



Analysis of the Danish Energy System with Balmorel model

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CITIES Third General Consortium Meeting - Session on planning tools



Agenda

- What is the Balmorel model?
- Danish Energy System towards 2050
- Value of flexible demand with Balmorel model
- Future development of the Balmorel model

What is the Balmorel model?

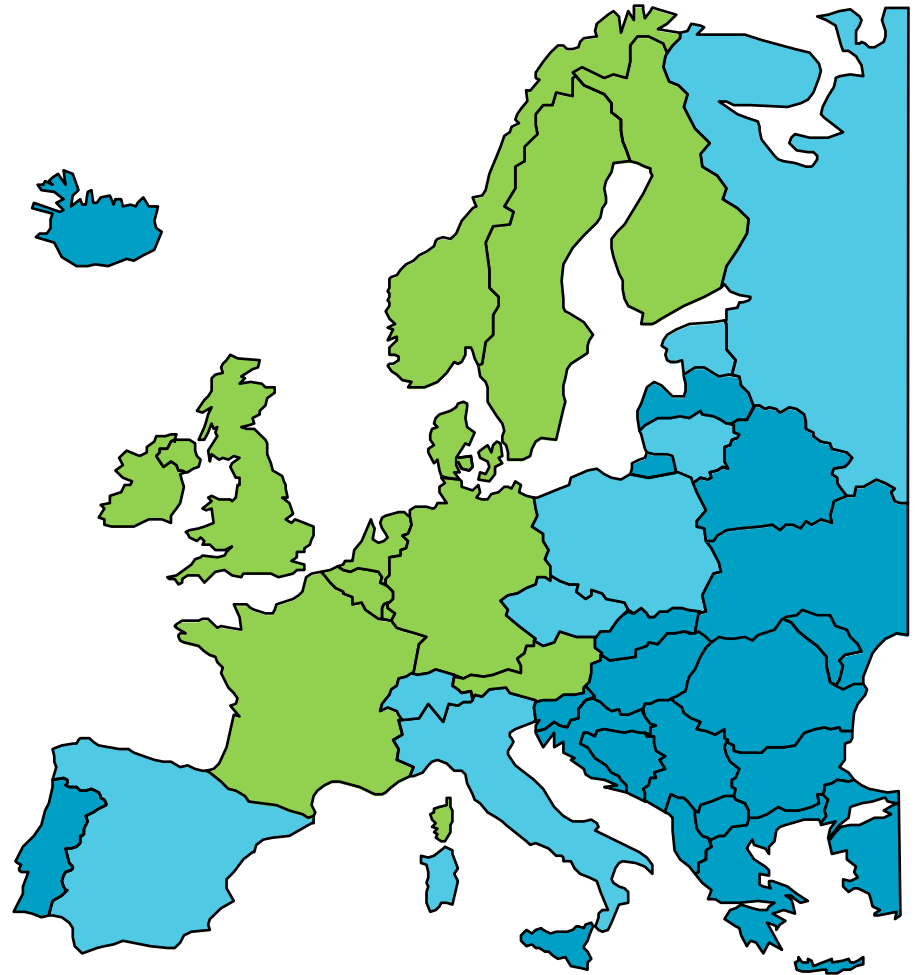
Input to the model

Balmorel runs



Input to model

- Fuel costs
- CO₂-prices
- Taxes and subsidies
- Technical and economical data of power plants
- Transmission capacity
- Power and district heating demand
- Flexible demand
- Time variation of consumption, PV and wind



Green countries modelled explicitly – light blue with exchange profiles

What is the Balmorel model?

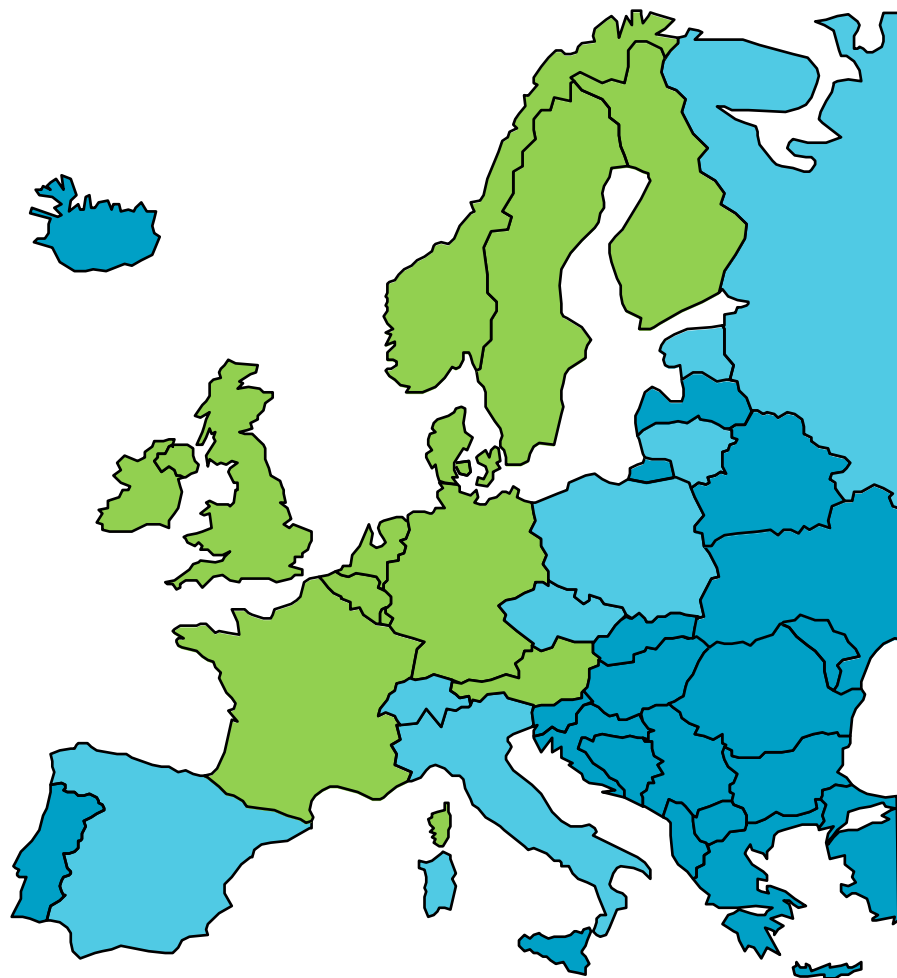
Output of the model

Balmorel runs



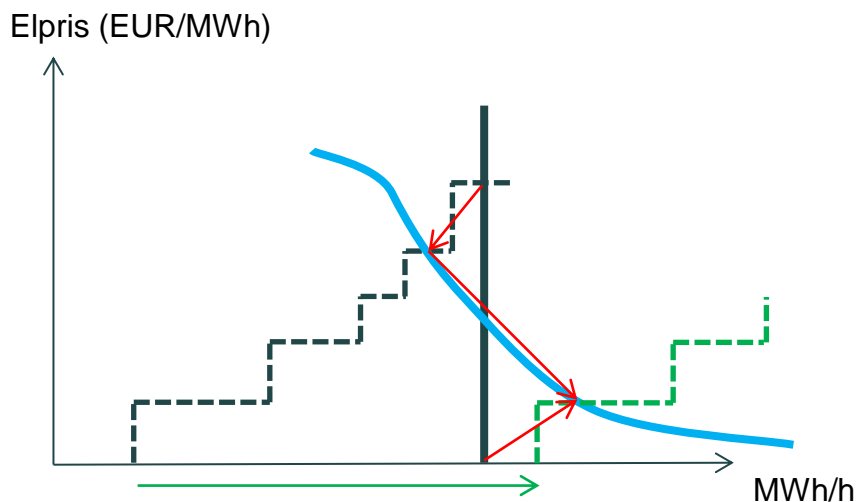
Results of model

- Investments
- Power prices
- Power production
- Power exchange
- District heating production
- Fuel consumption
- CO₂-emissions
- Costs
- Subsidy demand of RES

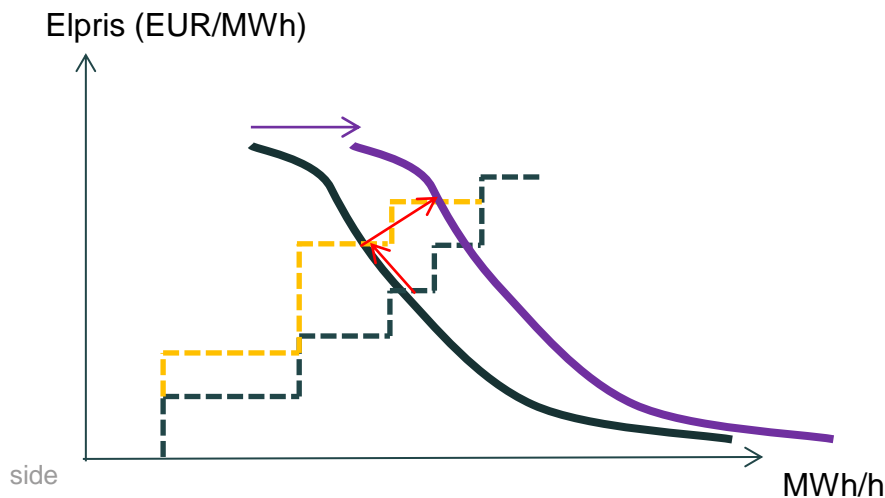


Green countries modelled explicitly – light blue with exchange profiles

Power prices is affected by changes in costs and volume of demand and supply



- Price flexible demand
- Additional wind and PV



- Increased fuel and/or CO₂-prices
- Additional power consumption – eg EV's and hydrogen

What is the Balmorel model?

Key messages

- Day ahead spotmarket in Northwest Europe
 - Hourly resolutions
 - Focus on power and district heating system
 - Integration to individual heat, transport and hydrogen
- Denmark is part of a very large Northwest European power system
 - Development in other countries have great impact on Danish prices
- What does the Balmorel model not cover?
 - Distribution grid costs
 - Commitment of units to other markets (Intraday, ancillary services)
 - Security of supply outside Day ahead market

What is the Balmorel model?

Key messages

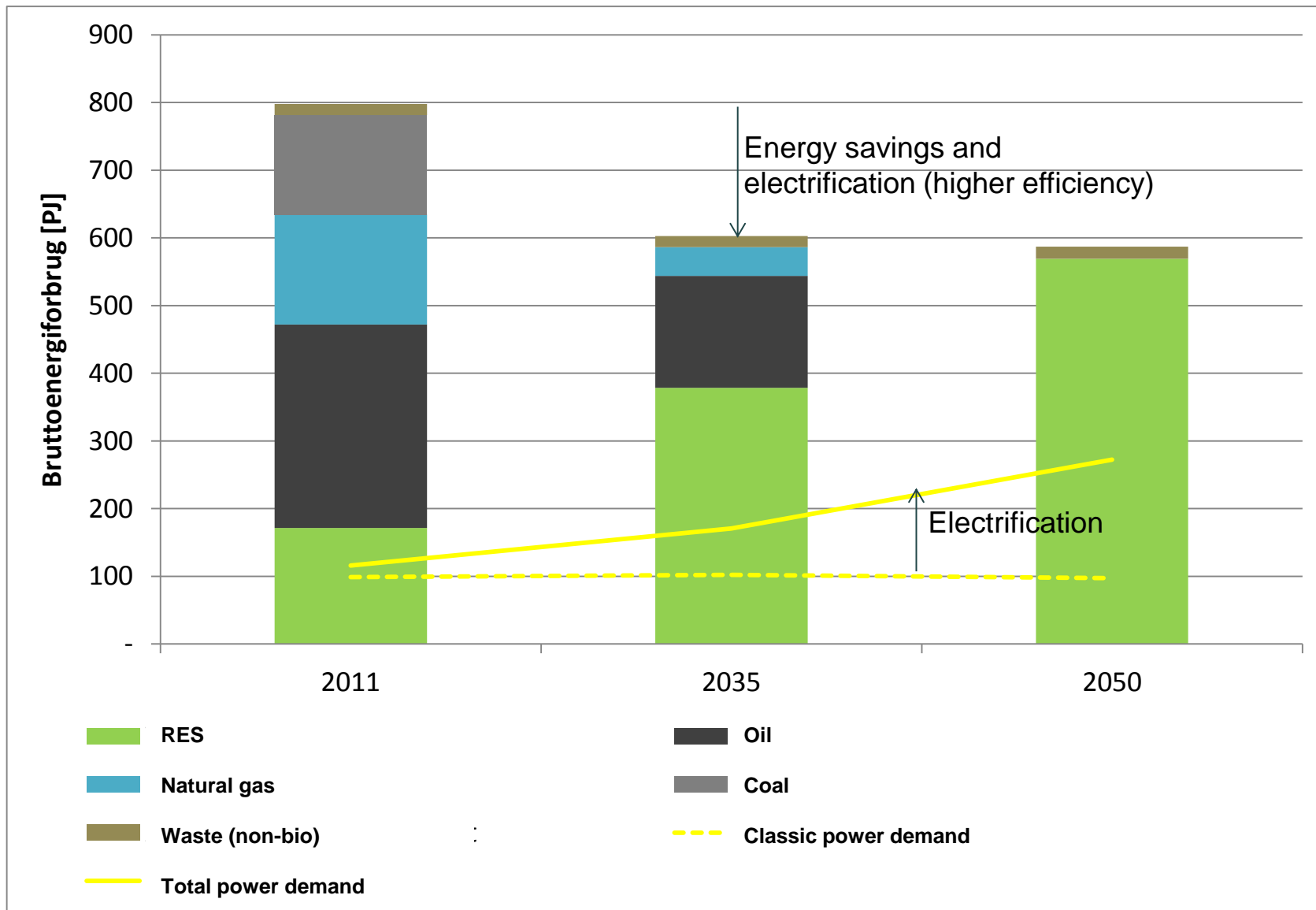
- Balmorel minimizes overall costs in the system
 - Power prices reflects costs and restrictions
 - Investment in new technologies to minimize costs
 - System costs (socio economic) can be calculated for all countries
- Effect of changes in the energy system can be quantified regarding:
 - Impact on system costs (socio economic)
 - Impact on power prices
 - Impact on technologies: Wind turbines, power plants etc.
 - Impact on actors: Consumers, TSO's etc.

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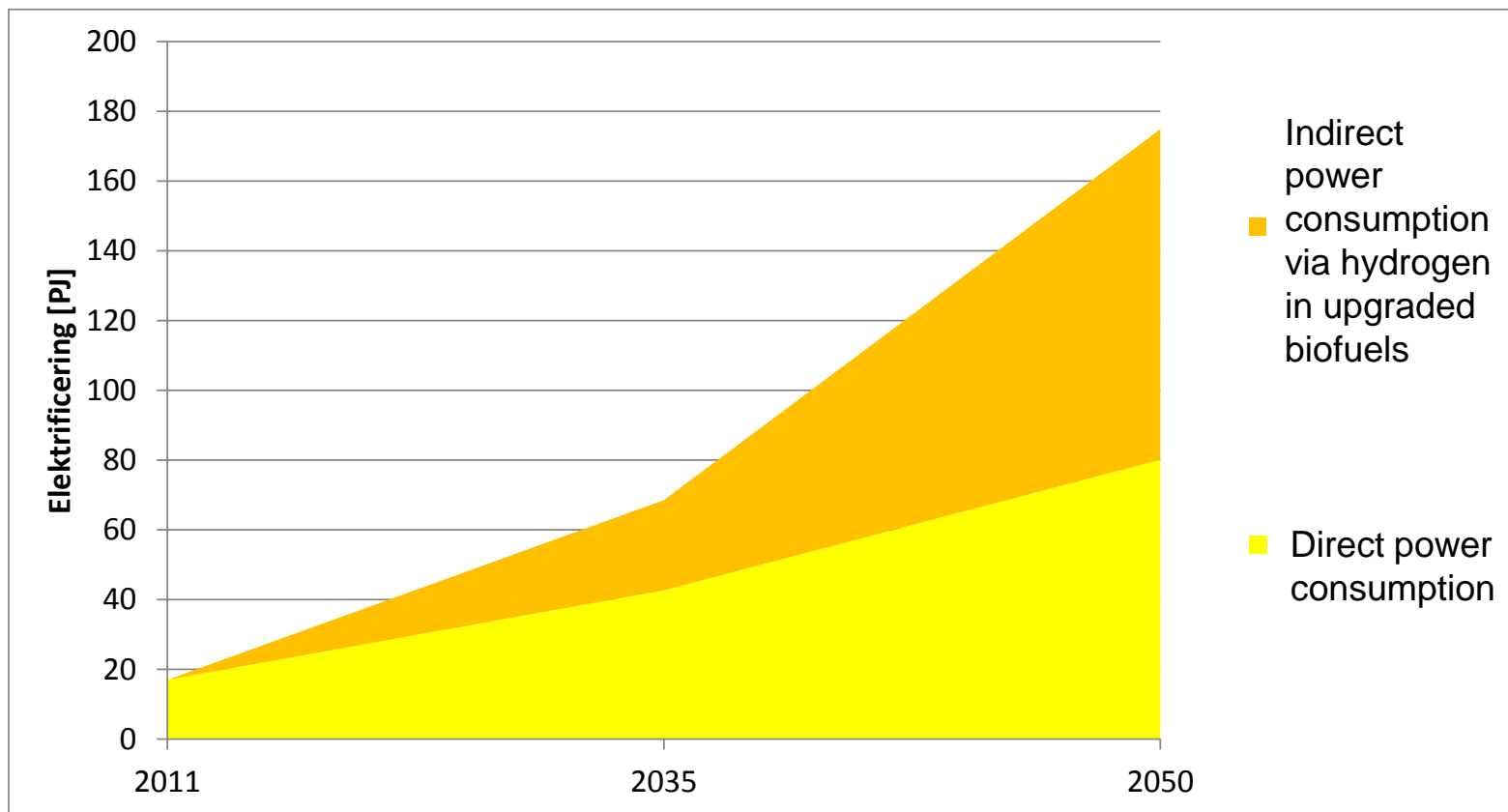
The "Wind scenario" (Danish Energy Agency)

One way towards fossil free energy system 2050



The "Wind scenario"

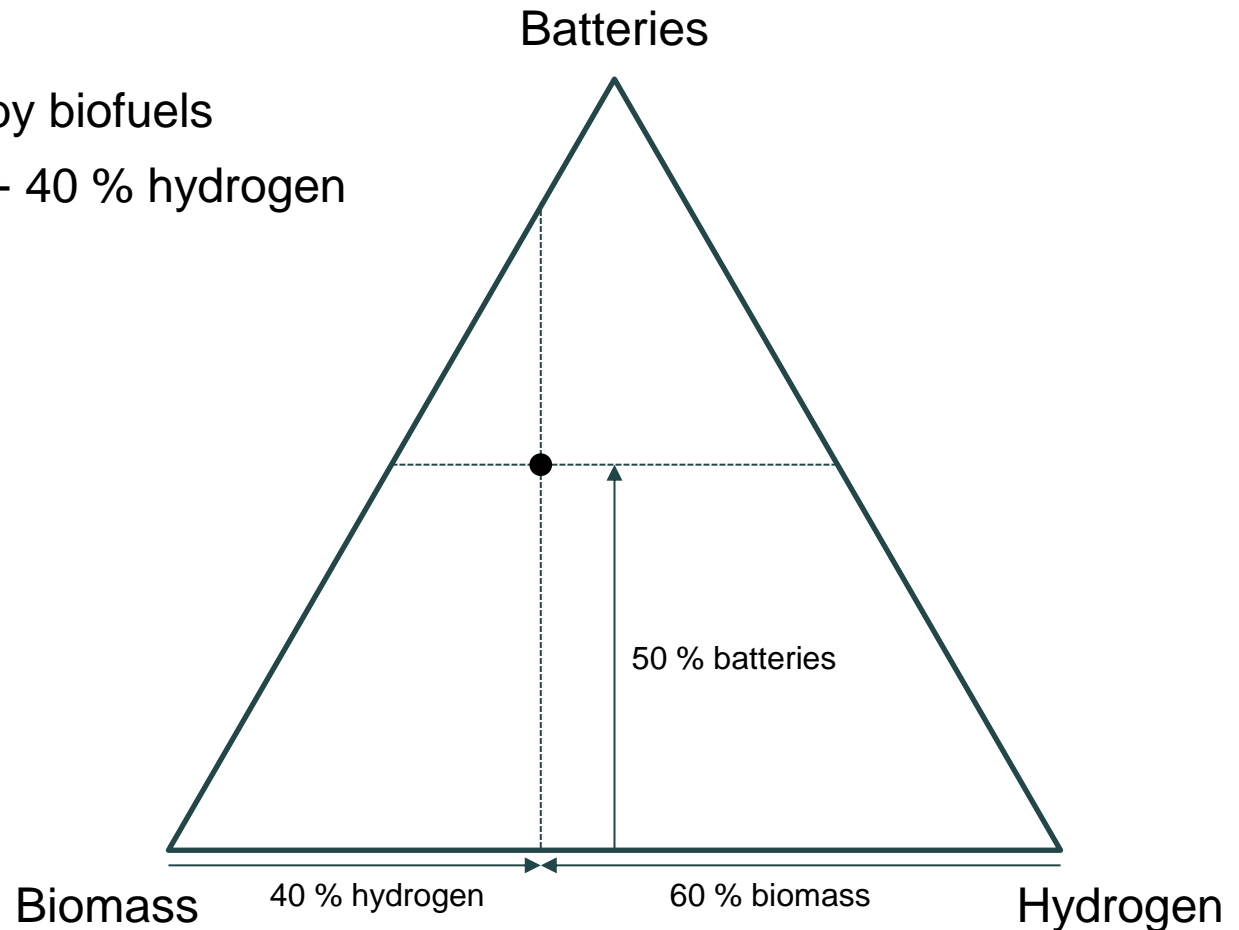
Energy carriers in transport and heating is important for total power consumption



Power consumption in transport sector 2050

Illustration

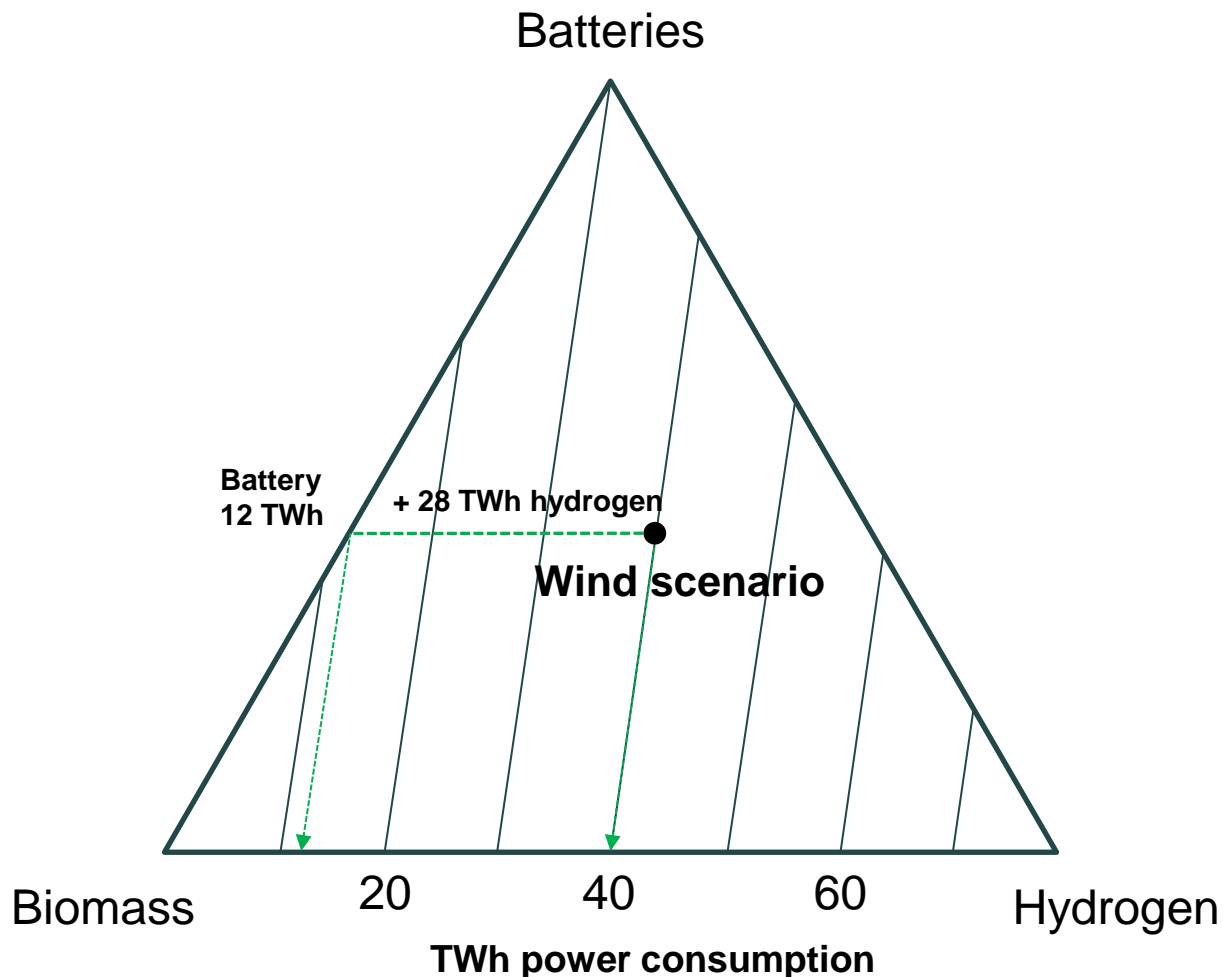
- 50 % of road work by batteries
- 50 % of road work by biofuels
 - 60 % biomass + 40 % hydrogen
- Result
 - 50 % batteries
 - 30 % biomass
 - 20 % hydrogen



Power consumption in transport sector 2050

Total transport work: 25 TWh

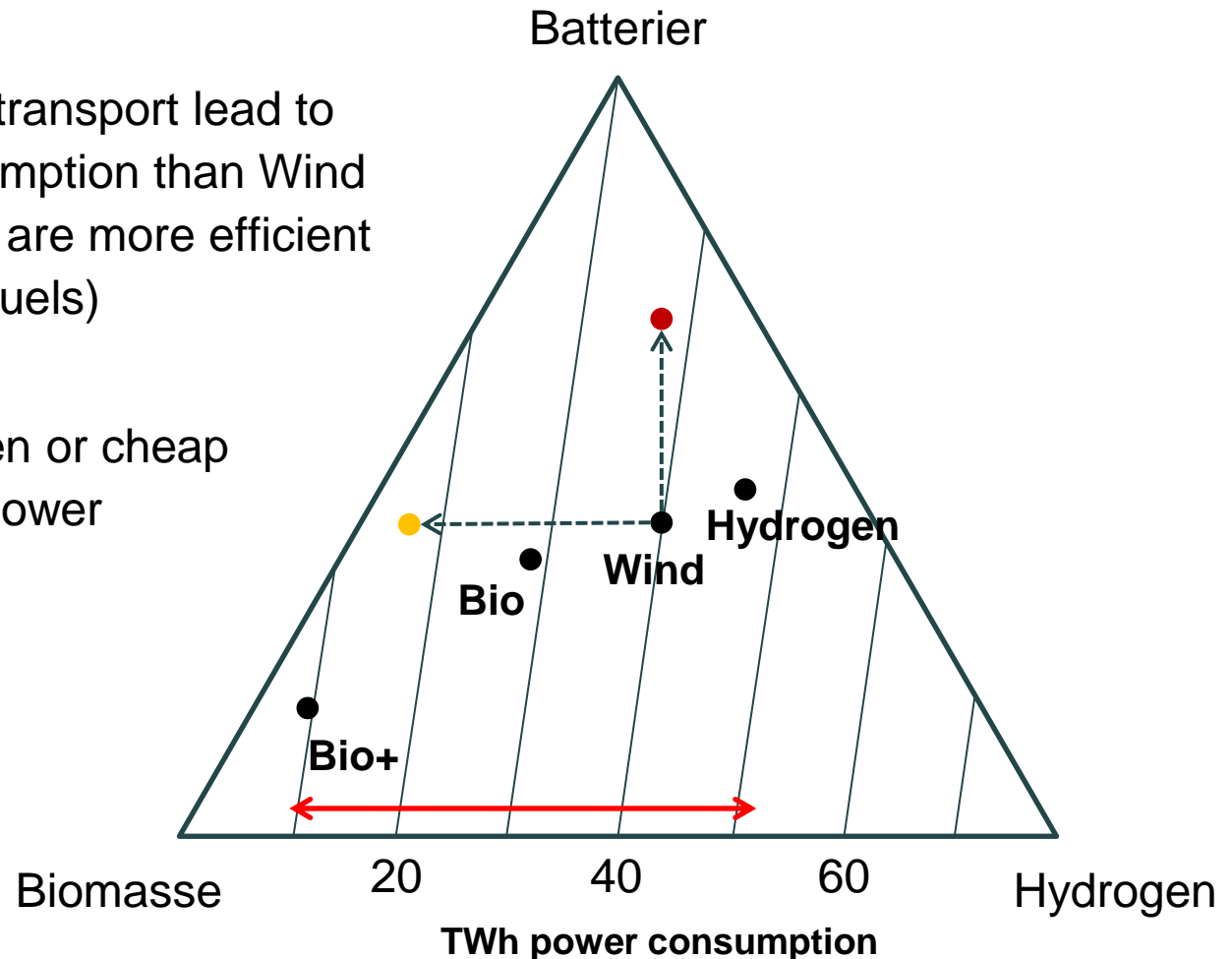
- Wind scenario 2050



Power consumption in transport sector 2050

Total transport work: 25 TWh

- Danish Energy Agency scenarios 2050
- Batteries in heavy transport lead to lower power consumption than Wind scenario (batteries are more efficient than upgraded biofuels)
- Expensive hydrogen or cheap biomass reduces power consumption



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Increasing need of flexibility in the system

Flexible demand is one of the suppliers

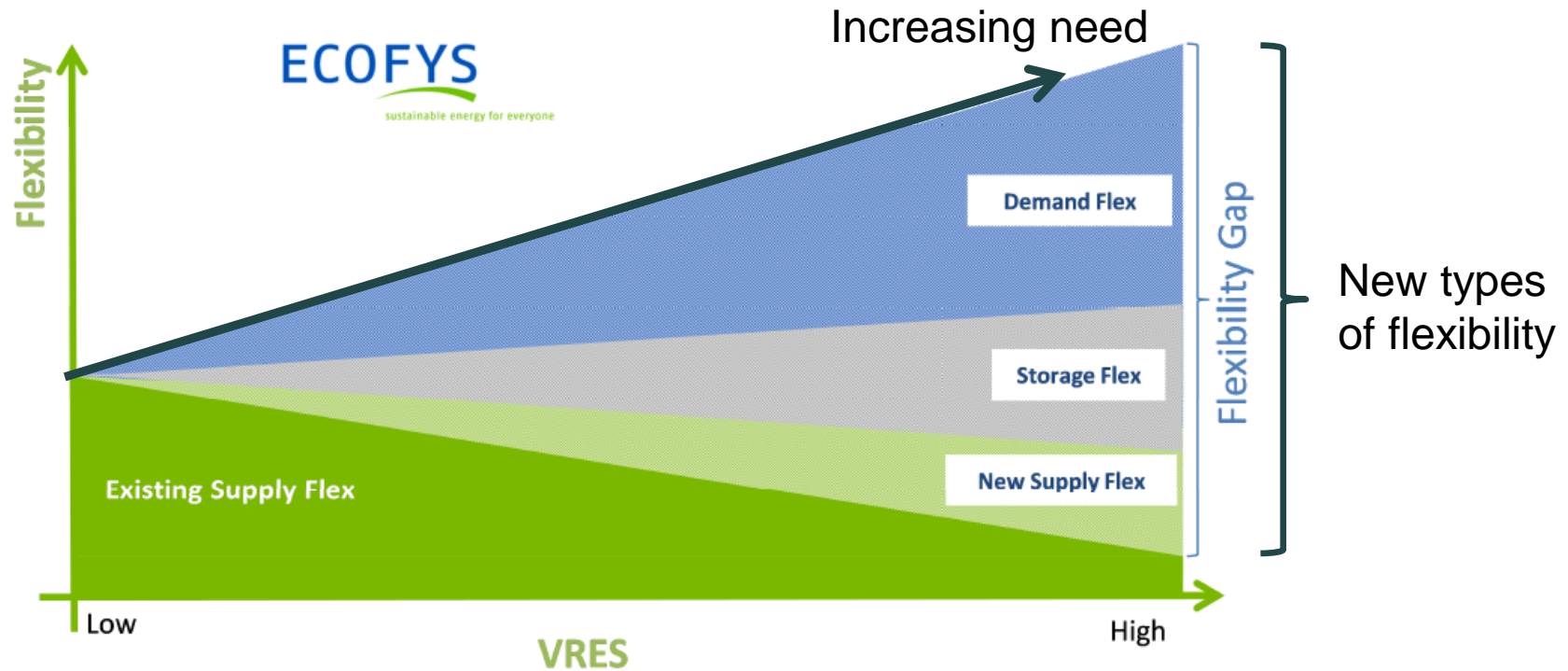


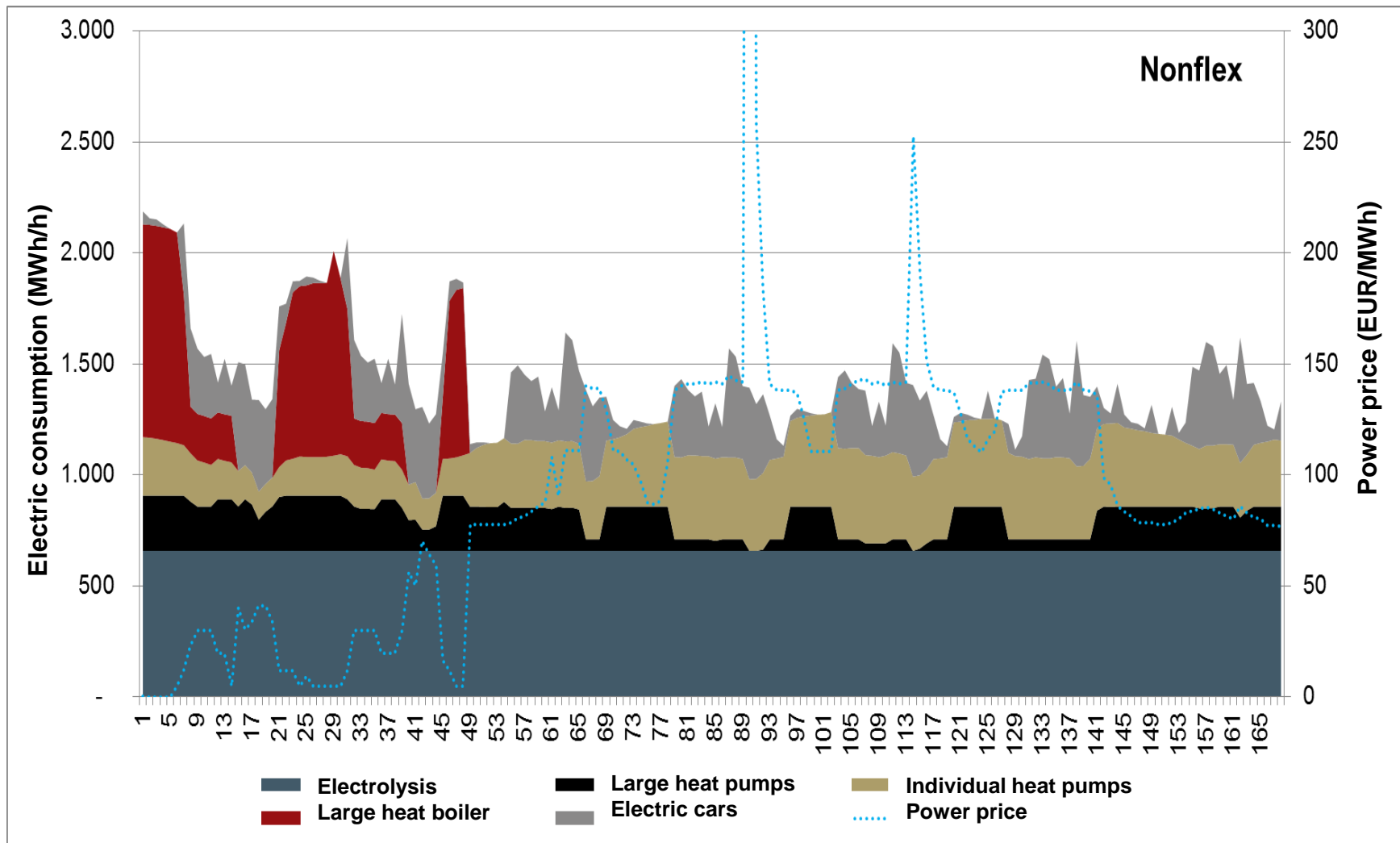
Figure 11: Flexibility gap in European electricity systems with different shares of VRES

Value of flexible demand with Balmorel model

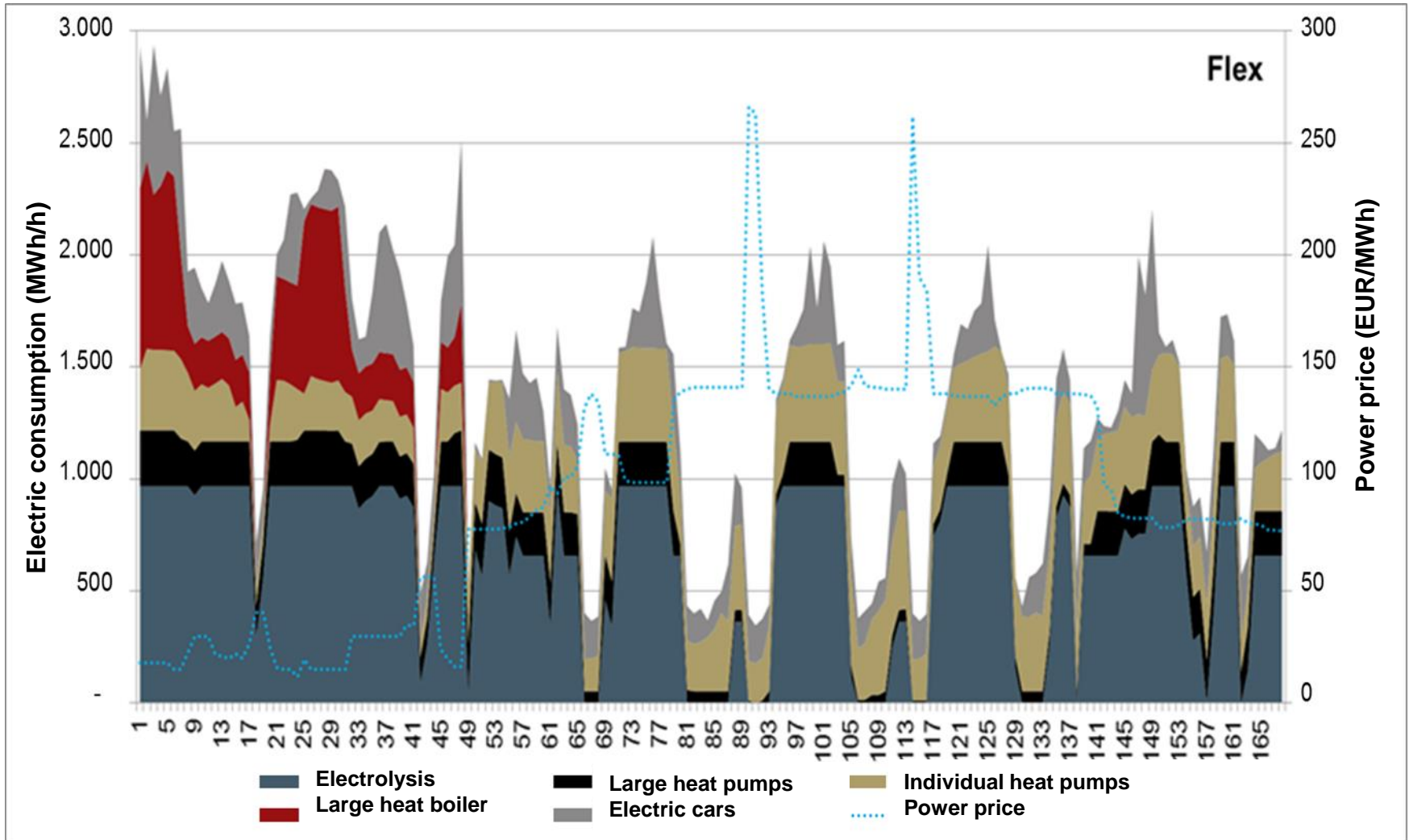
- Danish energy system based on Wind scenario 2035
- Analyses the need for flexibility in the power system in Denmark and Northwestern Europe towards 2035
- Quantifies the socio-economic and commercial value in 2025 and 2035 of electricity consumption from households and industry that can:
 - Curtail consumption during high price periods
 - Electric vehicles, heat pumps and electrolysis responds to prices in Day ahead market
- In Denmark the reduction in distribution grid costs due of spotprice-flexible demand is analysed



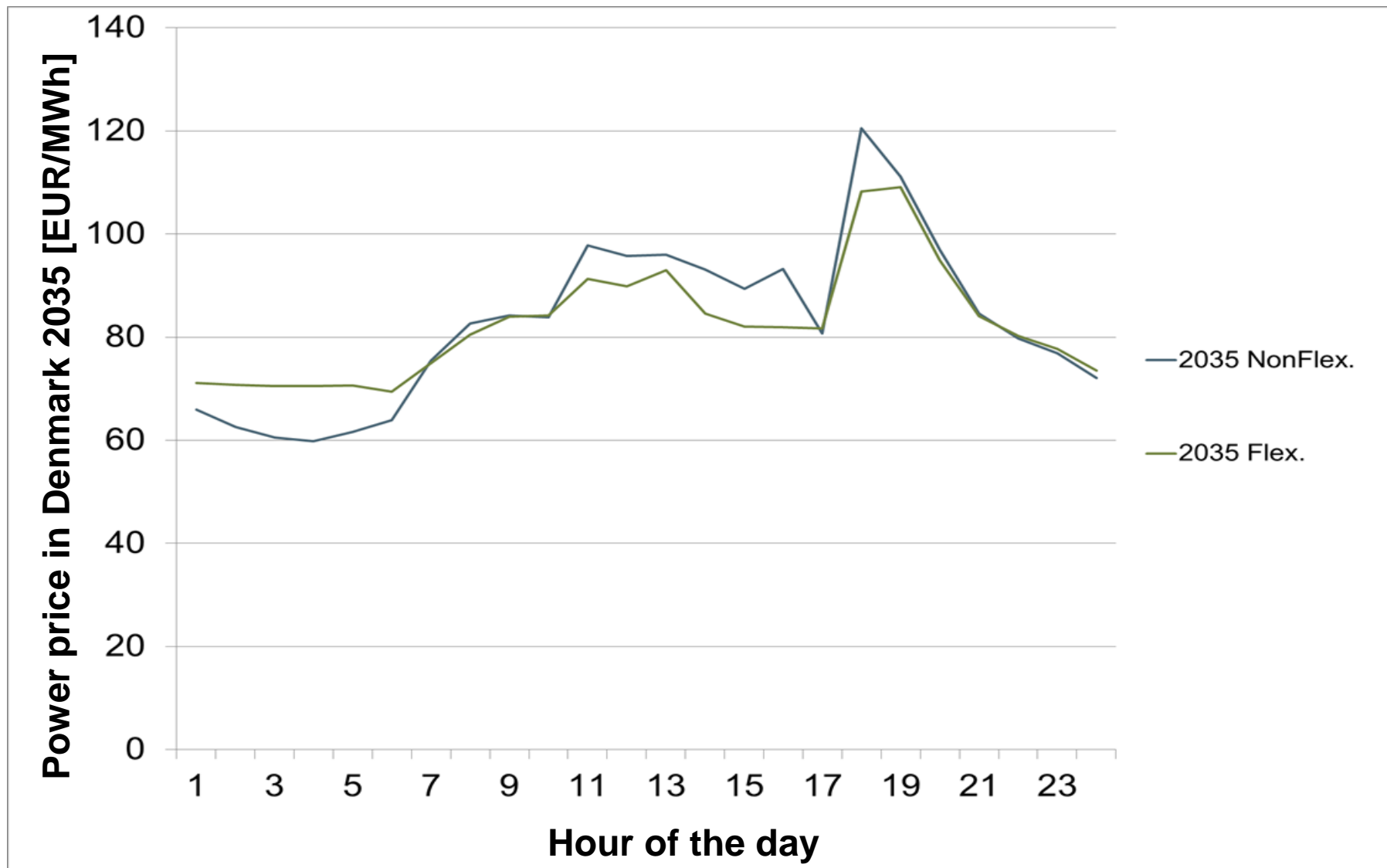
Operational pattern of flexible demand (Nonflex) Denmark



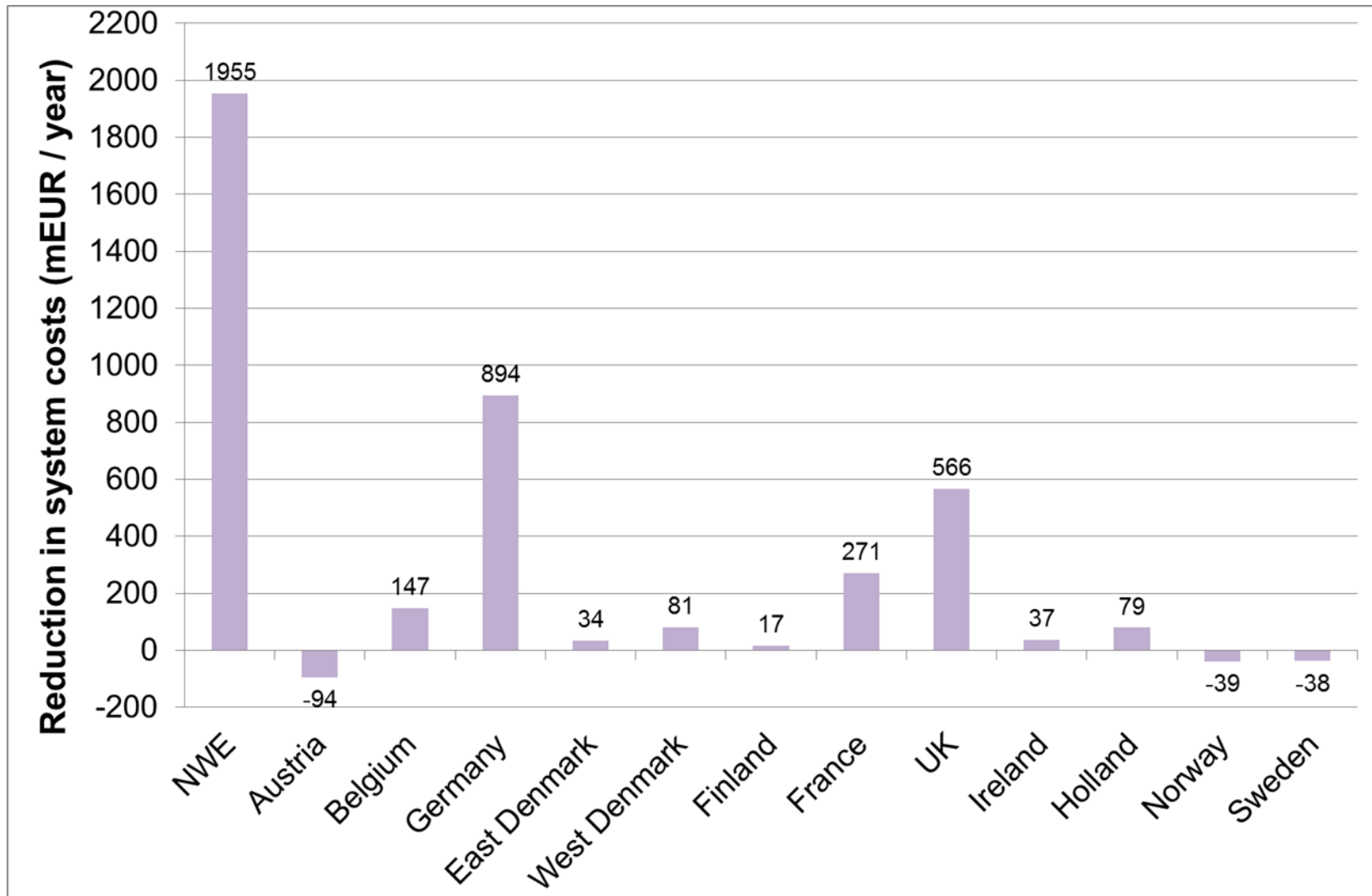
Operational pattern of flexible demand (Flex) Denmark



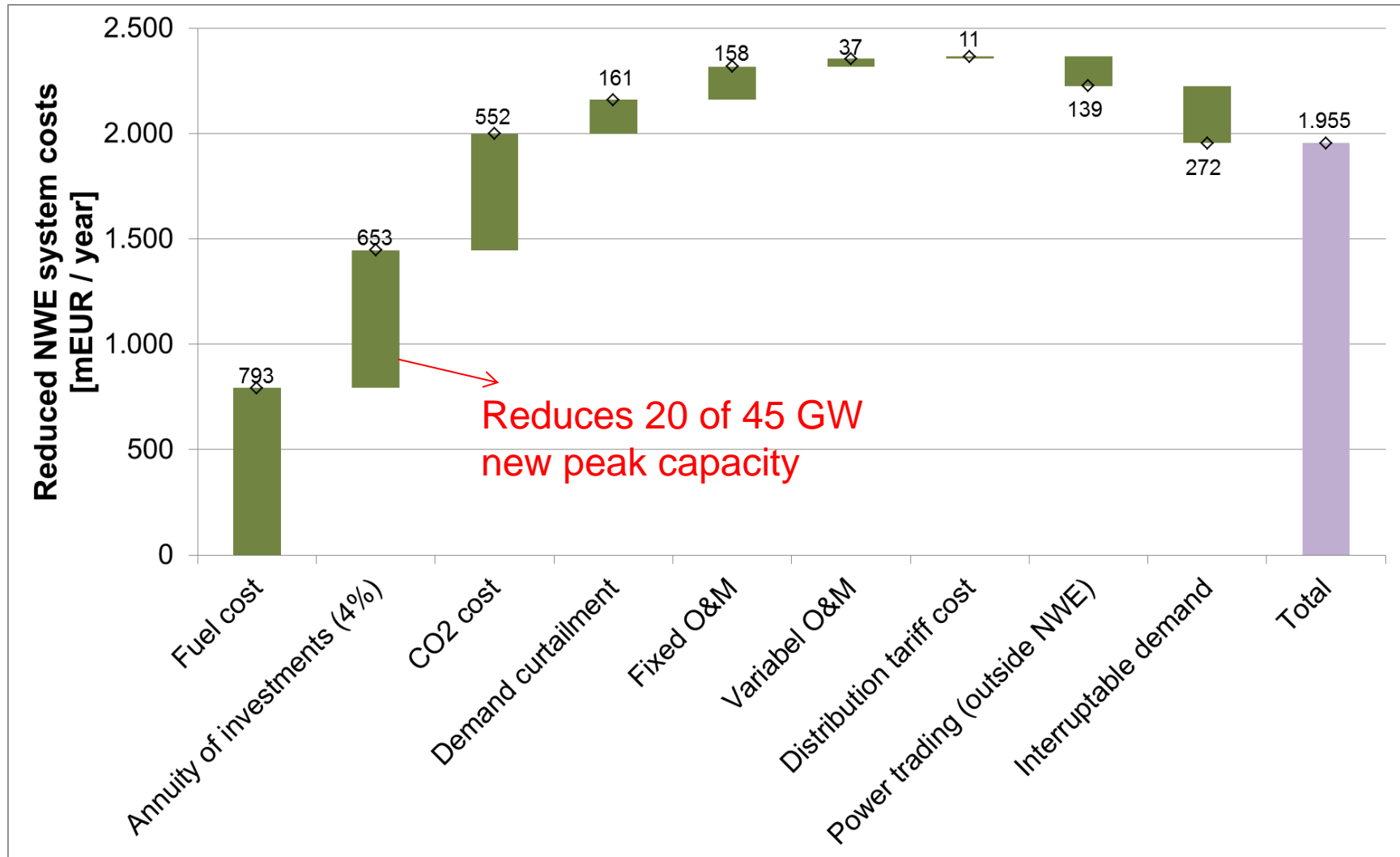
Impact of flexible demand on Danish power prices



Value of increased flexible demand in Northwest Europe 2035 – by country

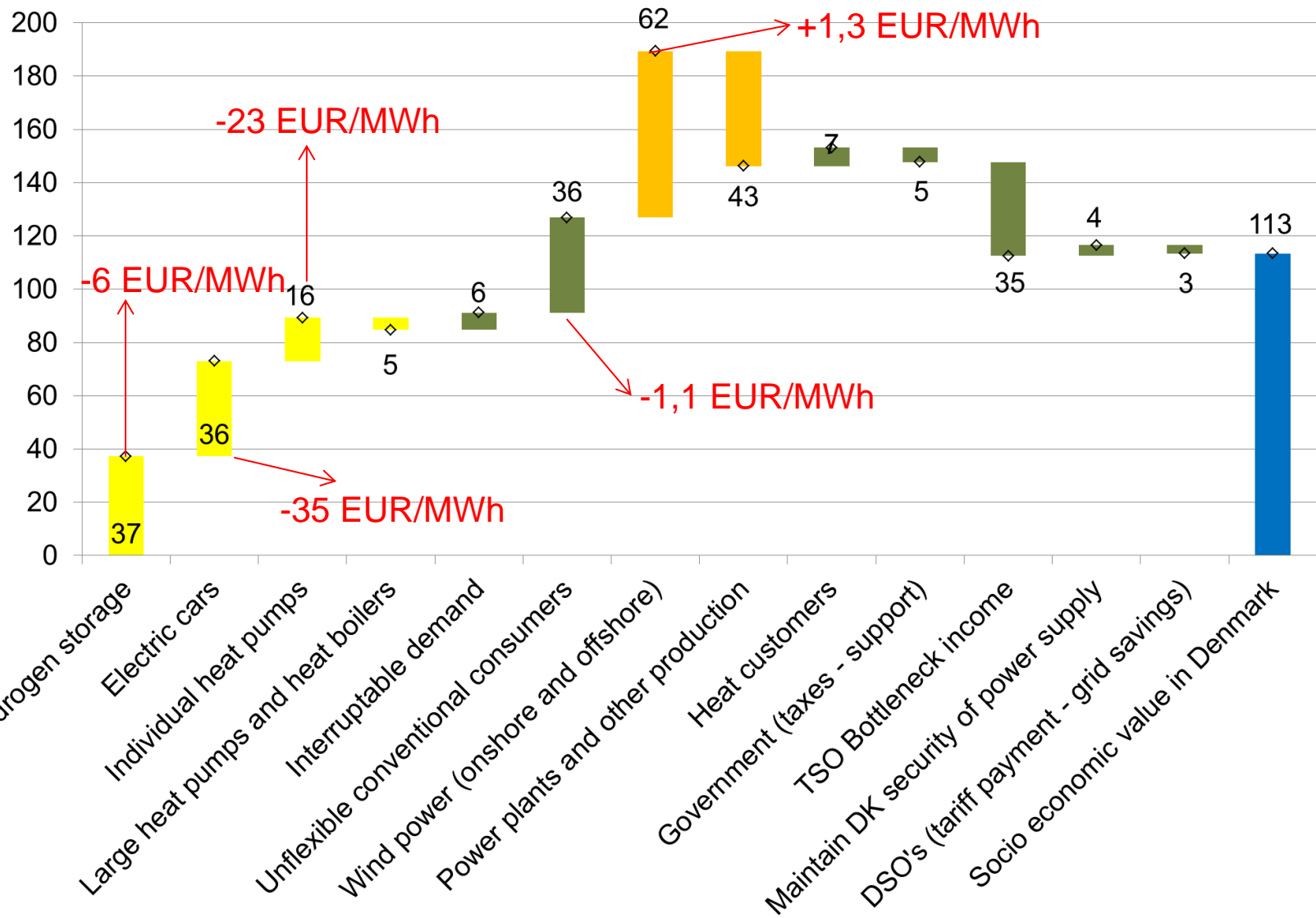


Value of increased flexible demand in Northwest Europe 2035 – by cost category

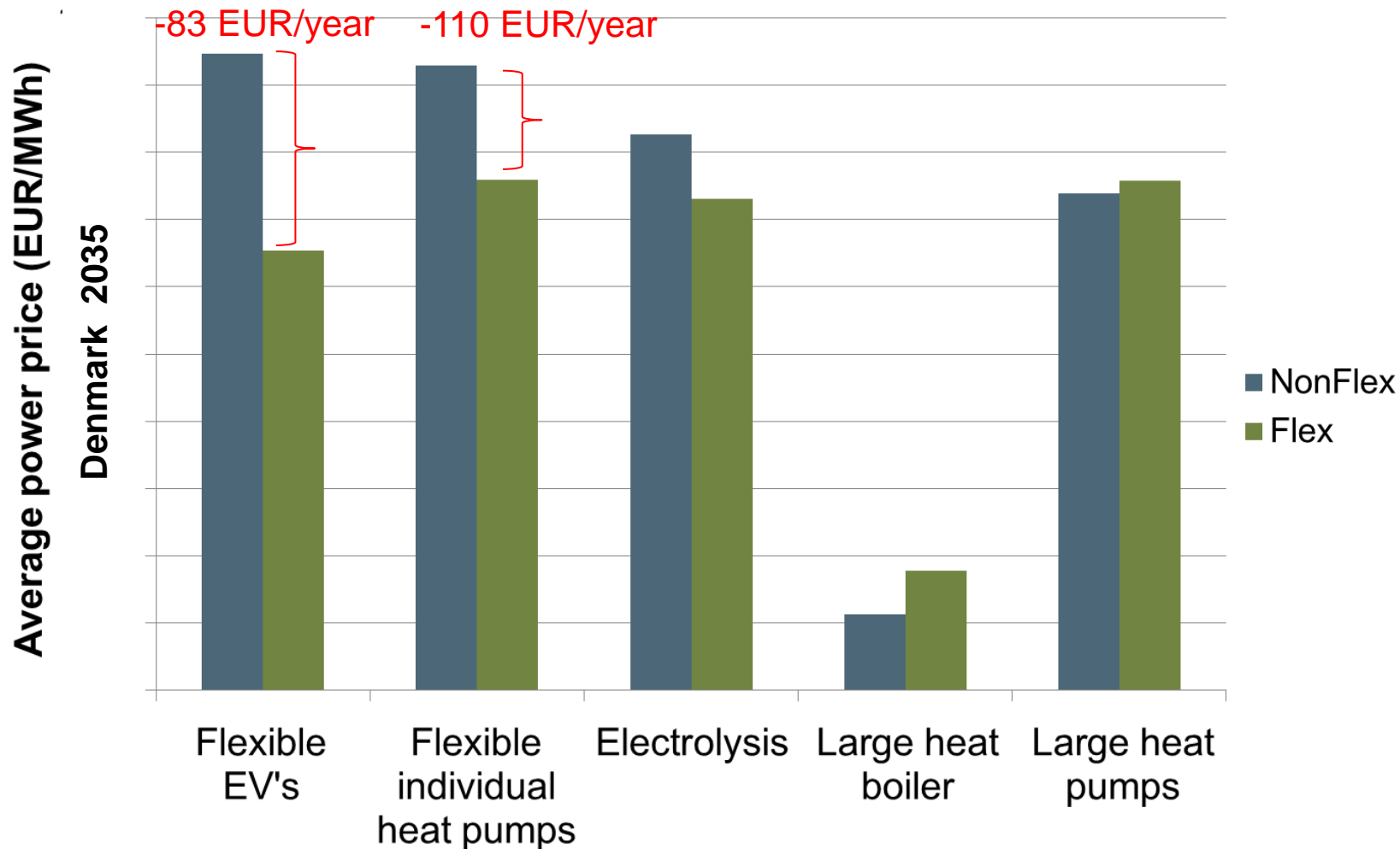


Value of flexible demand in Denmark 2035

Profit in i Denmark due to increased
flexible consumption [mEUR/year]



Change in power price due to flexible demand of EV's, individual heat pumps and electrolysis



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Important trends in the Day Ahead market

	Trends	Considerations in Day Ahead market model
1	Market integration	<ul style="list-style-type: none">• Price formation (real algorithm vs. model)• Transmission grid constraints
2	Increased RES production	<ul style="list-style-type: none">• Start/stop costs• Capacity adequacy• Dimensioning of RES production (125 GW x 2000 FLH vs. 83 GW x 3000 FLH)<ul style="list-style-type: none">• Impact on grid costs and flex. demand• Few operating hours make capital costs increasingly important!
3	Electrification	<ul style="list-style-type: none">• Flexible demand profiles• Distribution grid constraints• Tariff design

Future development of the Balmorel model

- Investment horisont
 - Today: Investment decision based on current year economics
 - Future: Investment based on future expectations of technology costs, capacity balance, fuel and carbon prices.
- Decommission of assets
 - Today: Technical lifetime
 - Future: Decomissioning based on economic criterias

Future development of the Balmorel model

Possible insights from the CITIES project

- Optimisation of urban energy system?
 - Optimum between distribution costs and system costs
 - Smart Energy – interaction between energy systems



**Thank you for the
attention
Questions?**