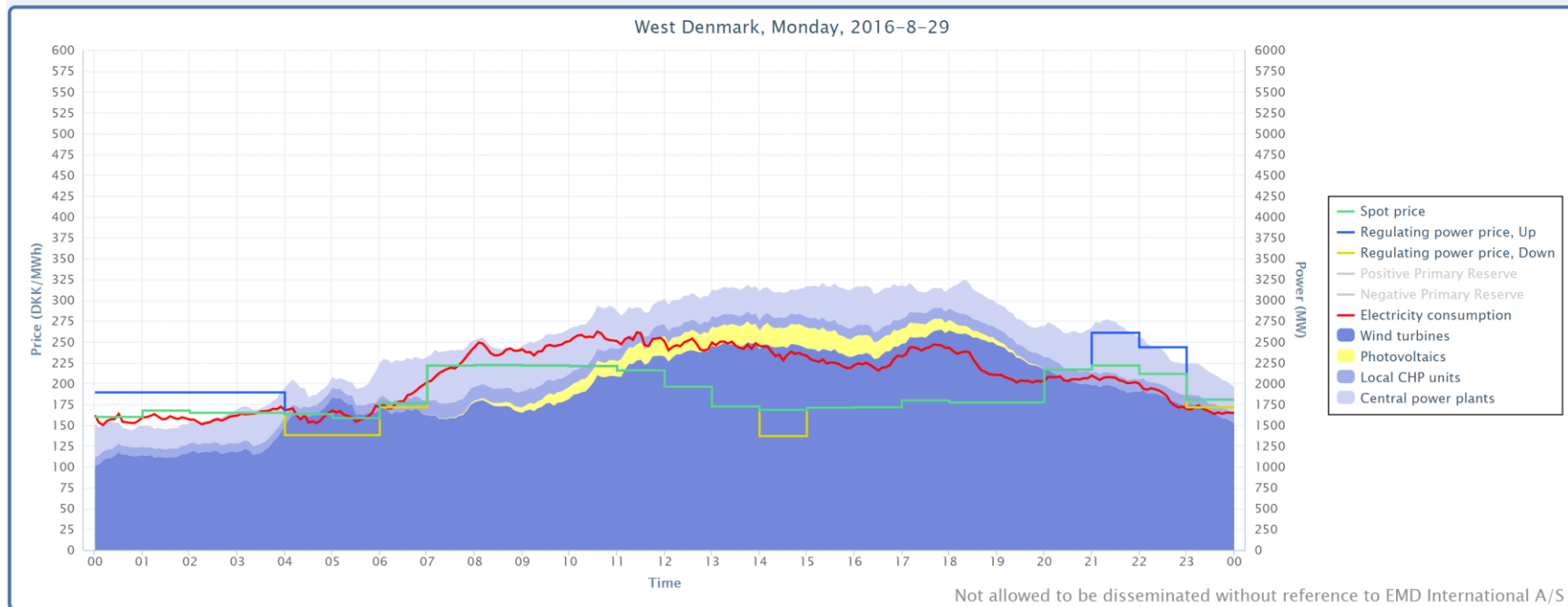
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# REGIONAL COOPERATION (NORD POOL) AND DEREGULATION



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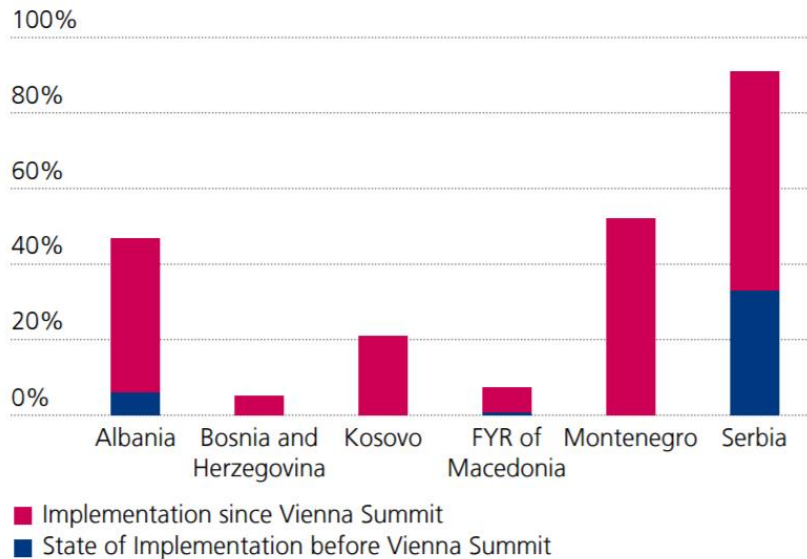
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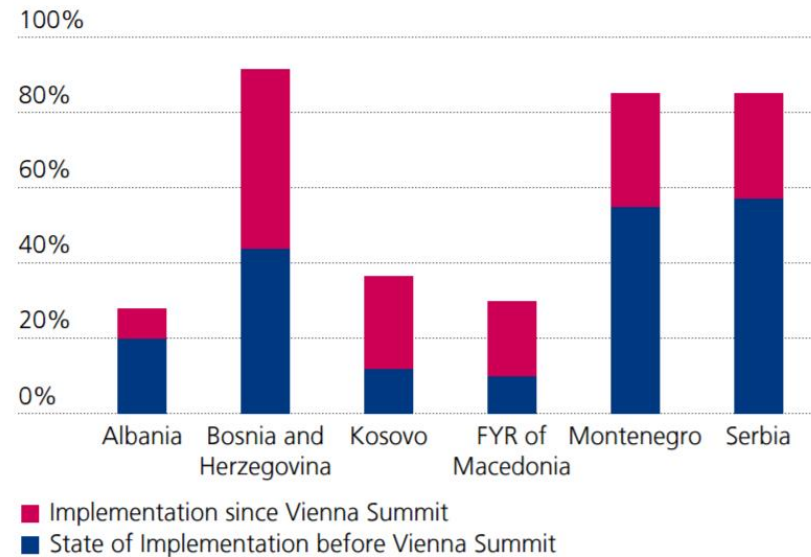


# CREATING A REGIONAL ELECTRICITY MARKET IN THE WESTERN BALKANS?

## Spot Market Development



## Cross-border Balancing



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# 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 providing flexibility and energy storage
- Many coordinated steps are needed in order to reach zero carbon energy system
- Strategies and actions must be identified, planned and coordinated on EU, macroregional, national, regional, city and local levels



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# THANK YOU FOR YOUR ATTENTION!

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Министарство просвете,  
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## Zero carbon energy system of South East Europe in 2050

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# CROATIAN ENERGY TRANSITION



4dh



STRATEGO



CoolHeating



BEAST



HRE



Bin2Grid



AGROCYCLE



fosterREG



PlanHeat

