Danish TSO experiences with large scale integration of DERs

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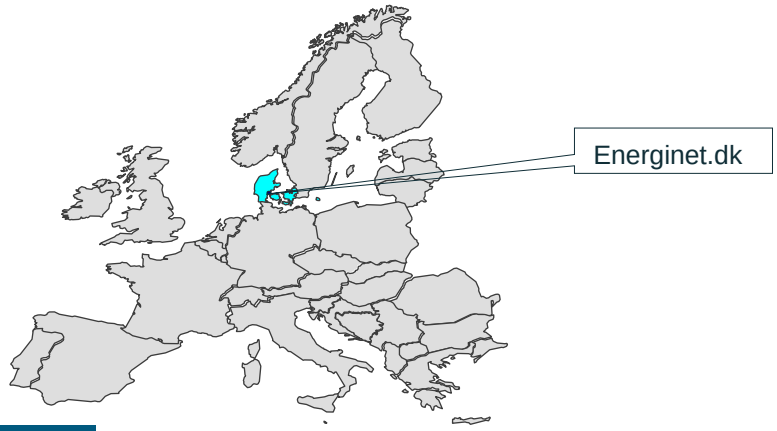
Henning Parbo
Chief Economist – Market Development
Energinet.dk

Agenda

- Briefly about Energinet.dk
- Political goals and regulatory means
- Challenges with a large share of DERs

Energinet.dk

- National Transmission System Operator for Electricity and Gas in Denmark
- Independent public enterprise with approx. 800 employees
- Owns and operates the main electricity and natural gas grids
- Core tasks:
  - Develop a more flexible power system capable of handling considerably larger amounts of renewable energy.
  - Ensure well-functioning electricity and gas markets.



The transition from central planning to distributed generation

- The electricity market was introduced in 2000

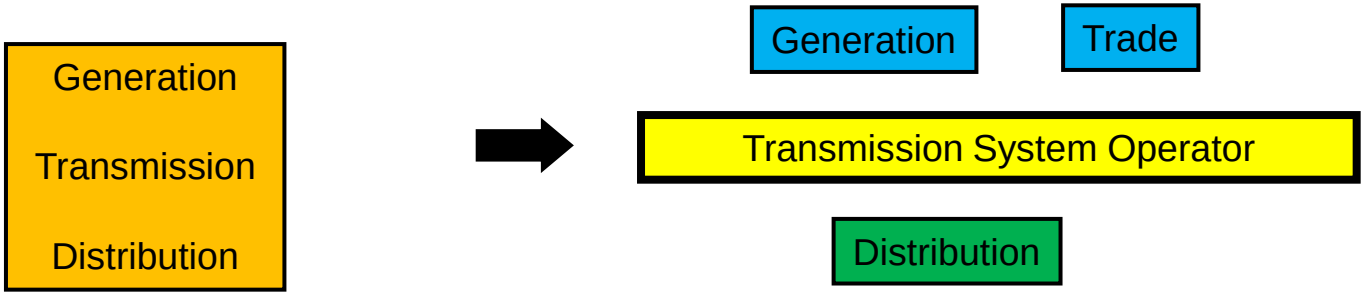
1990

2000

2015

From primary coal fired to local CHP, wind power and PV

From vertically integrated monopoly to competitive electricity market



The Danish Power System
Installed Capacity, January 1st, 2016

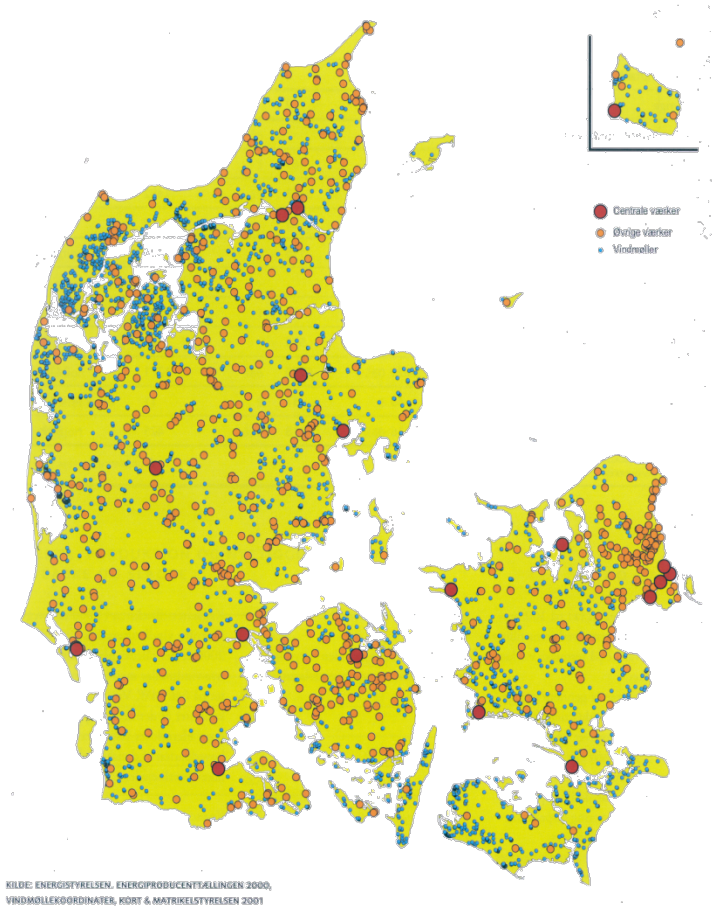
ENERGINET.DK

20 Central Power Stations

4,200 MW

670 Local CHPs

2,300 MW



5,300 Wind Turbines

5,070 MW

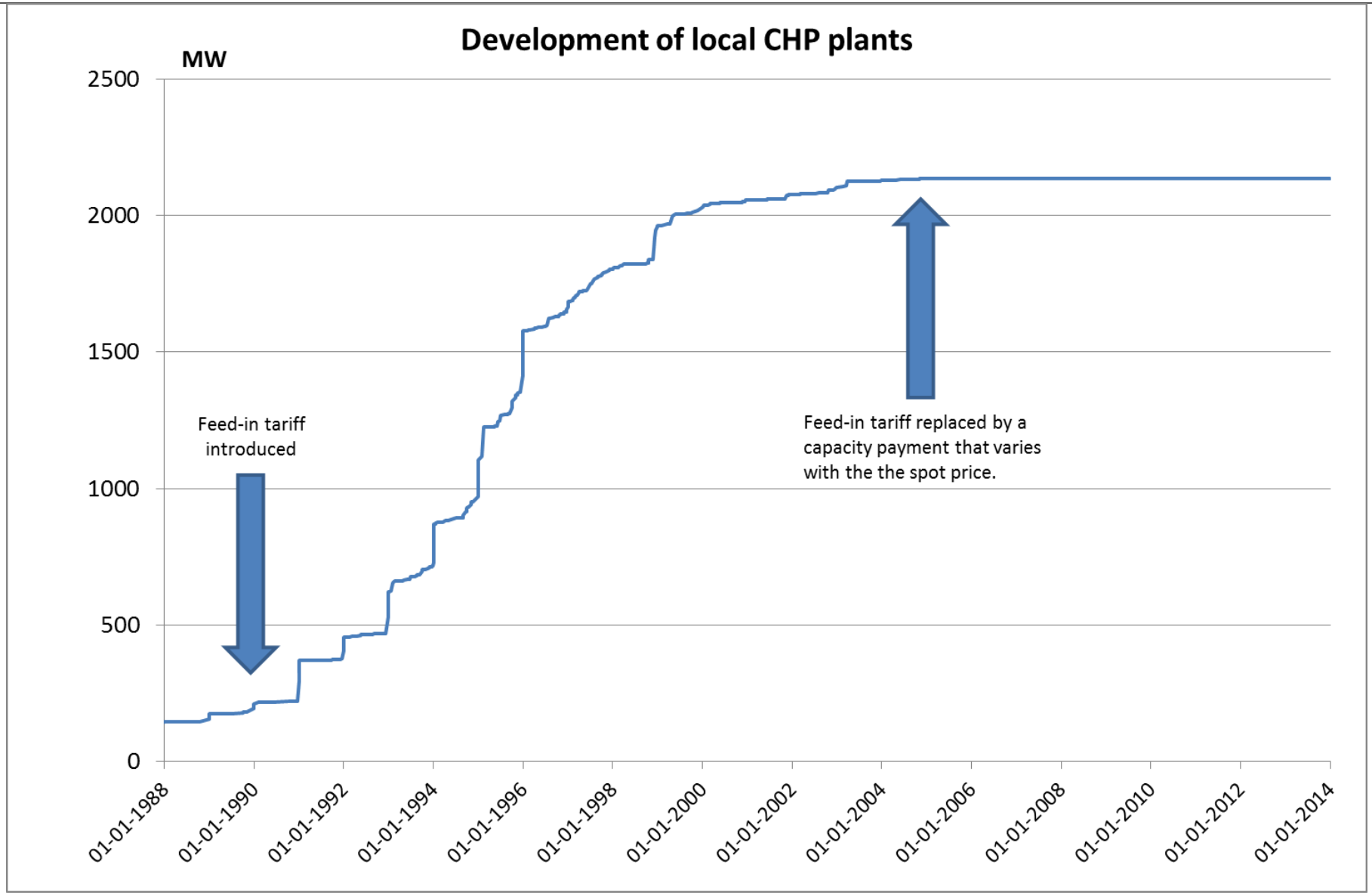
94,000 Solar PV

785 MW

Demand is between 2100 MW and 6300 MW

The development of local CHPs

- The political discussions began in the mid-1980s in the wake of the oil crises.
- Keywords: Energy efficiency, co-production of electricity and heat.
- A feed-in tariff was approved by the government i 1990
  - A time-of-day tariff ~ The long term marginal costs of a coal fired unit
  - The tariff was maintained when the electricity market was introduced
- The feed-in tariff was replaced by a capacity payment in 2005 to better suit the electricity market environment. At the same time it was decided not to incentivise new plants.
- The cost of the incentive is socialized – i.e financed through a Public Service Obligation tariff paid by the final customers.
- The incentive is announced to end in 2018.


Development of local CHP plants
MW
2500
2000
1500
1000
500
0
Feed-in tariff introduced
Feed-in tariff replaced by a capacity payment that varies with the the spot price.
01-01-1988
01-01-1990
01-01-1992
01-01-1994
01-01-1996
01-01-1998
01-01-2000
01-01-2002
01-01-2004
01-01-2006
01-01-2008
01-01-2010
01-01-2012
01-01-2014

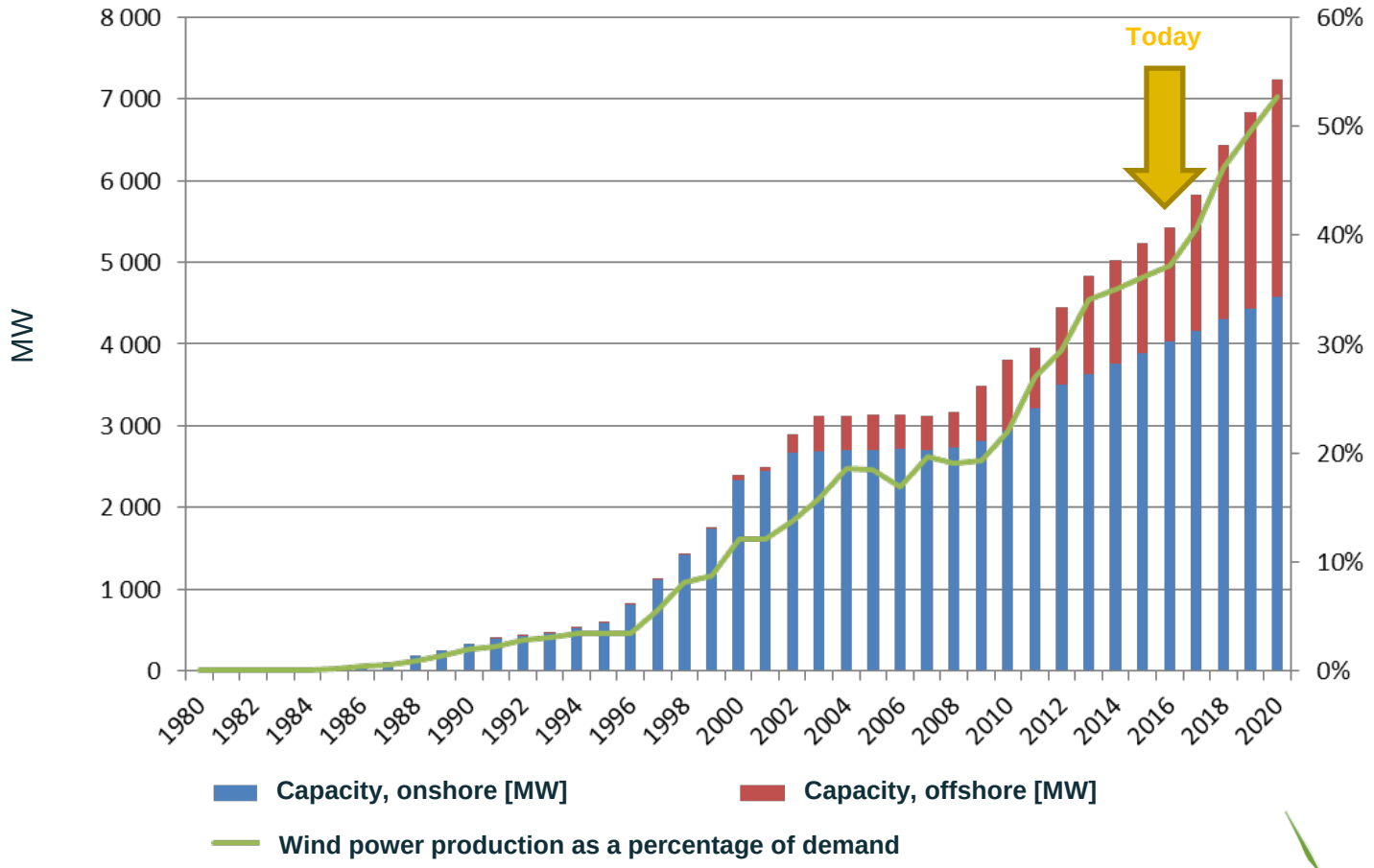
The development of wind power

- The political discussions began in the late1980s.
- Conditions for wind power has been the most discussed issue in Danish energy policy during the last 20 years.
- Keywords: CO_2-reductions, green transition, ensure that the Danish wind power industry remains a frontrunner.
- Today: Consensus in the Danish parliment about green transition and the role of wind power in that context.
- Specific goal: By 2020, wind power must constitute 50% of the electricity consumption. In 2050 Denmark must be independent of fossil-fuels.

Incentives for the development of onshore wind power

- Extensive regulation and financial incentives are in place with regard to the development onshore wind power and to promote public acceptance:
  - More than 20 different subsidy schemes have been applied during the last 15 years, including fixed feed-in tariffs, premiums with and without caps etc.
  - Possible grid expansion costs due to environmental friendly production are socialized – i.e. the owner just pays for the connection to the nearest location with the correct voltage level.
  - The ”loss of value” scheme: If a property loses value due to the erection of new wind turbines, the owner is ensured full compensation for his loss.
  - The ”option to purchase” scheme: Allows the local citizens to purchase a minimum of 20 % of the project at cost price.
- All the above costs are included in the PSO tariff.

Development of wind power in Denmark

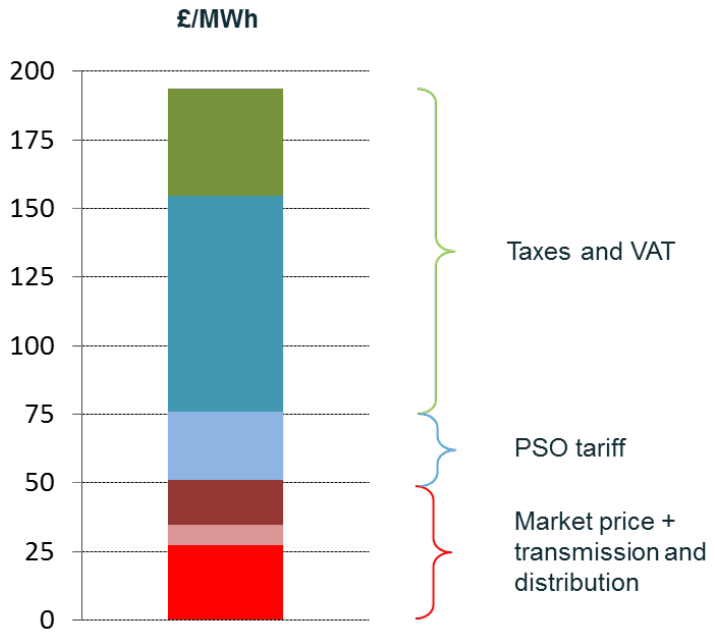


Offshore wind power

- Regulation regarding the development of offshore power:
  - A number of locations have been pointed out
  - Wind farms are built by public tender
  - Fixed feed-in tariff applies (~ the offer price)
    - Latest addition: The subsidy disappears in case the spot price is negative
  - Grid connection costs are socialized
    - Latest addition: This rule does not apply to near-sea wind turbines
- All the above costs are included in the PSO tariff.

The development of solar PV

Since 1998 households have been able to set up solar power plants (max 6 kW) and achieve net settlement – i.e. production from the PV system in a calender year can offset the household own consumption within a calendar year.

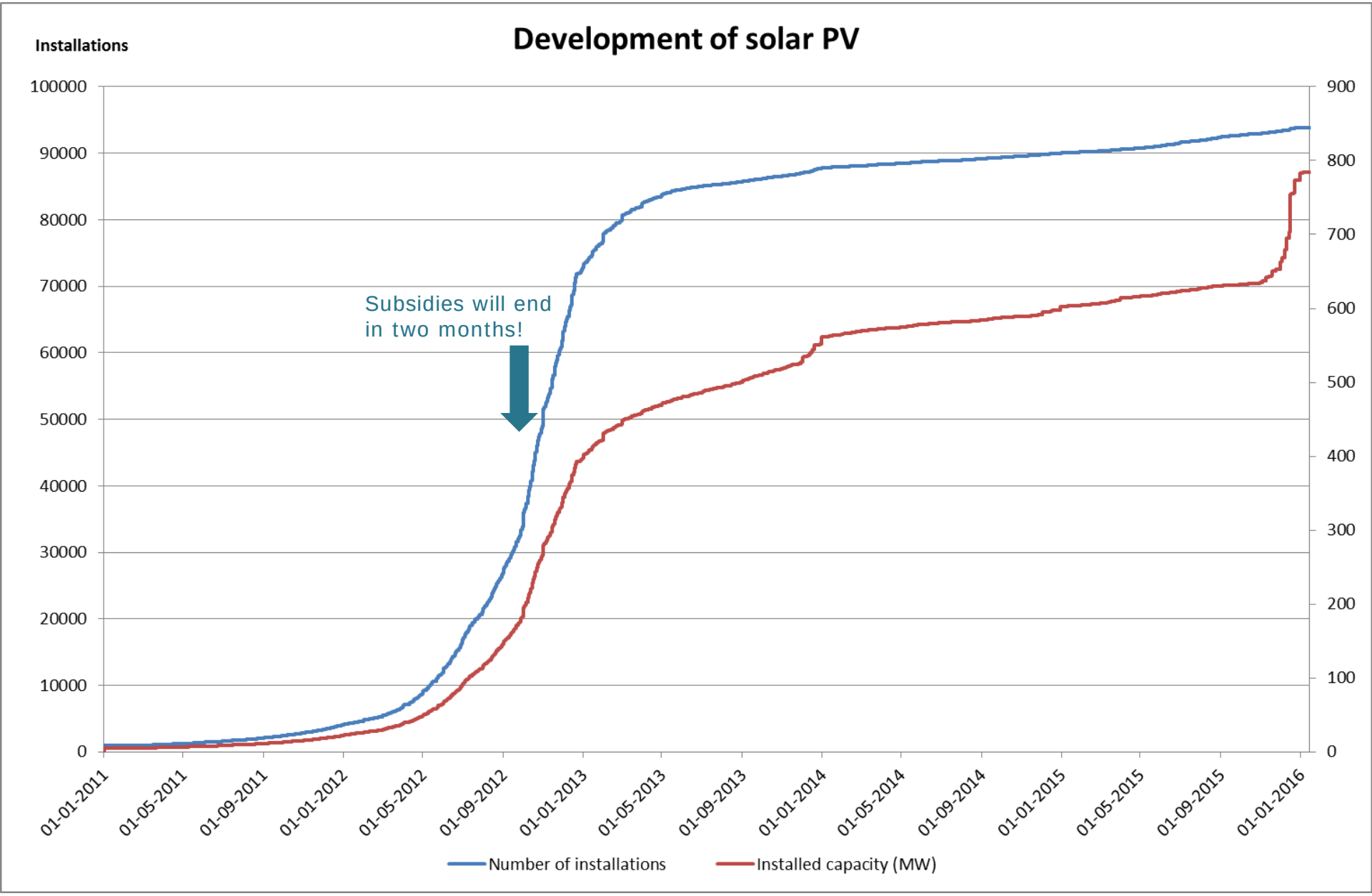


Danish households pay extremely high electricity taxes and PSO tariffs.

The cost of solar PV installations started to decrease significantly in 2011.

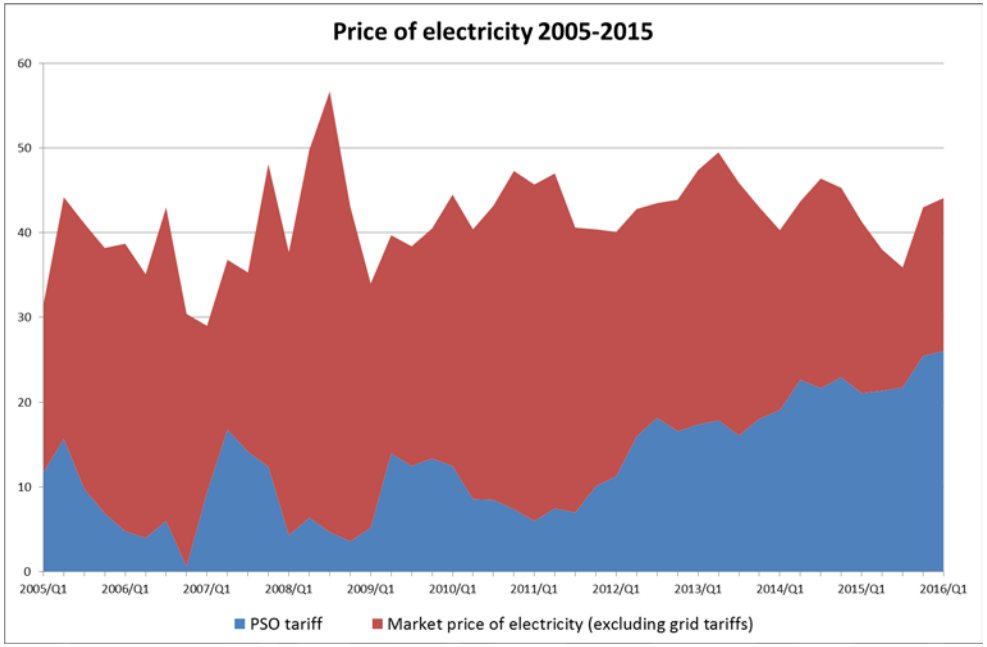
This combination made the investment in solar more and more attractive and created a boom in Denmark in 2012.

The cost of the incentive is socialized.


Development of solar PV
Installations
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
900
800
700
600
500
400
300
200
100
0
Subsidies will end
in two months!
01-01-2011
01-05-2011
01-09-2011
01-01-2012
01-05-2012
01-09-2012
01-01-2013
01-05-2013
01-09-2013
01-01-2014
01-05-2014
01-09-2014
01-01-2015
01-05-2015
01-09-2015
01-01-2016
Number of installations
Installed capacity (MW)

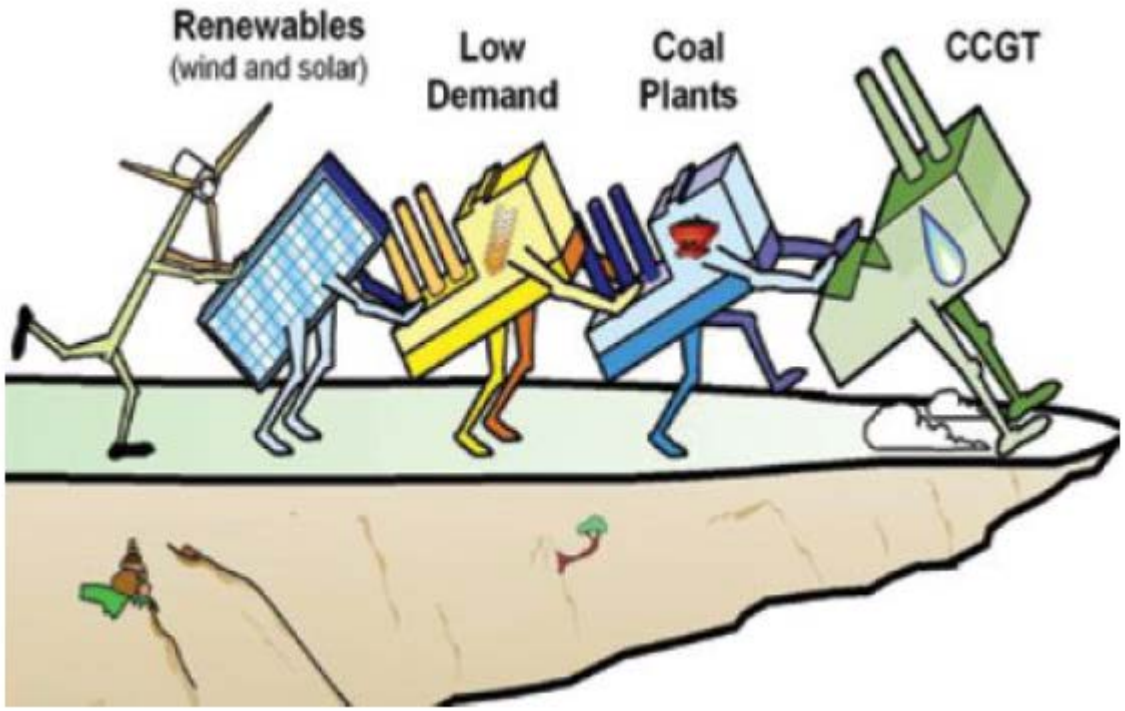
Main drivers behind the green transition

- *Attractive feed in tariffs/ guaranteed prices*
- *Favorable grid connection conditions*



Socializing grid expansion costs means that the owner does not take into account local grid conditions – i.e. there is a risk of inefficient and expensive grid extensions and lack of socioeconomic optimal considerations.

Further consequences of the development



- The continued governmental support around Europe to renewables with zero marginal costs drives conventional units out of the market.
- Traditional sources of flexibility under pressure. Endangers secure system operations and security of supply.

Agenda

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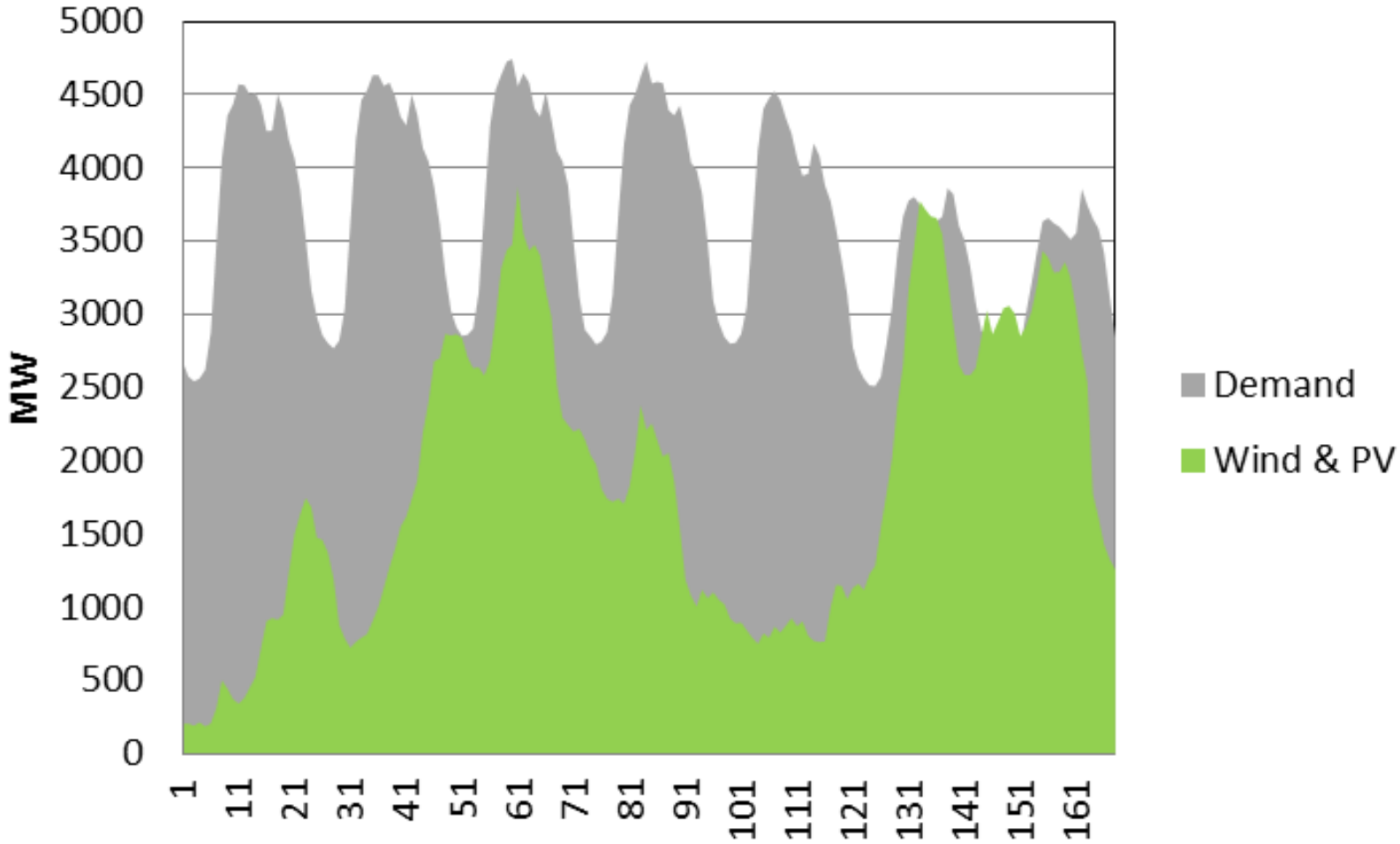
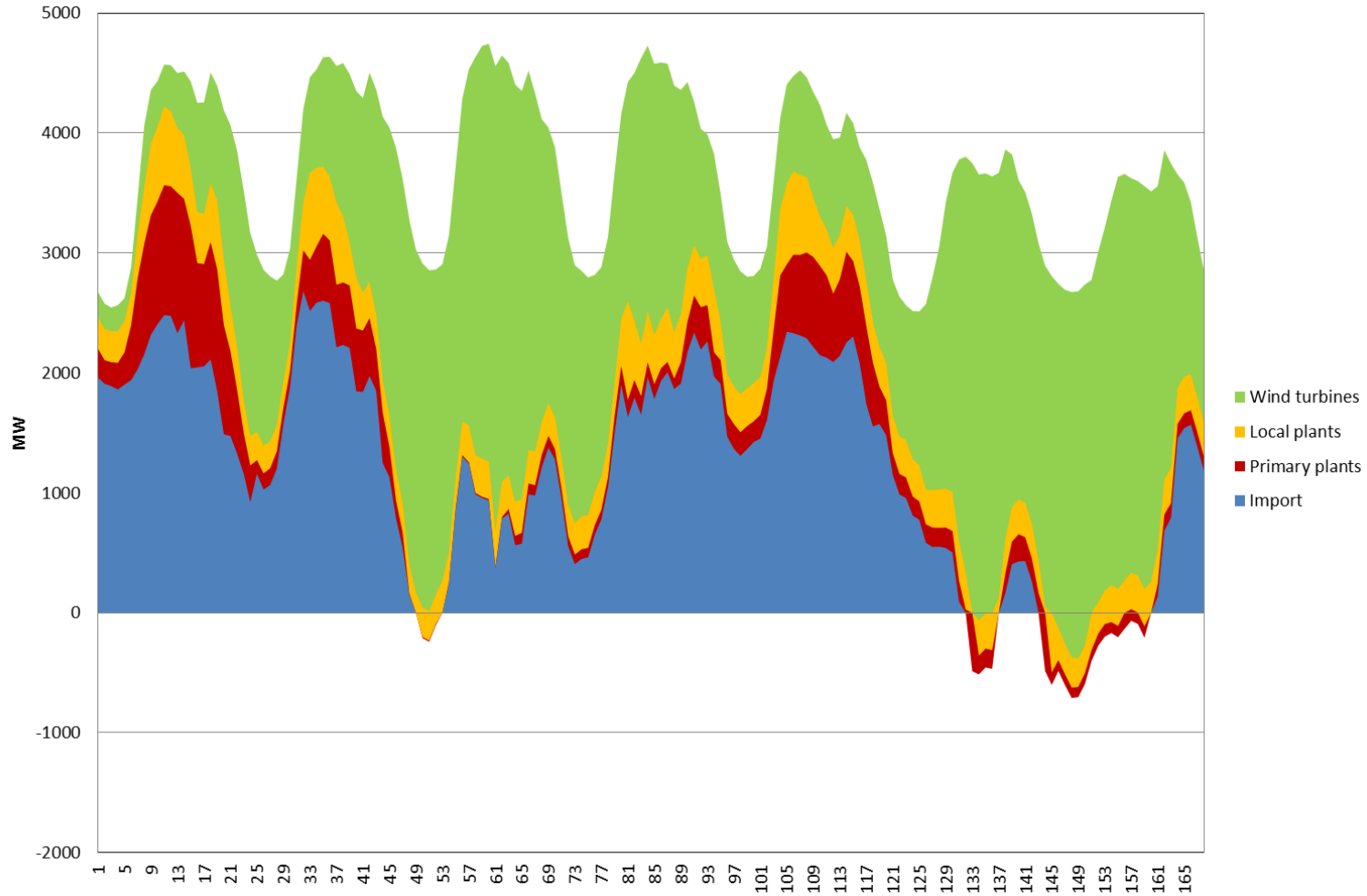
One week in September 2015

- 51% wind power

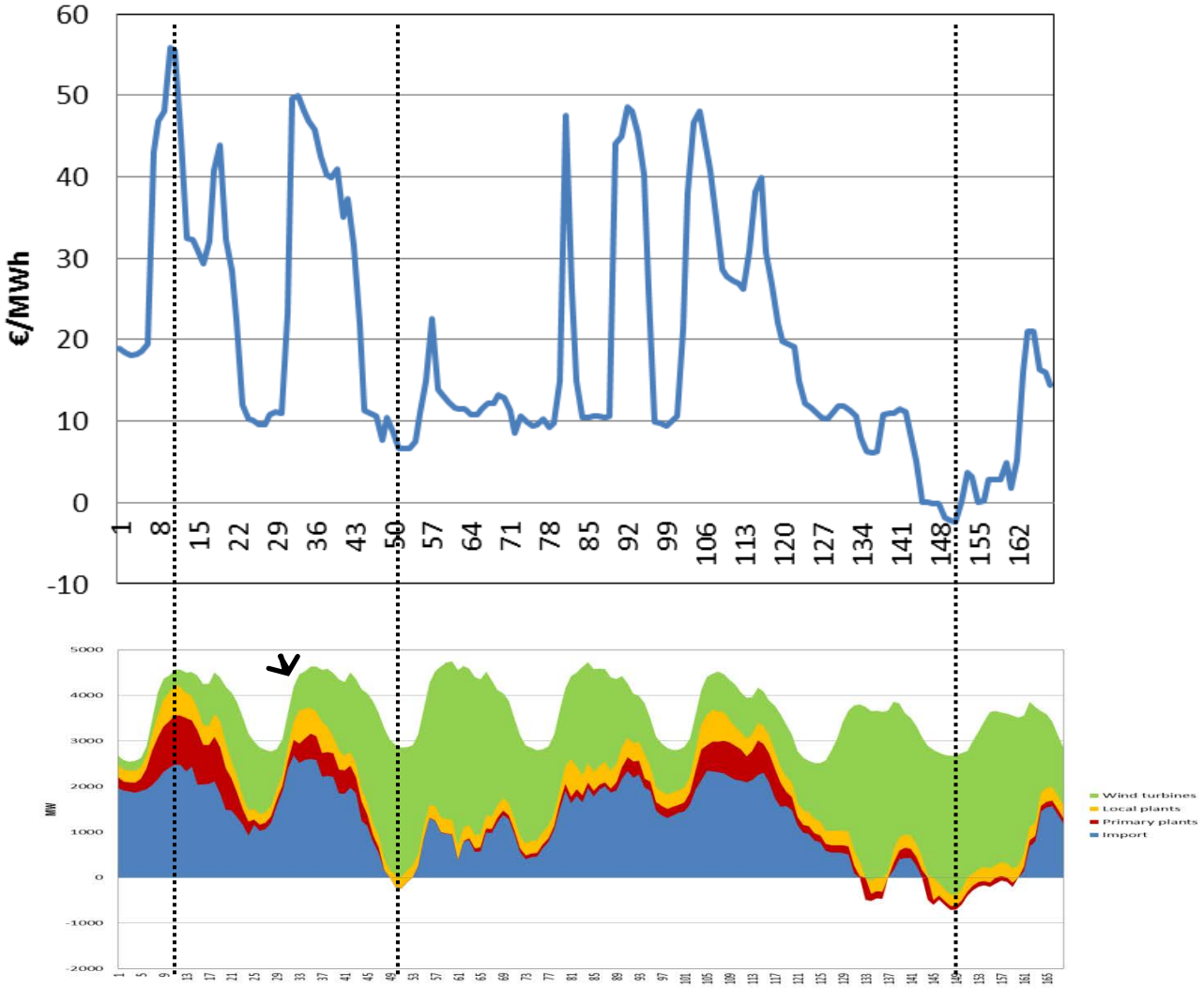


Flexibility in the electricity system

- hourly dispatch 31 August – 6 September 2015



Spot price, wind power and market dynamics

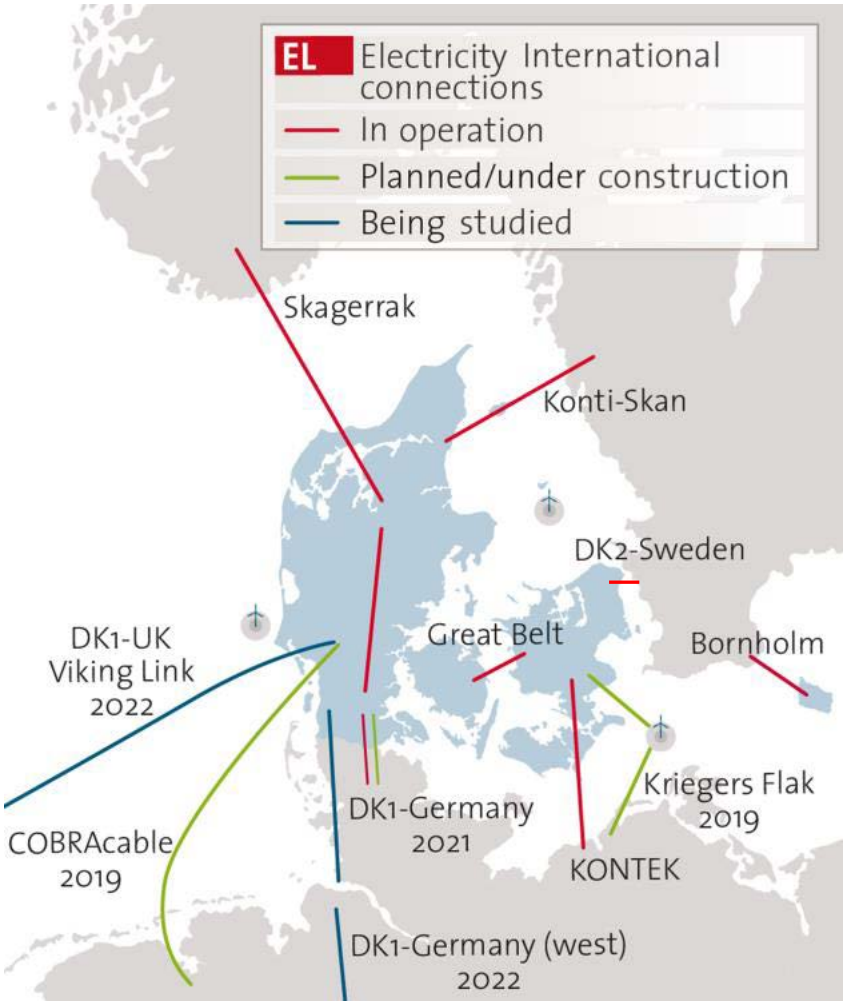


Toolbox for efficient large scale DER integration

- Strong transmission grids and interconnectors
- Coherent international electricity markets
- Specialized operational planning tools for TSOs – forecasting etc.
- Flexibility in the entire value-chain from producer to consumer

The tools needed are increasingly regional or continental

Strong transmission grids and interconnectors

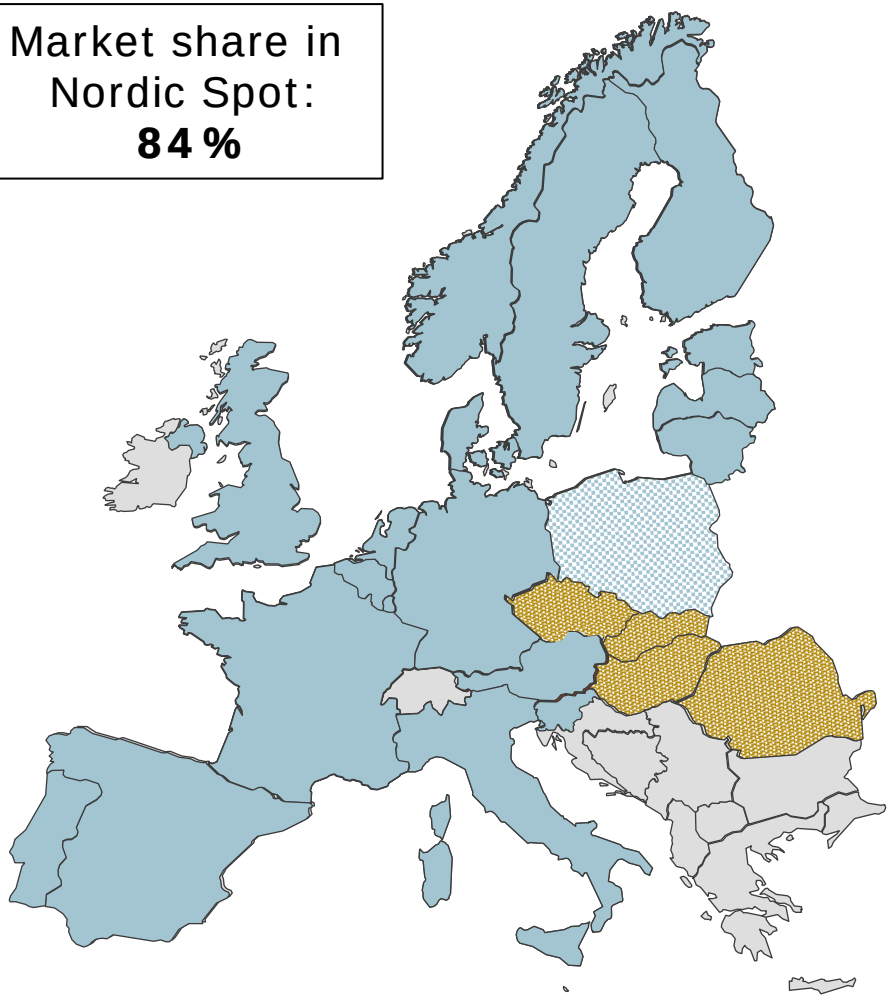


EXISTING	Exports	Imports
East Denmark-Sweden	1,700	1,300
East Denmark-Germany (Kontek)	600	600
West Denmark-Norway (Skagerrak)	1,700	1,700
West Denmark-Sweden (Konti-Skan)	740	680
West Denmark-Germany (East) I	1,640	1,500
Great Belt	600	600
Bornholm-Sweden	60	60
UNDER CONSTRUCTION	**Exports**	**Imports**
West Denmark-Netherlands (COBRA)	700	700
East Denmark-Germany (Kriegers Flak)	400	400
West Denmark-Germany (East) II	860	1,000
BEING INVESTIGATED	**Exports**	**Imports**
West Denmark-UK (Viking)	1,400	1,400
West Denmark-Germany (West)	500-1,000	500-1,000

Interconnector capacity equals maximum demand!

Market Coupling in Europe

Market share in Nordic Spot:
84%



	Nordic Region	Price coupling since 1999 (Eastern Denmark 2000)
	Belgium, France, Netherlands (TLC)	Price coupling since 2006
	Nordic region-Germany (operated by EMCC)	Volume coupling since November 2009
	Central West Europe (CWE)	Price coupling since November 2010
	CWE-Nordic region (+ Estonia) Flow calculated by EMCC Prices calculated by PXs	Interim solution NWE: Interim Tight Volume Coupling (ITVC) since November 2010
	Nordic region– SwePol/ Nordic region-Lithuania/ Nordic region-Latvia	Price coupling since Dec. 2010 / June 2012/ June 2013
	North West Europe (NWE) - One price calculation for entire area	Price coupling since February 2014 = target model
	NWE+SWE = MRC (multi regional coupling) One price calculation	Price coupling since May 2014
	MRC + Italian borders	Price coupling since February 2015
	4M – not yet coupled to MRC	Price coupling since November 2014

Energinet.dk forecasts
- Wind power
- Solar PV
- Load

BSP power schedules
- Planned production
- Technical min/max.

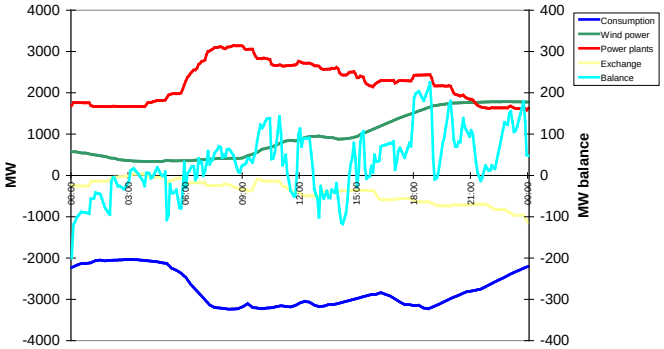
Energinet.dk online measurements
- Production
- Exchange
- Load

Interconnector schedules
- Germany
- Sweden
- Norway
- DK1-DK2

Energinet.dk

Operational planning tool

Forecast of system imbalances



Proactive Balance Management
- common Nordic regulating power market
- wind power participates in this market

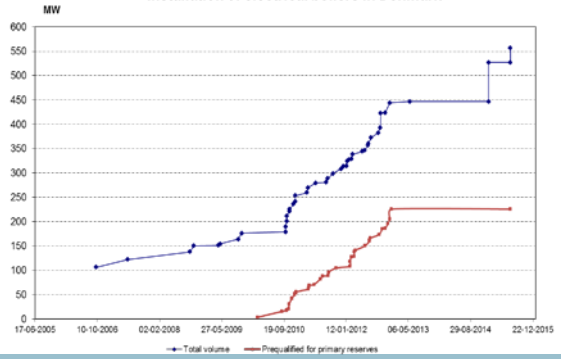
Three examples:

- High flexibility of large coal fired central units
  - Minimum stable generation: 10% - 20%
  - High ramp rates: 3-4% per minute

- Installation of new grid components
  - A number of synchronized condensers have been installed in order to secure stability in the system without any large central units running

- New flexibility in terms of electrical boilers
  - Low investment costs – fast to install
  - Utilize low prices in the market to produce heat
  - Capable of delivering different types of ancillary services

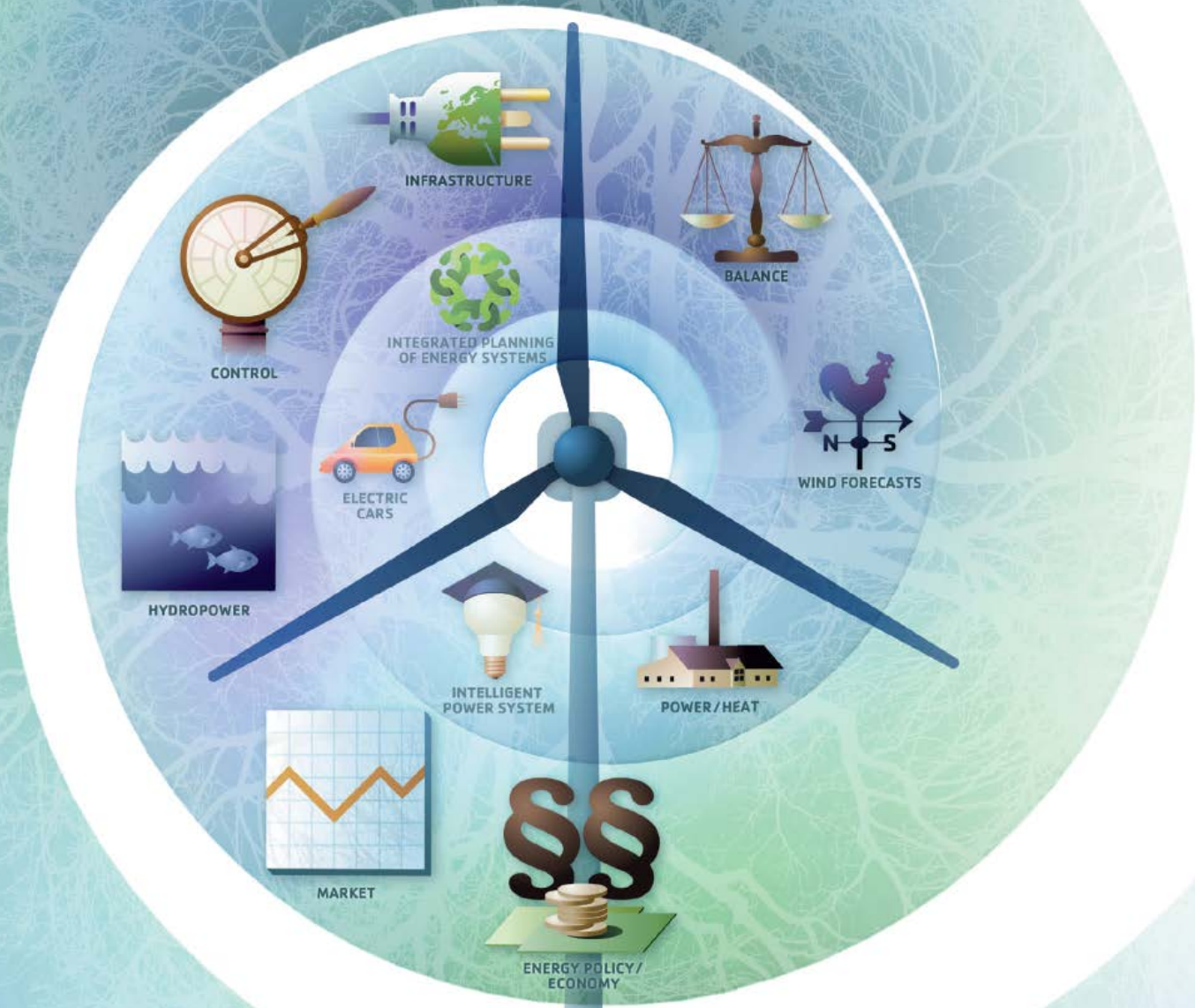
Installation of electrical boilers in Denmark



The missing link

- More intermittent energy sources require the demand side to act more flexible.
- Although a lot of R&D has already been carried out practical results from ”real” demand response are still very limited.
- In addition, consumers today have little incentive to take responsibility for their own security of supply.

- There is a need for re-orientation of smart grid and creation of innovative business models in order to make demand flexibility play a bigger role.



Thank you for your attention!