Danish Energy Policy

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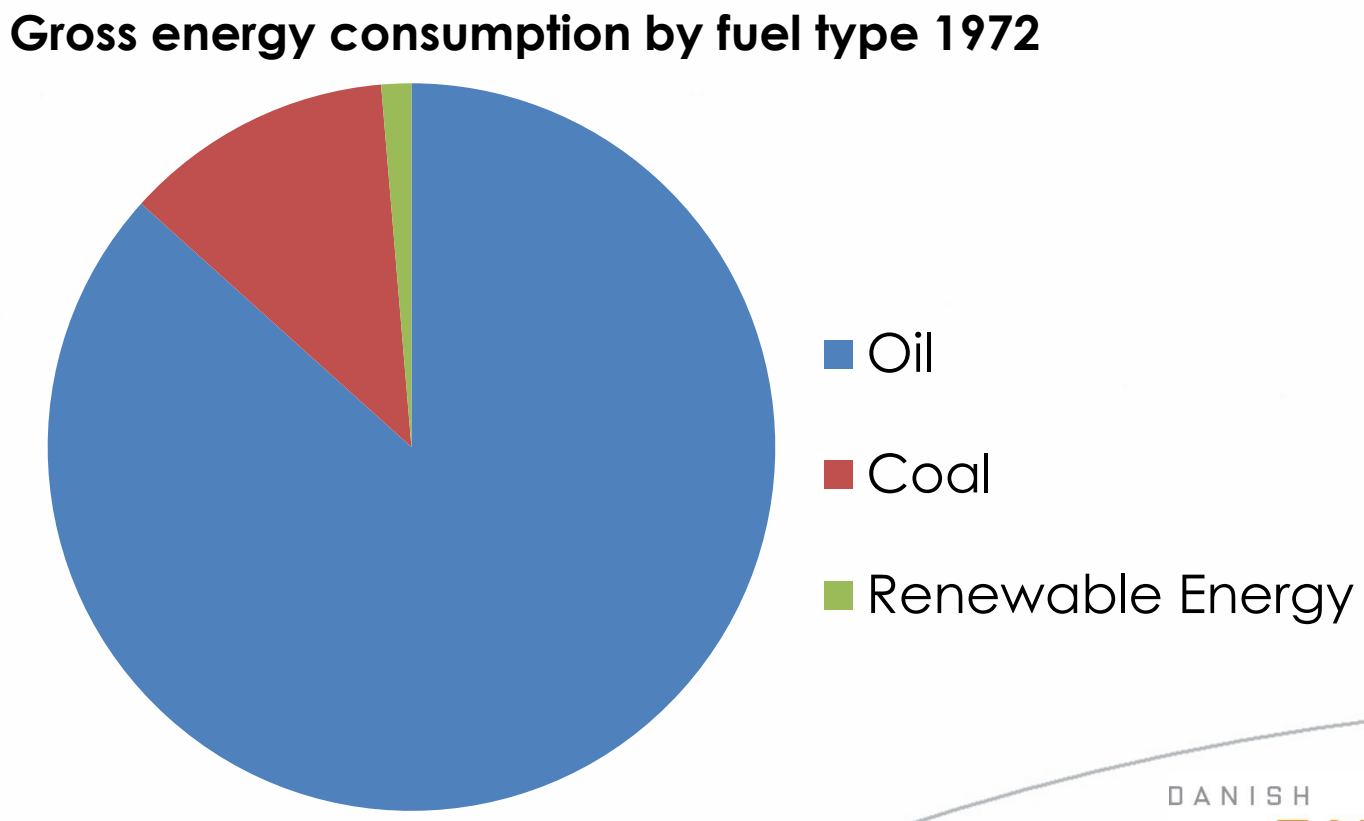
Denmark's energy consumption 1972

- More than 90% of the total energy use was covered by imported oil.



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Lessons learned over 40 year period

- Catalyst: 1973-74 oil crisis. Denmark was 99% dependent on imported energy
- Oil crisis caused a severe economic crisis, unemployment - and car-free Sundays
- Danish policy makers realized something had to be done to improve energy security.

Car free Sundays in Denmark as a result of the oil crisis in 1973

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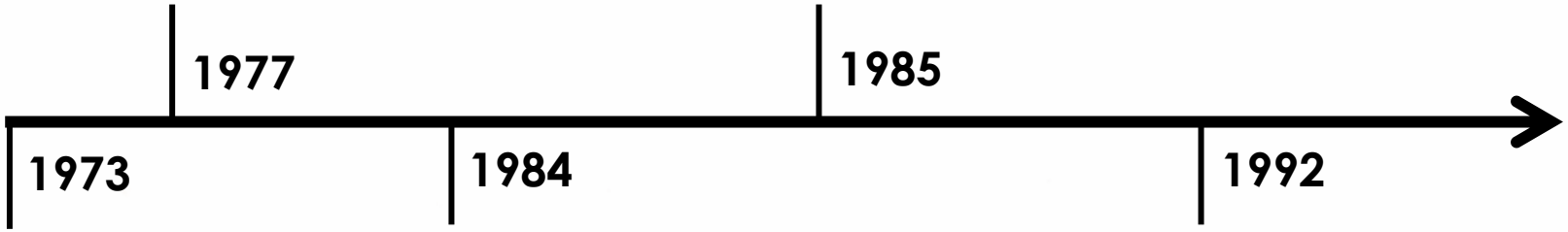
Policy steps towards a sustainable energy system

Energy taxes on electricity and oil.

Government set targets for power plant operators to install wind power.
- Incentive to down regulate their power plants.



Oil crisis

Support to electricity produced by wind turbines.

CO_2 taxes were introduced.
- Promotion of energy savings and CO_2 reductions.
- Financing part of the state budget.

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40 years later: an energy system transformed

- Highest contribution to electricity from new renewables (non-hydro) world wide: 46,7% in 2013. 39% of Danish electricity came from wind power in 2014.
- Lowest energy consumption per GDP-unit in EU.
- Highest export share of energy technology in the EU: 10.8 % of total export of goods in 2013. Export of green energy technology increased 17.6 % last year (2013).
- Leader in advanced energy solutions: district heating and CHP, wind turbines, biomass plants, energy saving technologies.
- Result: high degree of energy security.

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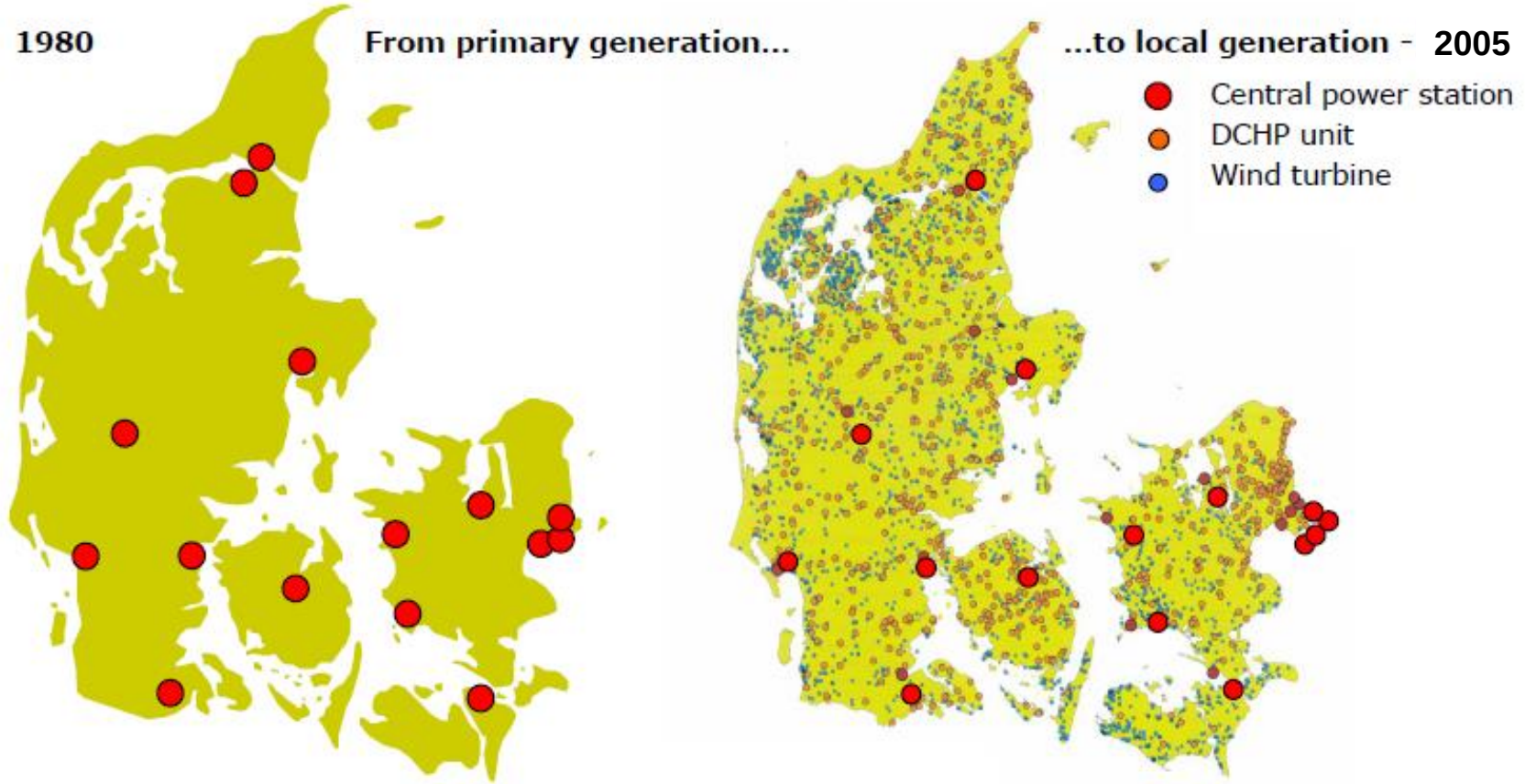
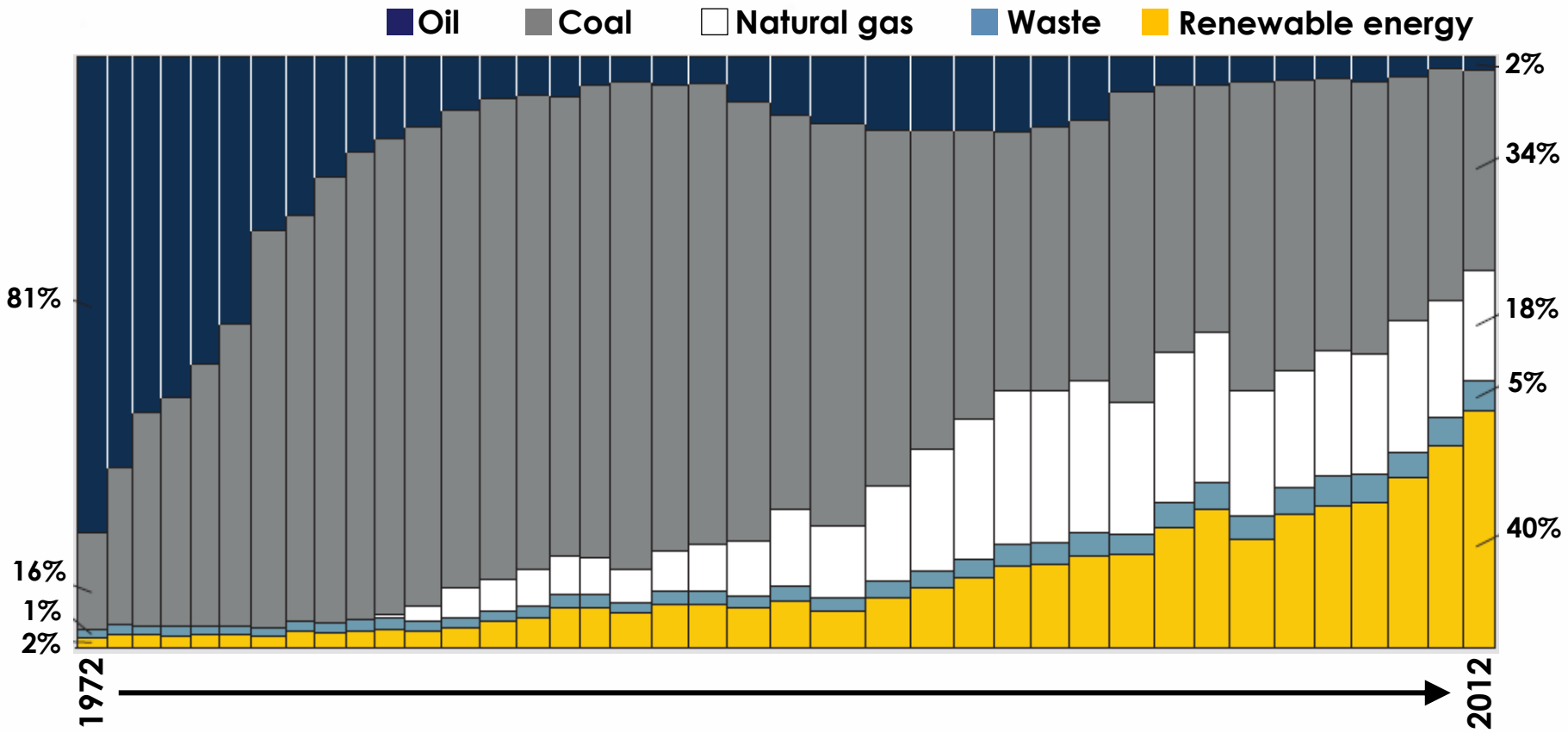
The electric power infrastructure

Centralised coal based power system → **Decentralised power system, with greater reliance on renewable energy sources**



40 years later: An energy system transformed

Electricity and heat production by source



39% of Danish electricity came from wind power alone in 2014.

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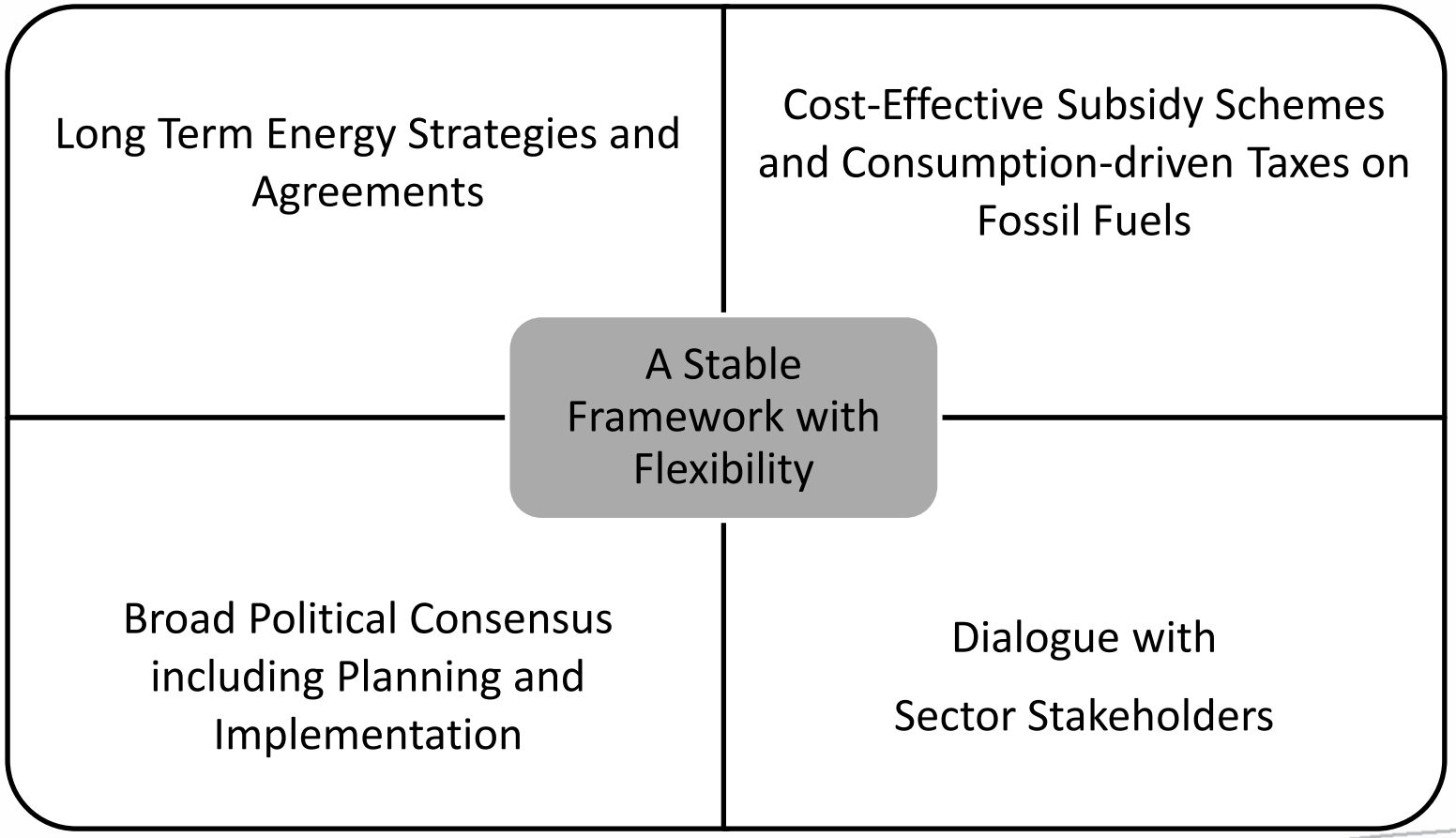
Key elements of Danish energy policy agreements



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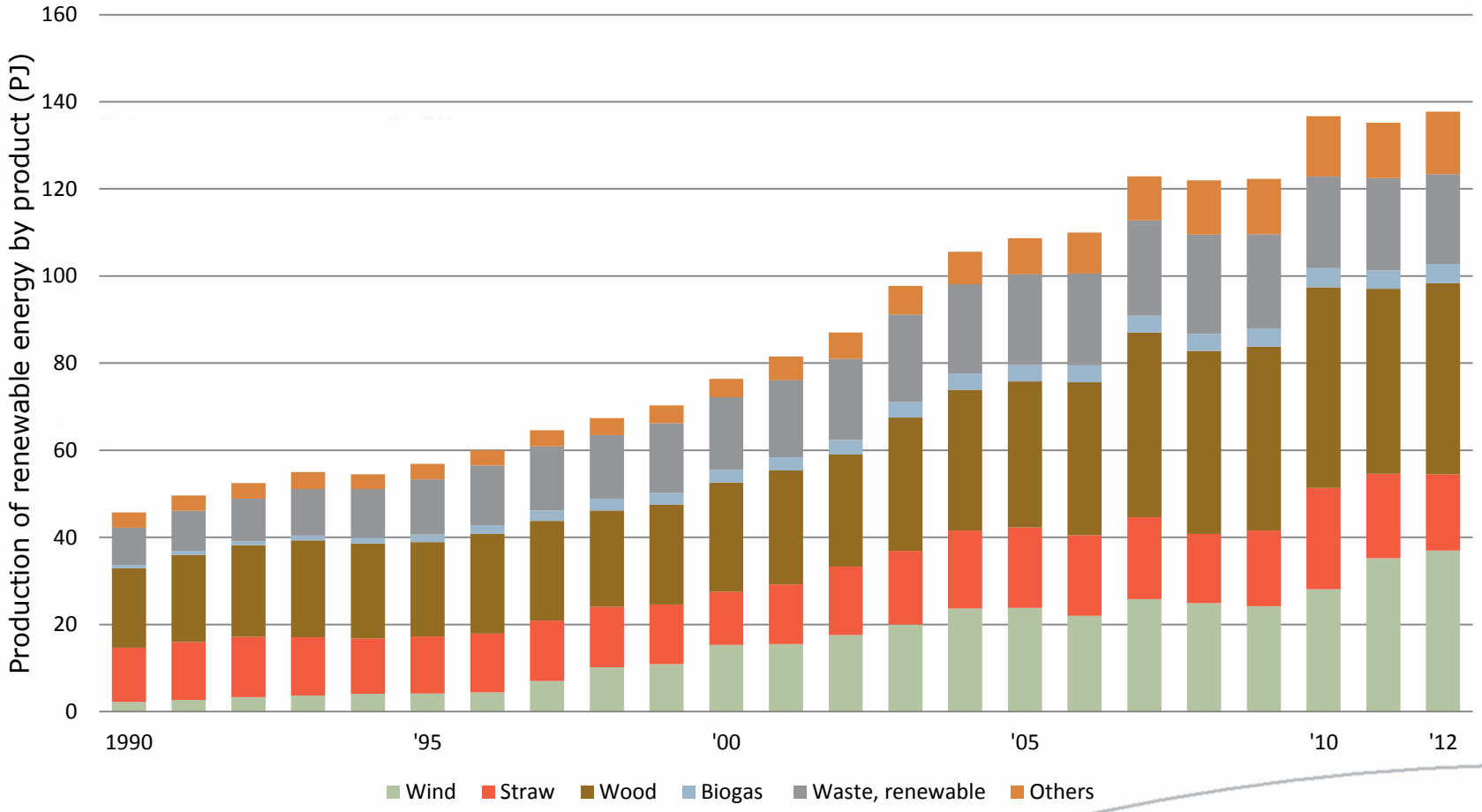
Renewable energy in Denmark - greening the energy supply



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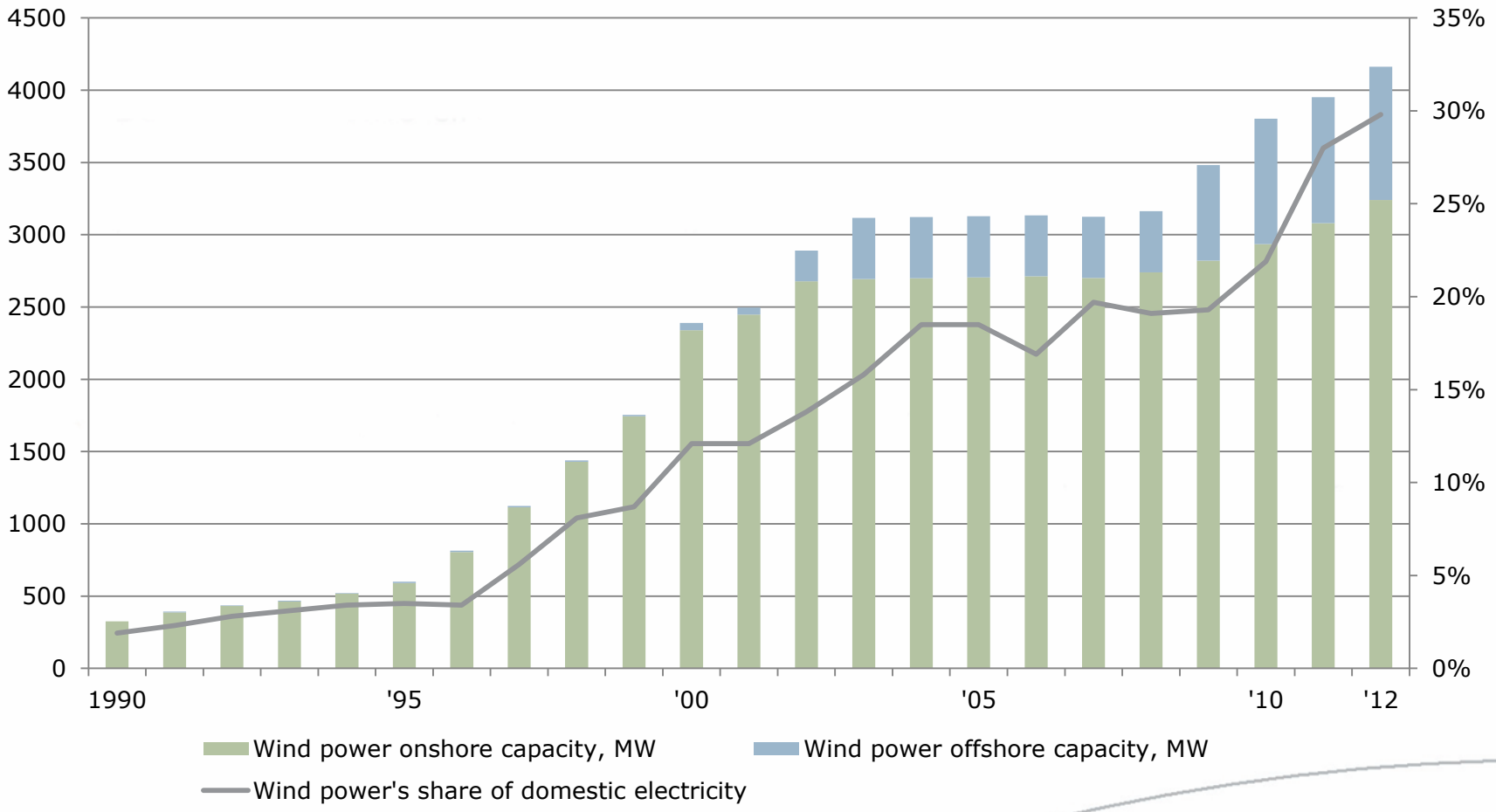
Wind power integration

Capacity and share of domestic electricity supply



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Main challenges of renewable energy integration

- Where will the power come from when there is no wind?
- What will we do with the surplus power when there is so much wind that we cannot use all the wind power generated?
- How do we ensure that a power system with a high wind penetration is so dynamic and flexible that it is capable of responding sufficiently fast to unpredictable events?

Flexibility in generation and consumption

Interaction between sectors

- District heating covers 2/3 of heat demand for spacing heating and hot water in the residential sector.
- A main part of the district heating is covered by combined heat and power (CHP) plants, which all have electricity storage.
- Hence, the district heating system serves as an important flexibility tool.
  - CHP plants can decrease their production when there is plenty of electricity in the system, and they can increase their production when there is a need of electricity in the system.

Strong interconnections

Connection to neighbouring countries

- Interconnector capacity has been constructed over the years with regional benefitted.
- On days with low wind Denmark receives cheap hydro power, and on days with excess wind Denmark delivers excess wind power.
- Power flow between countries managed through market mechanisms.

Strong transmission grid

Grid planning

- Reinforcement and expansion of the power grid.
  - Grid connection for new projects is available in due time.
  - Electricity can be transmitted from new offshore wind farms to where the demand is in the international electricity market.

- A strong transmission grid makes trading and balancing in a wide geographical area possible.

- Clear financing of grid connection to wind farms.
  - In Denmark there is cost sharing between the wind farm developer and the transmission system operator – Energinet.dk

A well functioning market

European Power Markets

- The liberalisation and integration of the European power market is first of all a political initiative in the European Union with the vision of creating competition and reducing costs.

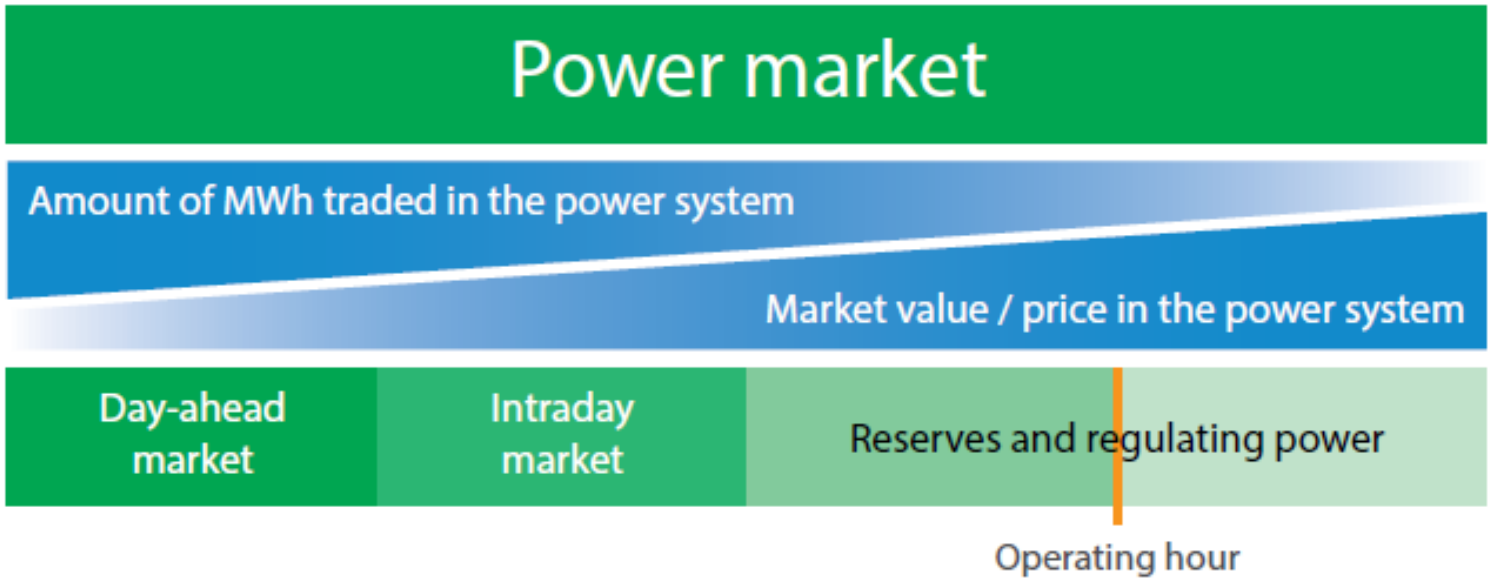
- The liberalisation process started in the 1990s.

- Market organisation has proven to be efficient:
  - For the integration of renewable energy.
  - Providing stronger grids and interconnectors is a way to jointly use the resources more efficient.

A well functioning market

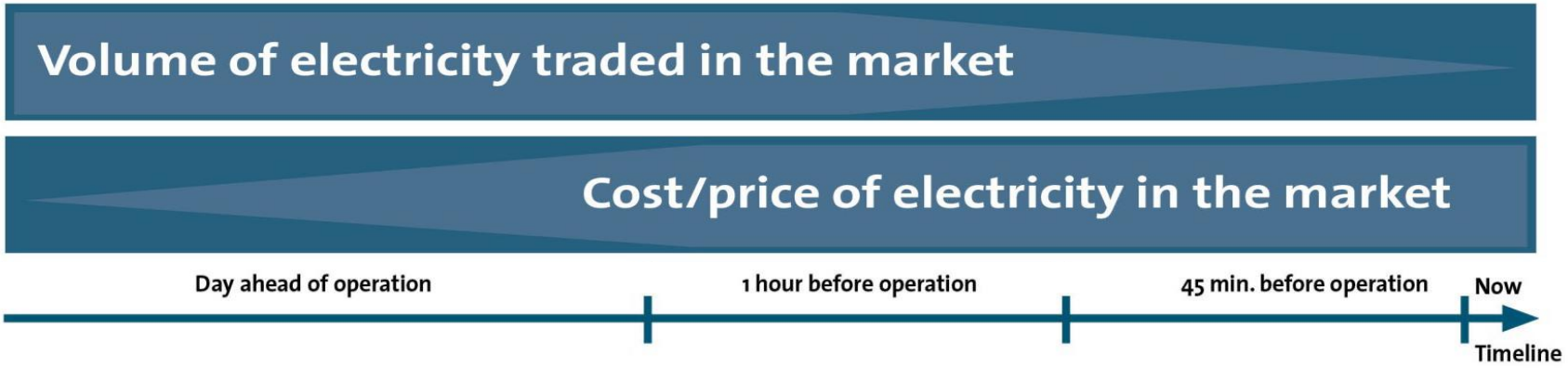
Electricity market setup – Nord Pool

- Deregulations started in the Nordic countries in the early 1990s and Nord Pool is established for trading power.
- West Denmark joins Nord Pool 1998, East DK in 2000.
- Day ahead market trades power between the Nordic countries and the Baltic region.



A well functioning market

Trading example

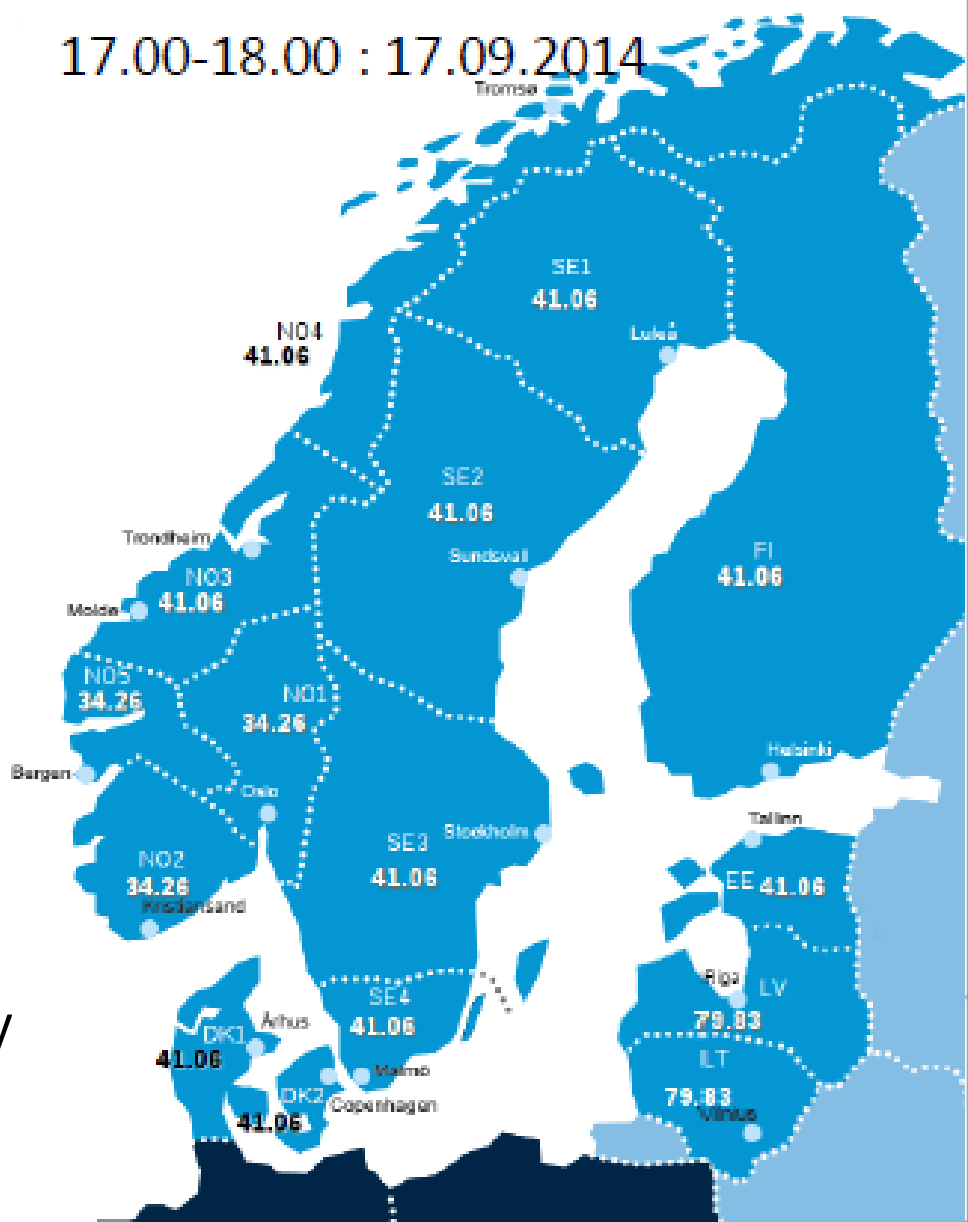


Day ahead market Elspot	Intraday market Elbas	Balancing market (Capacity reserves)
110 MWh forecasted production from wind farm the morning on the day before trading and sold on the spot market by balance responsible.	100 MWh forecasted production from wind farm after spot market is closed. 10 MWh purchased from a generator in ELBAS market.	95 MWh of real generation from wind farm. Balance responsible pay TSO for the 5 MWh of upregulating power needed to ensure balance.

A well functioning market

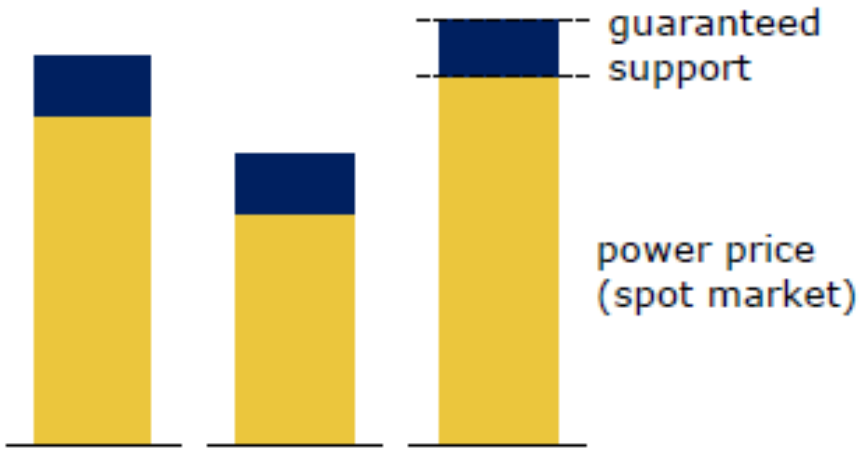
Day Ahead Market

- The day ahead market consists of 14 bidding areas.
- Potential up to 14 price zones, hence, there may be up to 14 different spot prices within 1 hour.
- The electricity flow from low price area to a high price area.
- Market splitting occurs when capacity on interconnections is fully utilised.



Support schemes

Large onshore wind – feed in premium



Feed-in Premium

25 øre/kWh (premium)

+ 2.3 øre/kWh (balancing compensation)

+ spot price (ca. 30 øre/kWh)

- Premium for the first ~25,000 full load hours. Hereafter, only spot price + balancing compensation.

- Premium is reduced by any amount that the spot market price exceeds 33 øre/kWh.

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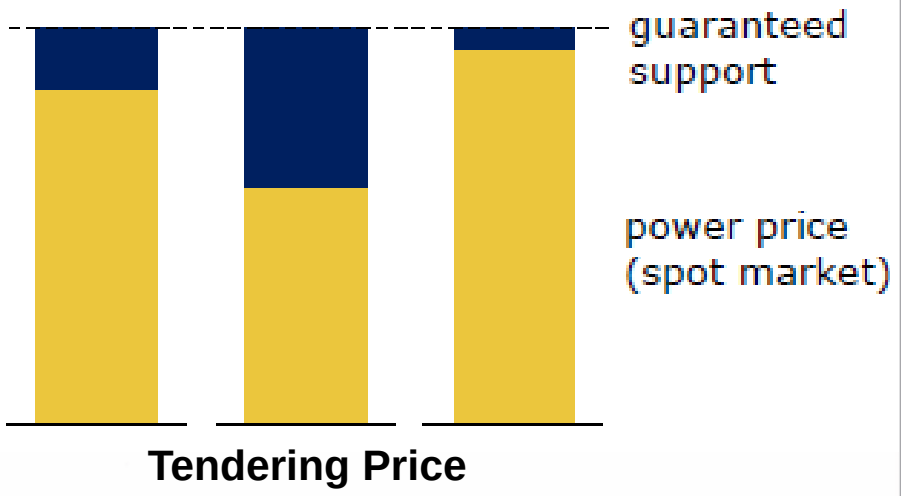
Support schemes

Offshore wind – Tendering price

Tendering Price

- For auctioned wind park, guaranteed price dependent on the winning bid, previous wind parks between 52-105 øre/kWh.
- Duration ~50,000 full loads hours, then only spot market price



Open Door

- Projects initiated next to auctions receive feed-in premiums at the same conditions as large onshore wind.

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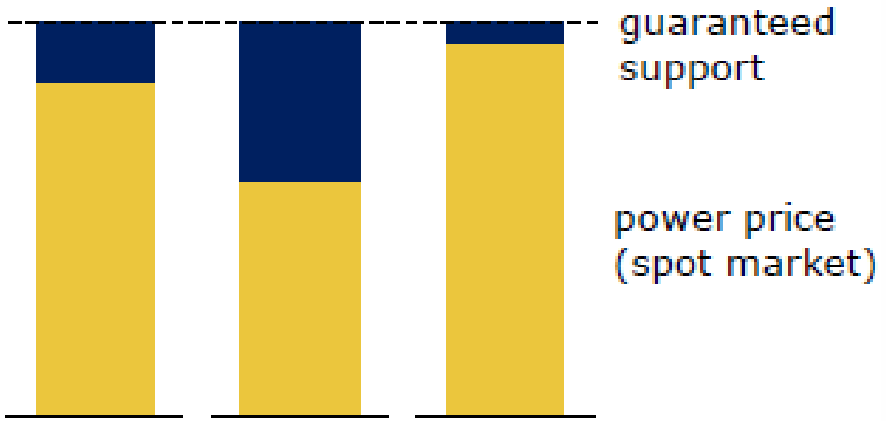
Support schemes

Photovoltaic – Feed-in tariffs

- Net metering savings effect of ca. 200 øre/kWh for private households and ca. 80 øre/kWh for companies. Net settlement within 1 hour.

- Tariff of 60 øre/kWh for 10 years followed by 40 øre/kWh for 10 years.



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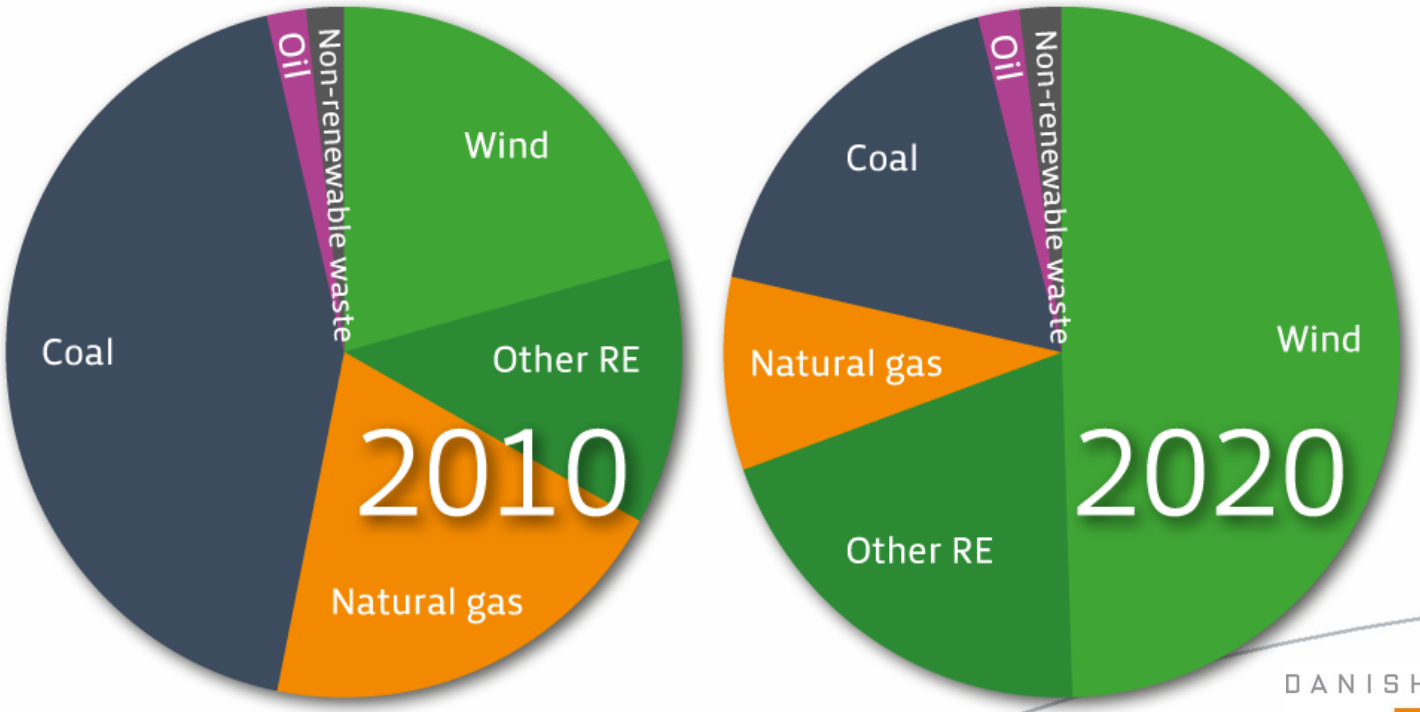
Results and projections

- Cheapest / most cost-efficient offshore wind in Europe.
- Ability to export electricity to neighboring countries on windy days.



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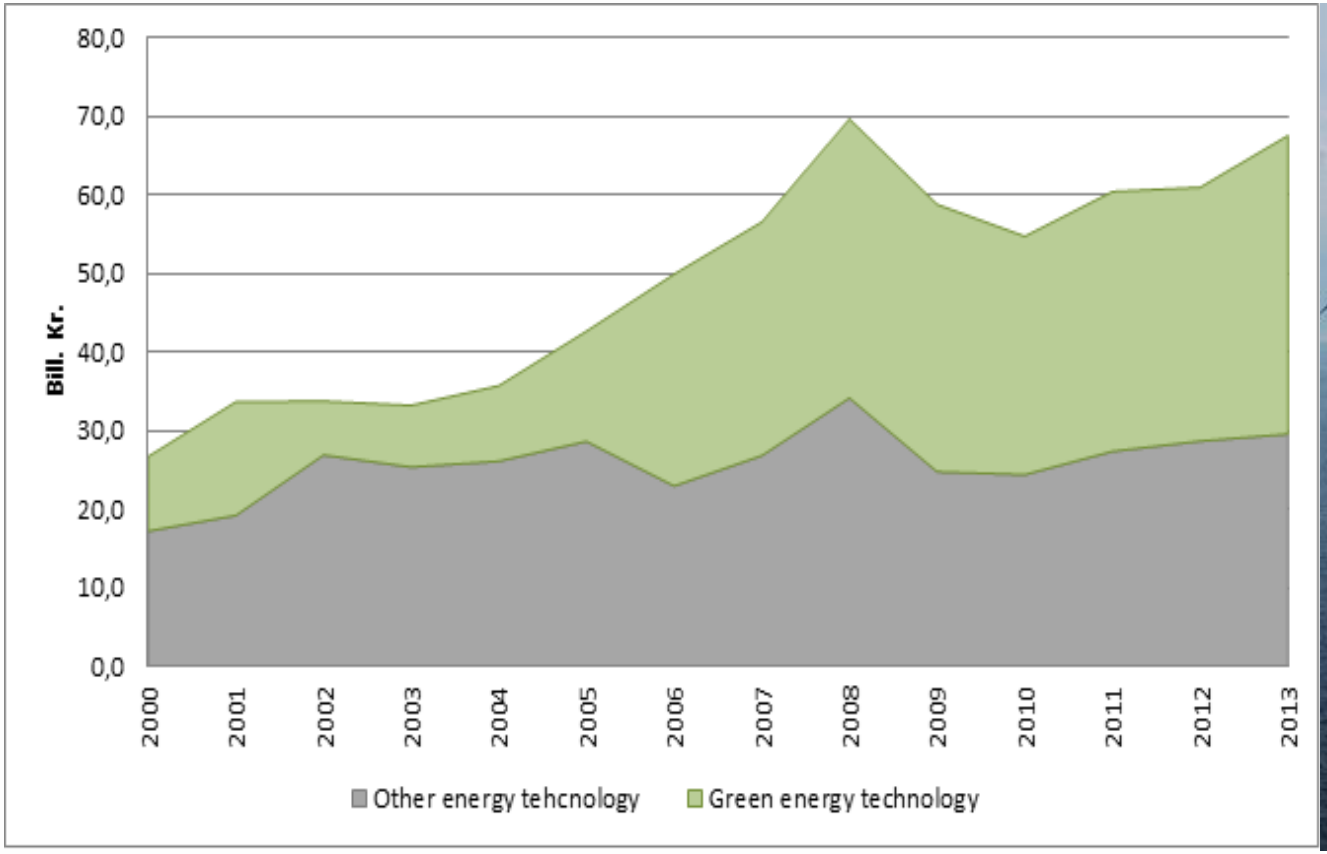
Export of Green Energy Technology



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Conclusion

- ✓ De-linking Economic Growth, GHG Emissions and Energy Consumption
- ✓ Stable Policy Frameworks for Investment Security
- ✓ Dedicated Private Sector Needed to Deliver Solutions

Thank you

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