

# Integracija OIE i centraliziranih toplinskih sustava na razini gradskih čtvrti

**Prof.dr.sc. Neven Duić**

Zavod za energetiku, energetska postrojenja i ekologiju  
Fakultet strojarstva i brodogradnje  
**Sveučilište u Zagrebu, Croatia**

Hrvatska energetska tranzicija

RADIONICA "Kako planirati, financirati i voditi projekte s integracijom mjera  
energetske učinkovitosti u urbanoj obnovi,, 15.2.2017, Zagreb

## 3 options for heat sector

### 1. Savings (Everywhere)

- Reduce our demand for heat:
  - Space heating
  - Hot water













### 2. Individual Units (Everywhere)

- Use a heating unit in each building:
  - Boilers:
    - Oil
    - Biomass
  - Heat Pumps
  - Electric Heating

### 3. Networks (Urban Areas)

- Share a heating network:
  - Gas
  - Water (i.e. district heating)

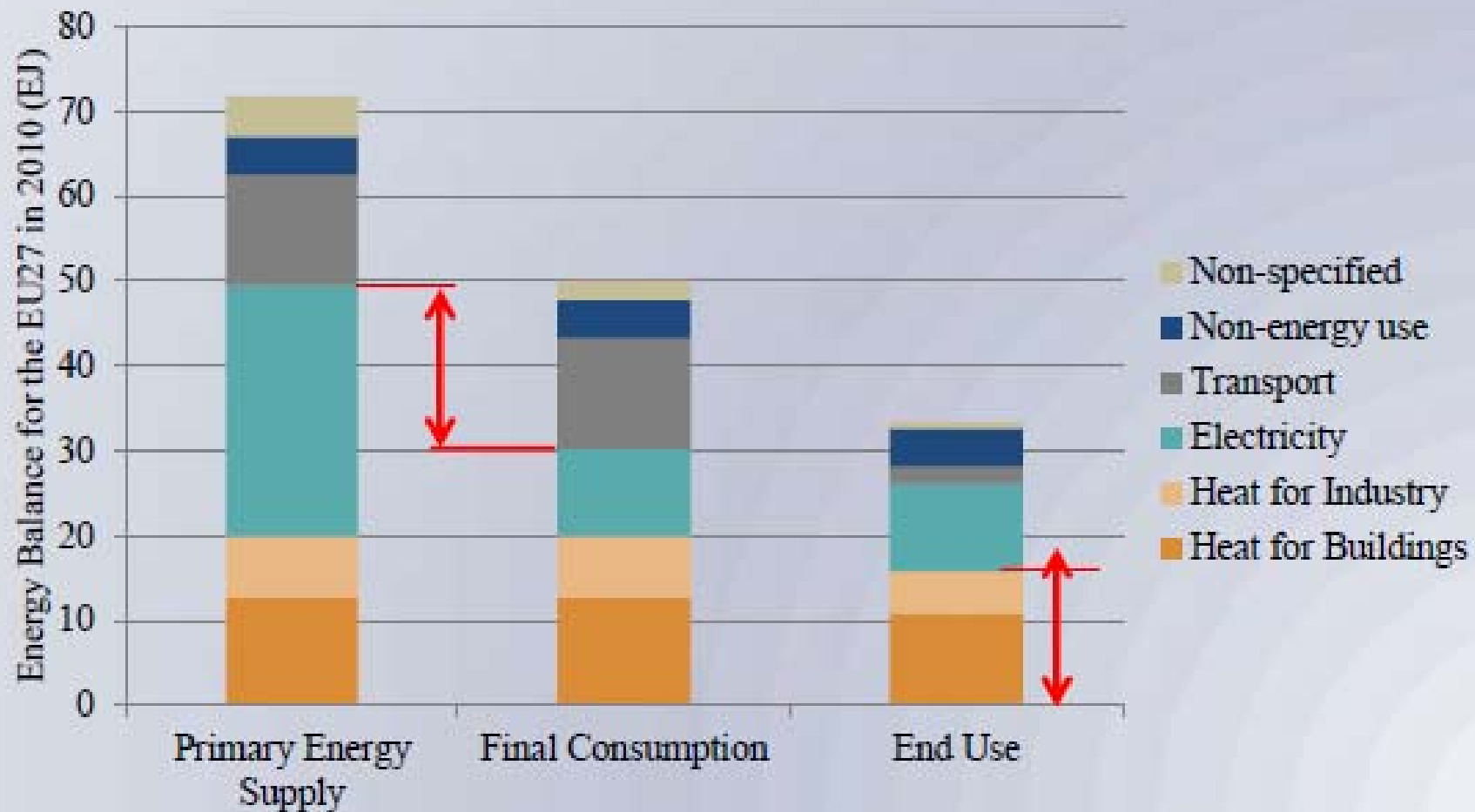
# Individual heating

Heating Unit	Sustainable Resources	Efficient	Cost
Electric Heating			
Heat Pumps			
Oil Boilers			
Biomass Boilers			

# Heat networks

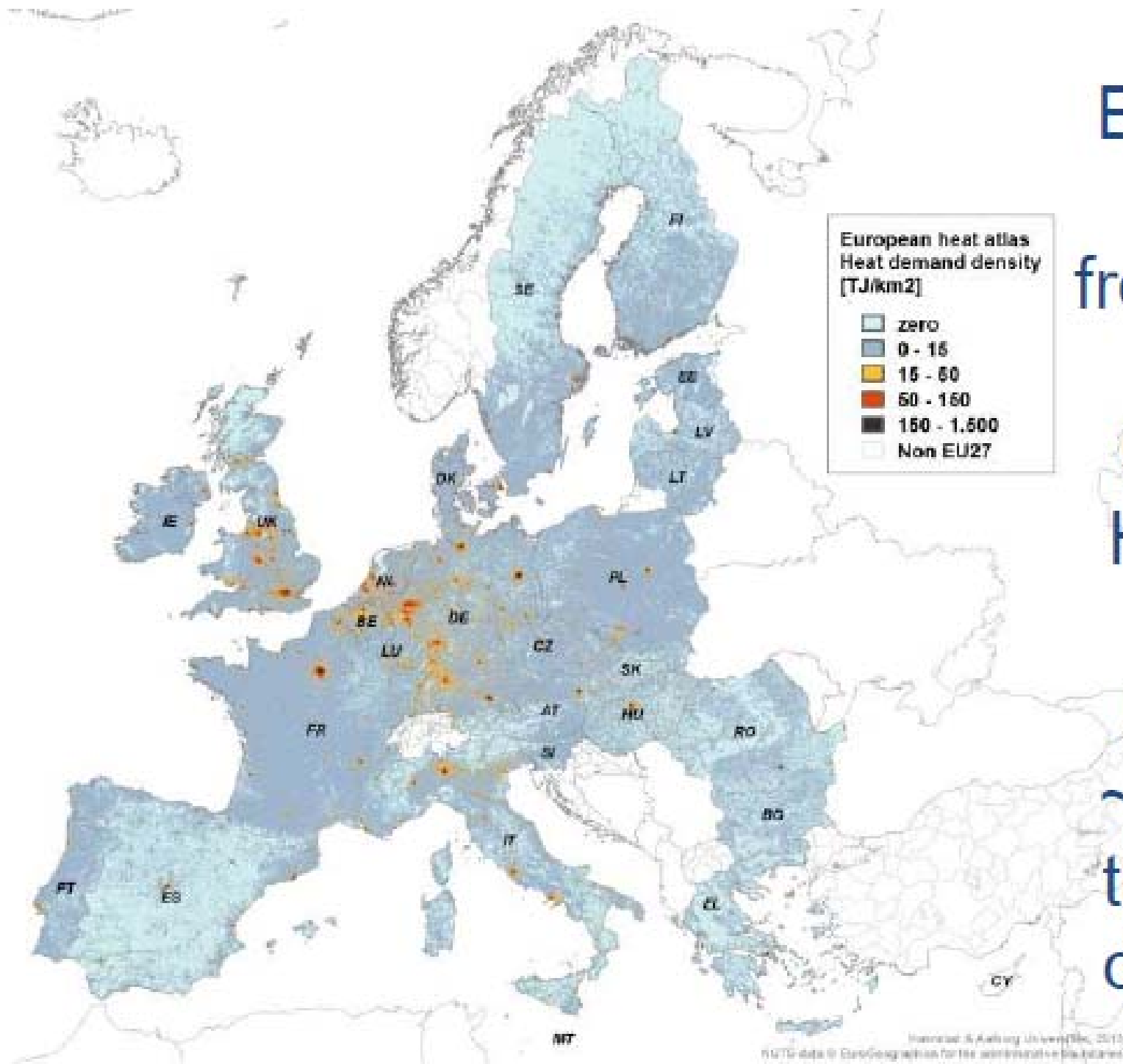
Heating Unit	Sustainable Resources	Efficient	Cost
Gas Grid			
District Heating			

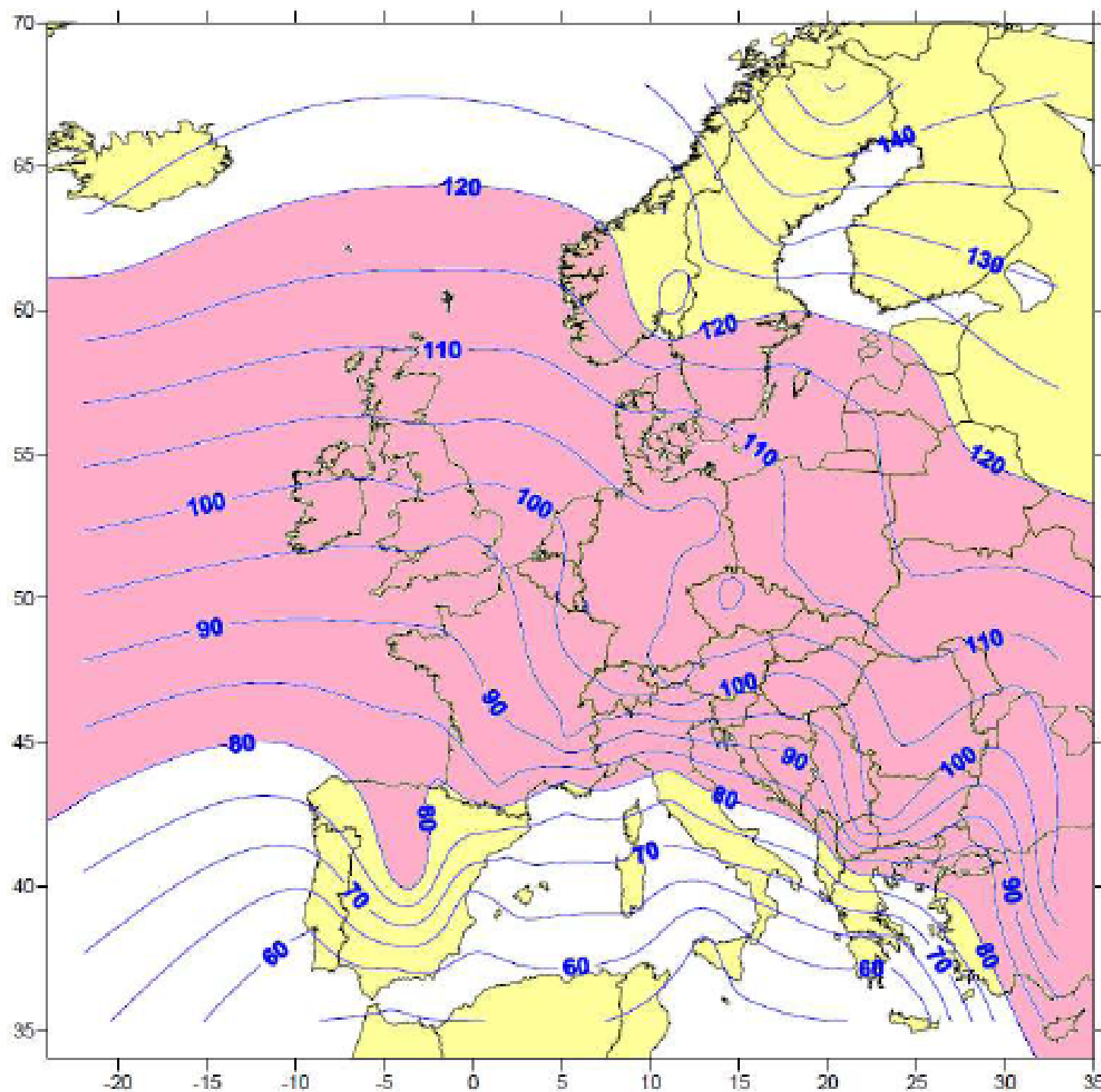
# Surplus heat today in Europe



# EU Heat Atlas from HRE

District  
Heating  
can  
supply  
~50% of  
the heat  
demand





# European Heating Index

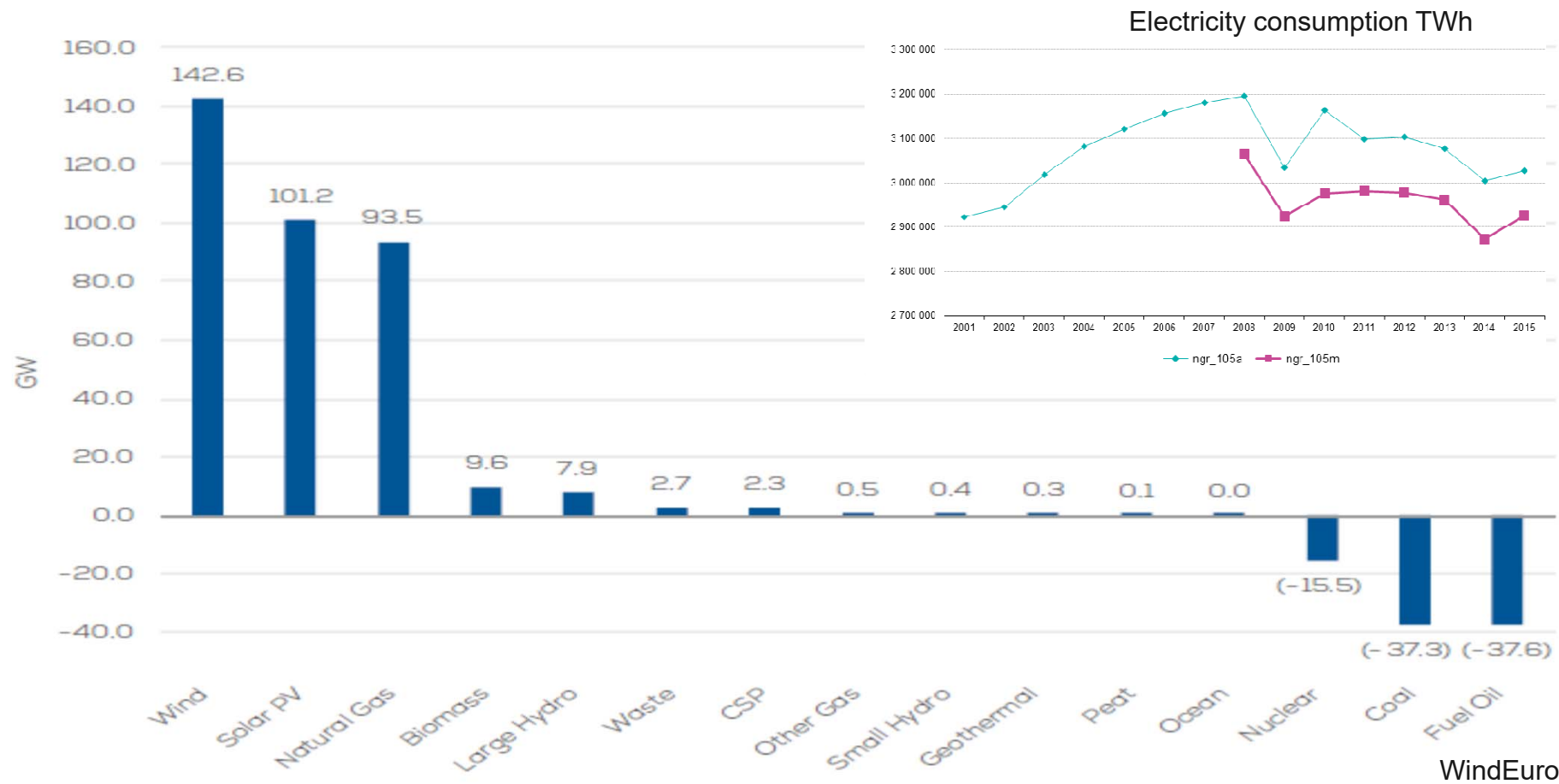
(Source: ecoheatcool)

$\pm 20\%$



# Power sector developments

## EU electricity generation installed capacity net change, 2000-2016 [MW]





## Wind share in electricity demand 2015

Denmark – 42%

Ireland, Portugal – 24%

Cape Verde, Spain – 20%

Nicaragua, Germany – 15%

Costa Rica, Romania – 13%

Sweden – 12%

Uruguay, EU – 10%

Estonia – 9%

Lithuania, Greece, Poland – 7%

Austria, Belgium, Netherlands, Morocco, UK – 6%

Croatia, Cyprus, Honduras, India, Italy, N. Zealand, US – 5%

Australia, Bulgaria, Canada, China, France, Tunisia, Turkey,

World – 4%

Brazil, Chile, Finland – 3%

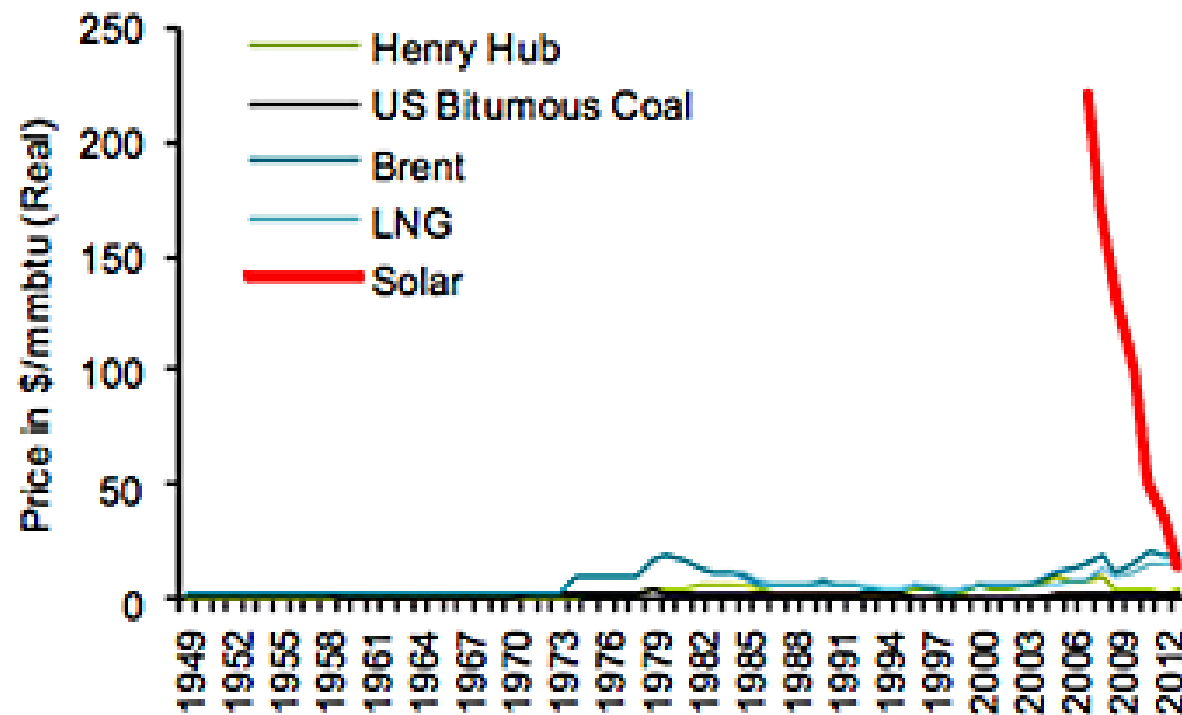
Dominican R, Hungary, Latvia, Lux., Macedonia, Norway, – 2%

Czechia, Japan, Mexico<sup>2014</sup>, Ukraine – 1%

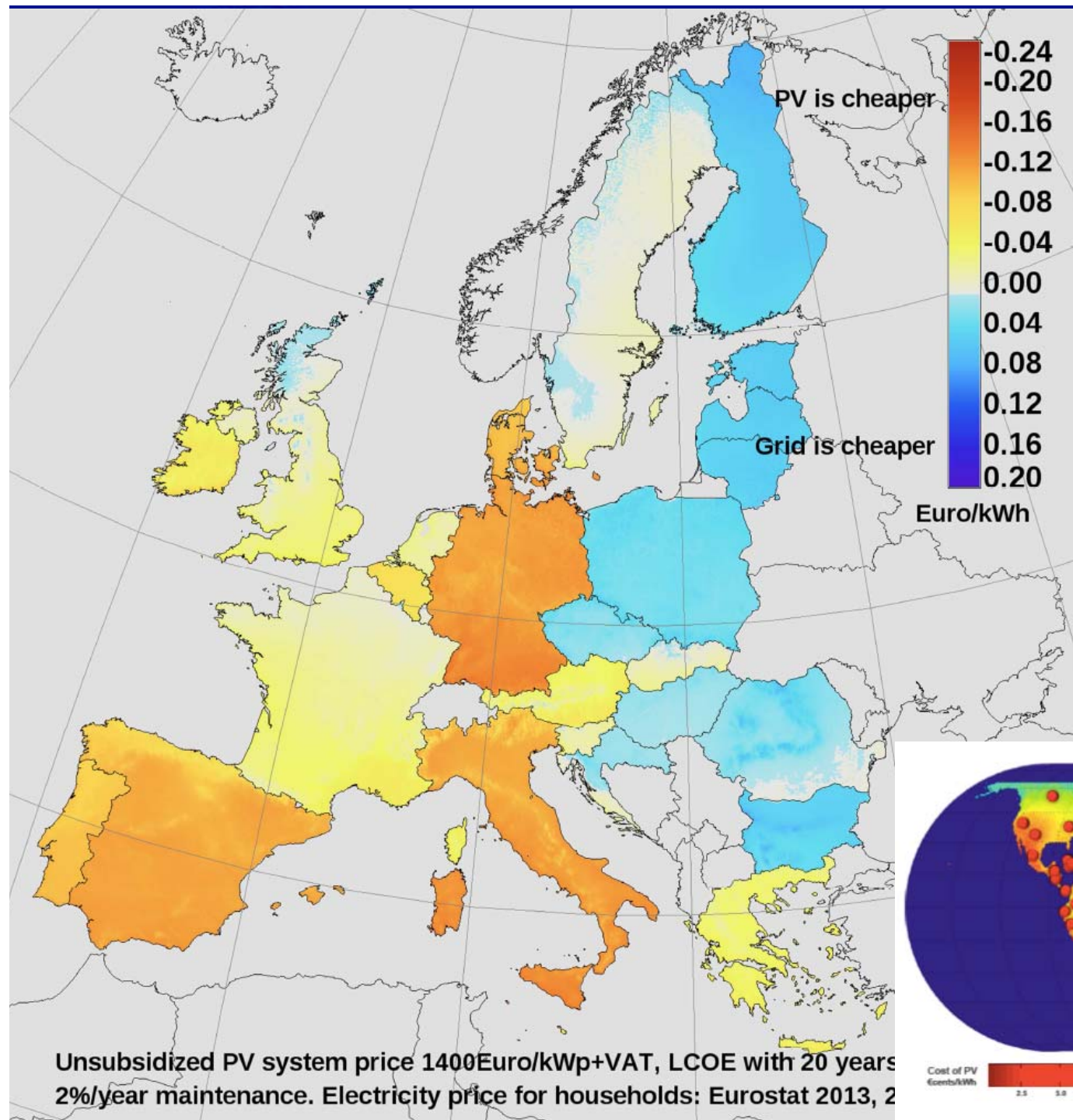
hard  
easy

## Exhibit 2

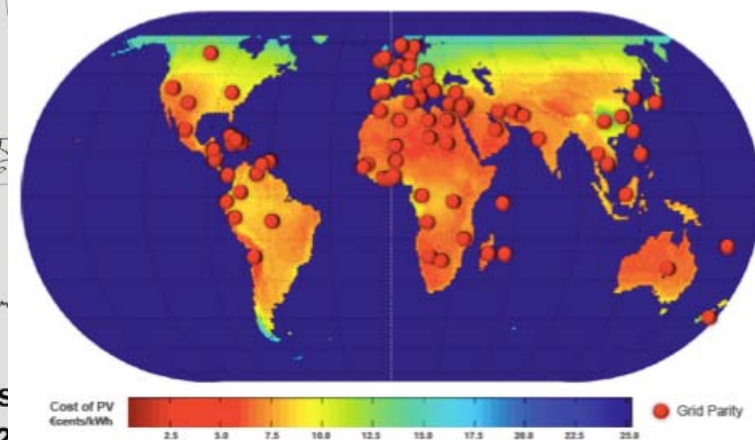
### Welcome to the Terrordome... \$/MMBTU by Energy Type



Source: EIA, CIA, World Bank, Bernstein analysis



Grid parity  
reached in  
102  
countries



## PV revolution

### Solar share in electricity demand 2015

Greece, Italy – 8%

Germany – 7%

EU, Belgium, Bulgaria – 4%

Czech Rep., Romania, Spain – 3%

**World**, Denmark, Malta, Lux., Slovakia, Slovenia,

UK – 2%

Austria, Cyprus, France, Netherlands, Portugal,

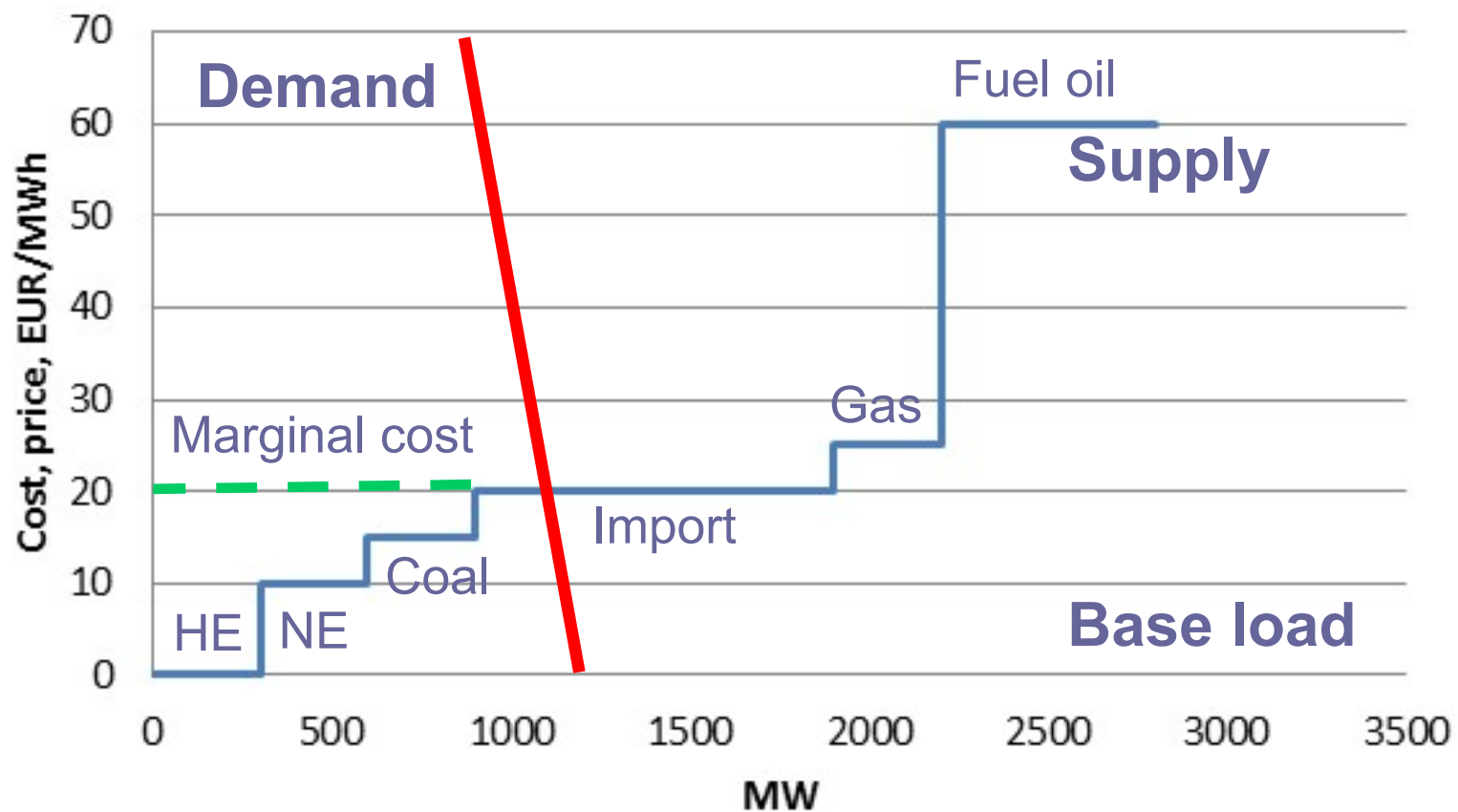
**US** – 1%

Croatia, Hungary – 0.5%



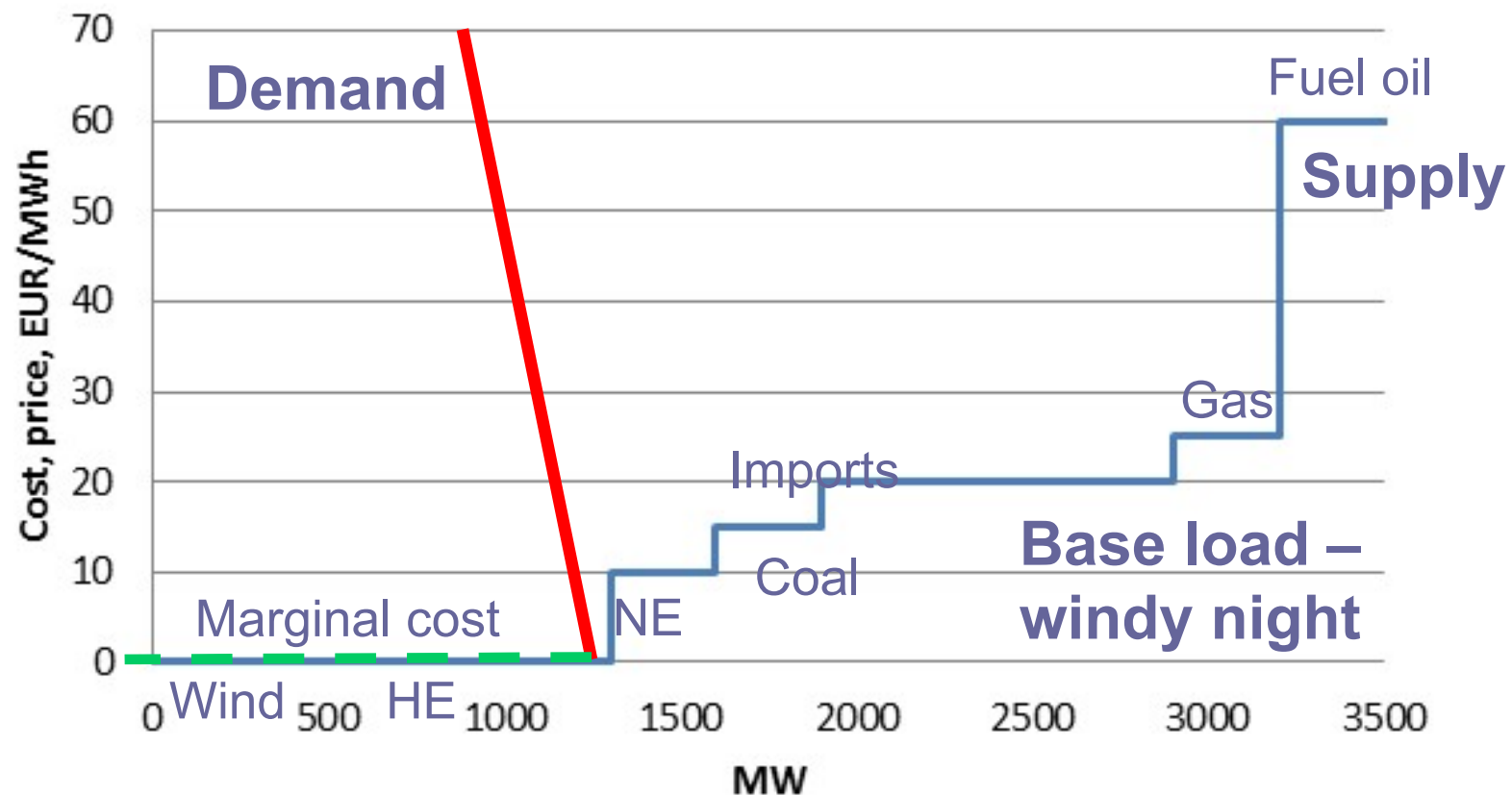
# Electricity market

**Electricity price = marginal cost**

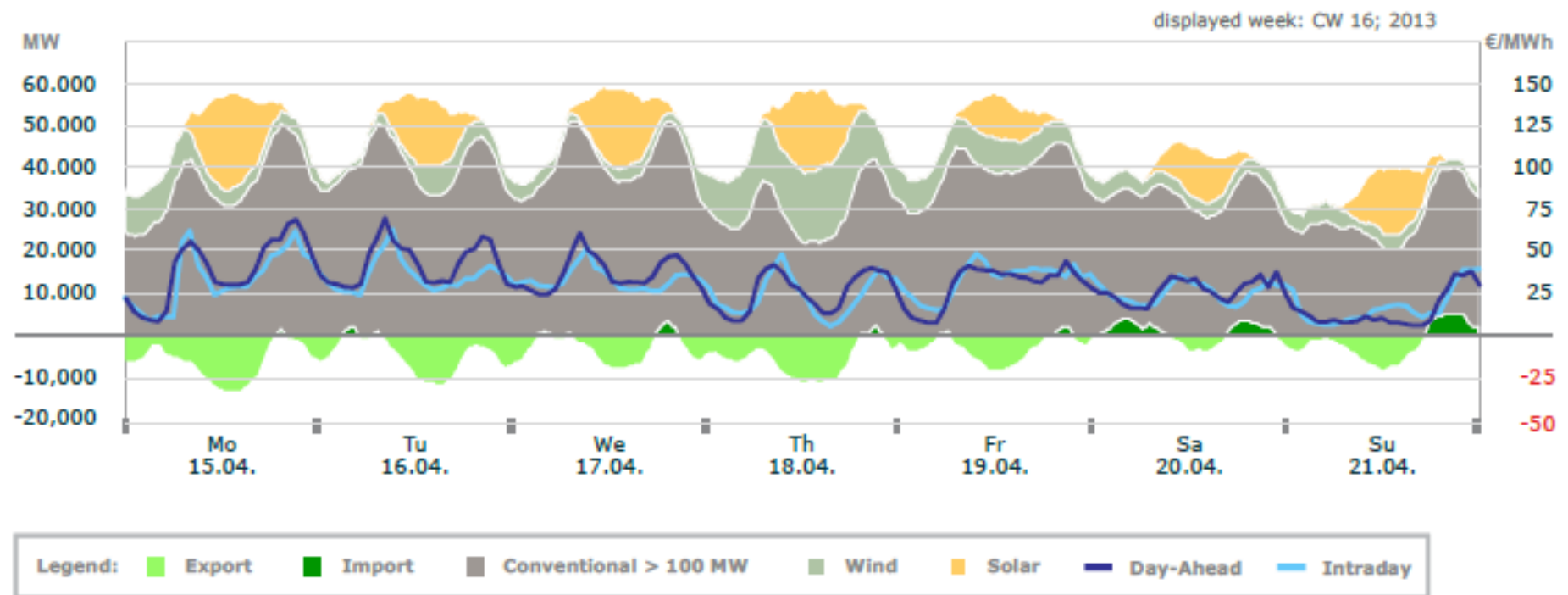


# Electricity market

Electricity price = marginal cost



# Electricity Production and Spot-Prices: CW 16 2013

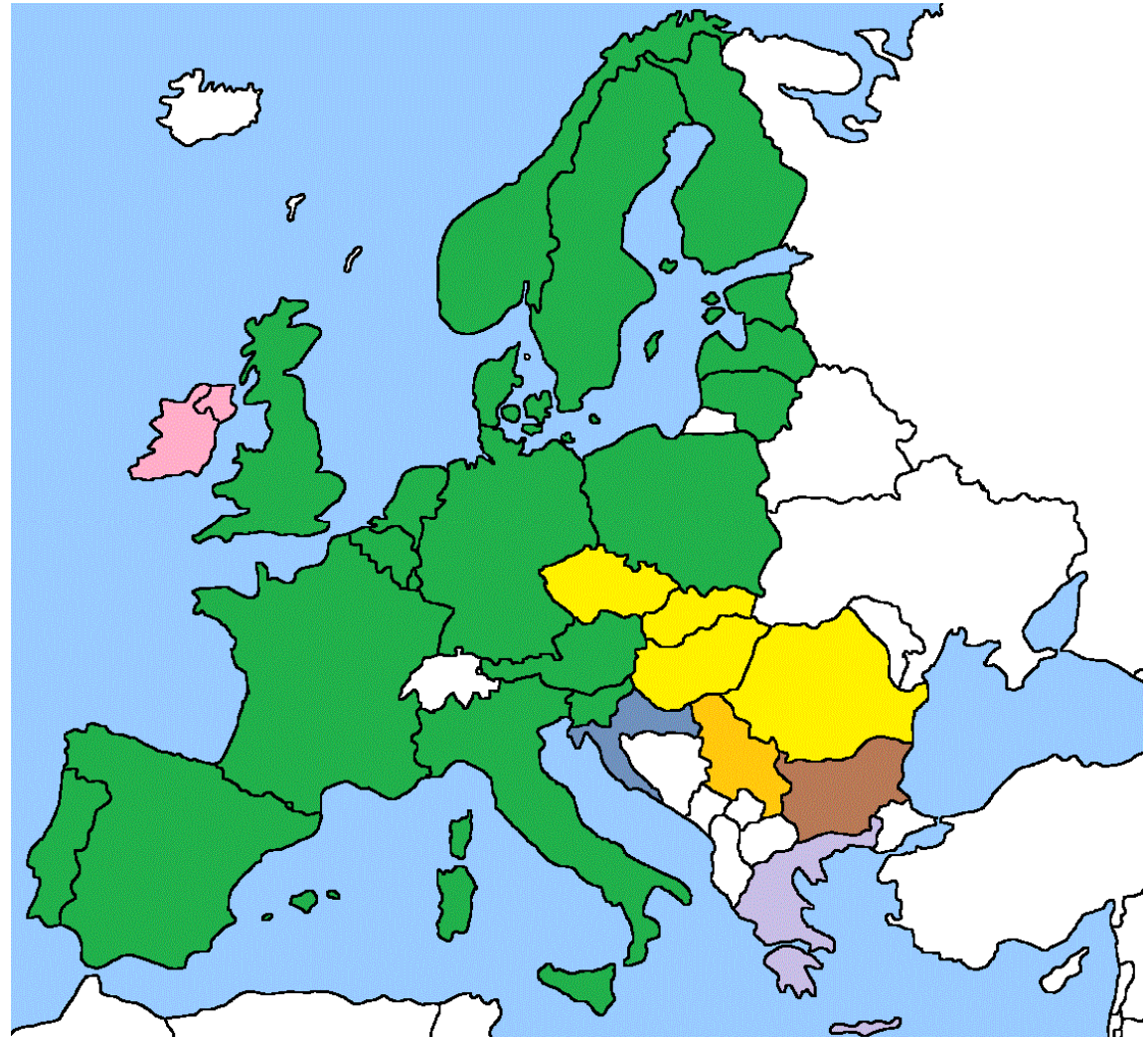


€/ MWh	Period Mean	Period Min	Period Max	Std Deviation
<b>Day-Ahead</b>	<b>32.25</b>	<b>7.60</b>	<b>70.70</b>	<b>14.54</b>
<b>Intraday</b>	<b>30.74</b>	<b>6.80</b>	<b>63.70</b>	<b>12.11</b>

Source: Johannes Mayer, Bruno Burger, Fraunhofer Institute for Solar Energy Systems; Data: EEX, Entso-e



**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**

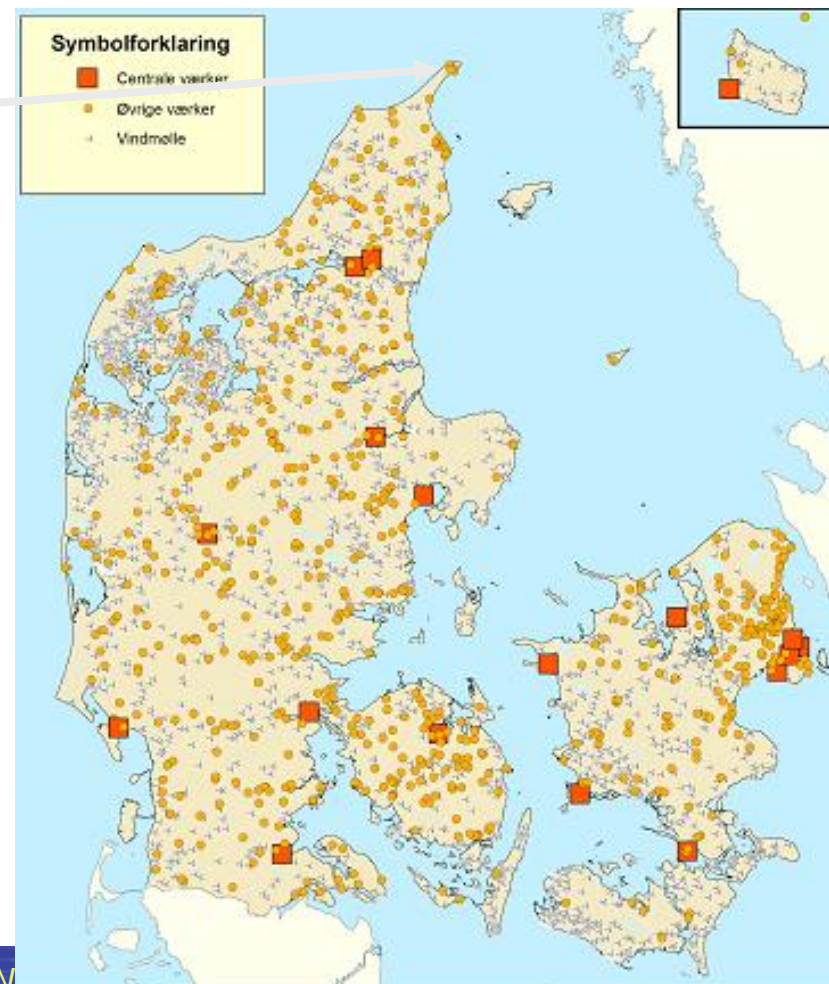
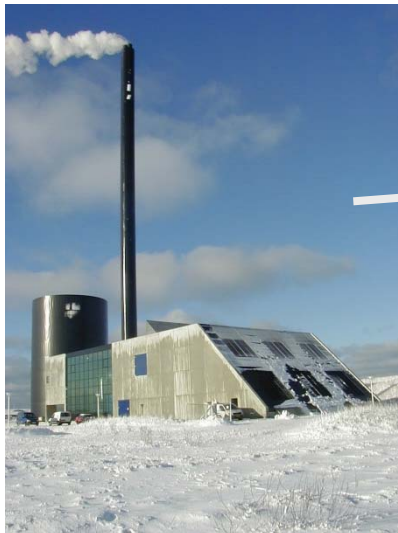


## Markets and RES

- 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 (time delay, power-to-heat, power-to-water, e-mobility, demand management, power-to-e-fuels)



# Case: Skagen CHP plant



## Skagen CHP plant

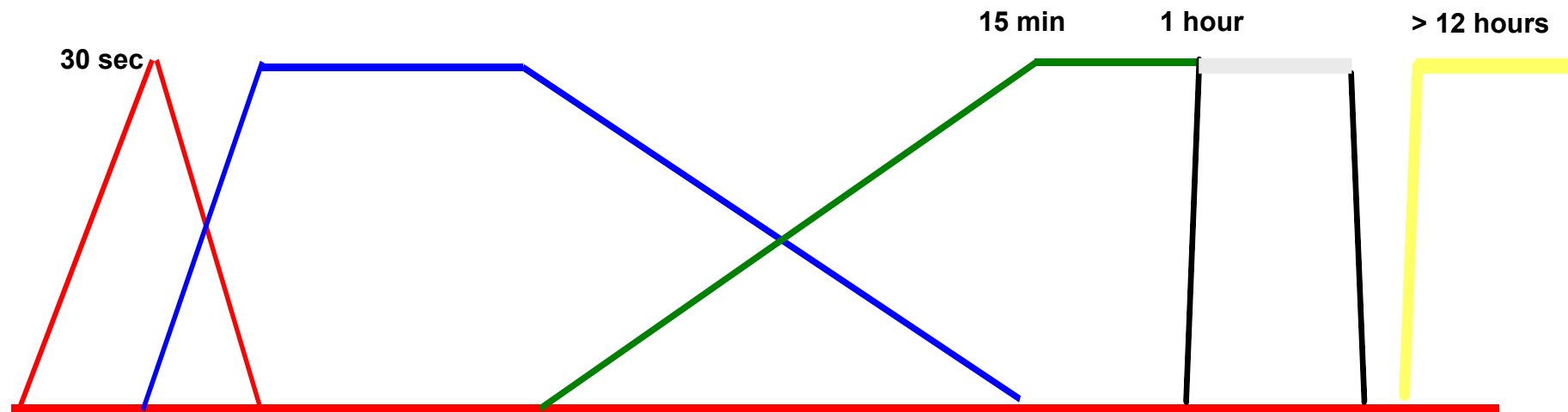
- CHP capacity: 13 MWe and 16 MWth  
(Three 4.3 MWe Wärtsilä Natural Gas engines)
- 250 MWh heat storage
- 37 MW peak load boilers
- 10 MW electric boiler
- Heat Pumps Investment under consideration



Operated together with a Waste Incineration plant (heat only).

## The main electricity markets

- Primary reserves (frequency controlled production)
- Secondary reserves (controlled by status of primary reserves)
- Manuel regulating power (Tertiary reserves)
- Intra day market
- Day ahead spot market



## Skagen

- Day ahead spot market in Jan. 2005
- Regulating power market in approx. 2006
- Automatic primary reserve market  
in Nov. 2009



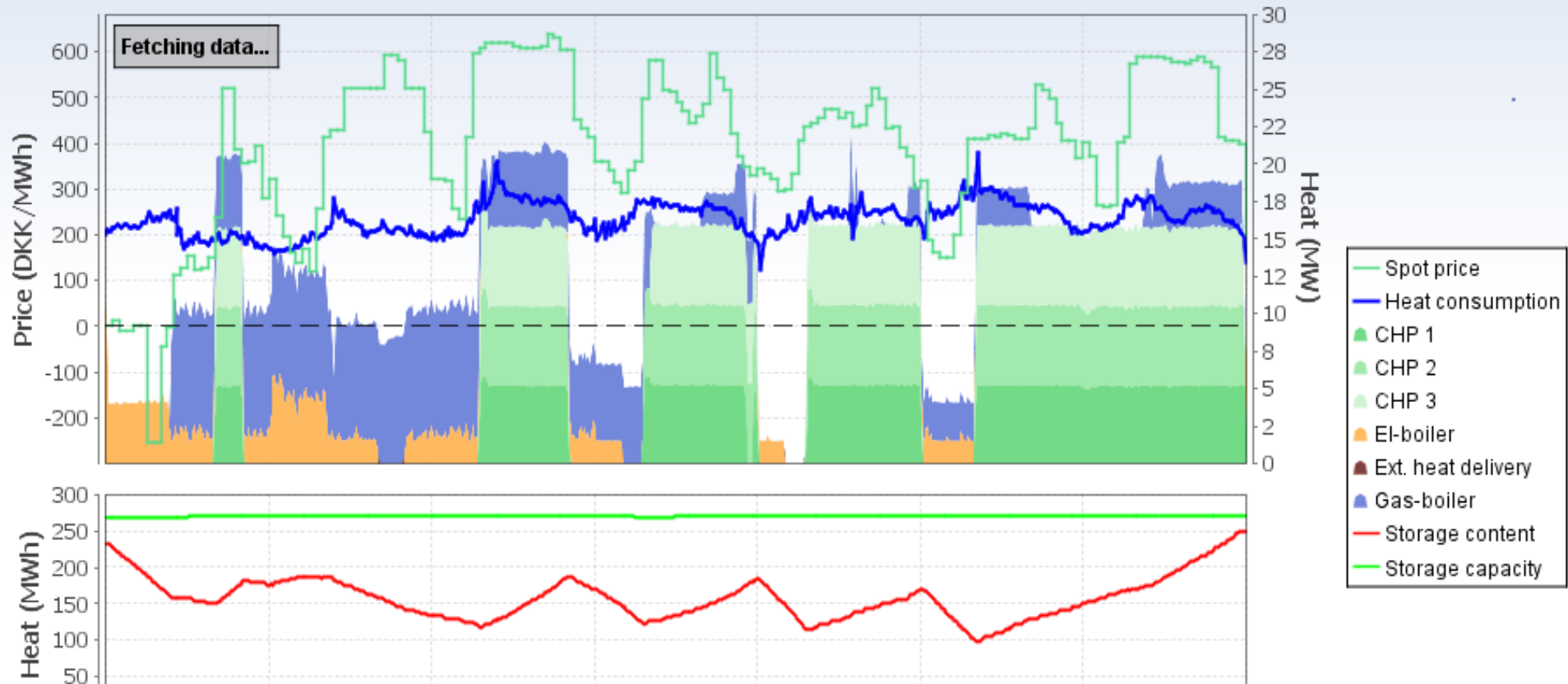
## Cost of entering primary automatic reserves market

- Cost of making  $\pm 1.4$  MW available on the engines: Only approx. 27.000 EUR.
- Investing in 10 MW electric boiler:  
Approx 0.7 MEUR.



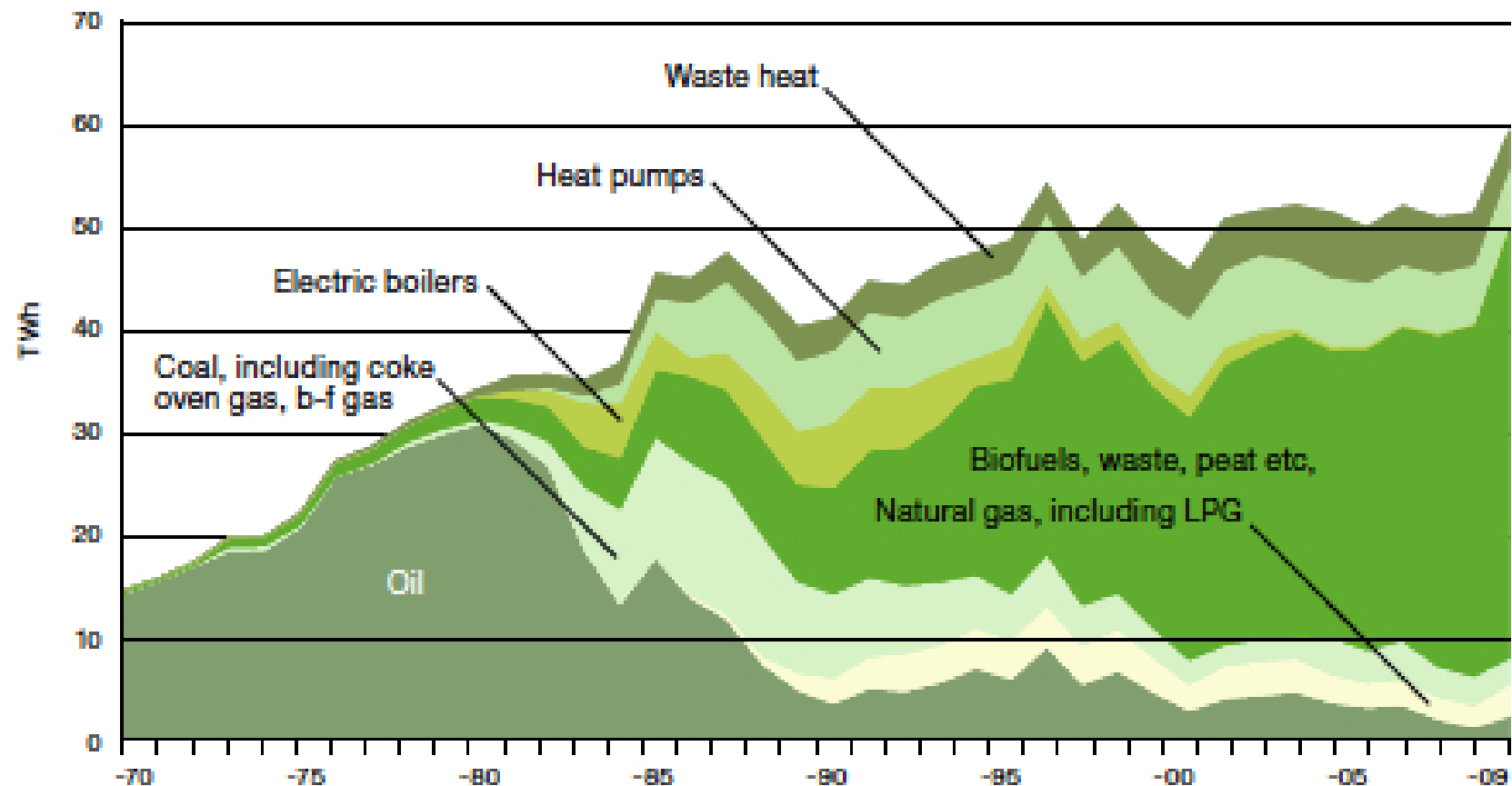
# Skagen CHP plant

Skagen District Heating, Saturday, 2011-01-01 to Friday, 2011-01-07



## DH in Sweden

**Figure 30** Energy input for district heating, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency

## District heating

- 4<sup>th</sup> generation district heating
  - Low temperature 60-70/40
  - Low ratio heating/hot water – continuity of heat load
  - Heat storage (4 m<sup>3</sup>/customer)
  - CHP – follows electricity market
  - Waste heat from various sources (power plants, waste to energy, industry)
  - Heat from solar, biomass, gas
  - Electric heaters – primary reserve market (in future heat pumps, also secondary reserve)



Thank you for your attention!

[neven.duic@fsb.hr](mailto:neven.duic@fsb.hr)

[www.het.hr](http://www.het.hr)

