Energy Planning for Smart Energy Systems in Southeast Europe

Prof.dr.sc. Neven Duić

International Centre for Sustainable Development of Energy, Water and Environment Systems

Power Engineering and Energy Management Chair
Department of Energy, Power Engineering and Environment
Faculty of Mechanical Engineering and Naval Architecture
University of Zagreb, Croatia

Sustainable energy systems for CEE countries – modelling and cooperation 2016, Budapest

Review paper on energy planning tools

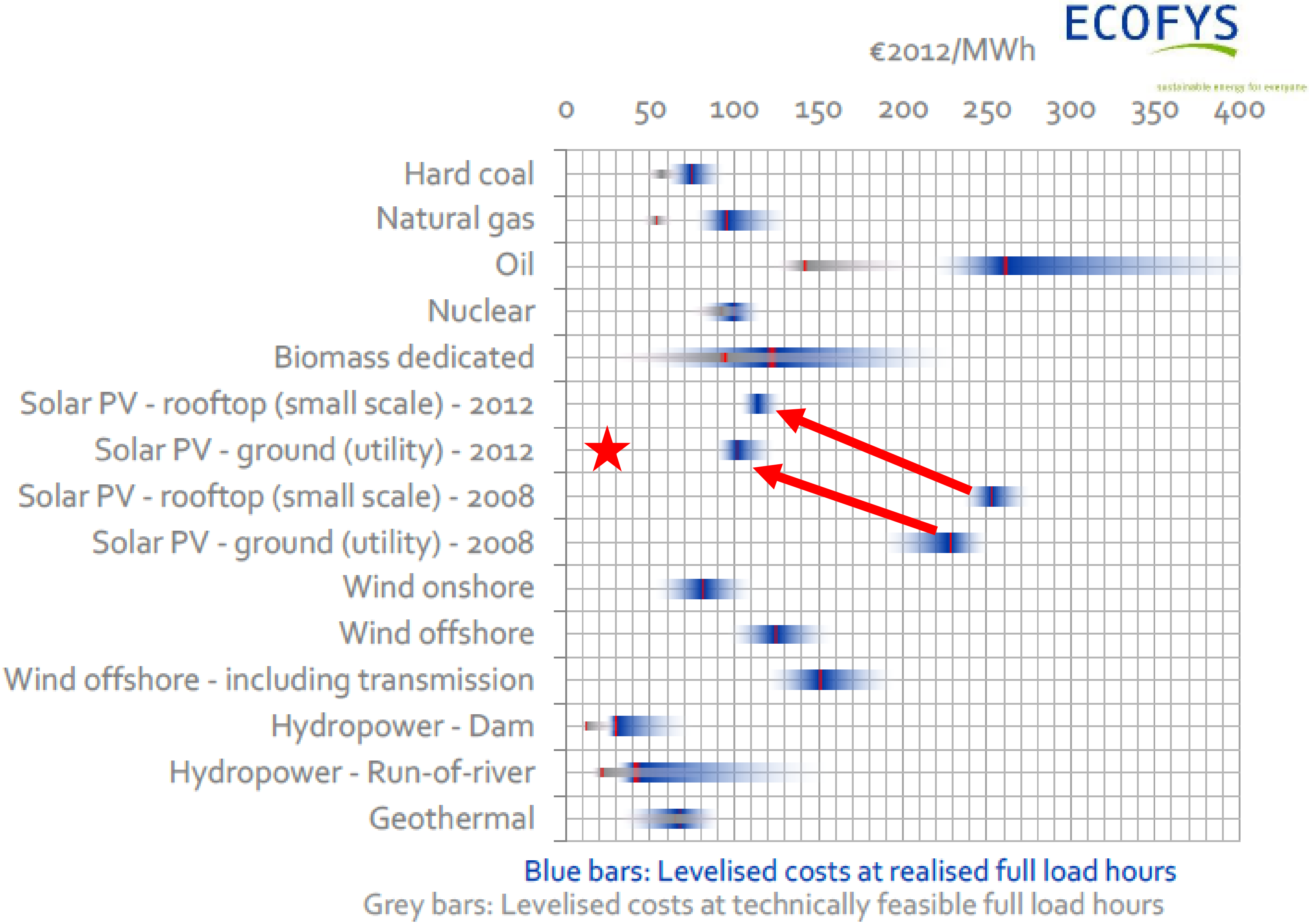
- Connolly, D., Lund, H., Mathiesen, B.V., Leahy, M., A review of computer tools for analysing the integration of renewable energy into various energy systems (Review), Applied Energy 87 4, April 2010, Pages 1059-1082, http://dx.doi.org/10.1016/j.apenergy.2009.09.026

Energy demand modelling

- Energy demand modelling
  - Traditional top down econometric approach with final energy use and GDP growth elasticity breaks down due to innovation and energy efficiency, as shown in http://dx.doi.org/10.1016/j.energy.2014.06.045
  - Demand must be modelled bottom up, base on useful energy needs, in order to catch decoupling
  - One has to understand what is being done!!!
  - Buildings and transport crucial!

Energy supply modelling

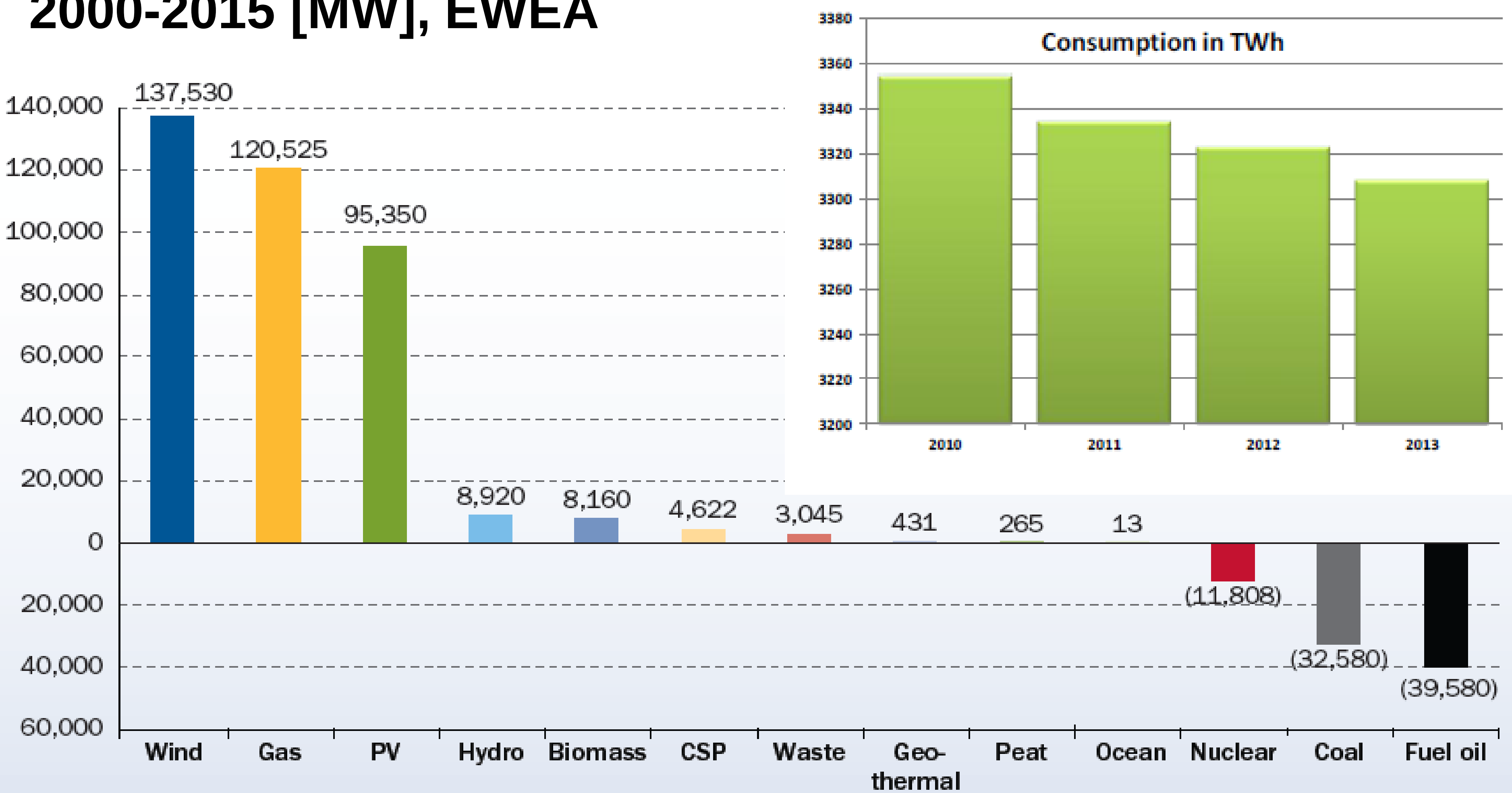
- Energy supply modelling
  - Due to variability of wind and solar, time series analysis must be taken – 8760 h
  - Due to incoming integration of power, heating/cooling, transport, water etc. systems, all energy supply must be modelled together



LCOE – various technologies

Power sector developments

EU electricity generation installed capacity net change, 2000-2015 [MW], EWEA



Wind share in electricity demand 2015

Denmark – 42%
Ireland, Portugal – 24%
Cape Verde, Spain, Uruguay – 20%

hard

Nicaragua, Germany – 15% Costa Rica, Romania – 13%
Sweden – 12% **EU**, UK – 11%
Estonia – 9% Lithuania, Greece, Poland – 7%
Austria, Belgium, Netherlands, Morocco, Turkey – 6%
Australia, Canada, Croatia, Cyprus, Honduras, India, Italy, N. Zealand, US – 5%
Bulgaria, China, France, Tunisia, World – 4%
Brazil, Chile, Finland, Mexico – 3%
Dominican R, Hungary, Latvia, Lux., Macedonia, Norway,– 2%
Czechia, Egypt, Japan, Ukraine – 1%

easy

PV revolution

Solar share in electricity demand 2015

- Greece, Italy – 8%
- Germany – 7%
- EU, Belgium, Bulgaria, Spain – 4%
- Czech Rep., Romania – 3%
- World, Australia, Denmark, Israel, Japan, Malta, Lux., Slovakia, Slovenia, Switzerland, UK – 2%
- Austria, Chile, Cyprus, France, Netherlands, Portugal, Thailand, US – 1%
- China, Croatia, Hungary, India, Korea, South Africa – 0.5%

➢How to increase penetration of renewables in energy system?

- More grid capacity
- Cycling of thermal power plants
- Power exchanges
- Demand response and integration of power, heating, cooling, transport and water systems – smart energy systems
- Energy storage

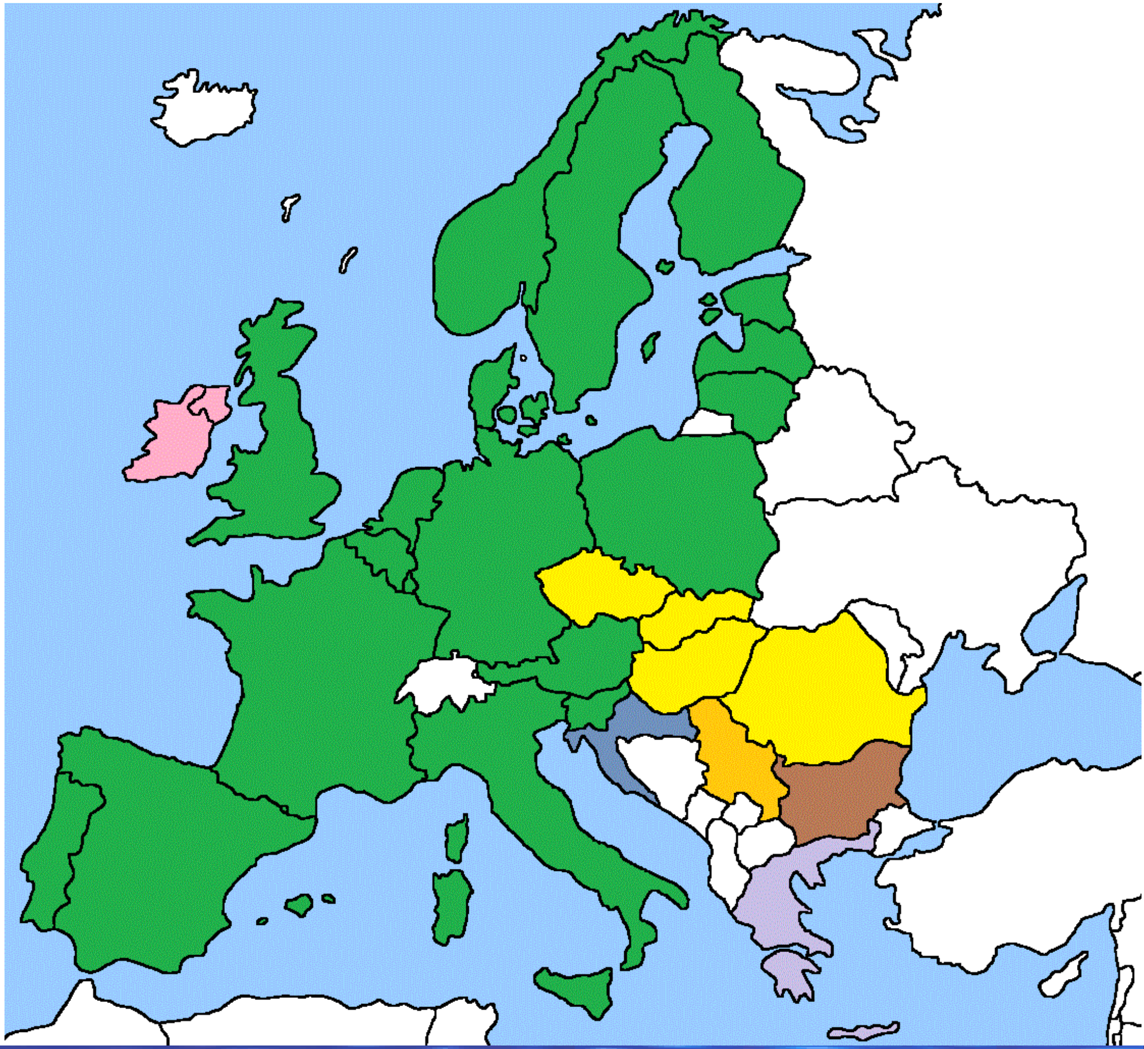
Go-live!

NWE+CWE price coupling on February 4, 2014

75% of European power market

ES+PT connected in May 2014

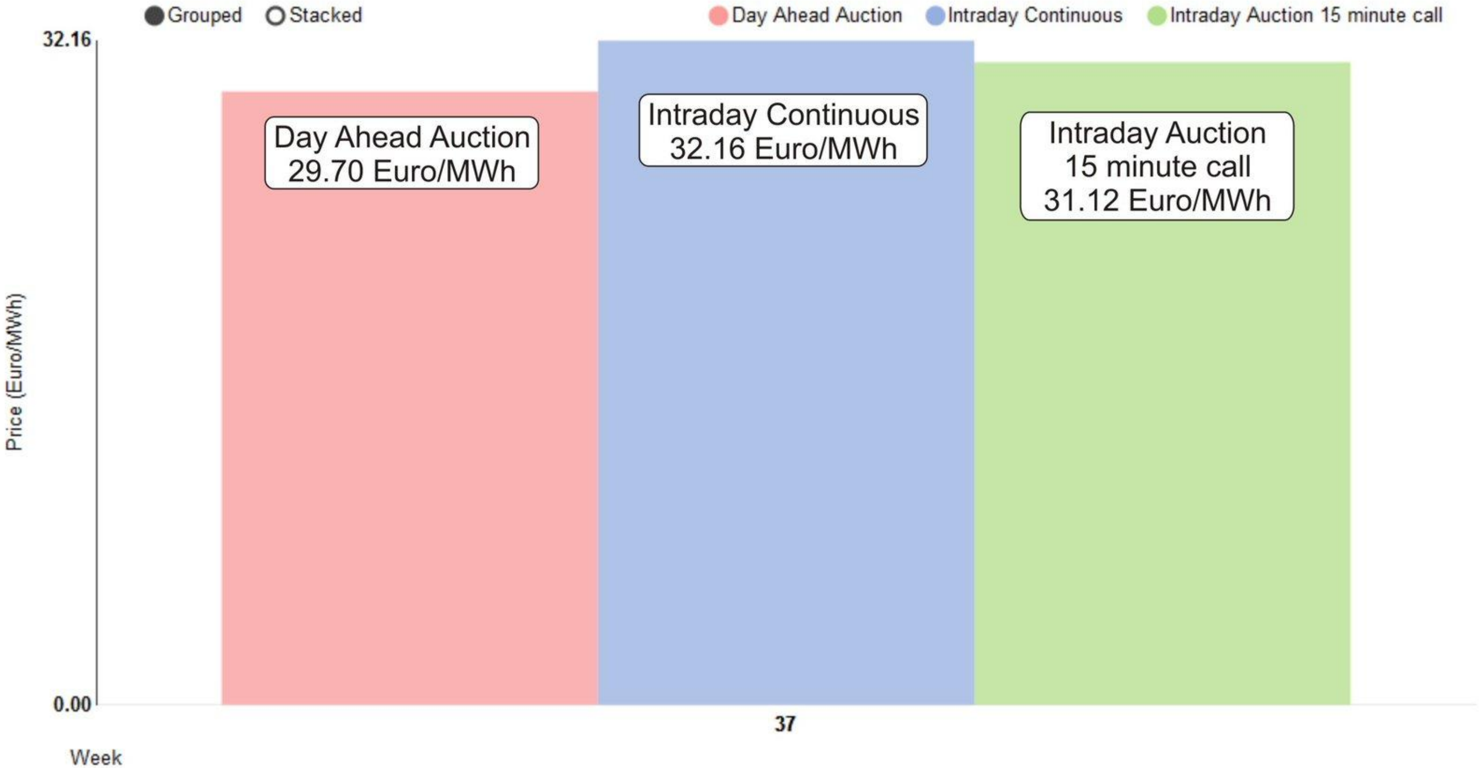
IT+SI connected in Feb 2015



Weekly electricity spot market prices in Germany in week 37 2016

usage tips

date selection
year: 2016 << >>
month: << >>
week: 37 << >>
annual
monthly
weekly
daily
nominal prices
real prices
print

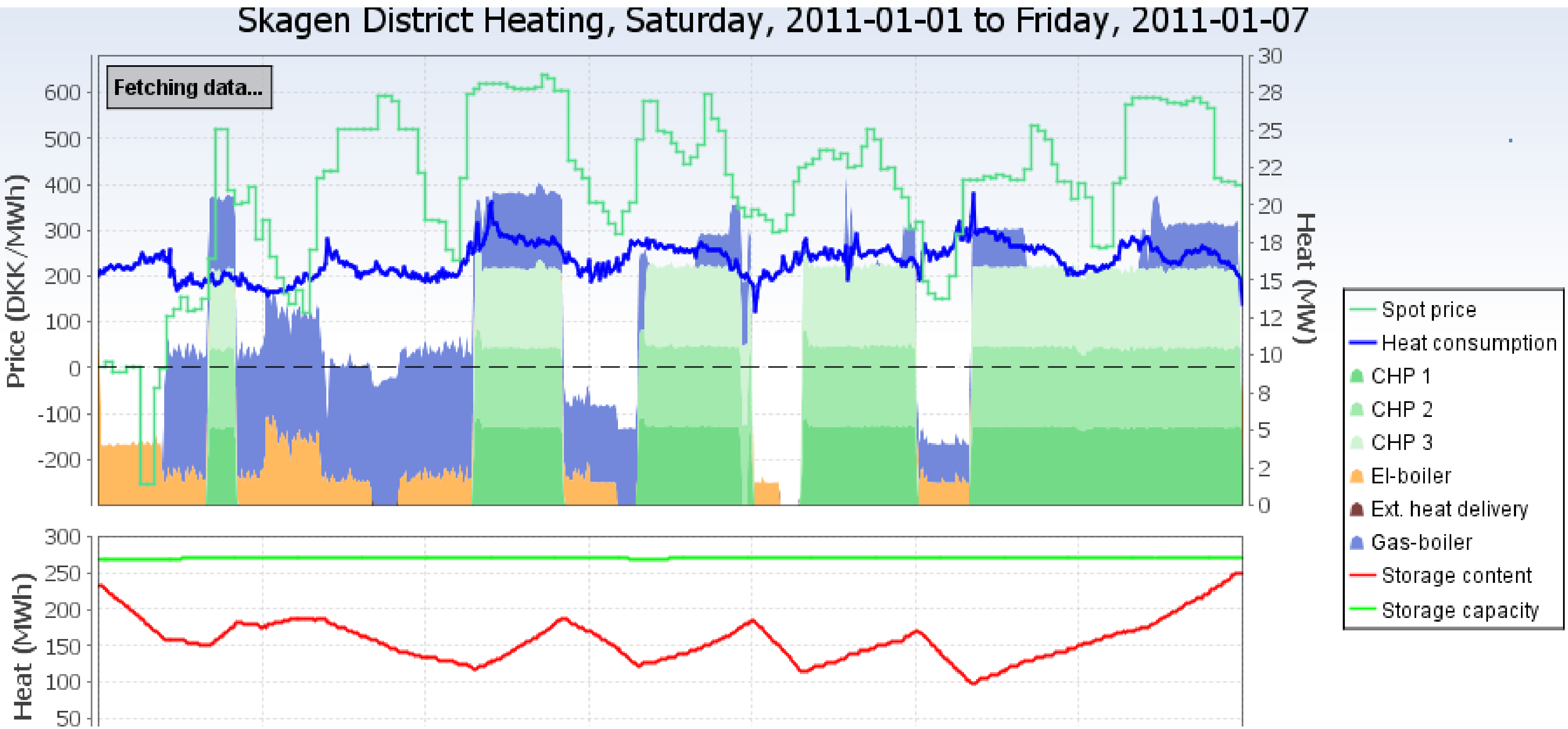


Nominal volume weighted average prices, not adjusted for inflation rates.
Datasource: EPEX
Last update: 21 Sep 2016 13:17

Markets and RES

- Consequences of market liberalisation:
  - Demission of base load
  - The importance of balancing power (gas, hydro)
  - Cycling of old coal power plants (4000 hours by 2020)
  - Market arbitrage and demand response (power-to-heat, power-to-water, e-mobility, power-to-efuels)

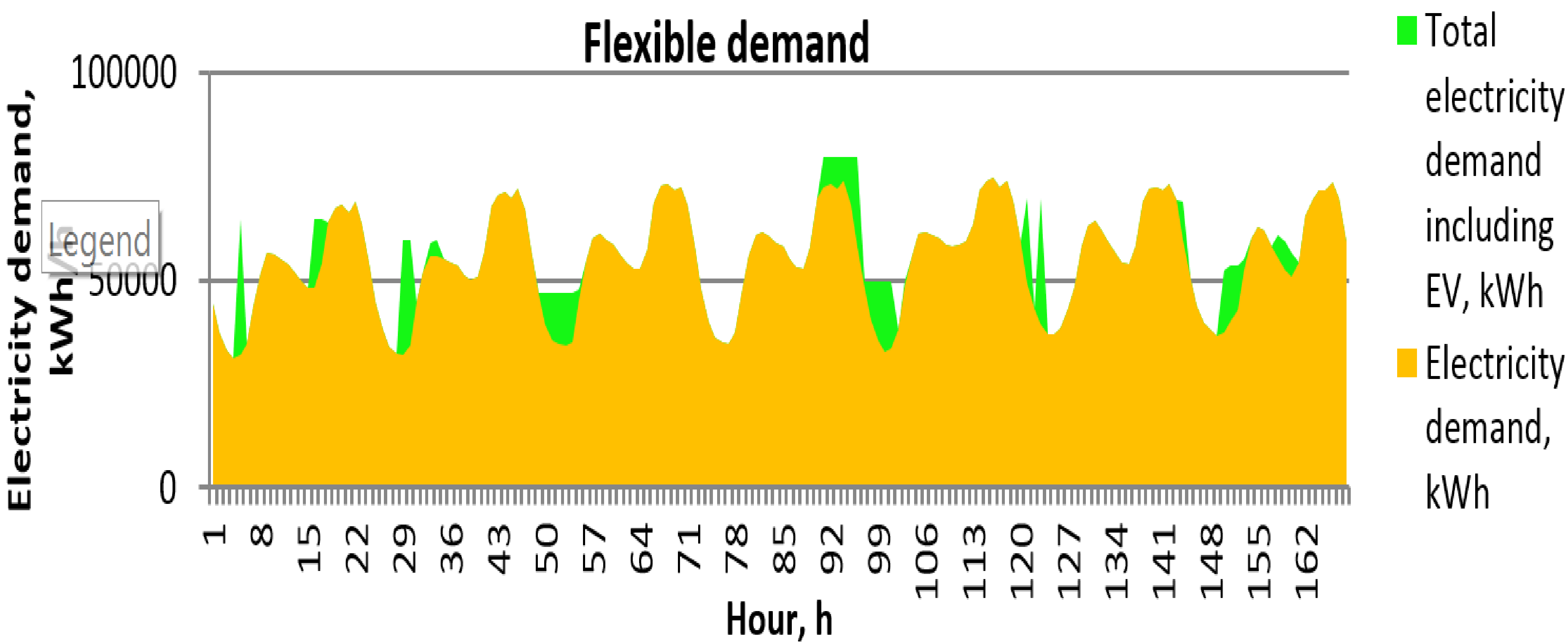
Power to heat

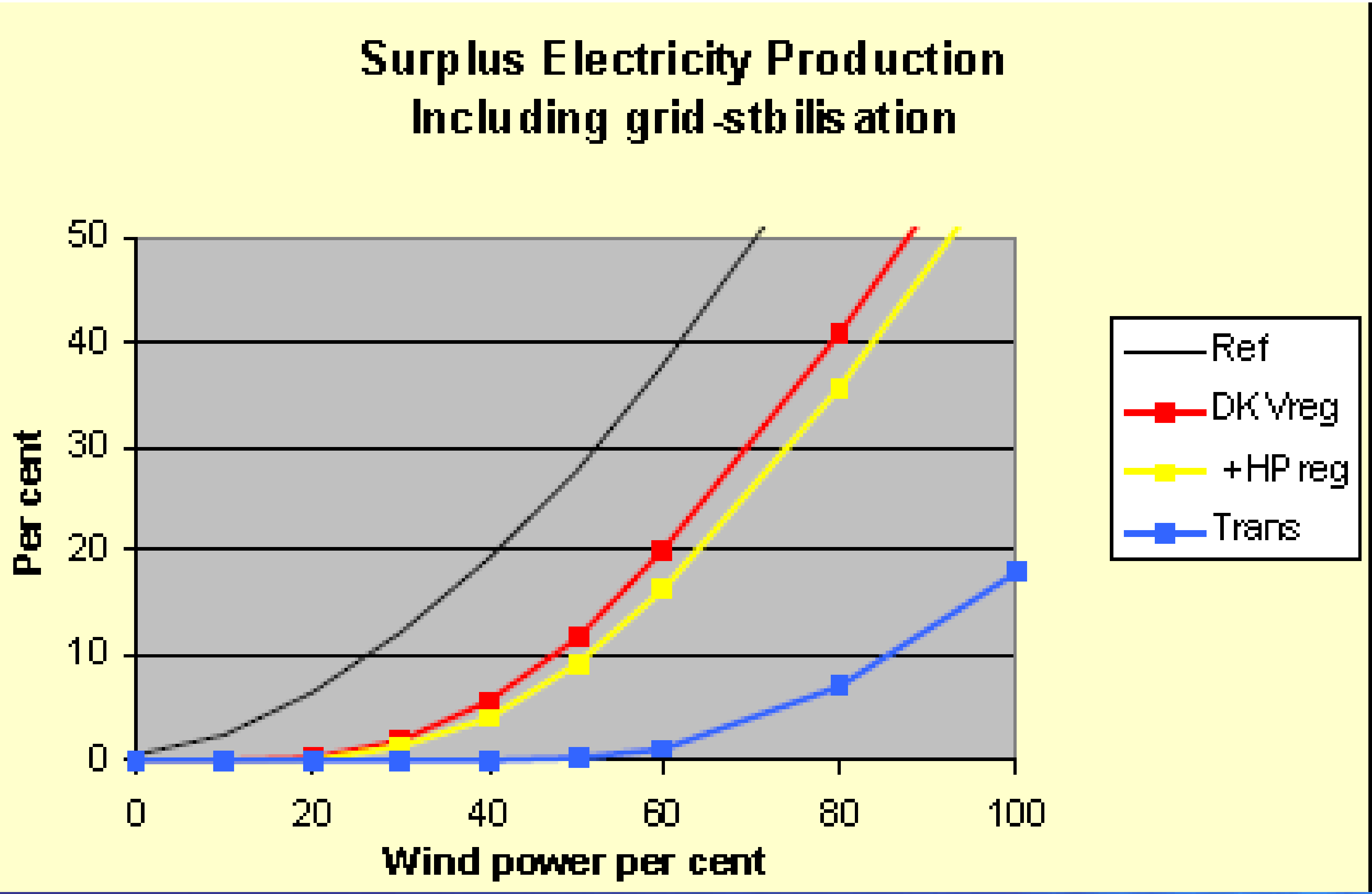


Demand management

- Electromobility
  - Only personal cars and short distance utility vehicles, 550000 PHEV and BEV sold in 2015 (http://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf)
  - If RESe 80% reduction of primary energy
  - Fast charging 70 kW – huge problem if left uncontrolled, ex AT, 4 mln cars arrives home, plugs in – 280 GW (14 GW installed cap)
  - Smart charging – market based, smoothing the demand

Smart charging




Surplus Electricity Production
Including grid-stbilisation
50
40
30
20
10
0
Per cent
0
20
40
60
80
100
Wind power per cent
Ref
DK Vreg
+HP reg
Trans

Issues on the way

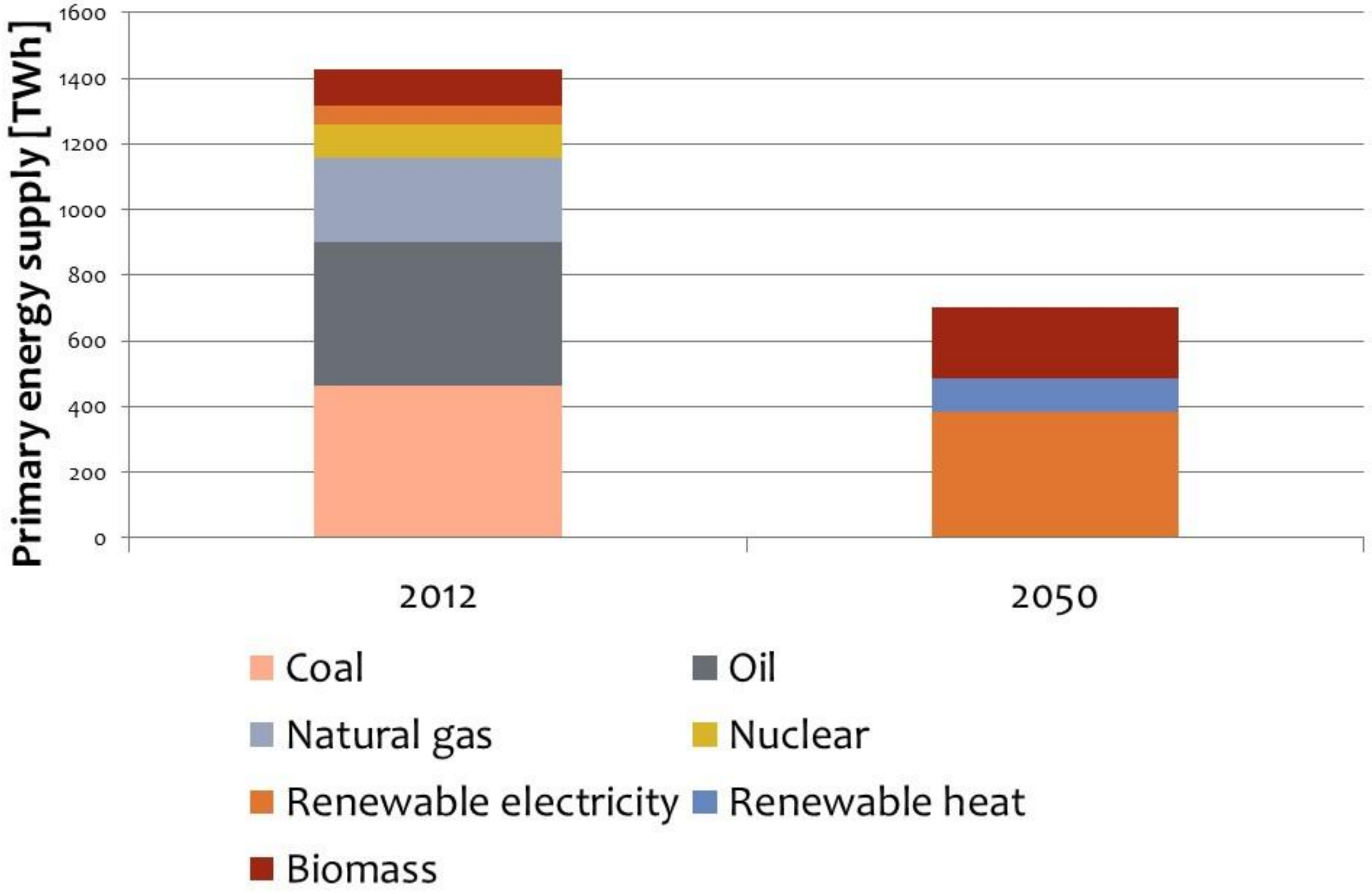
- Transport – road freight, shipping, aviation cannot be electrified
- High temperature processes sometimes cannot be electrified
- Both makes last 20% of demand
- If biomass is used only for the above it could cover half of the missing demand
- And the rest? Synthetic fuels?

Supply side 2050 – SEE 100% RES

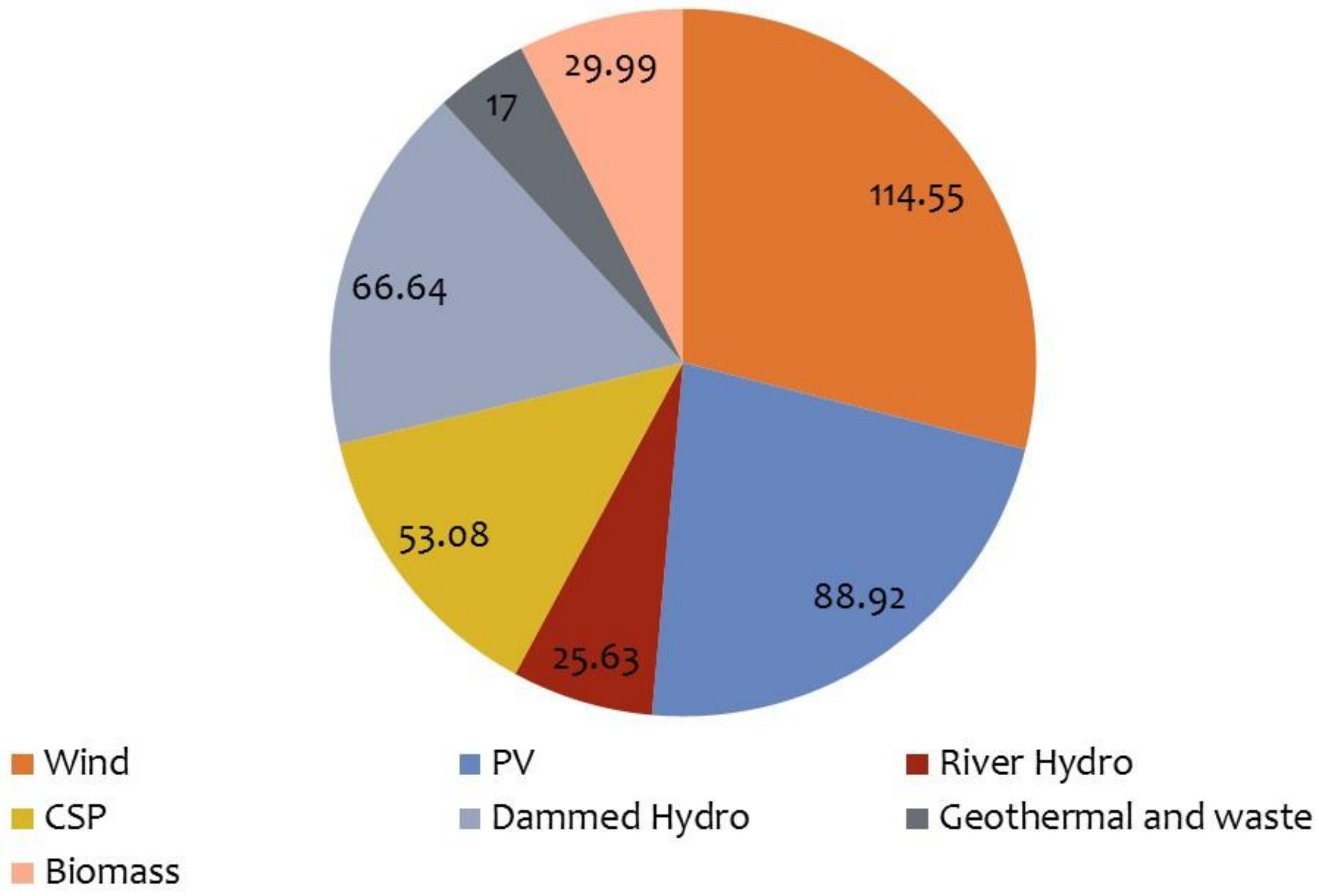
Zero carbon energy system of South East Europe in 2050, D.F. Dominković, I. Bačeković, B. Ćosić, G. Krajačić, T. Pukšec, N. Duić, N. Markovska, Applied Energy, doi:10.1016/j.apenergy.2016.03.046

- 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

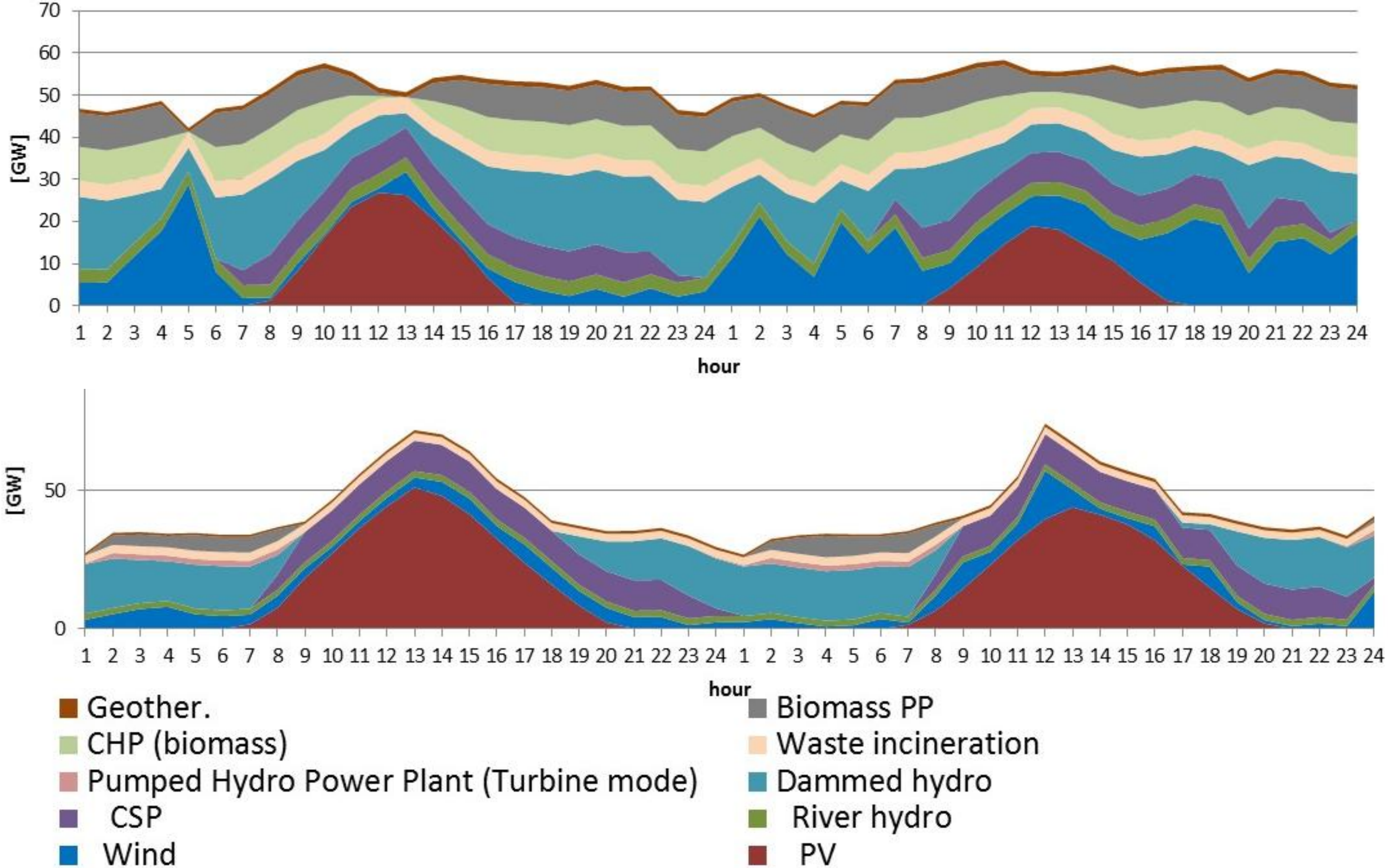
Energy systems: 2012 vs. 2050



Electricity generation mix in 2050 [TWh]



Winter vs. Summer Day



Conclusions

- Wind and solar are coming, but difficult to integrate
- Demission of base load. Natural gas and **hydro** critical for transition
- Integration of power, heating, cooling, water and transport system necessary
- Smart energy systems – cheap and simple
- Great time for engineers!

THANK YOU FOR YOUR ATTENTION!

Neven.Duic@fsb.hr