DRAFT

Distributed power participation in the Danish electricity market: regulation and dispatch issues

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Danish Energy Association

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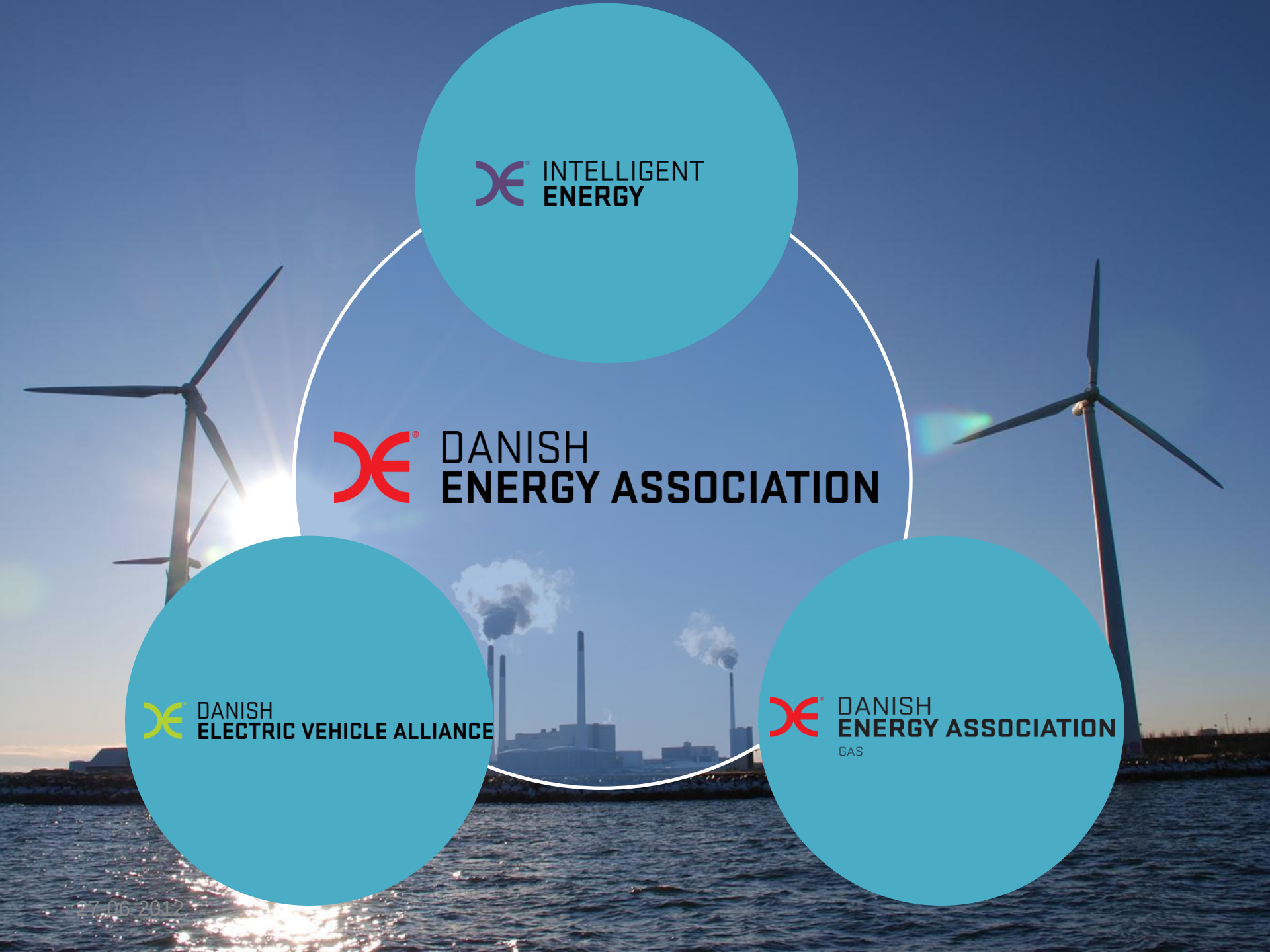
Agenda

1. Danish Energy Association
2. The Danish Power System – a brief
3. Are we witnessing a change of paradigm
4. Centralized vs. Distributed electricity generation
5. Distributed generation and the liberalized power market
6. Subsidies for Distributed Energy in Denmark
7. Technical constraints for DG
8. Efficiency issues – central vs. decentral


INTELLIGENT
ENERGY
DANISH
ENERGY ASSOCIATION
DANISH
ELECTRIC VEHICLE ALLIANCE
DANISH
ENERGY ASSOCIATION
GAS

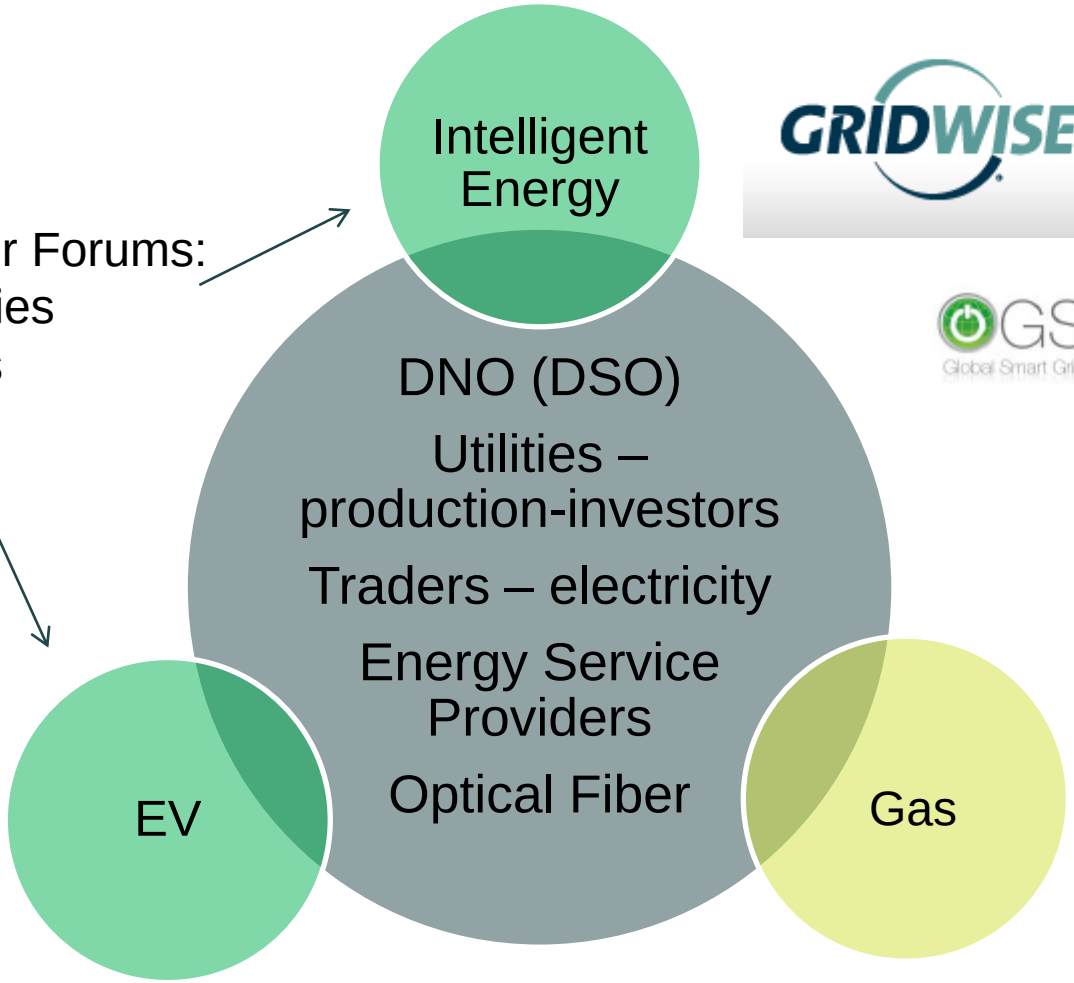
danish energy association

INTELLIGENT ENERGY

GRIDWISE ALLIANCE

GSGF
Global Smart Grid Federation

Broad stakeholder Forums:
- Energy companies
- Tech companies
- Academia



DANISH ELECTRIC VEHICLE ALLIANCE

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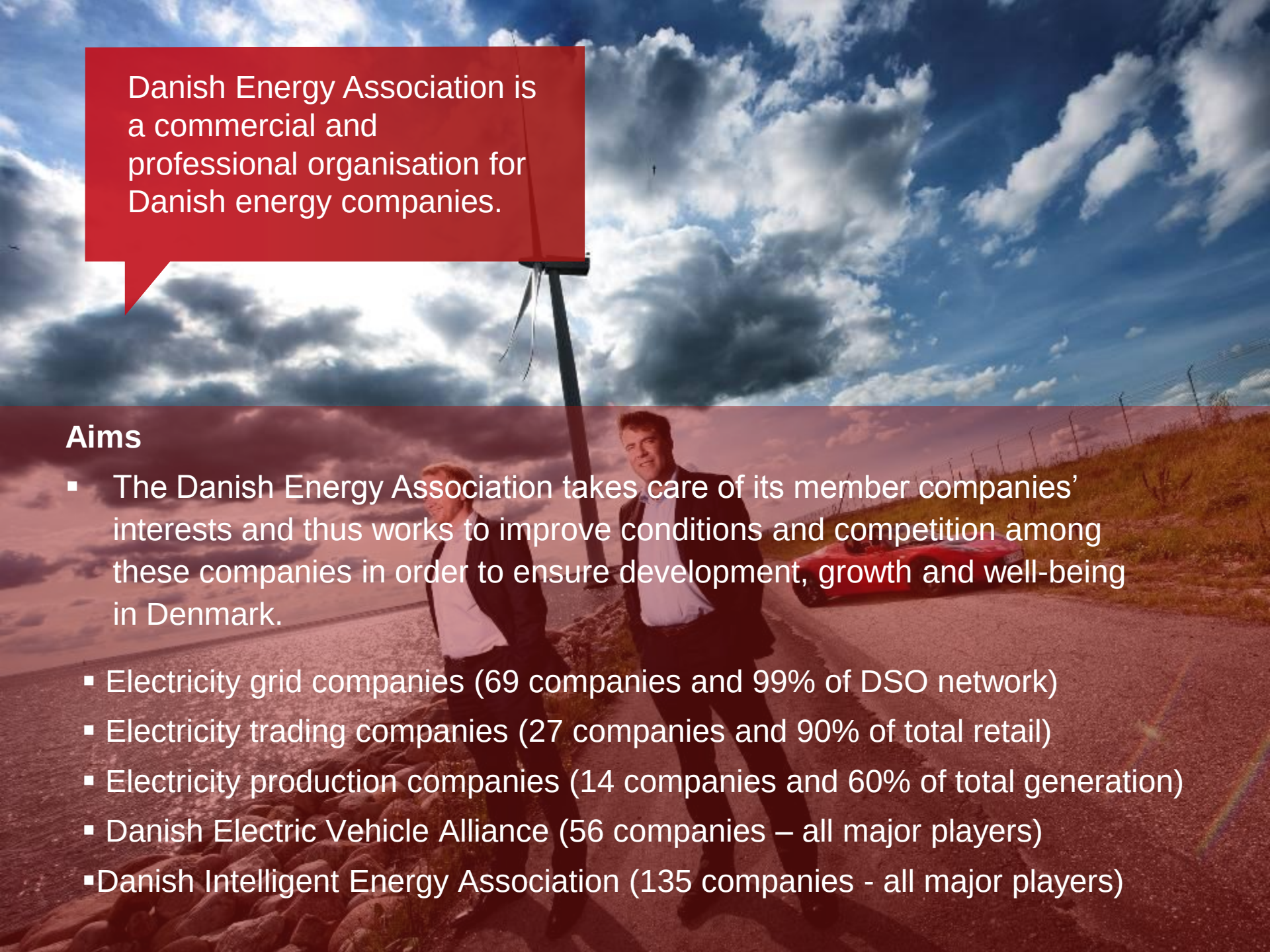

Danish Energy Association is a commercial and professional organisation for Danish energy companies.

Aims

- The Danish Energy Association takes care of its member companies' interests and thus works to improve conditions and competition among these companies in order to ensure development, growth and well-being in Denmark.

- Electricity grid companies (69 companies and 99% of DSO network)
- Electricity trading companies (27 companies and 90% of total retail)
- Electricity production companies (14 companies and 60% of total generation)
- Danish Electric Vehicle Alliance (56 companies – all major players)
- Danish Intelligent Energy Association (135 companies - all major players)

Our offices in Copenhagen and in Brussels

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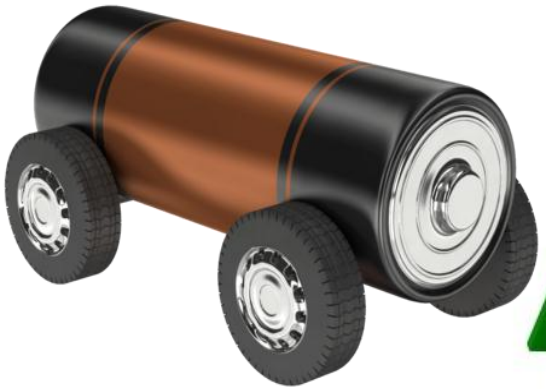
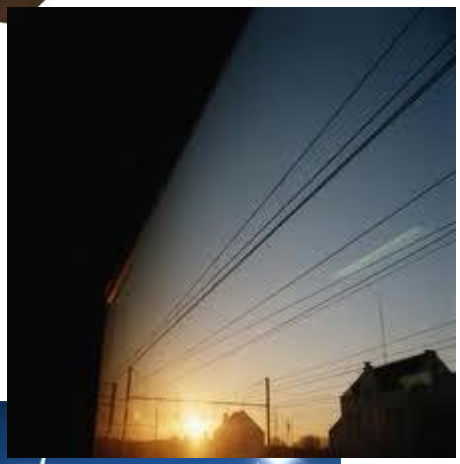
Energy companies and business areas





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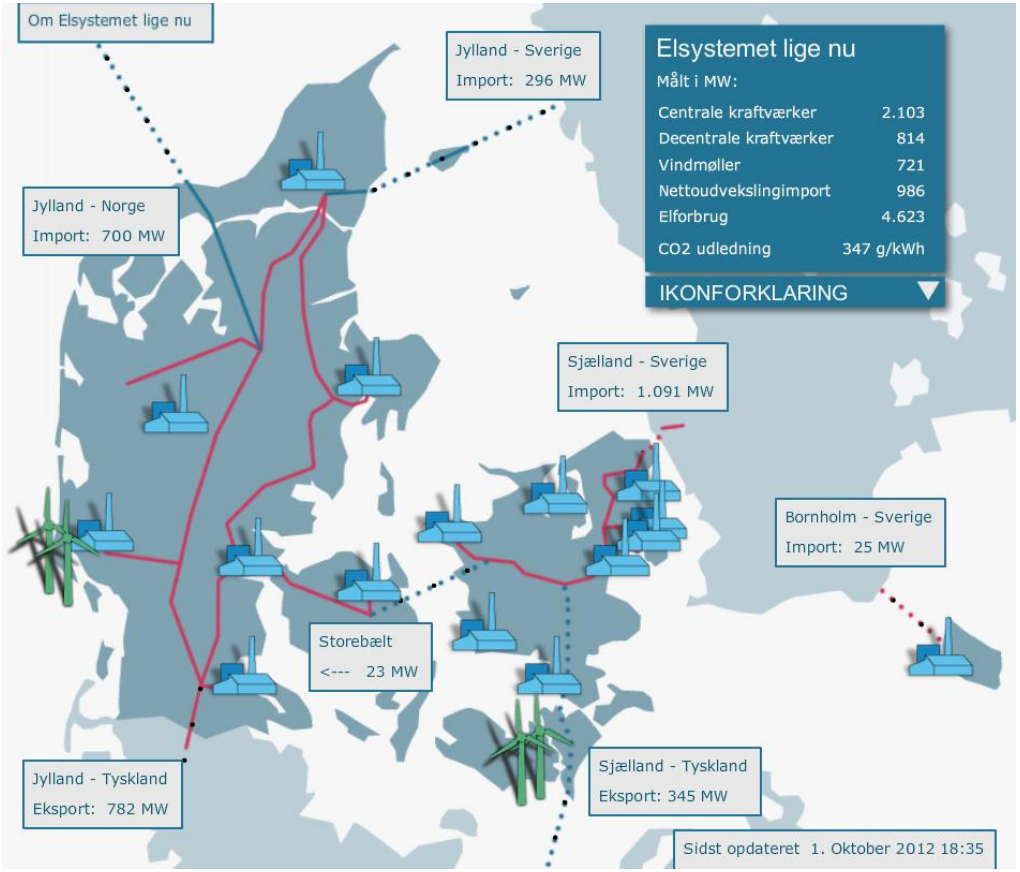
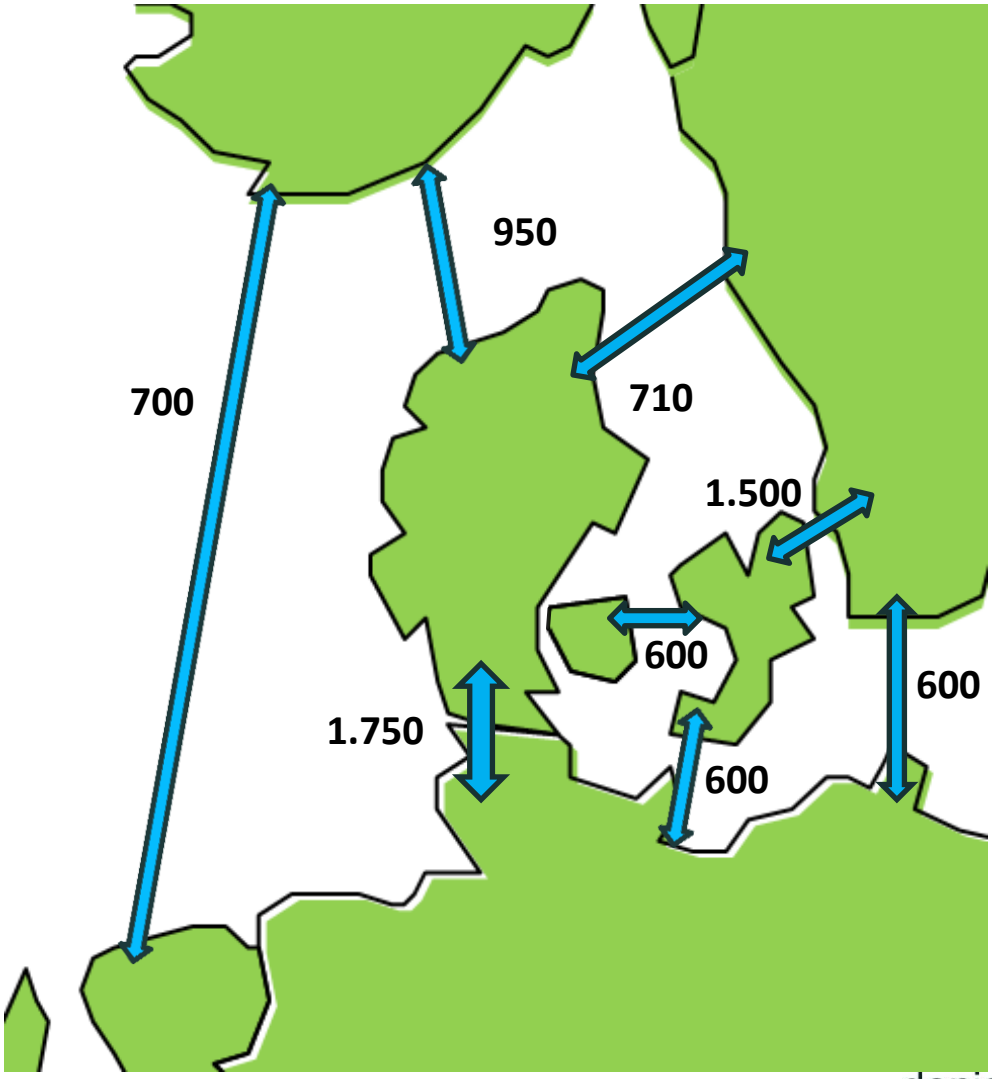
About Denmarks current power system

- Strong connections to neighbouring countries
- Part of Nord Pool market
- Relatively small market
  - Denmark 36 TWh
  - Sweden 150 TWh
  - Norway 136 TWh
  - Germany 600 TWh
- 4000 MW wind power installed (30 % of prod.)



Transmission capacities in 2012, MW



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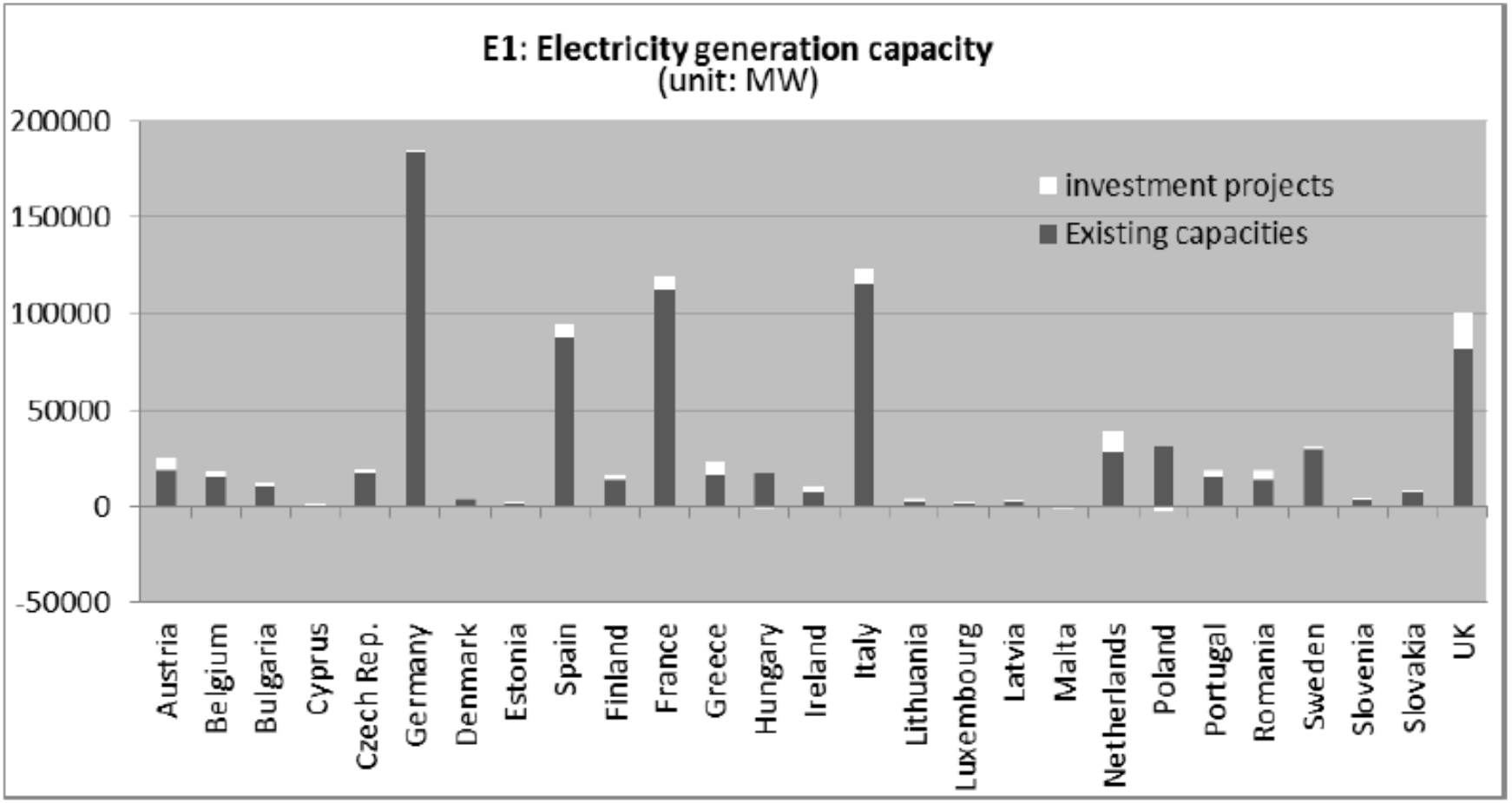
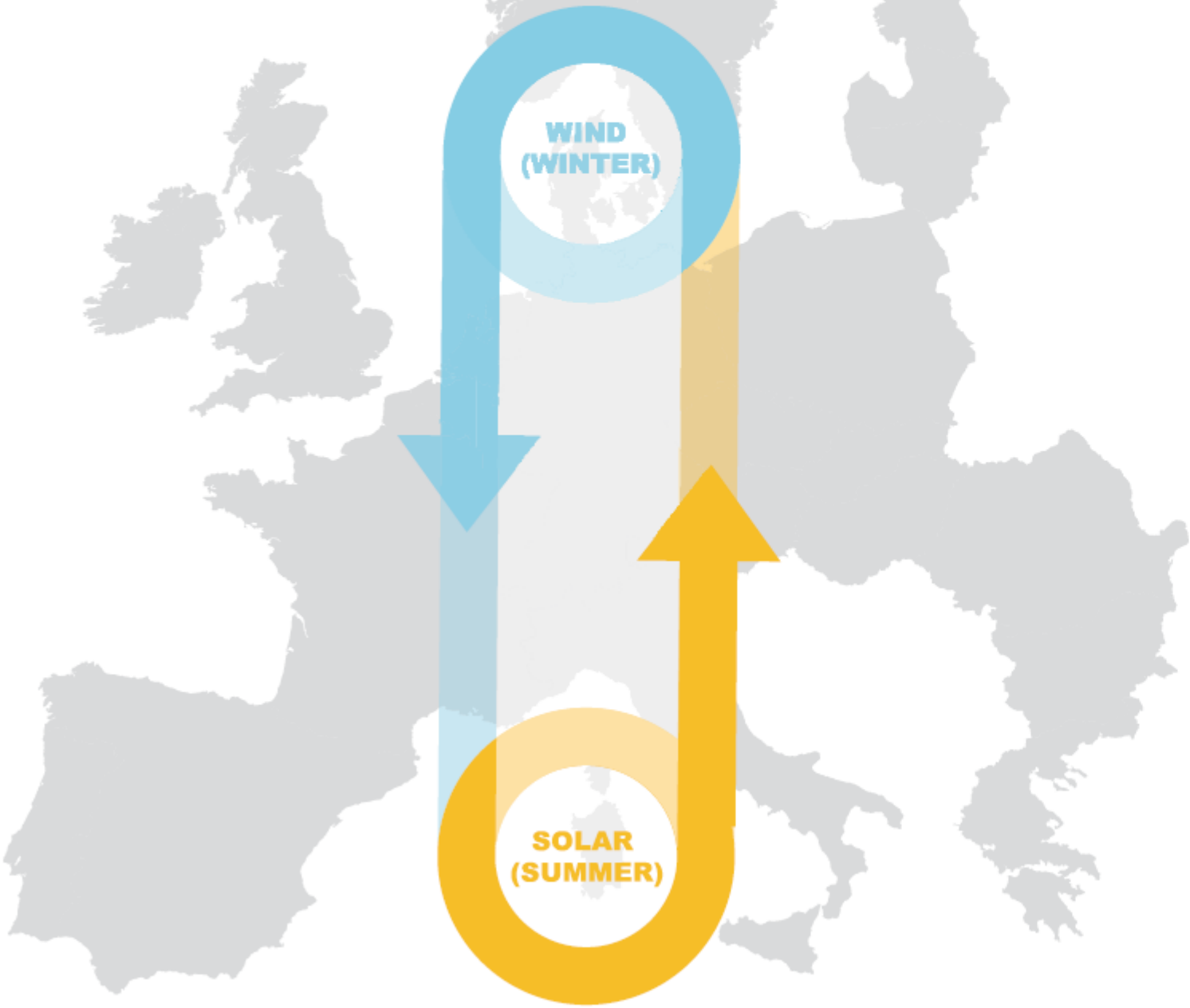
Electricity generation capacity – EU countries

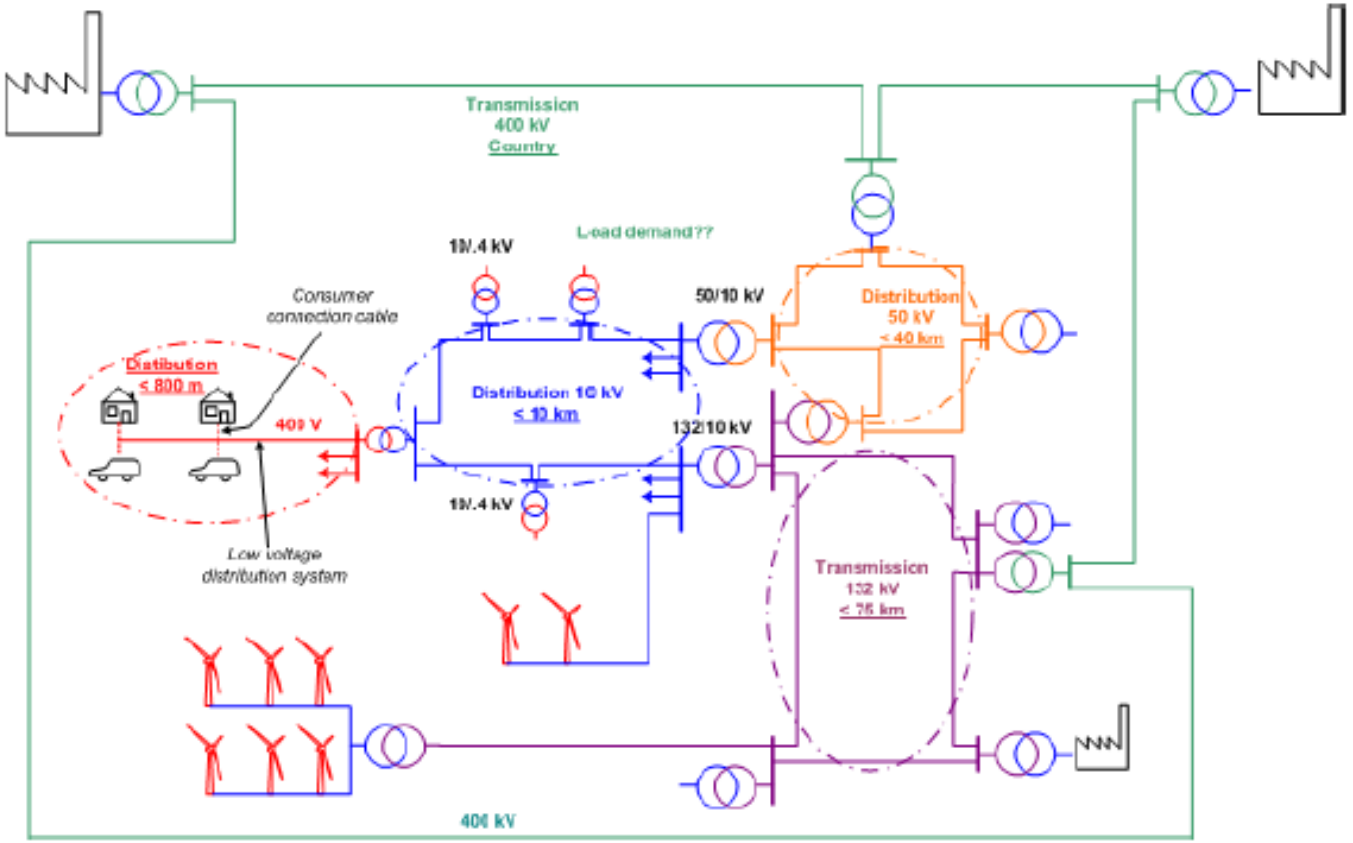


Existing capacity at 1/1/2011. Investment projects at 31/3/2011.

The revolution of the European energy system – long term perspective



The electrical grid in Denmark



Note: The voltage levels in the figure may differ from one electrical grid to another. The voltage levels shown in the figure are the ones used in Eastern Denmark which differ from the voltage levels in Western Denmark.

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Goals for Danish Energy system

2020: 50% wind power in electricity consumption

2020: 40% reduction of GHG emissions vs. 1990

2030: Coal out of power plants

2035: 100% renewable energy in electricity and heating sector

2050: 100% renewable energy

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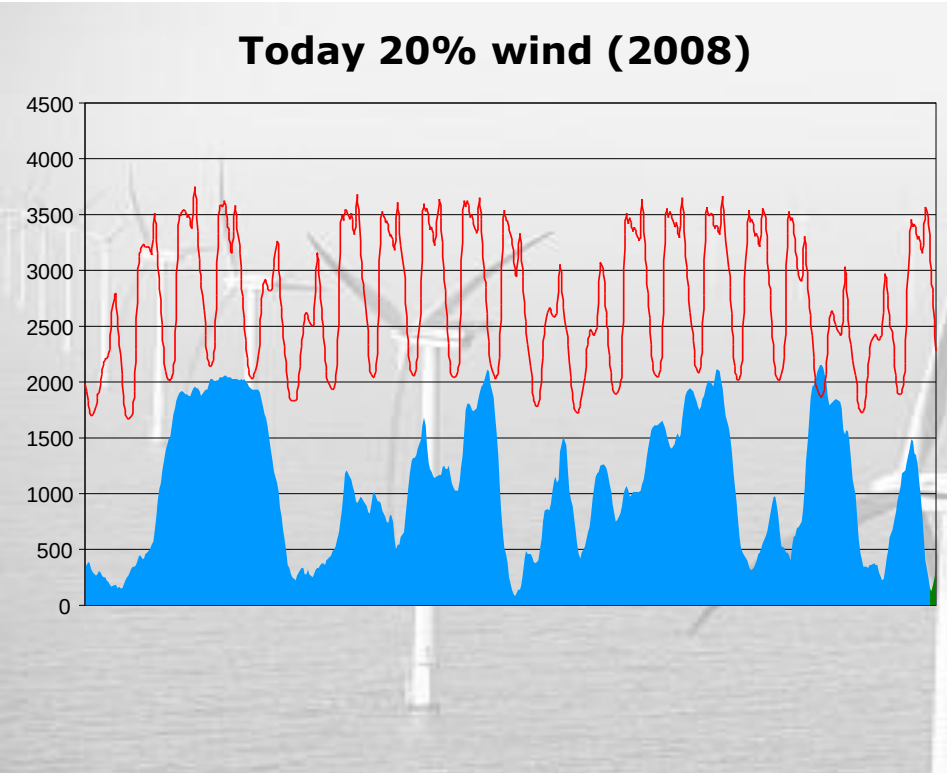
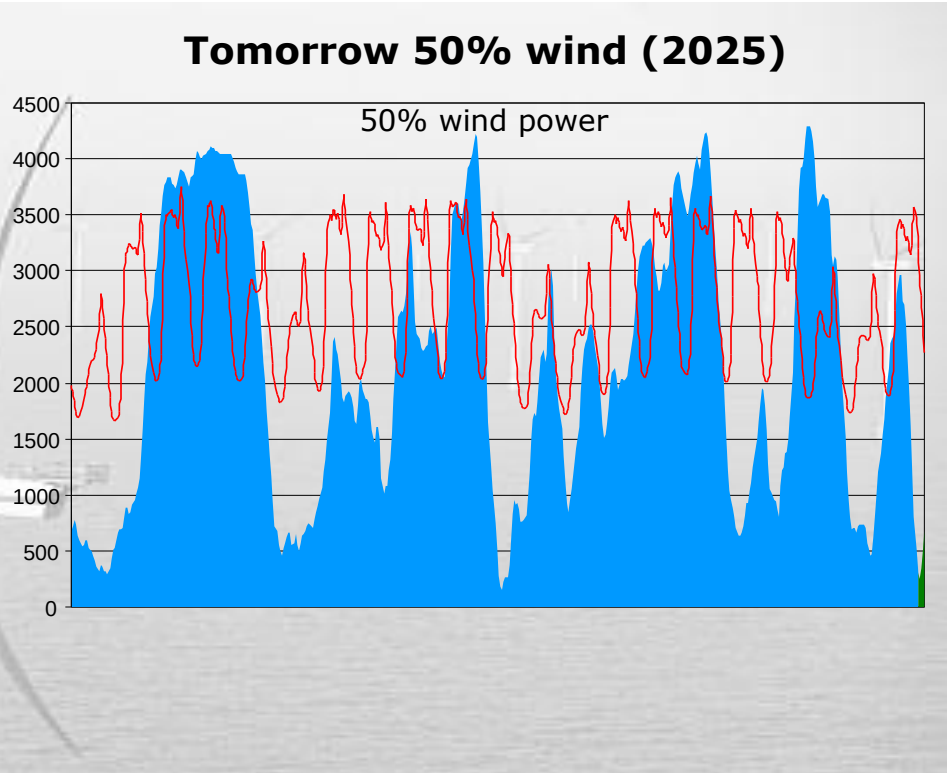
We need back up capacity with short back up time



Wind power covers the entire demand for electricity in 200 hours (West DK)



In the future wind power will exceed demand in more than 1,000 hours

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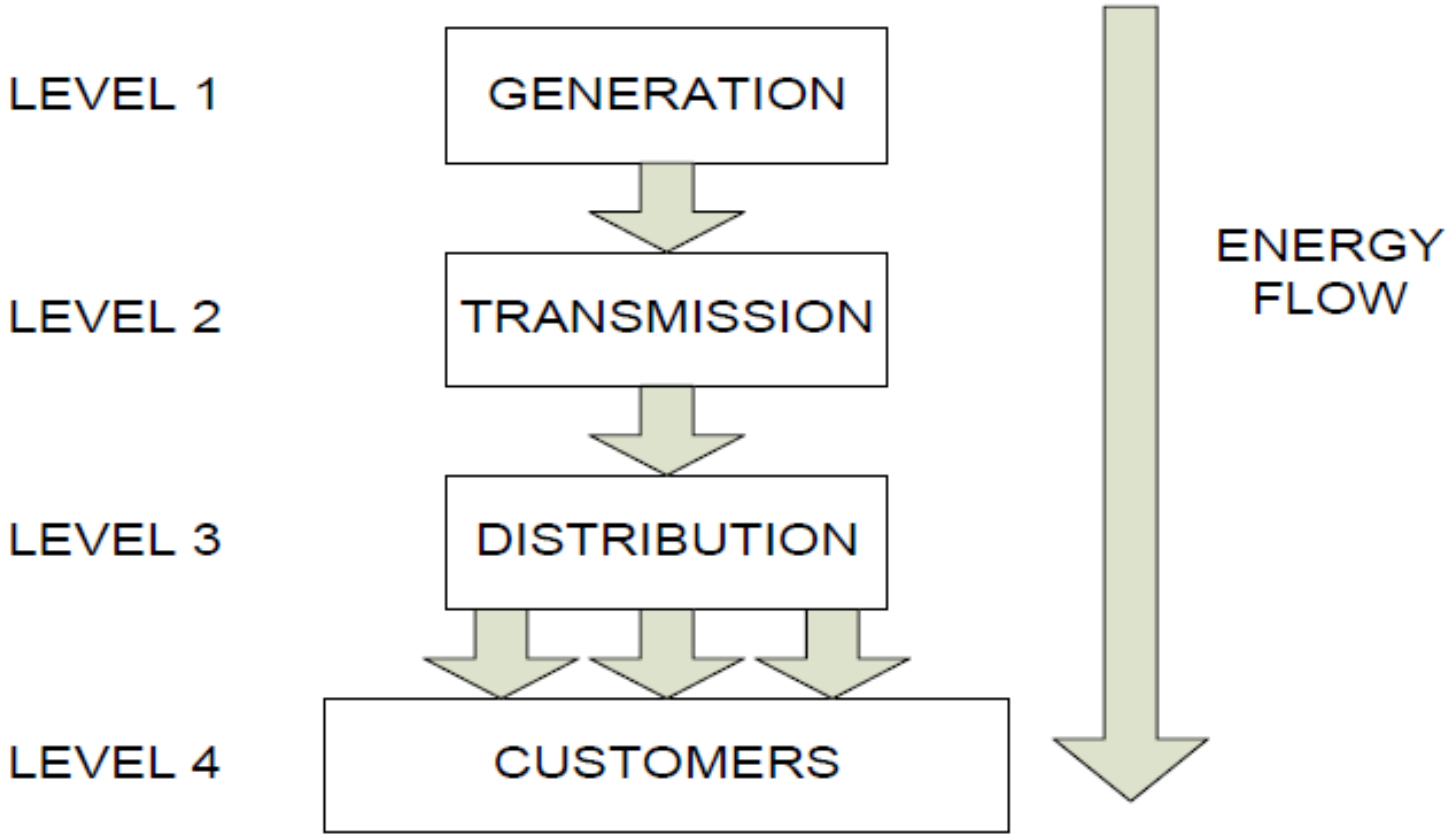
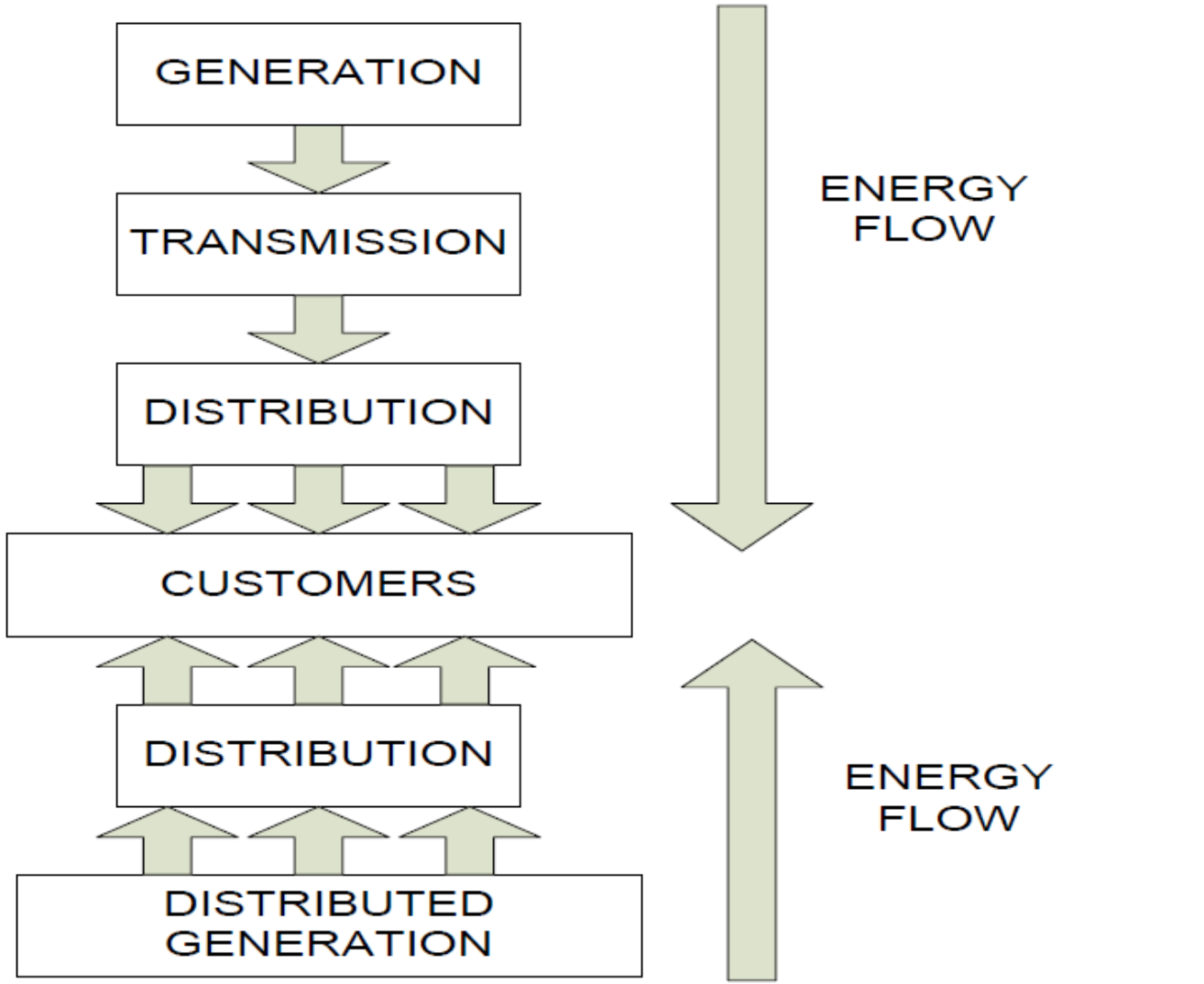
Traditional concept of power system



New concept of power system



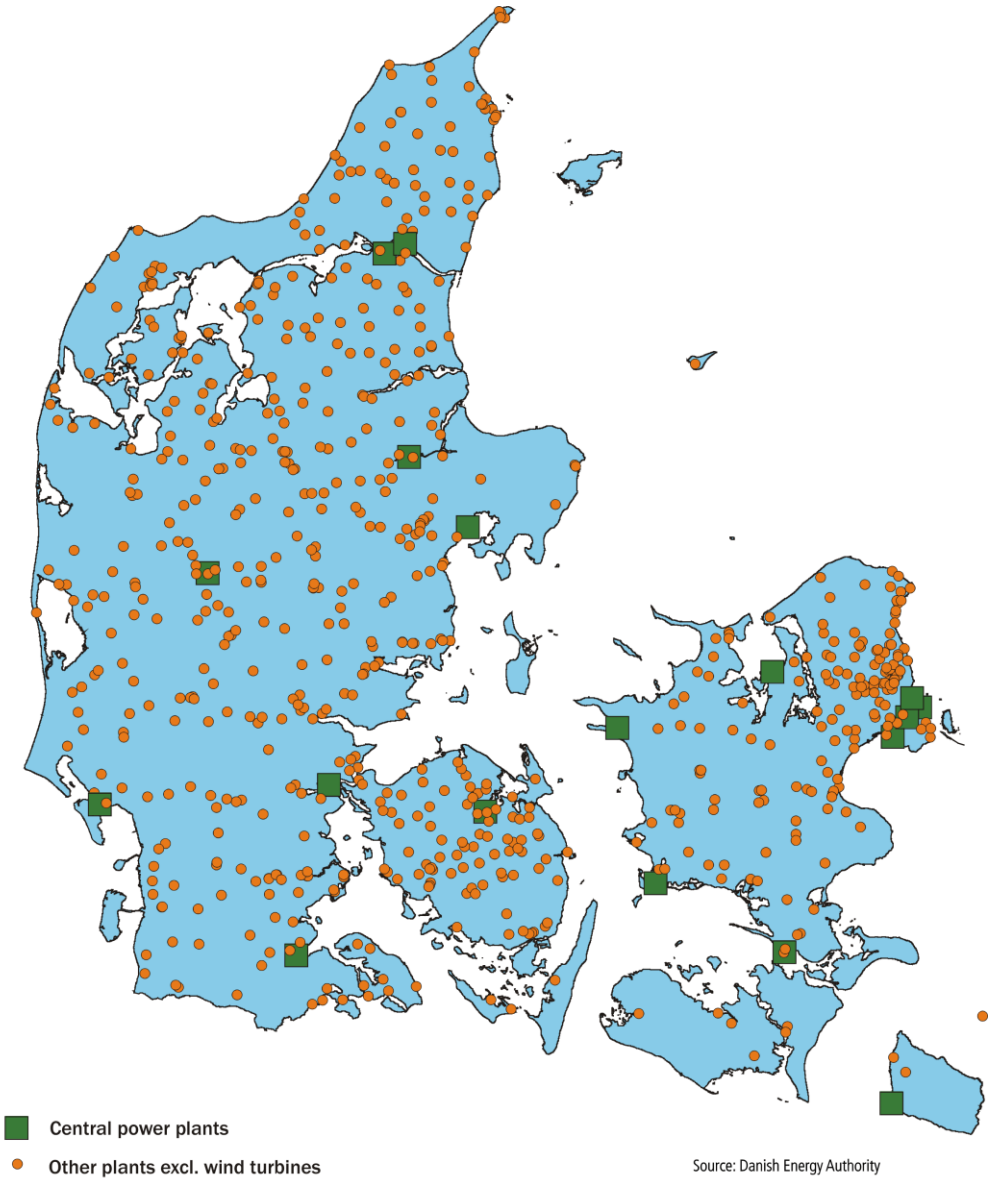
+ prosumers

Definition

Distributed generation is considered as an electrical source connected to the power system, in a point very close to/or at consumer´s site, which is small enough compared with the centralized power plants.

Denmark

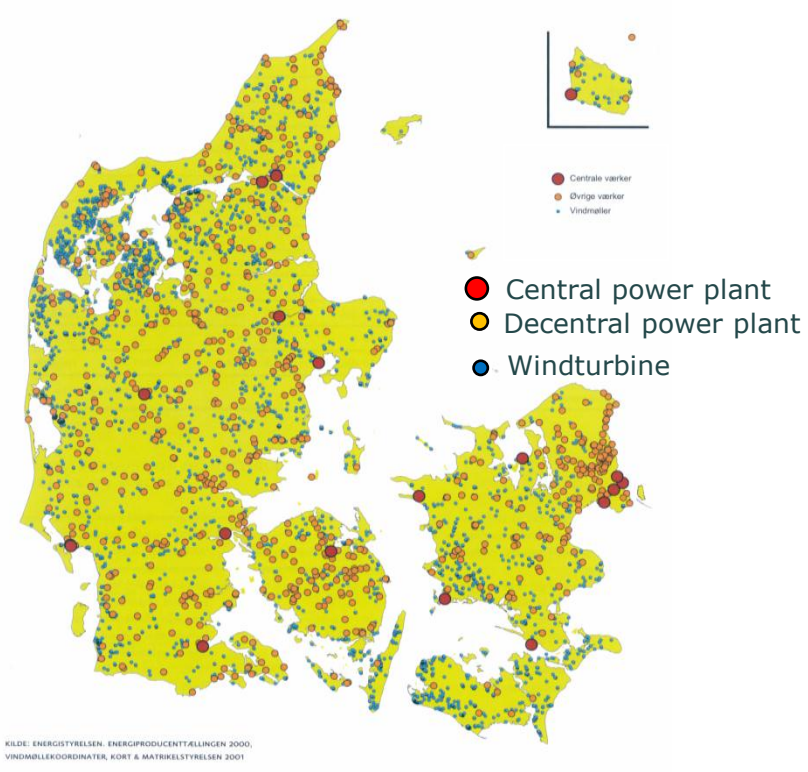
- *Population: 5.5 mio.*
- *BNP: 65500 mio. $*
- *Energy production: 1137 PJ*
- *Energi consumption: 864 PJ*
- *Degree of self sufficiency: 130 %*



Point of departure: From a centralised to a decentralised RES based energy system

1980

Today



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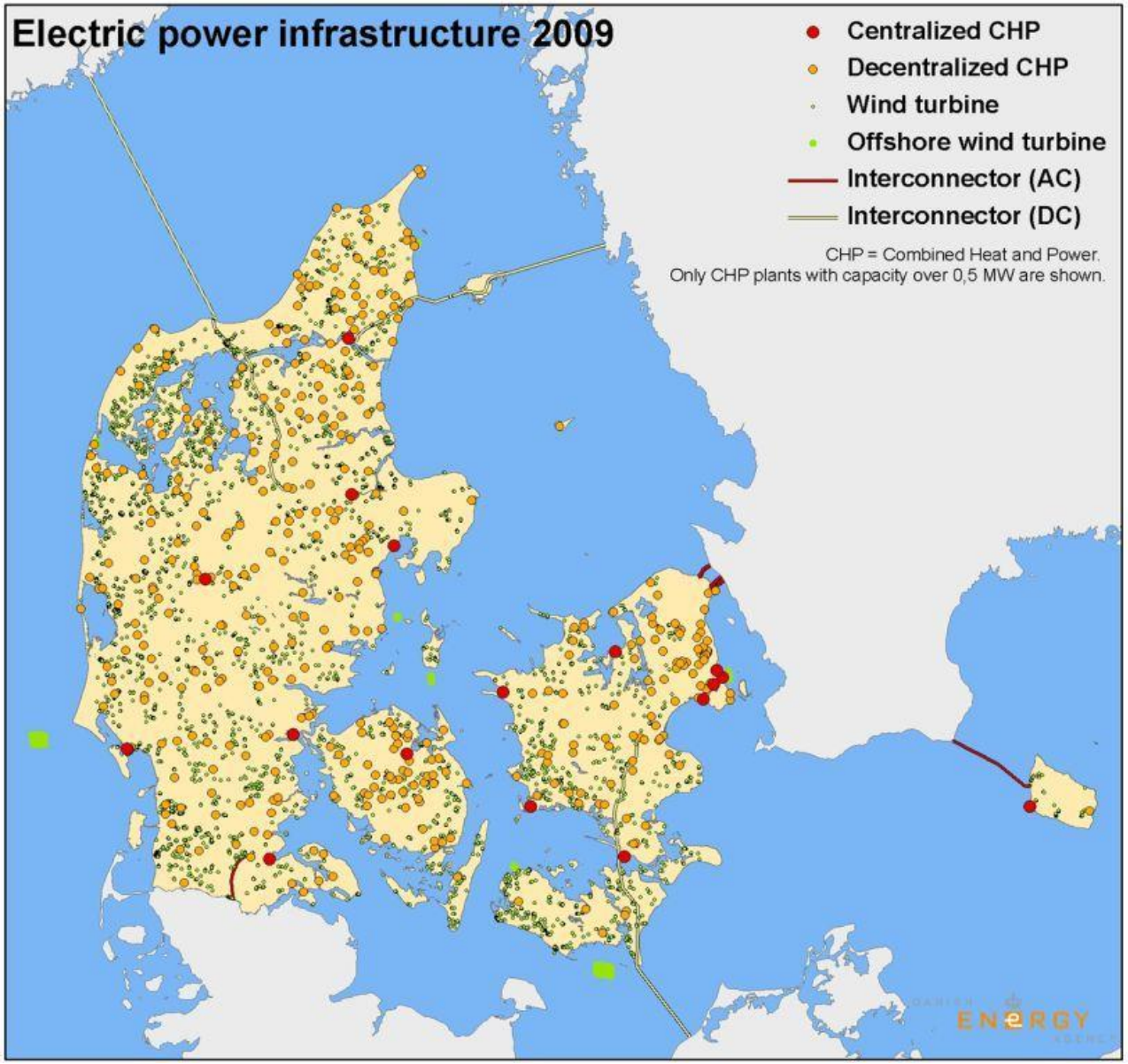
Danish power infrastructure, 2009



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NUMBER OF CHP AND DH PLANTS IN DENMARK

Public-heat supply (cities):
- 16 centralised CHP
- 285 decentralised CHP
- 130 decentralised DH plants

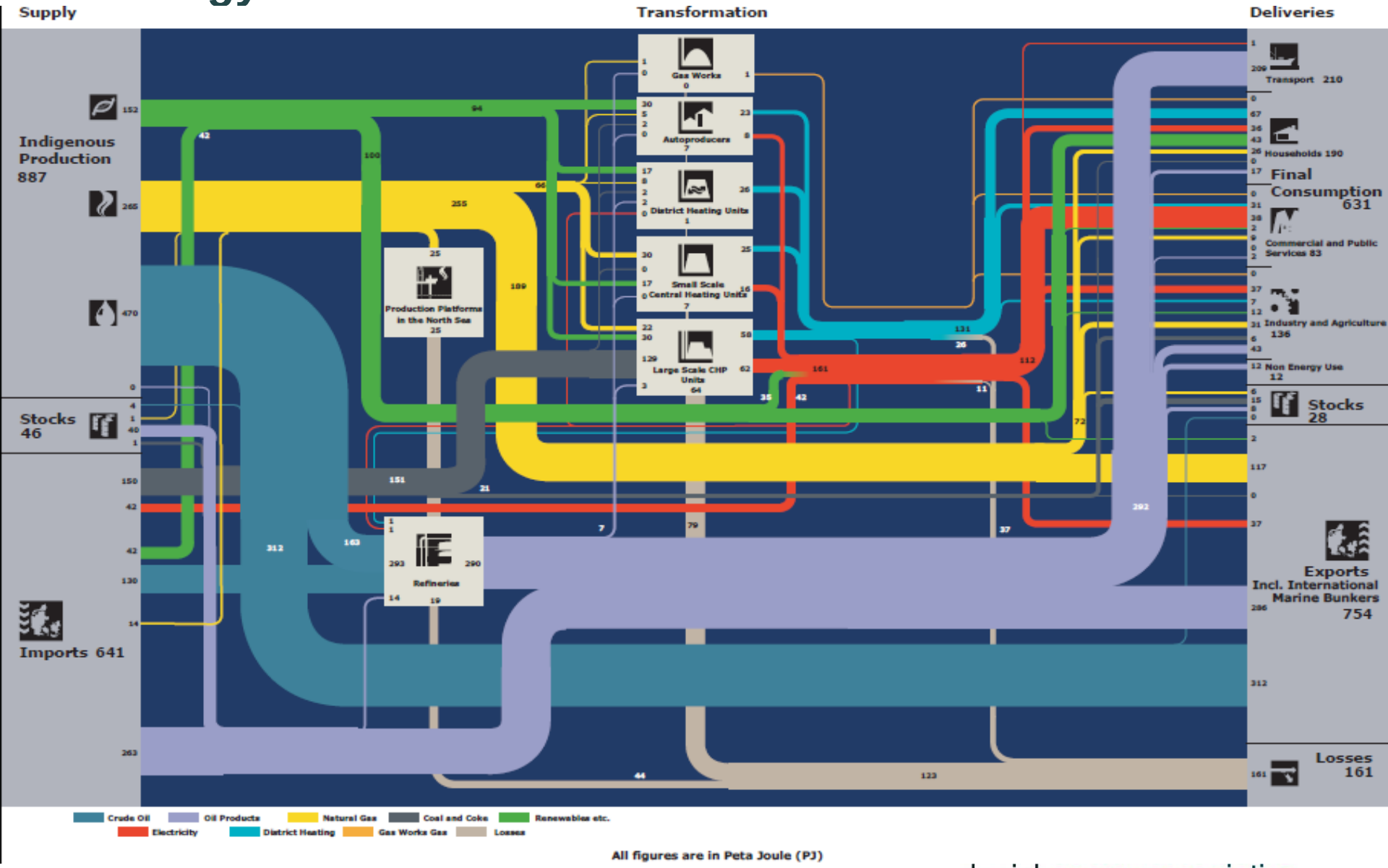
Private heat supply (enterprises, institutions):
- 380 CHP
- 100 DH plants

In all:
- 665 CHP
- 230 DH plants

From oil crisis to CHP and renewables (1970-2011)

- Oil crisis in the 1970s lead to focus on
  - Energy savings
  - Renewable energy
  - Combined heat and power
- Consequences
  - Decoupling on energy consumption and economic growth
  - Improved efficiency in consumption and production
  - Development of district heating
  - More decentralized energy system
  - Increase electricity trade beyond the borders
  - Increase in wind turbines
  - Decrease in emissions
  - Development of new technologies

Energy Flow - Denmark - 2011



All figures are in Peta Joule (PJ)

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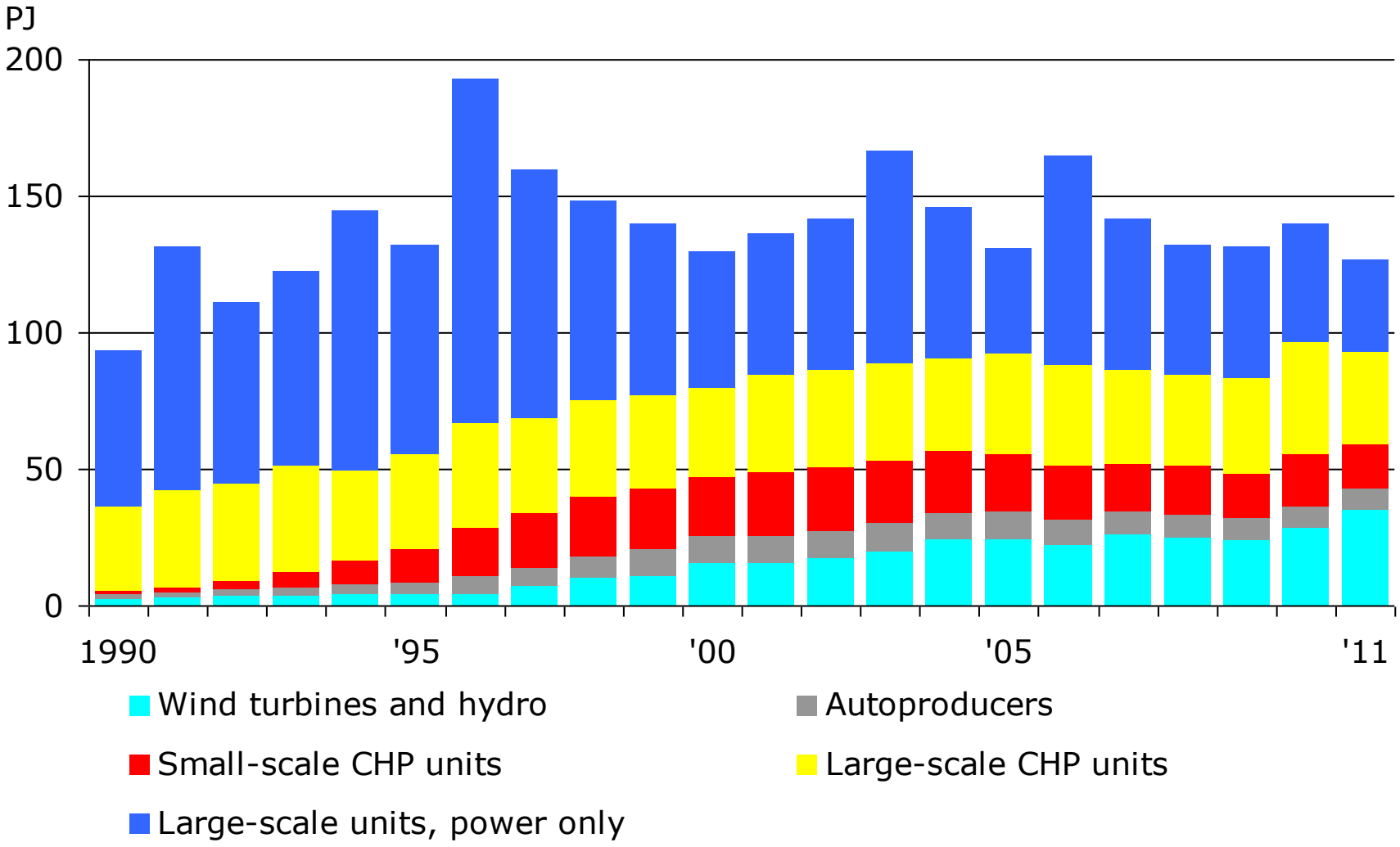
Electricity production by type of producer, Denmark



Source: Danish Energy Agency

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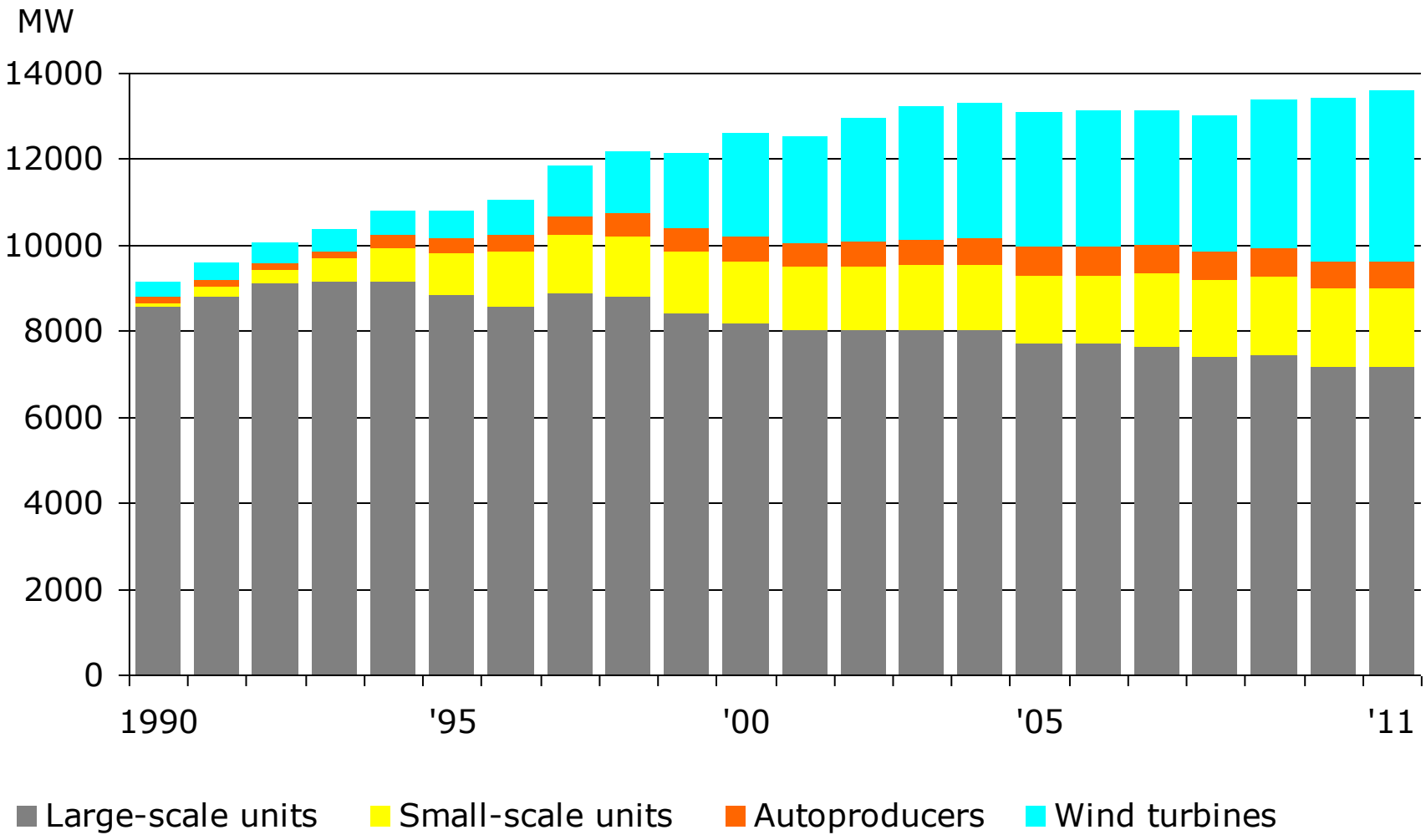
Electricity capacity, Denmark



Source: Danish Energy Agency

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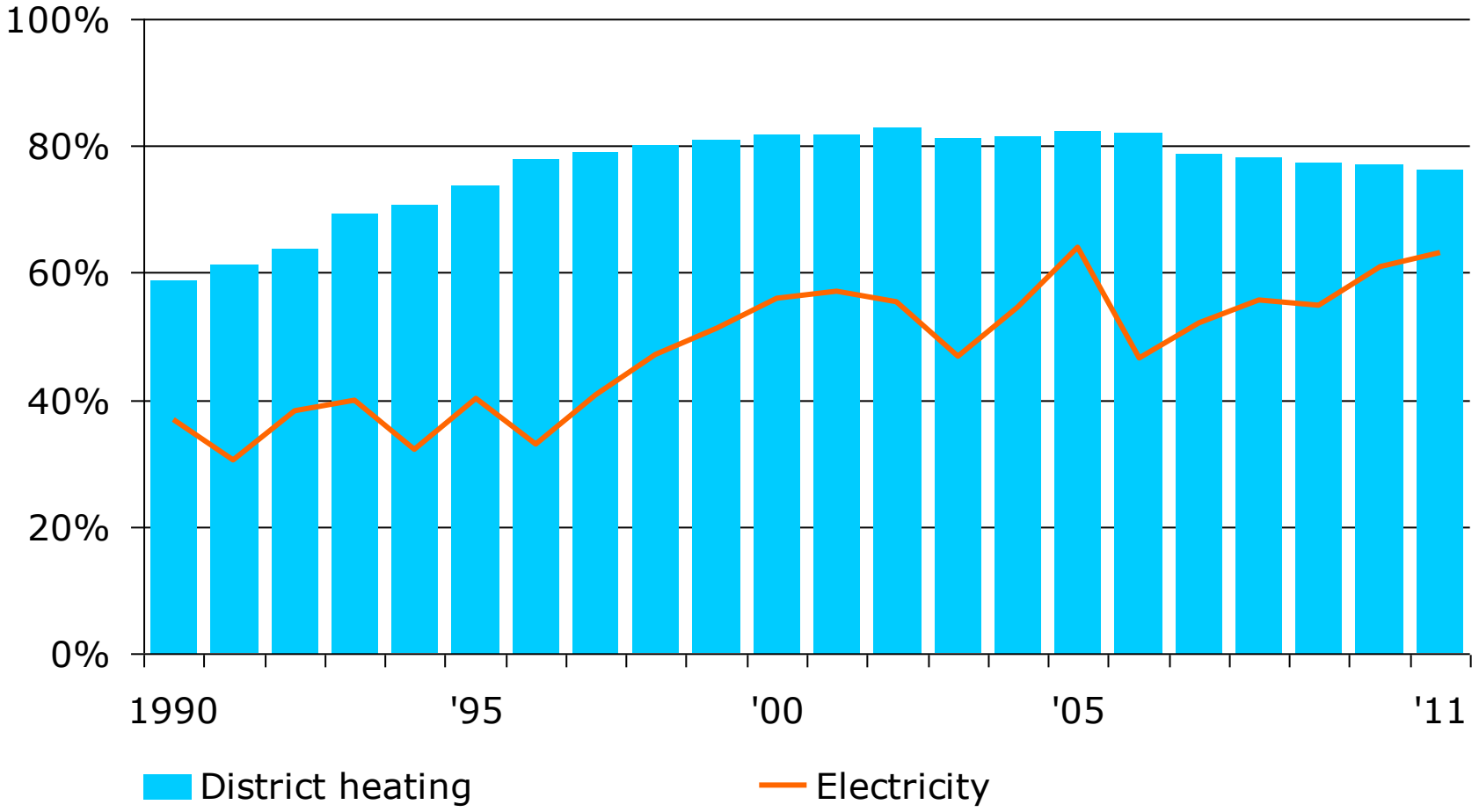
CHP share of thermal power and district heating production



Source: Danish Energy Agency

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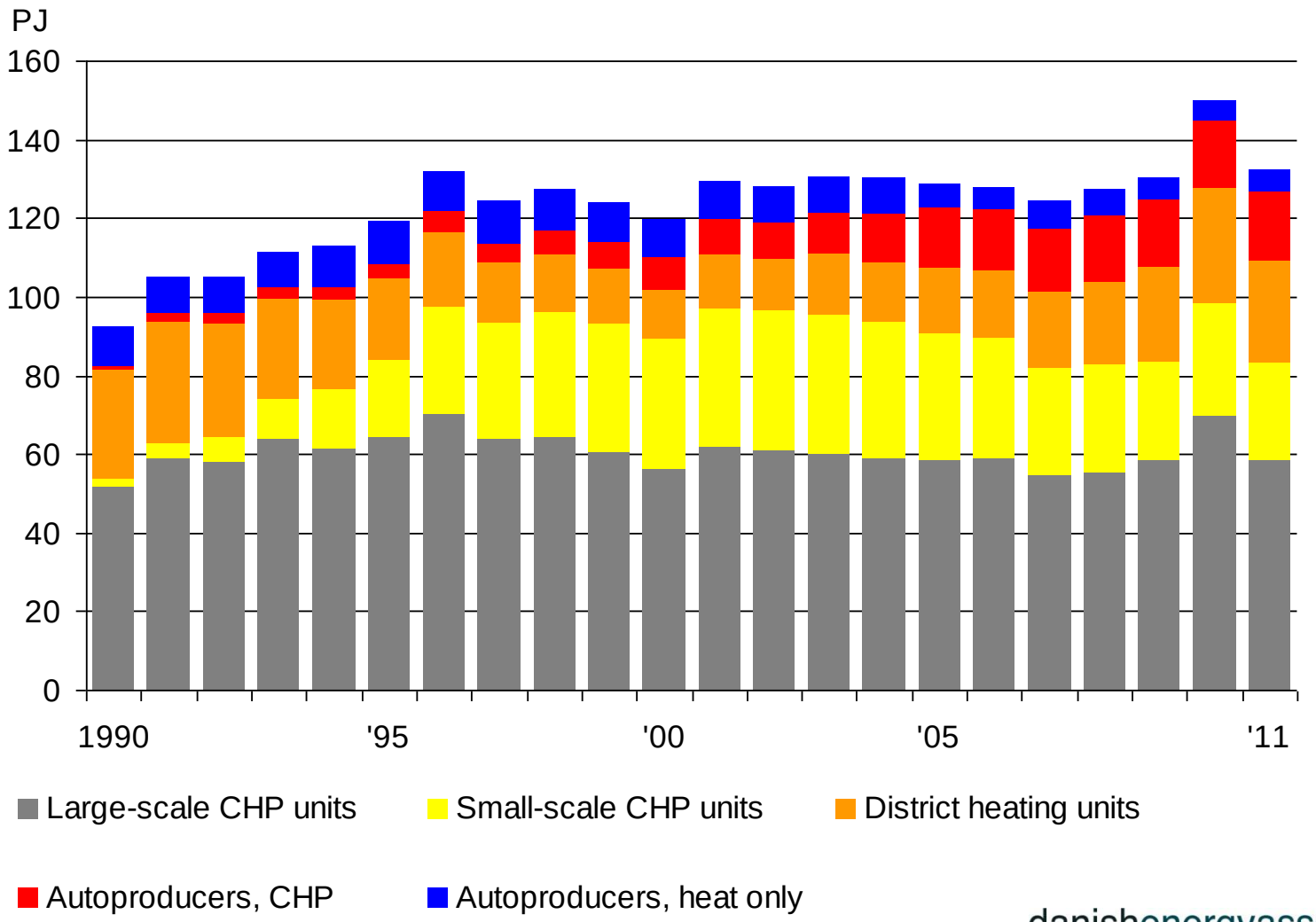
District heating production by type of production plant



Source: Danish Energy Agency

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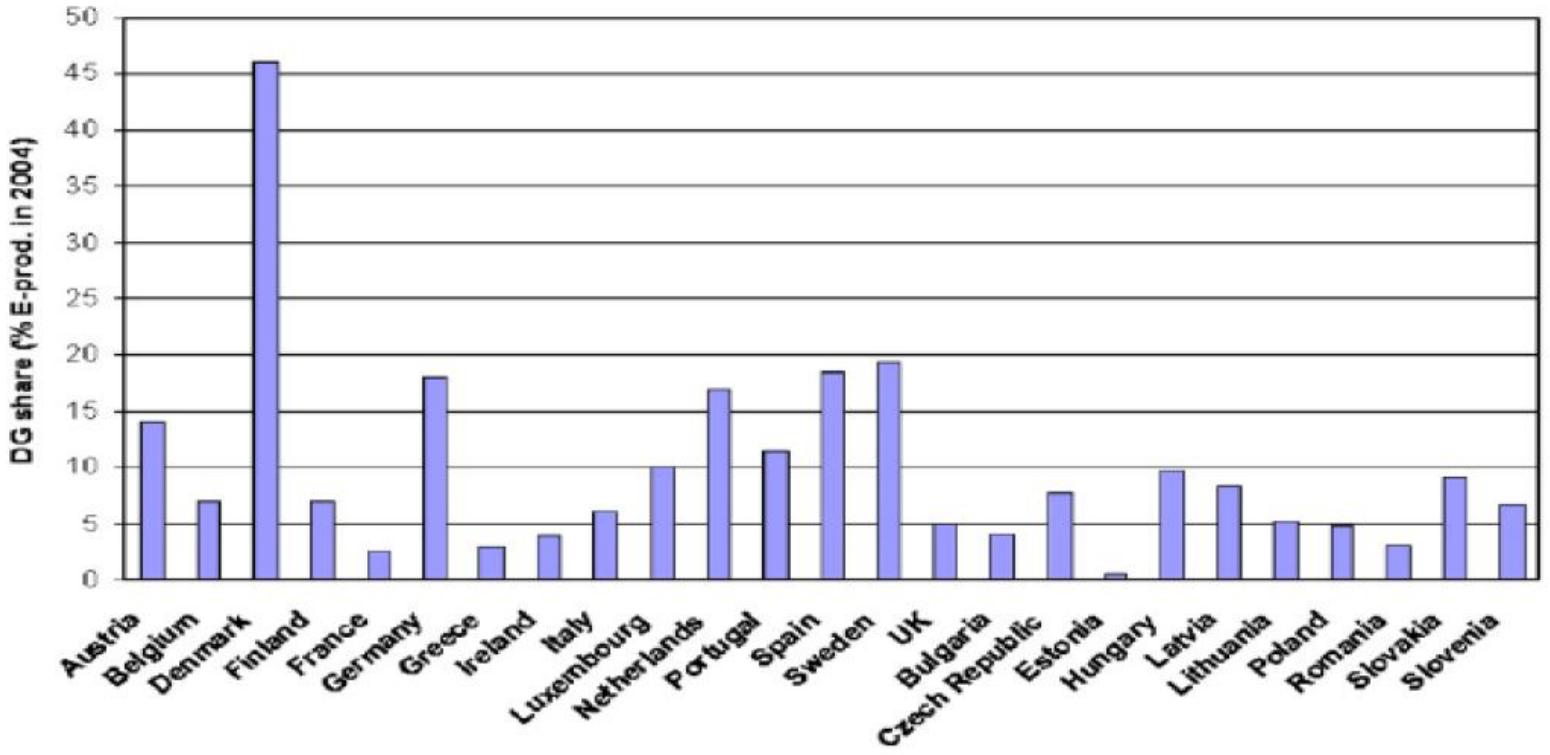
Distributed generation shares in total electricity production, EU-25



Cossent et al., 2009

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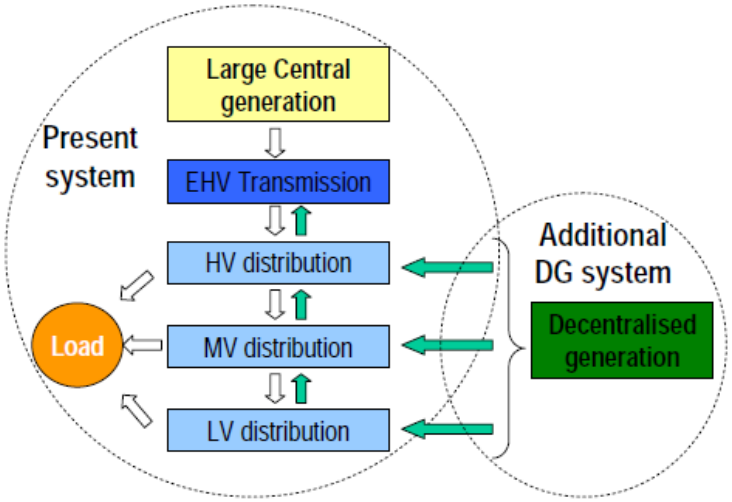
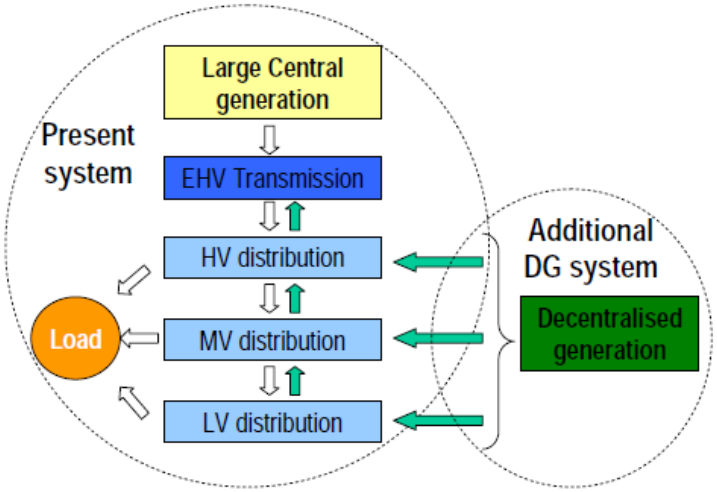
Why central power system?



<u>The traditional central power systems is driven by:</u>

- Economies of scale
- High energy efficiency
- Alternative current – less transmission loss
- Pooling of resources through transmission networks
- Environmental benefits
- Regulation favoring larger generation facilities

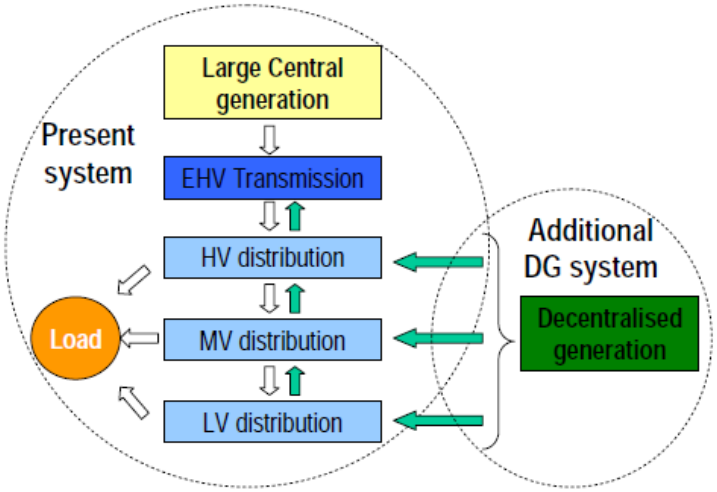
Drawbacks of centralized paradigm (I)



Decentralized power systems is driven by:

- Transmission and distribution costs – 30% of cost of delivered electricity and losses (line losses, unaccounted for electricity, conversion losses (changing voltage)).
- Rural electrification
- Investment costs to upgrade transmission and distribution networks
- Security and reliability (fuel diversity, back-up capacity to prevent operational failures)

Drawbacks of centralized paradigm (II)



<u>Decentralized power systems driven is by:</u>

- Environmental impact (NOx, SO2, …)
- Electricity deregulation and cost control device (to hegde against negative price impacts or to make a business based on price spikes on the market investments are made in distributed generation capacity)
- Energy efficiency – combined heat and power production to increase efficiency – steam and heat are even less easily transported than electricity, thus justifying distributed generation through production next to the point of consumption

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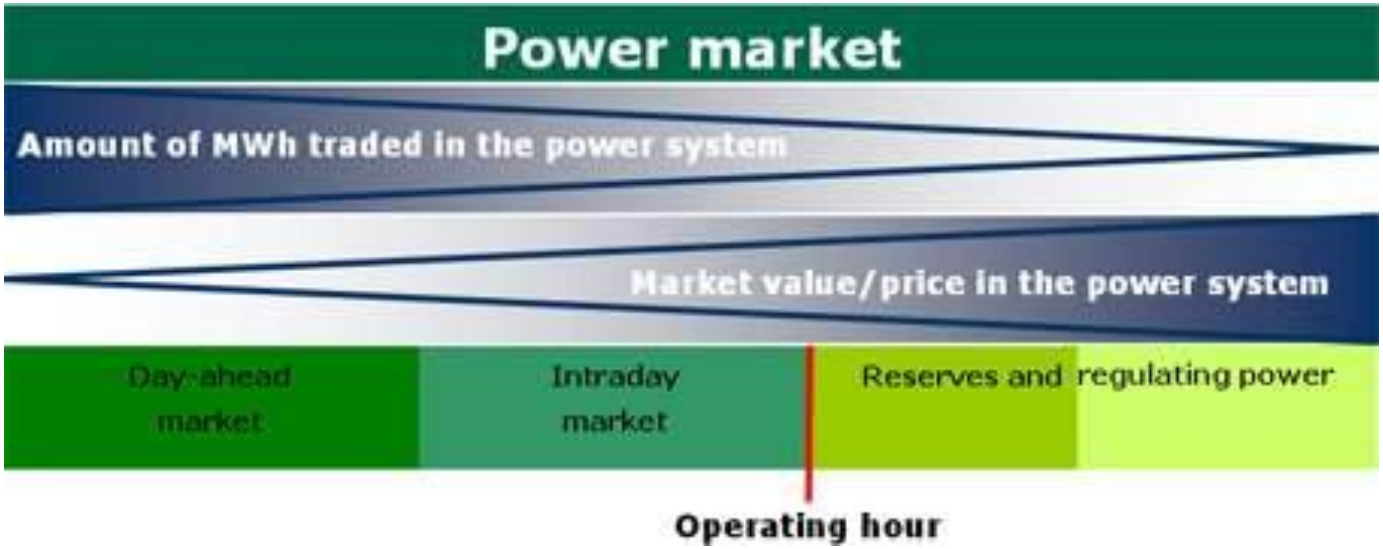
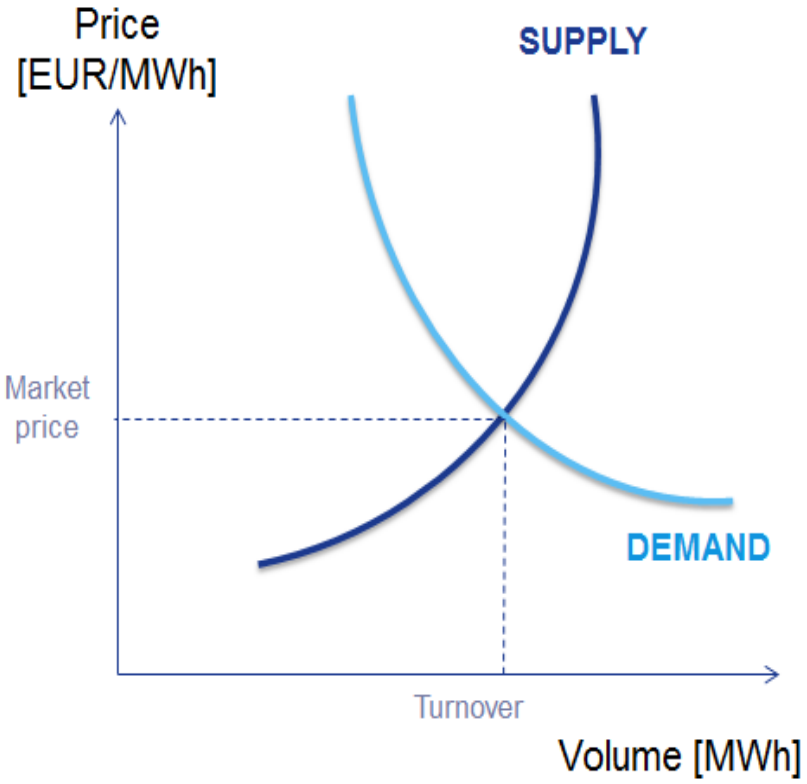
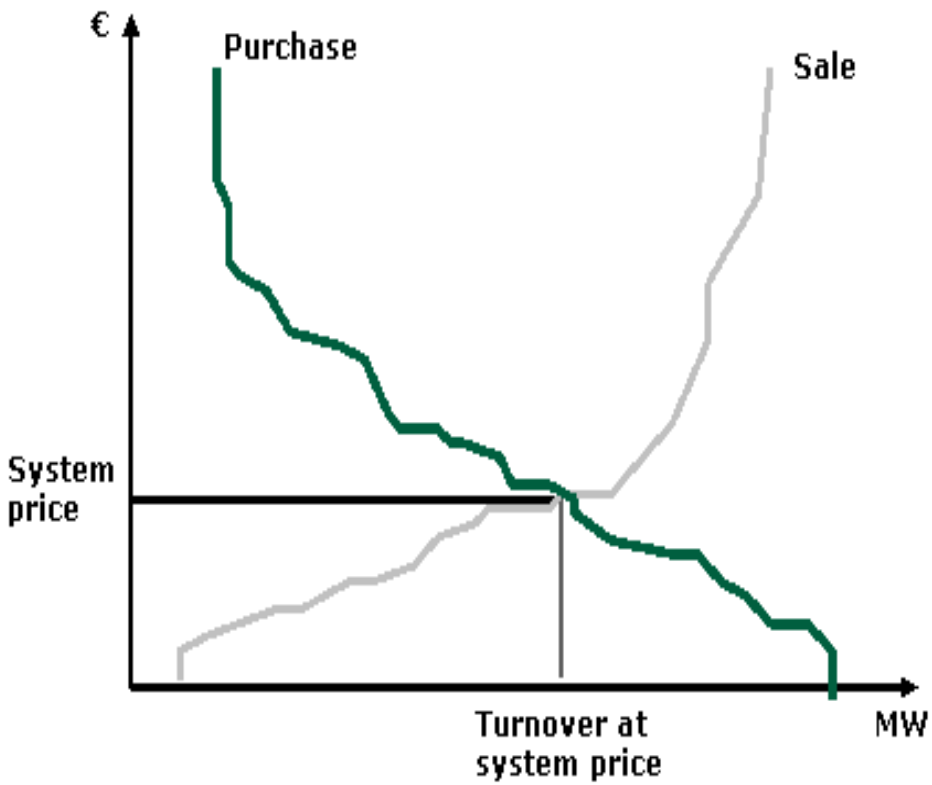
The power market in Denmark



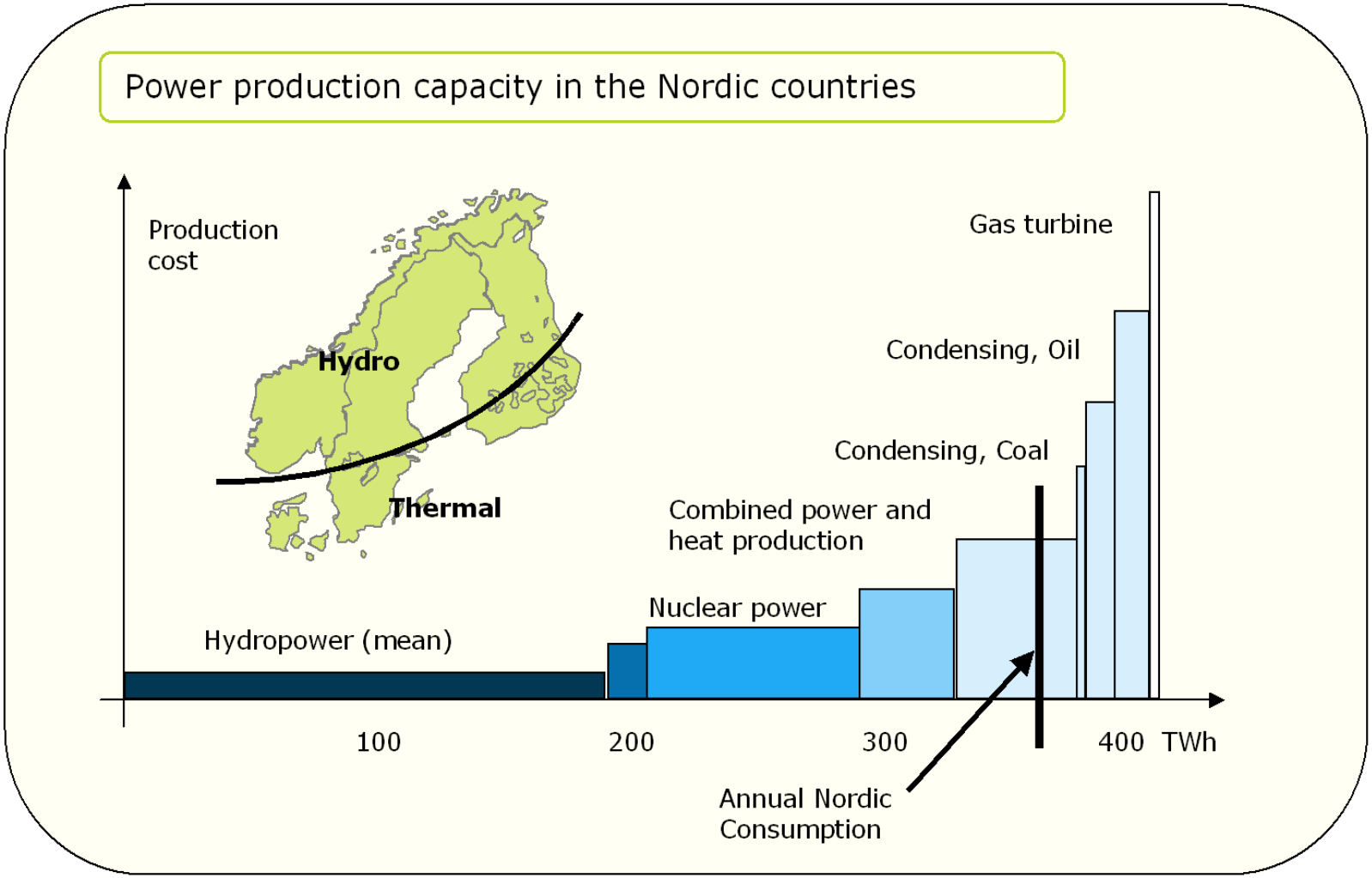
Trading takes place through different kinds of markets applying different kinds of trade; you can read more about trade on the pages: "Spot market", "Intraday" and "Reserve capacity and regulating power". Below please find a figure showing how the electricity market is structured.

Liberalized power market
Theoretical and in practice

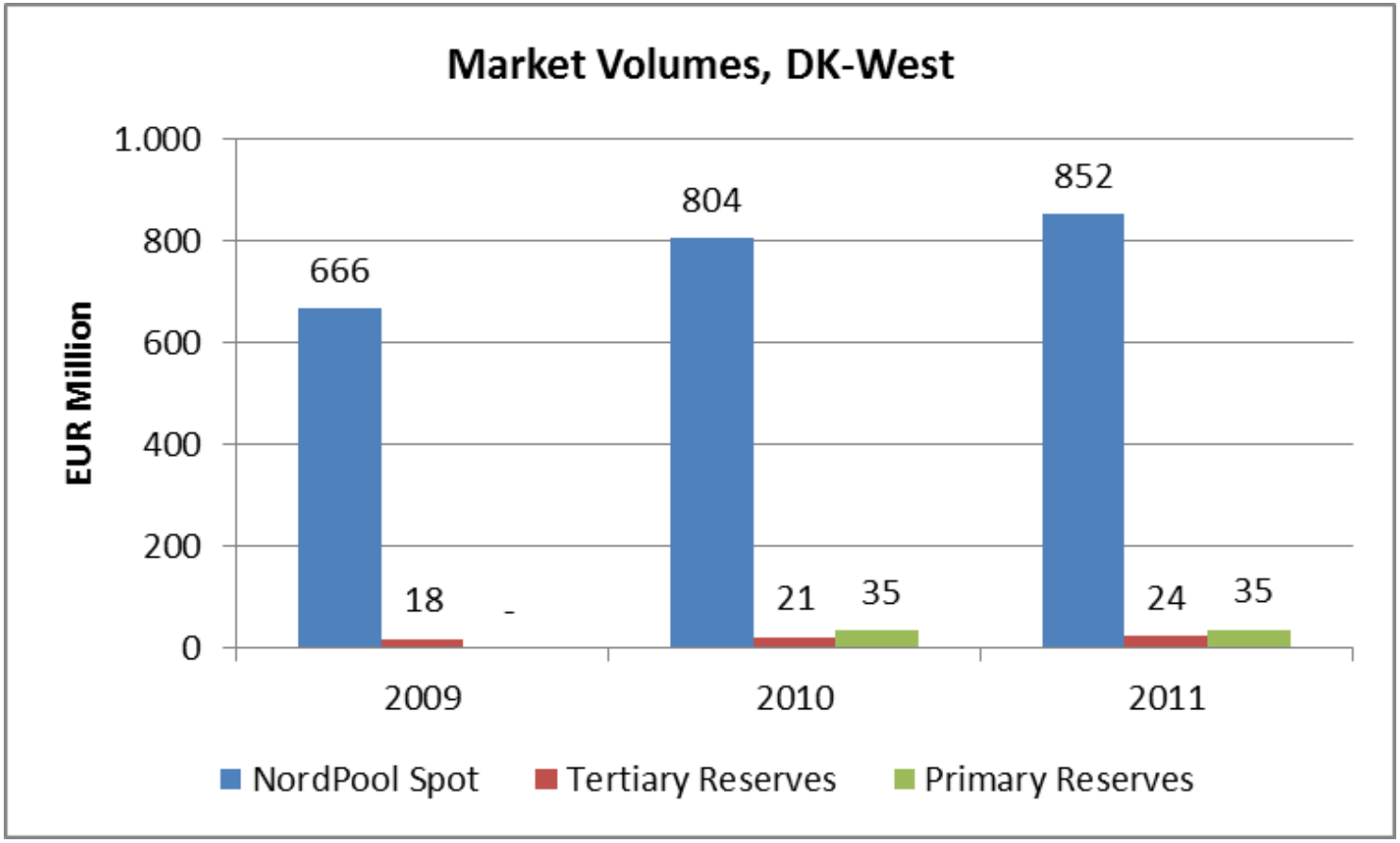




Power production capacity – Nordic countries



Market volumes electricity markets



Source: Market prices and traded volumes obtained from Energinet.dk

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Subsidy for DG in Denmark

Slides still under preparation

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Technical constraints for DG (I)

- Capacity: adding distributed generators at distribution level can significantly impact the amount of power to be handled by the equipment (cables, lines and transformers). May need reinforcement

- The critical piece will often be transformers – if power generated exceeds by far consumption, power will have to flow back from the low voltage network to the medium voltage network or from the medium to the high voltage network and be directed to other consumption areas.

- Voltage: When power is carried over long distance, voltage tends to drop due to resistance in cables. As generators connected to the distribution network tend to increase the network voltage. This could benefit the system. Adding another distributed generator might negatively impact the network by increasing voltage above the specifications.

Technical constraints for DG (II)

- Voltage and current transients: short term abnormal voltage or current oscillation may occur as distributed generators are switched on or off. The result of these oscillations can have a destabilizing effect on the network.

- Ancillary Services: As of today all the ancillary services positively impacting the quality of electricity delivered are provided by centralized generators. For example, centralized generators are requested to keep capacities in excess of peak load to adjust production in case of demand surge, to hold voltage control devices. As the share of distributed generation increases, distributed generators will have to provide a larger share of these services??

- The integration of distributed generation on a large scale will require the distribution network to be ***active*** in the sense that they will have to manage the flow coming from centralized generation through the transmission lines, forecast the levels of output from distributed generators (and especially peak generators), collect information, devise start-up procedures in case of system failures, automation

Vision - DSO will operate active networks – DSO will act as ***"local and regional TSO"***.

In the active networks vision, the principles of network management differ from the classical view of networks

The 'infinite network' as customers used to know it, no longer exists!!!!!!.

The network interacts with its customers and is affected by whatever loads and generators are doing

A dynamic pricing system and a market for "using" the network at DSO-level will evolve – ***DSO will set the framework, standards and rules for the market***

From passive to active network management at DSO-level will be accompanied by developing new services for the electricity market

With active management of distribution networks, the amount of DG that can be connected to existing distribution networks ***can be increased by a factor of three to five without requiring network reinforcement!!!!.***

Source: Akkermans and Gordijn,
Business Models for Distributed Energy Resources in a Liberalized Market Environment, summarising report of BUSMOD, Enersearch AB, Malmö, Sweden, 2004.

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Efficiency issues – central vs. decentral

Slides still under preparation

- **For more information:**

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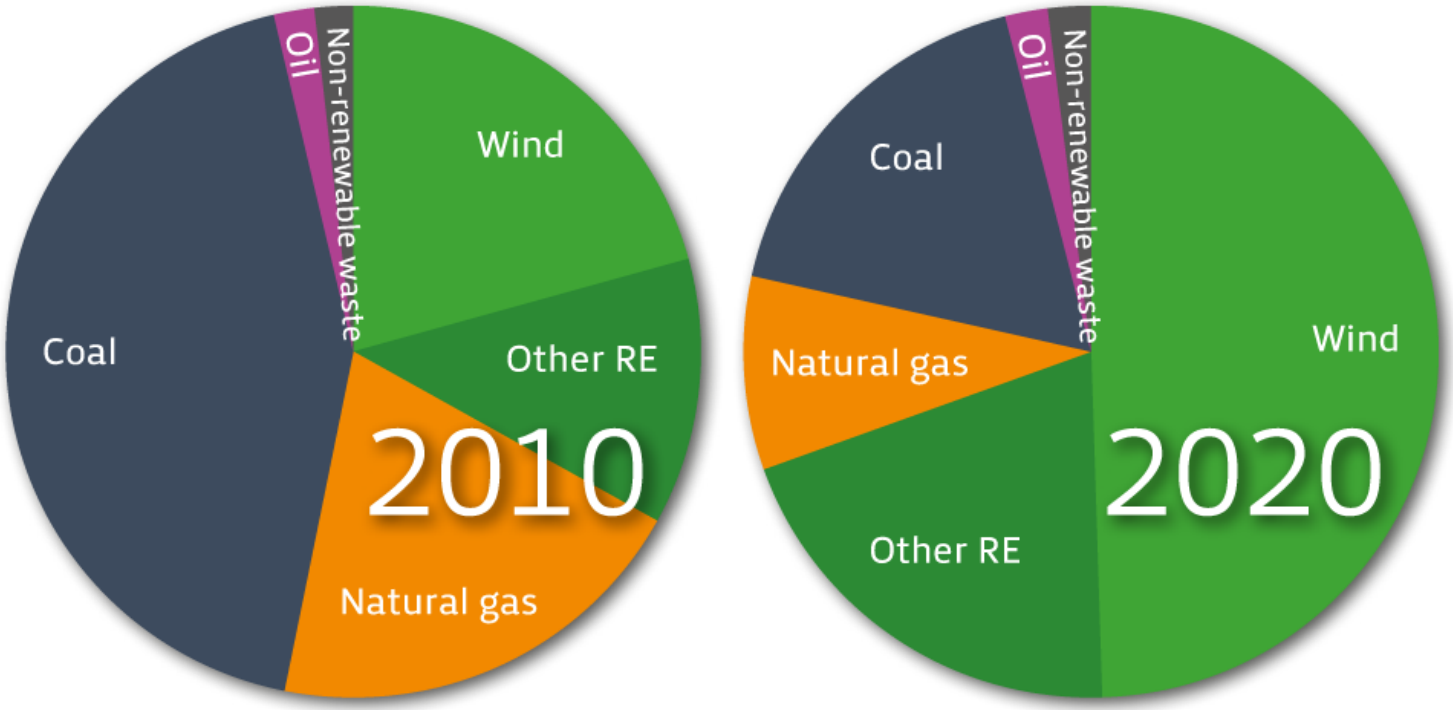
Extra

- In case of questions related to other issues

Electricity consumption by energy source



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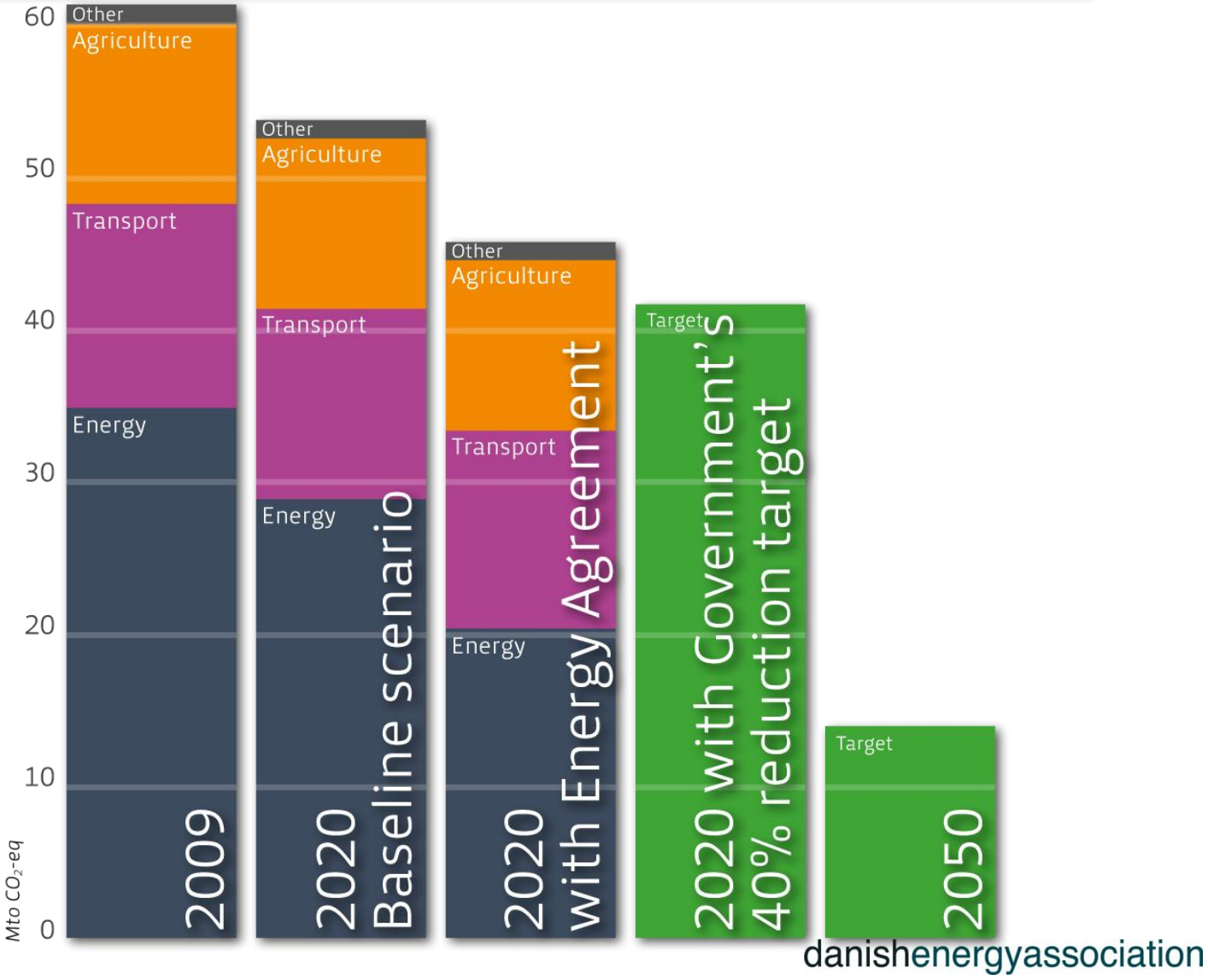
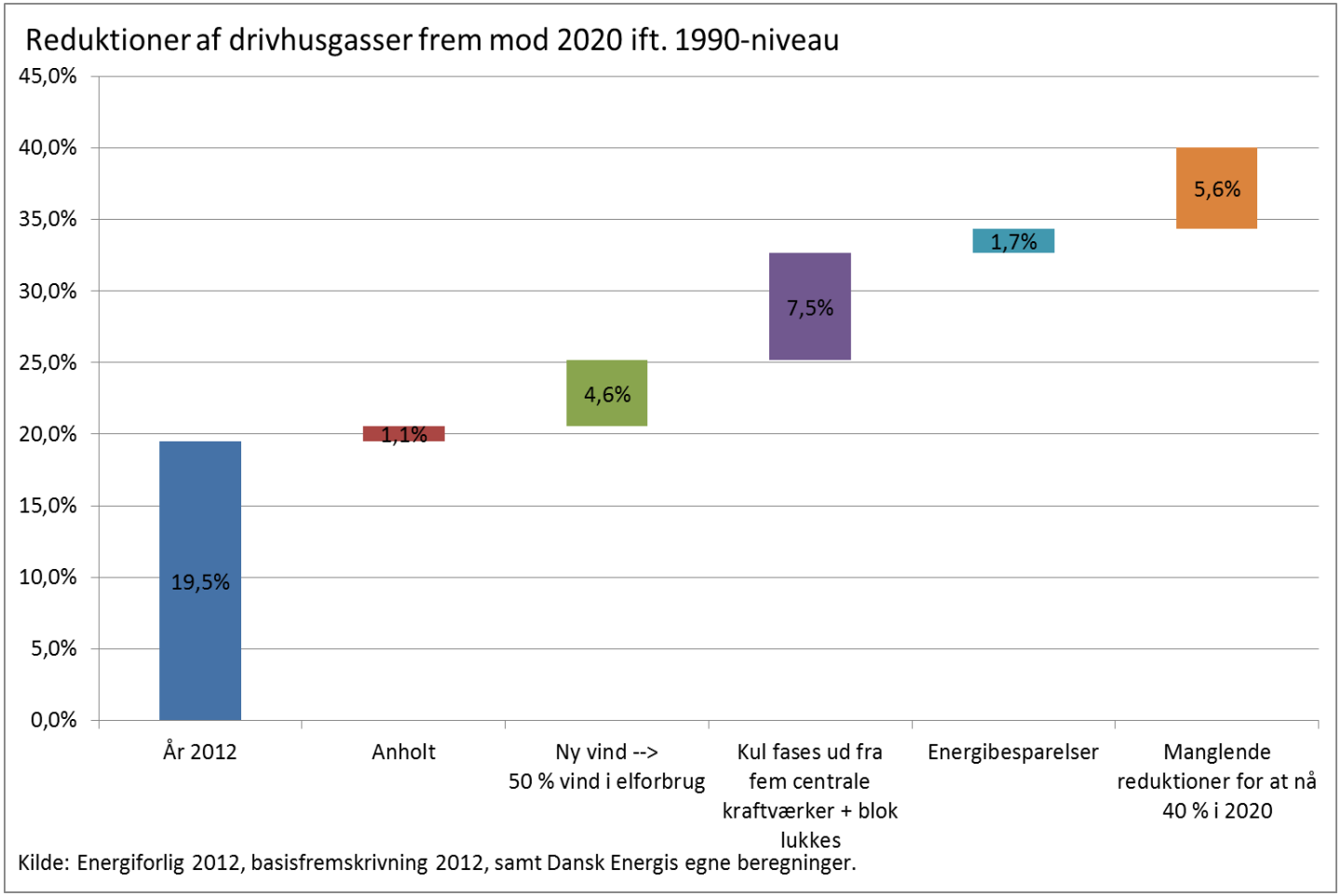
Total Danish greenhouse gas emissions



How will we reach 40% reduction of GHG emissions in 2020 vs. 1990



Wind

Biomass and closing of power plant units

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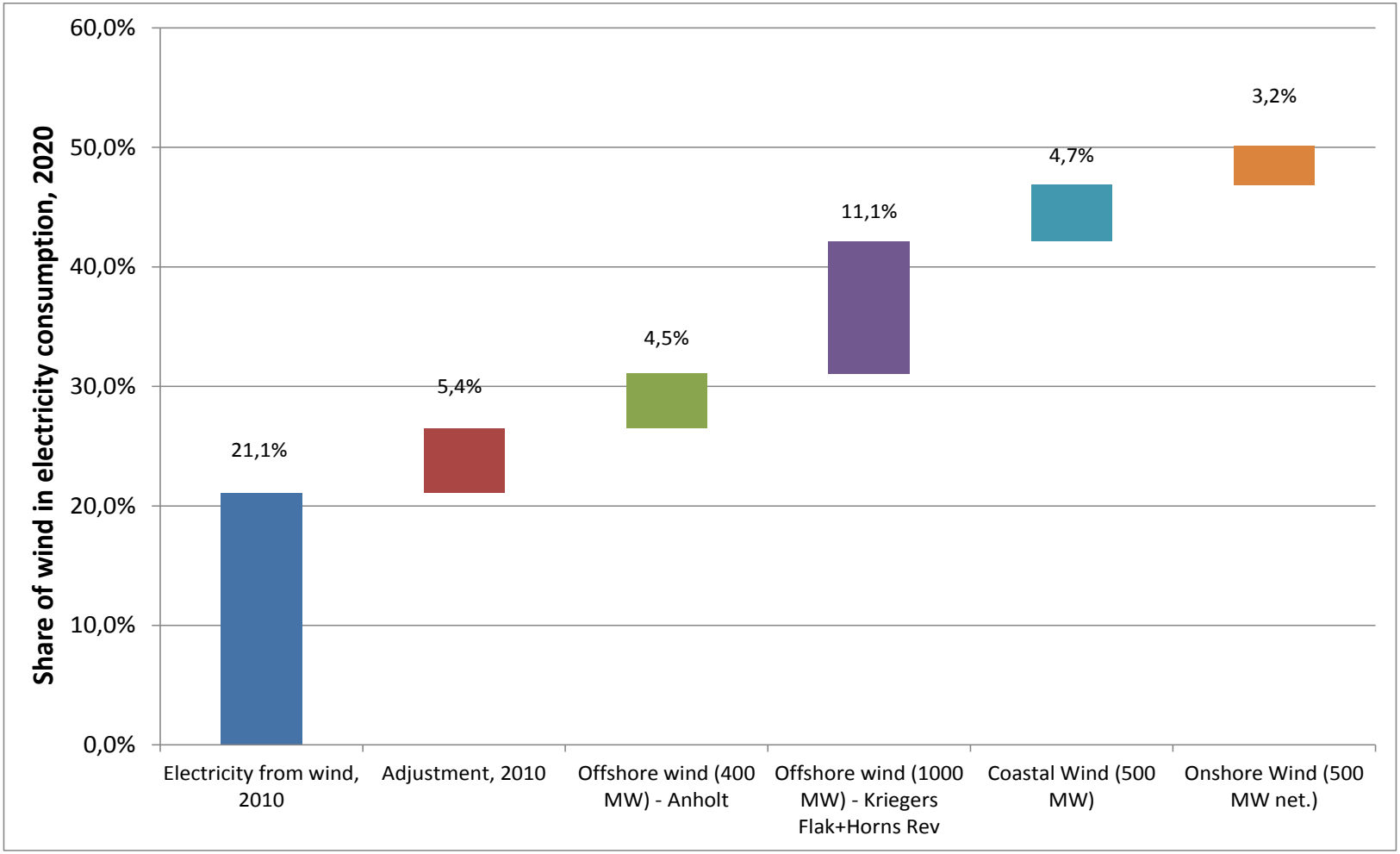
50% wind power in electricity consumption
How?



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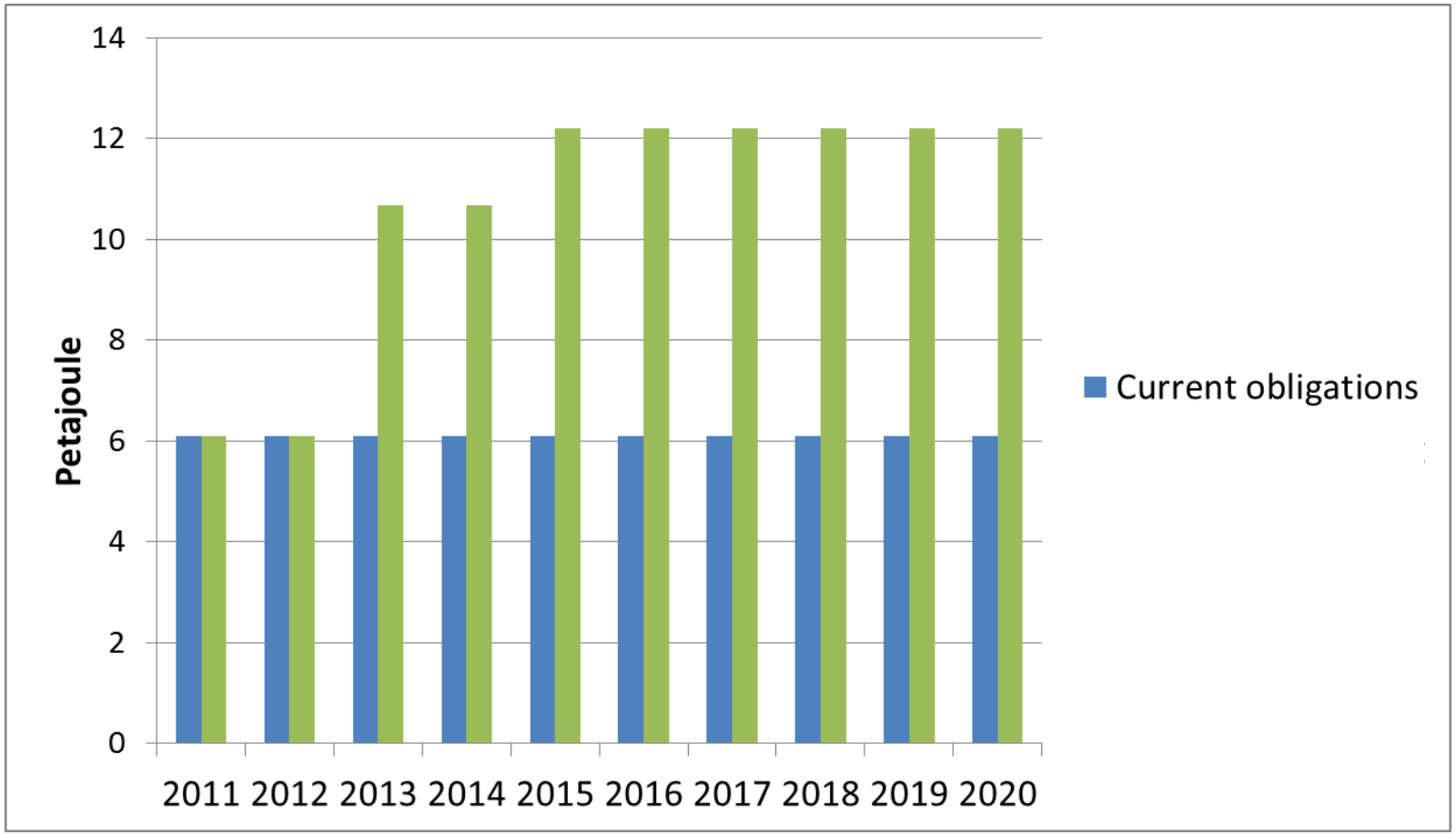
Calculations by Danish Energy Association

Doubling Energy Saving Obligations for energy companies - Focus on buildings and industry

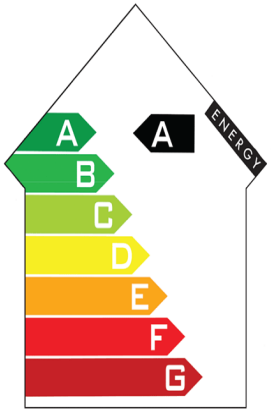


4 groups of challenges and solutions following the EU Energy Roadmap 2050

1. Generation

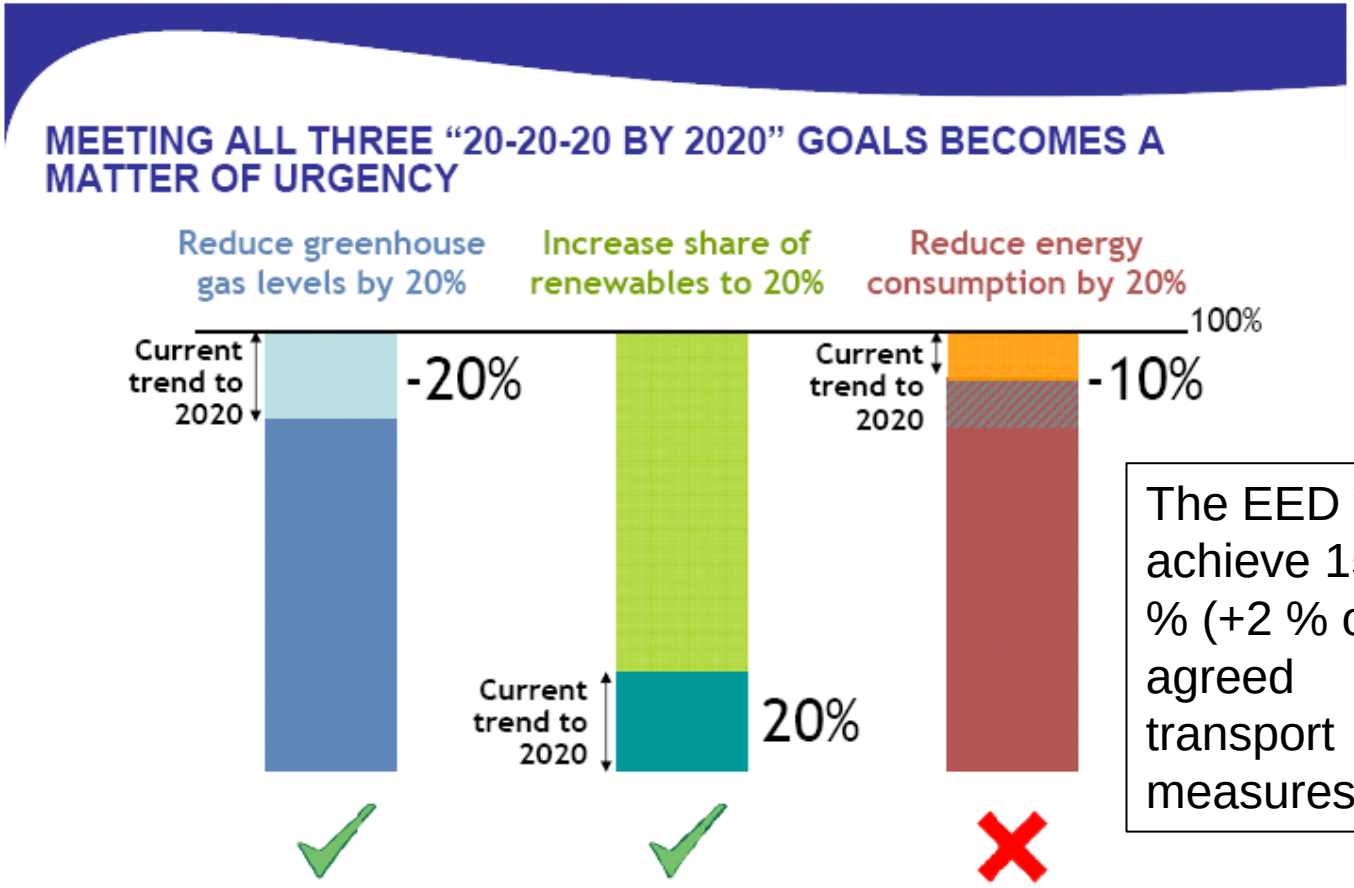
2. Infrastructure

3. Energy Efficiency



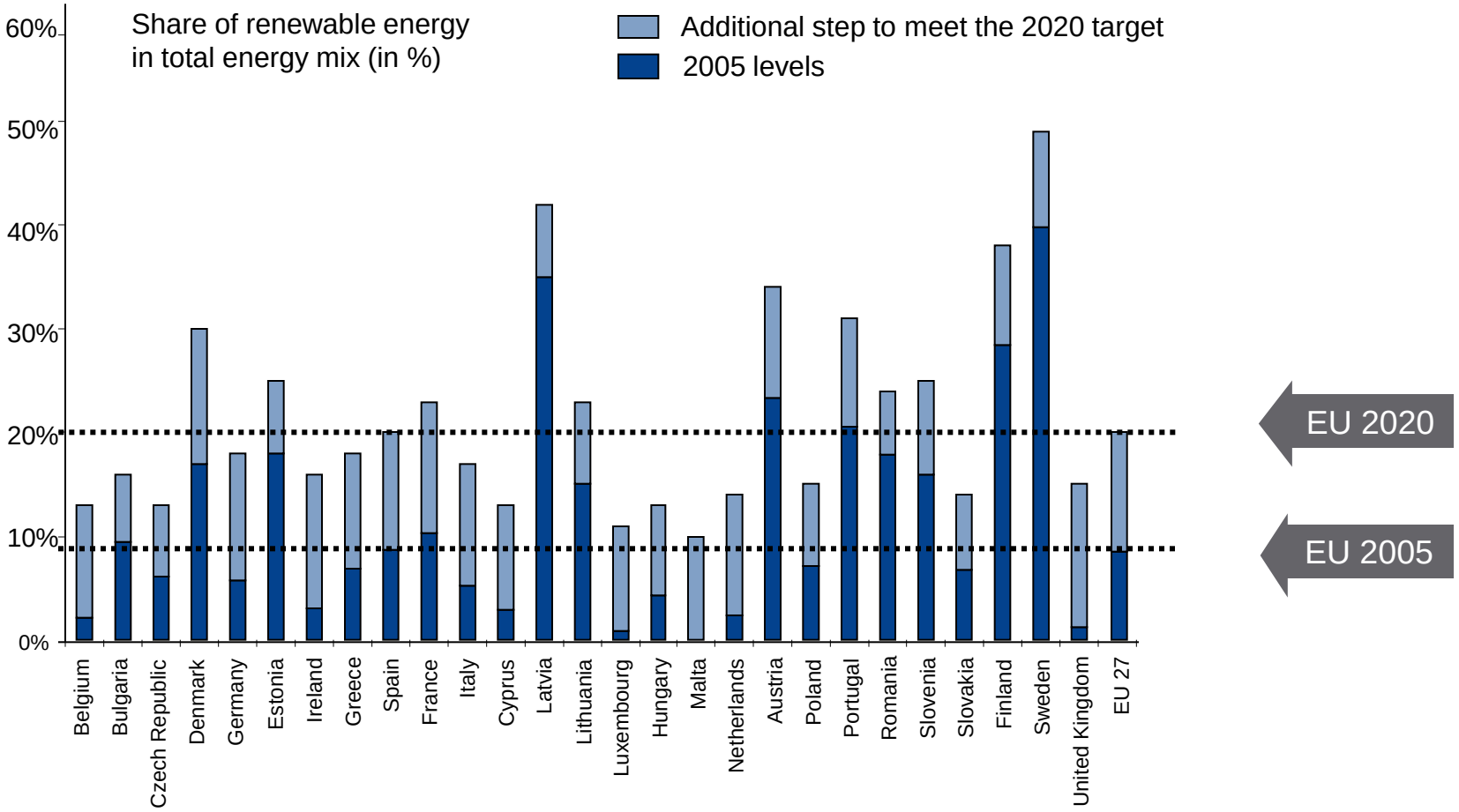
4. Internal Energy Market

Status for the 2020 targets before the adoption of the Energy Efficiency Directive



The EED will achieve 15 % (+2 % on agreed transport measures)

What the EU renewable target means
Will put pressure on thermal power plants!!!!



Each Member State has a binding target - set as a combination of renewable potential and GDP - to increase its share of renewable energy by 2020.

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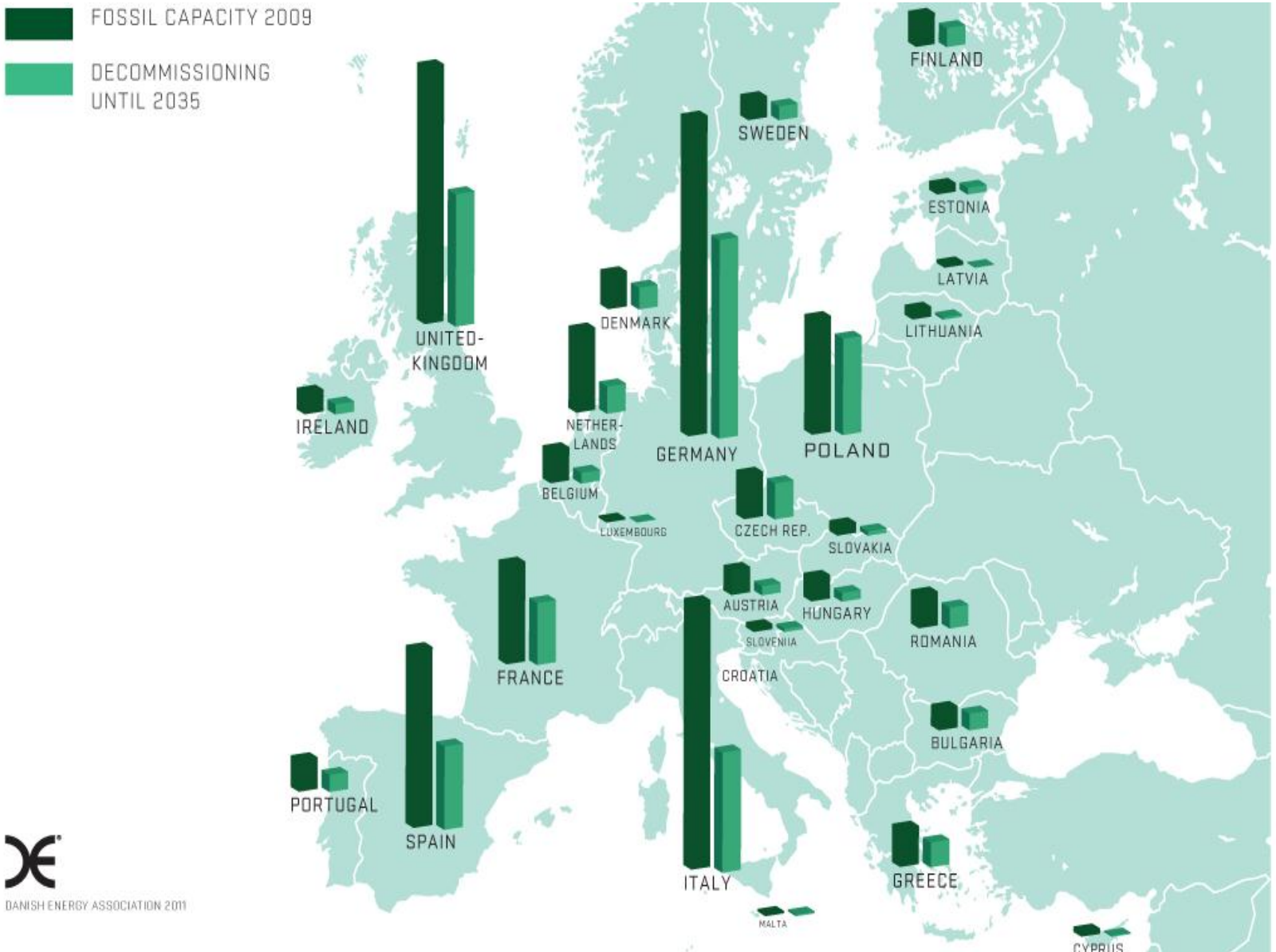
Aging fleet of power plant in Europe



Policy recommendations to facilitate modernisations and transition of the energy system

- *Align EU policy and incentives to investment life cycle in power generation*
  - *Life time of power plants: 25-50 years*
  - *900 TWH to be replaced before 2020*

- *Investors need certainty on post 2020 setup now*
  - *ETS phase IV in line with 2050 objectives (80-95% GHG reduction)*
  - *2030 GHG targets for non ETS sectors*
  - *EU wide RES targets for 2030*


Proposal from the Commission in 2013 on post 2020 policy framework
- The political battlefield:
onomic crisis
d unemployment
Internal market vs. national regulation
(GER, UK, PL, DK?)
No global agreemer
climate agreement
in sight
oland will veto all
ost 2020 targets
nd no MS but
enmark favour a
ew RES-target
Changes to the ETS

The Future – power plants

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50% WIND

What about
The other 50% ?

The future of the Danish Power Sector?

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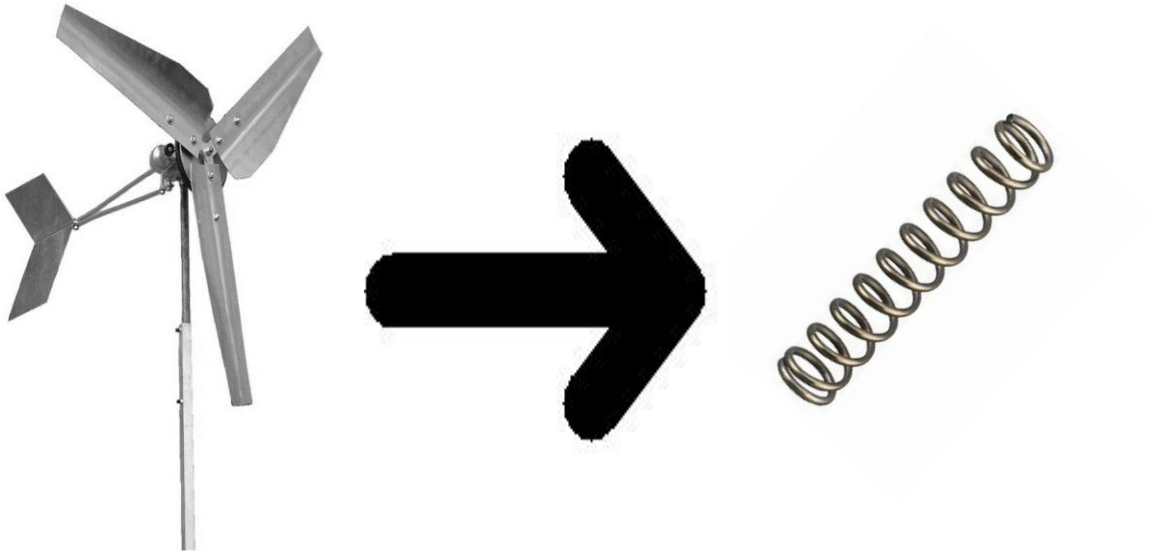
What’s in it for me?

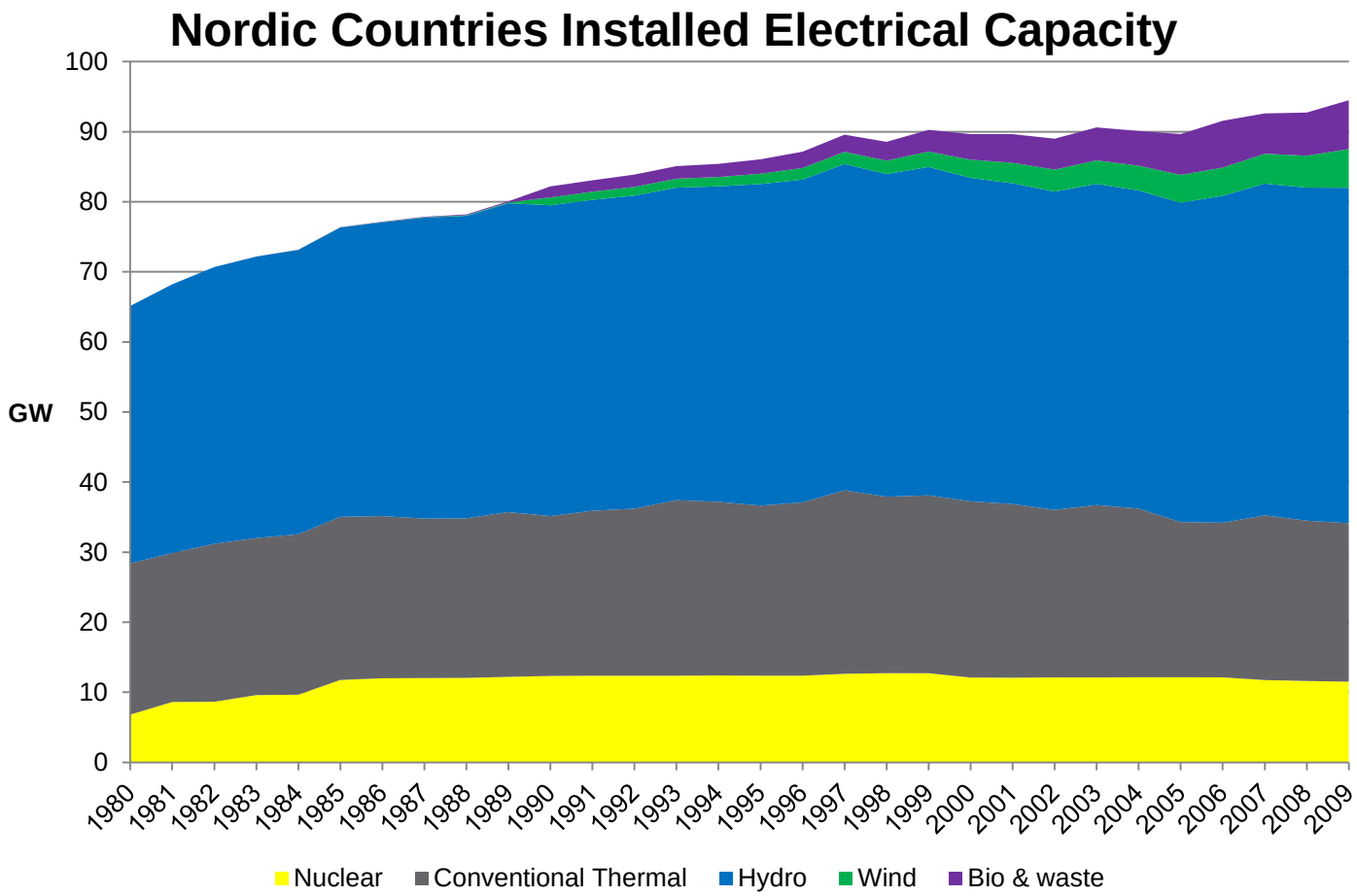
What’s in it for me?



What’s in it for me?

What’s in it for me?

Continuous investment in new capacity in the Nordic region



Source: EIA.gov, 2012

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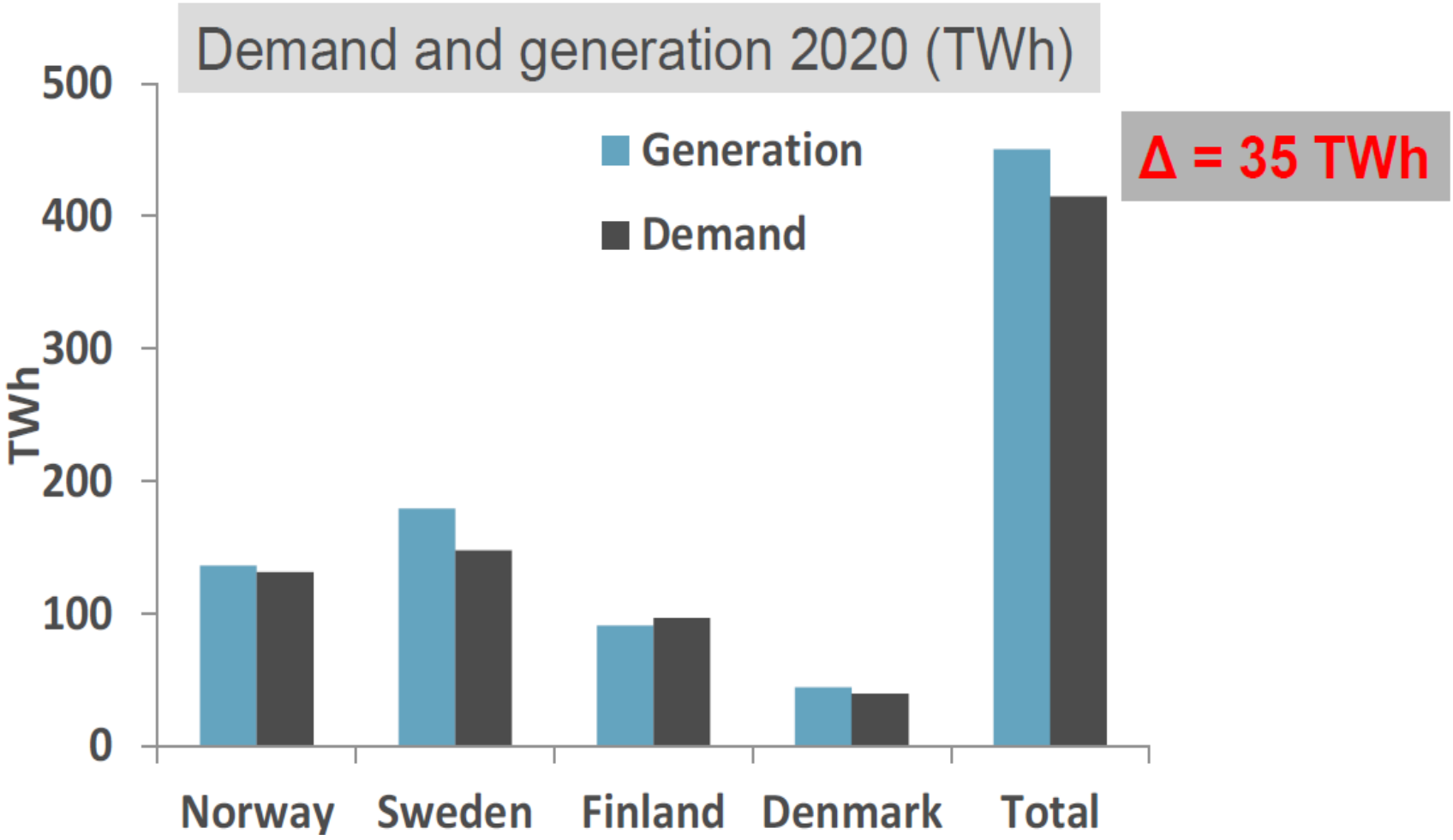
Power surplus in the Nordic region



Source: THEMA CONSULTING GROUP, 2012

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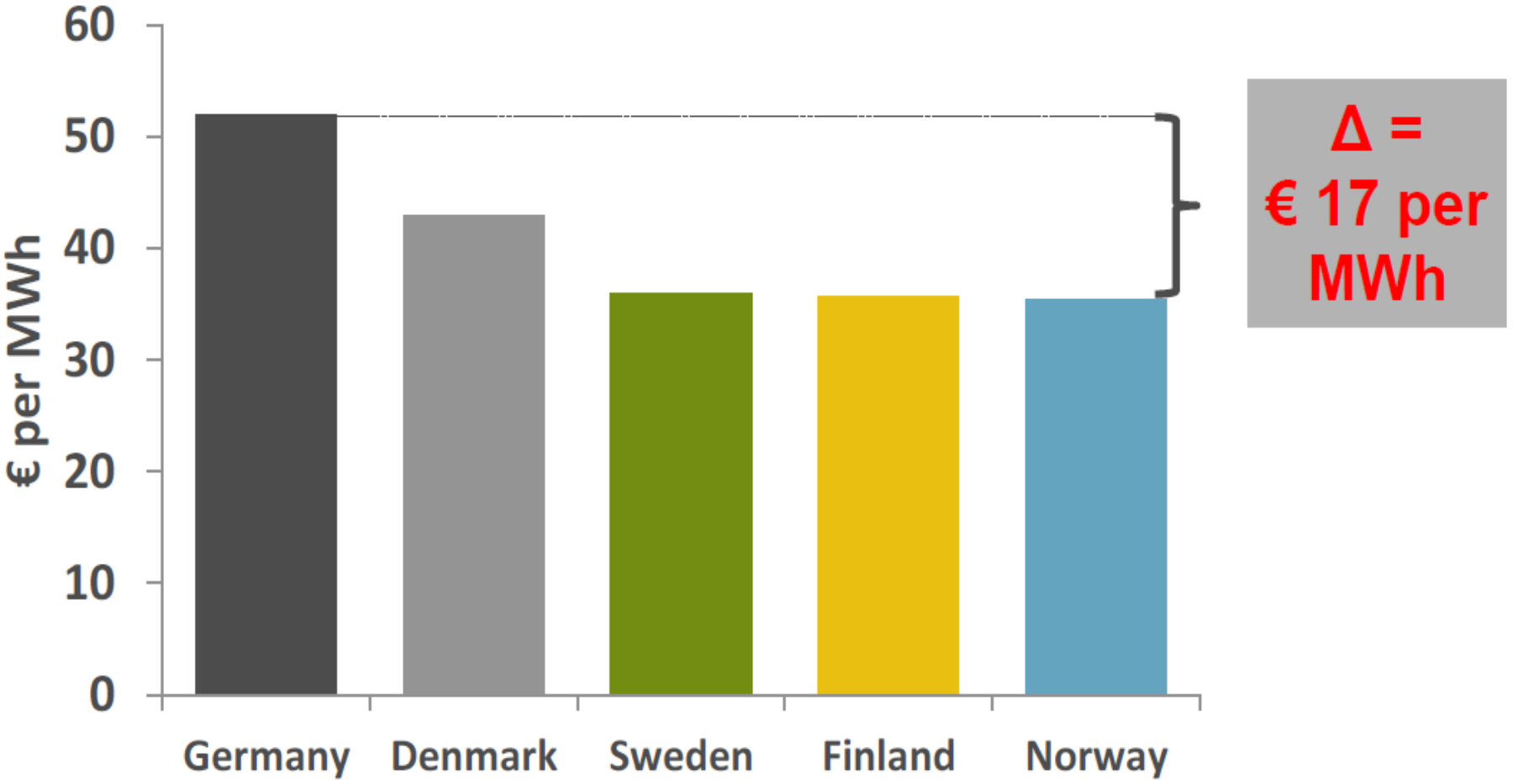
Surplus leads to substantial price differences to the Continent



Source: THEMA CONSULTING GROUP, 2012

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How to secure the market value of power plants in Denmark:

→ Focus on 3 or 4 types of Cash Flows ?

Electricity

Heat

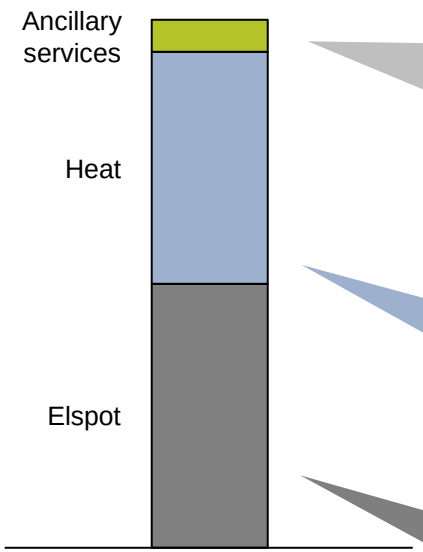
Ancillary services (systemydelser) + capacity payment?

Important issues

Cash flow elements	Issues that challenge the cash flow

Cash flow elements available to ensure sufficient flexible capacity

Earnings per MW



General
- Insufficient infrastructure due to constraints on existing cables and inertia in build-out of new cables
- Some products have been delivered implicitly as mandatory system services instead of in a well-defined specific market
- Markets closer to hour of operation lack liquidity

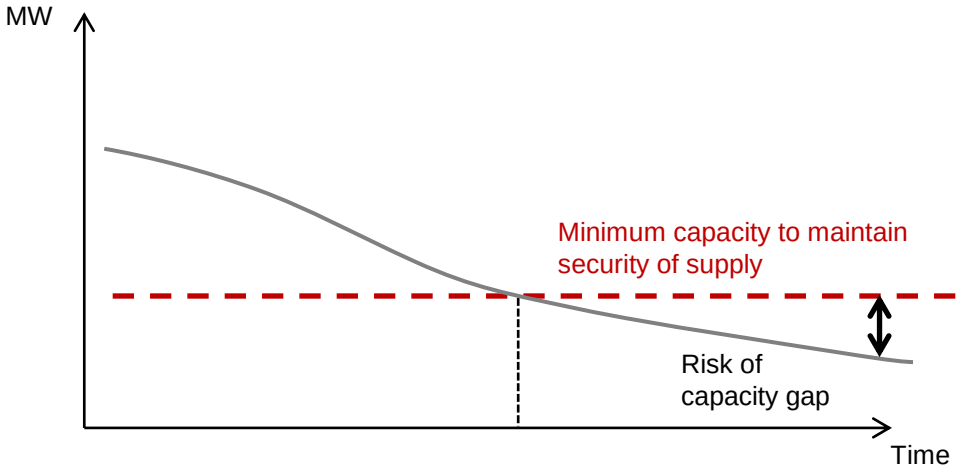
Reserves and other ancillary services
- Great uncertainty about products and volumes going forward
- Bilateral procurement in neighbouring areas without reciprocity reduce potential market size and earnings
- Roles and responsibilities of market players not clearly and unambiguously defined

Heat
- Current Danish regulation only allows for cost based price setting
- Transformation from being secondary to electricity production to becoming a primary product at certain times

Elspot
- Subsidized wind expansion puts downward pressure on price level
- CHP electricity production needs to take heat contracts into account
- Regulated maximum price does not allow for pricing of real scarcity

What will happen??

Purely market based capacity adjustment with no changes to current market design



- Current market design gives insufficient remuneration to flexible capacity

- If no intervention, a flexible capacity gap could arise (at least locally) in the medium term