Flexibility of the Polish Power System

Technologies supporting flexibility in heating sector

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- About me
- The Danish Energy System
  - Small scale gas chp is phased out
- The Danish Heating Sector
  - Political focus on electrifying the DH sector
- Electricity uptake technologies
- Energy storage (heating) technologies

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Development in DH

Trending: Wind (HP), solar, seasonal storage

Renewables
- Solar

Renewables
- Solar / Wind

P2E

Local Surplus
- Industrial

Local Surplus
- Industrial / Geothermal

Local Surplus
- Industrial / Geothermal / Residential

Storage
- Steam

Storage
- Heat

Accumulation
- Heat / Seasonal

Accumulation
- Heat / Seasonal / Cold

Surplus
- Coal

CHP Surplus
- Coal / Oil

CHP Surplus
- Coal / Gas / Waste

CHP Surplus
- Waste / Biogas / Biomass

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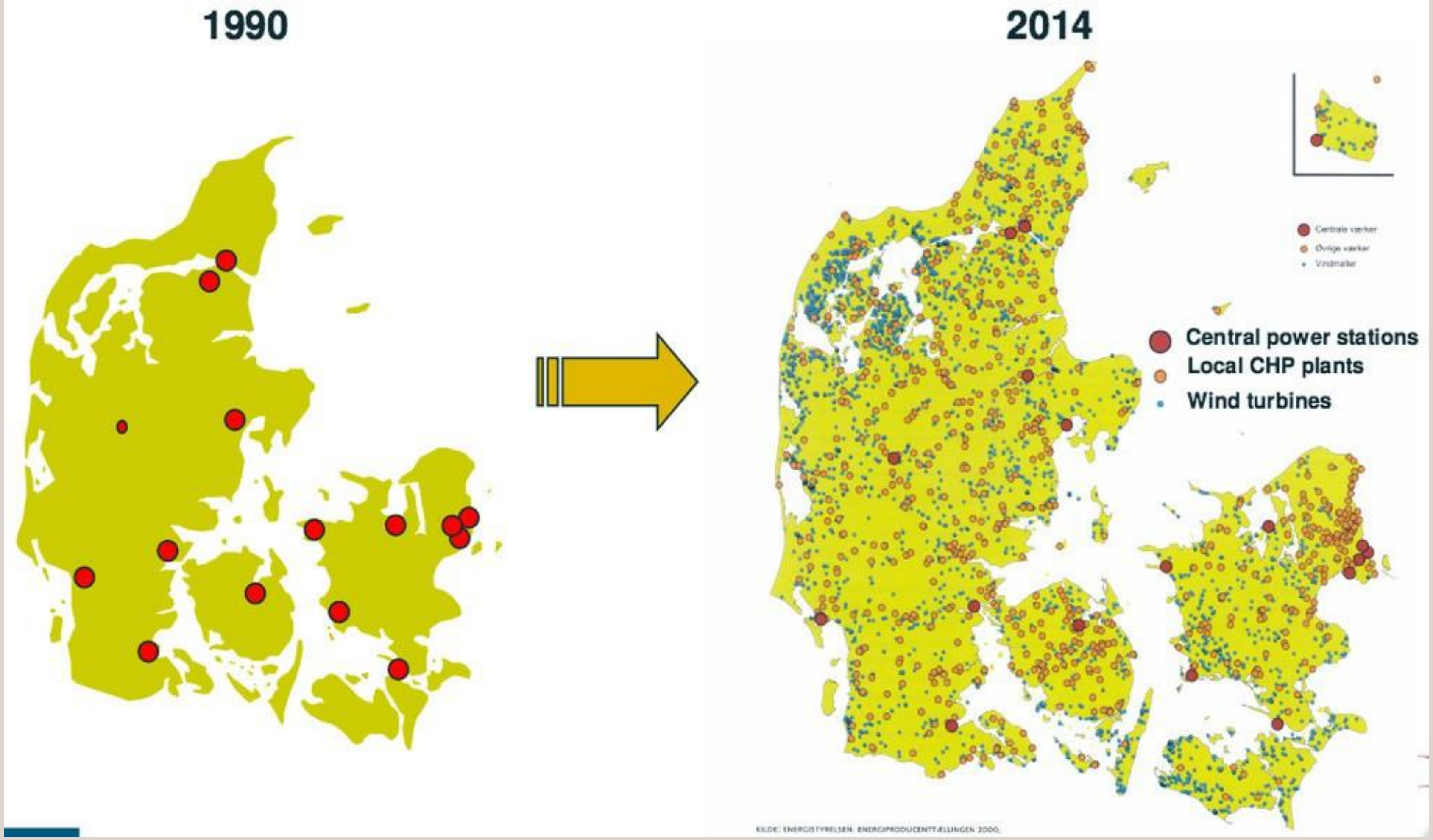
Historic development to decentral power production



Source:
Energinet.dk

The CHP standby support

For a small Danish District Heating Company using gas boilers and gas CHP units

The ”CHP standby support” is given to decentral CHP plants operating on the free electricity marked, to support decentral power production (balancing)

As the electricity price have declide the support have increased

In this exampel 90% of income from ”power” comes from standby standby support and only 10% from producing power

The CHP standby scheme will be phased out by the end of 2018

Year	Heat price Standard house Dkr.	CHP unit Support mio. Dkr.
2012/13	18.966	5.1
2013/14	17.835	7.0
2014/15	10.550	8.5
2015/16	9.450	*10.1*
2019/18	**17.950**	0

Plant data 2016:

- 1550 users
- 31 GWh heat sales
- 7.7 GWh power sales
- 11 mio. Dkr. revenue from electricity ”sale”
    - 90% income from CHP standby support

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Electrification of the District Heating Sector

Current situation

- The ”electrification of the District Heating Sector” have been a theme in Danish energy policy for a couple of year
- Main goal; use green electricity for heat production (political interest)
- Secondary goal; use the district heating system to balance an electricity marked with large amounts of fluctuating RES (marked interest)
  - What has happened so fare? not much, slow rollout
  - Main insecurities? Taxes and tariffs (Electricity tax, surplus heat tax and TSO/DSO tariffs)
- Main risk; Electrification of district heating system without balancing the electricity marked

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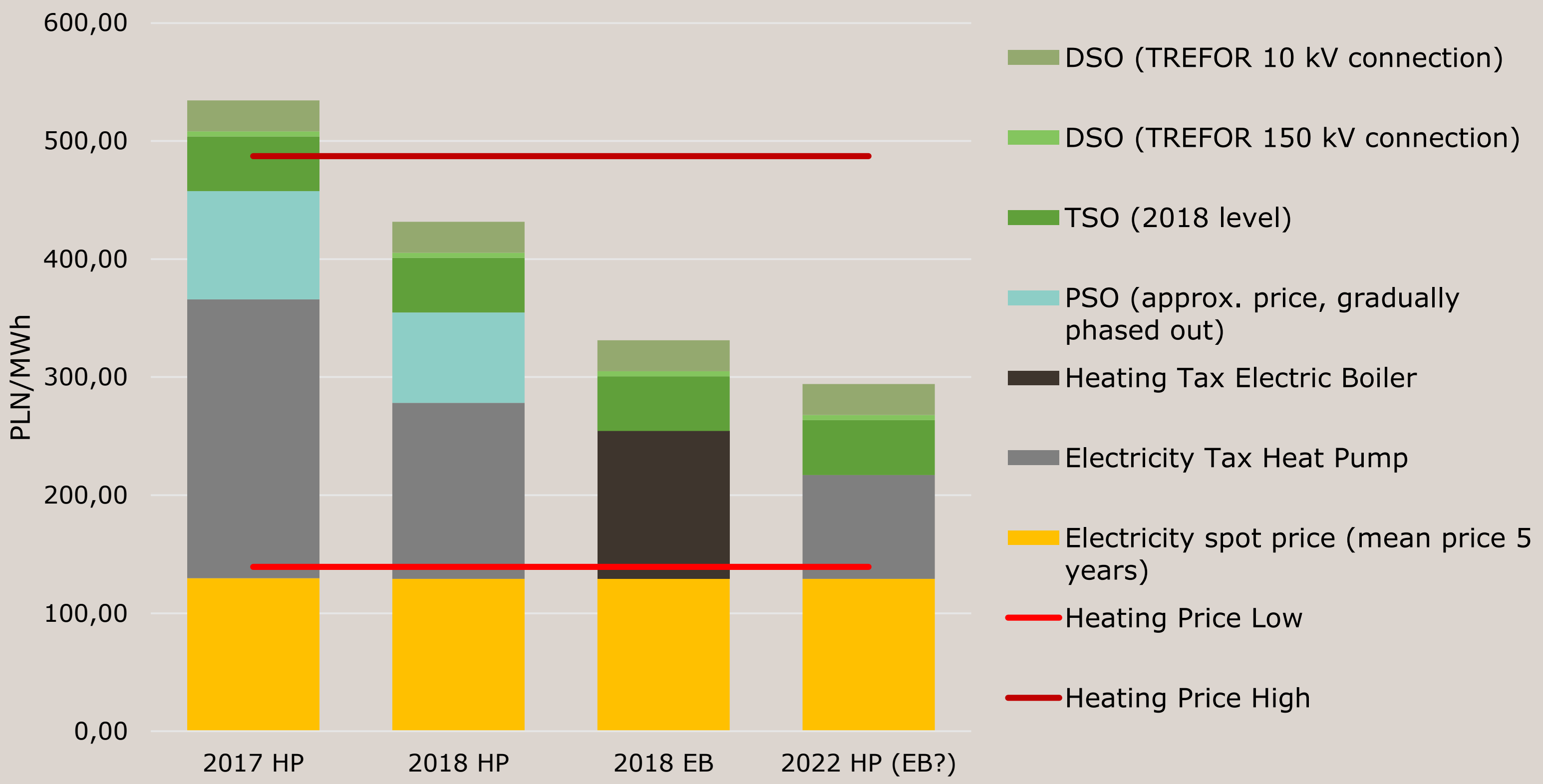
Electricity tax projections

Feasibility is determined by energy taxes



DSO cost depends on connection type

Public Service Obligation (**PSO**) is phased out towards 2022

For Heat Pumps (**HP**) tax is paid for electricity use

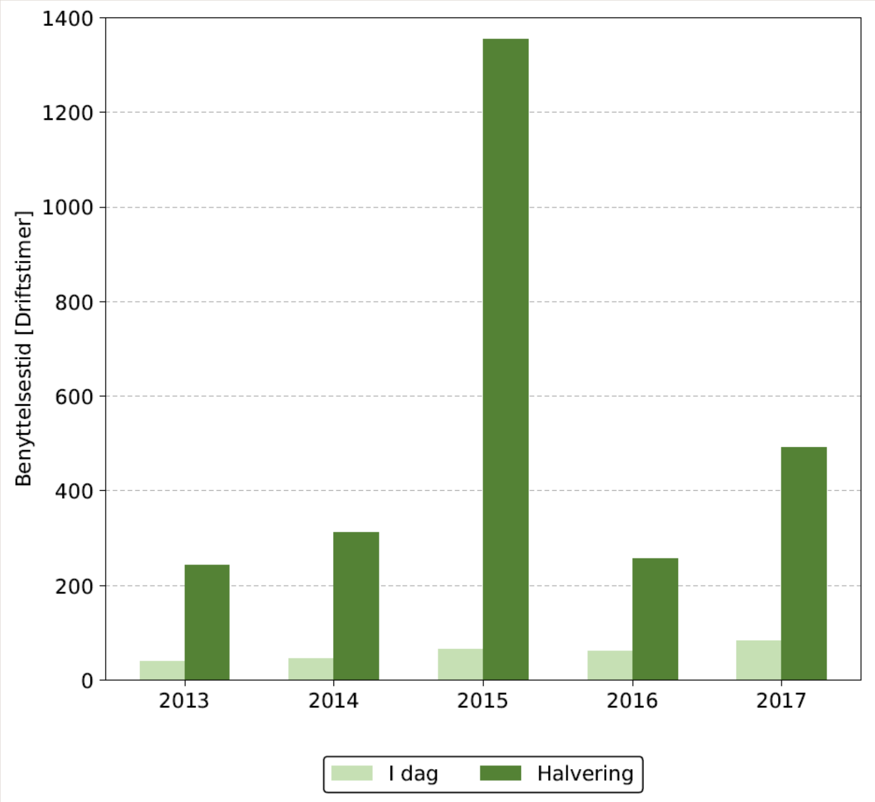
For Electric Boilers (**EB**) tax is paid for heat output

Political call to reduce taxes

2022 HP/EB shows a current political suggestion

Analysis of tariff impact on electric boilers

How would opperation look, if the tariffs were ½ current level?



The analysis from 2018 shows that halfing the tariffs would have incresed the production from the electric boilers

From 40-85 hours/year

To 240-1350 hours/year

This would have increased the income from the tariffs for the electricity companies as well, regardless of the reduction of the tariff

From 6000-14000 kr./year for 1 MW heat

To 20000-42000 kr./year for 1 MW heat

Electric Boilers and Heat Pumps

Main reason for choosing an electric boiler

Charateristics	Electric Boiler	Heat Pump
Investment Costs	Low	Relatively high*
Efficiency	**1:1**	**1:3-8**
Heat production cost	**High or balanced**	**Low or balanced**
Production profile	Green (if wind blows)	Very green
Operation and maintenance	Easy and cheap	Modest and cheap
Reaction time	**Rapid**	**Modest ******
Fuel security	High + spread of risk	High + spread of risk

*) capacity availability may also be an issue
**) to slow for regulation market special services, but production can be paused and used strategictly (smart grit opperation)

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Aarhus District Heating

Electric Boiler operation

Operation reason	Share of 1 year operation	Saving	Value pr. heating unit
Peak and reserve load	40 %	3-4 mio. DKK	118 DKK/MWh
Cheapest production unit	55 %	3-4 mio. DKK	86 DKK/MWh
Regulation power market	< 5 %	1 mio. DKK	270 DKK/MWh

Data from 2015-2016, 74 GWh operation (heat production equal to 0,7% of total heat production in Aarhus)

A simple study of the operation of a 80 MW electric boiler at Aarhus District heating, shows that the unit mainly run as a backup unit or alternative unit.

However the largest earnings per heating unit, comes from services to the ”regulation power market”.

The reason for operation may of cause vary a lot from year to year.

Electric Boilers

Experiences so far

- Currently most money earned on special services (Germany)
    - The commercial potential of the electric boiler is closely linked to the reaction times for the technical system - and how quickly decisions can be made.
- Connection charges for the electricity grit can run up (10-20 % of investment)
- For Heat production EB’s in Denmark are approx. on par with natural gas boilers, when investment costs and operational costs are compared
- Most are connected with ”limited net access”; the DSO can decouple the EB by remote (reduced connection fee)
- Heat accumulation capacity increases the value of the electric boiler significantly
- On the spot market (day-ahead) the EB will typically have very few operational hours. Therefore, it sould be on the market at all times (when it is operational)
- Future; direct use of windmill electricity

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Case: Wind for direct heat production

Electric boiler

Installed December 2017

35 MW (mid size)

Backup heat unit

Down-regulation power marked and Special Services Market (Germany)

For CHP companies; use of own produced electricity when price is low/negative

Possibility of connection neighboring wind turbines

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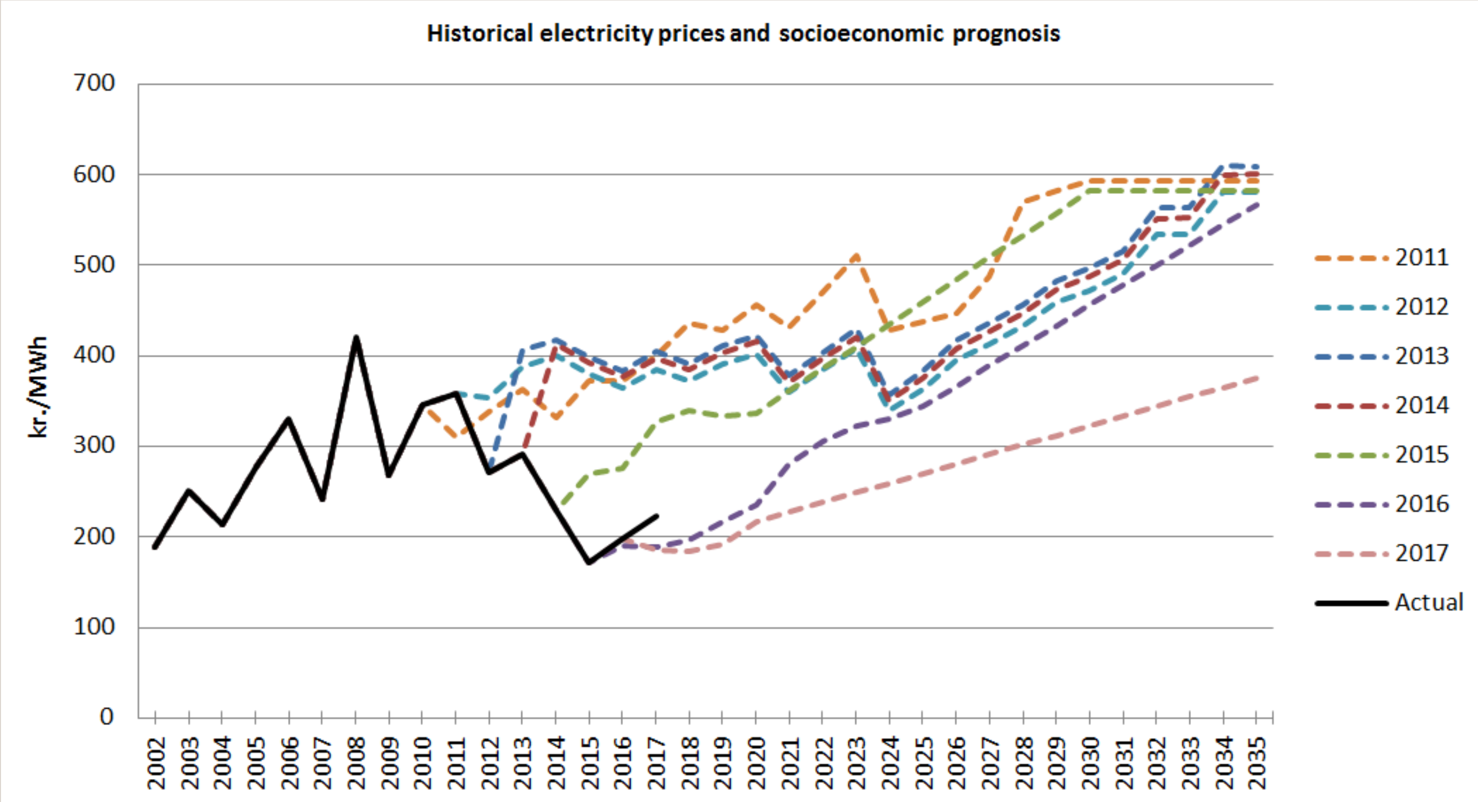
Future Electricity Prices

Comparison of electricity prognosis from National Energy Agency and actual prices

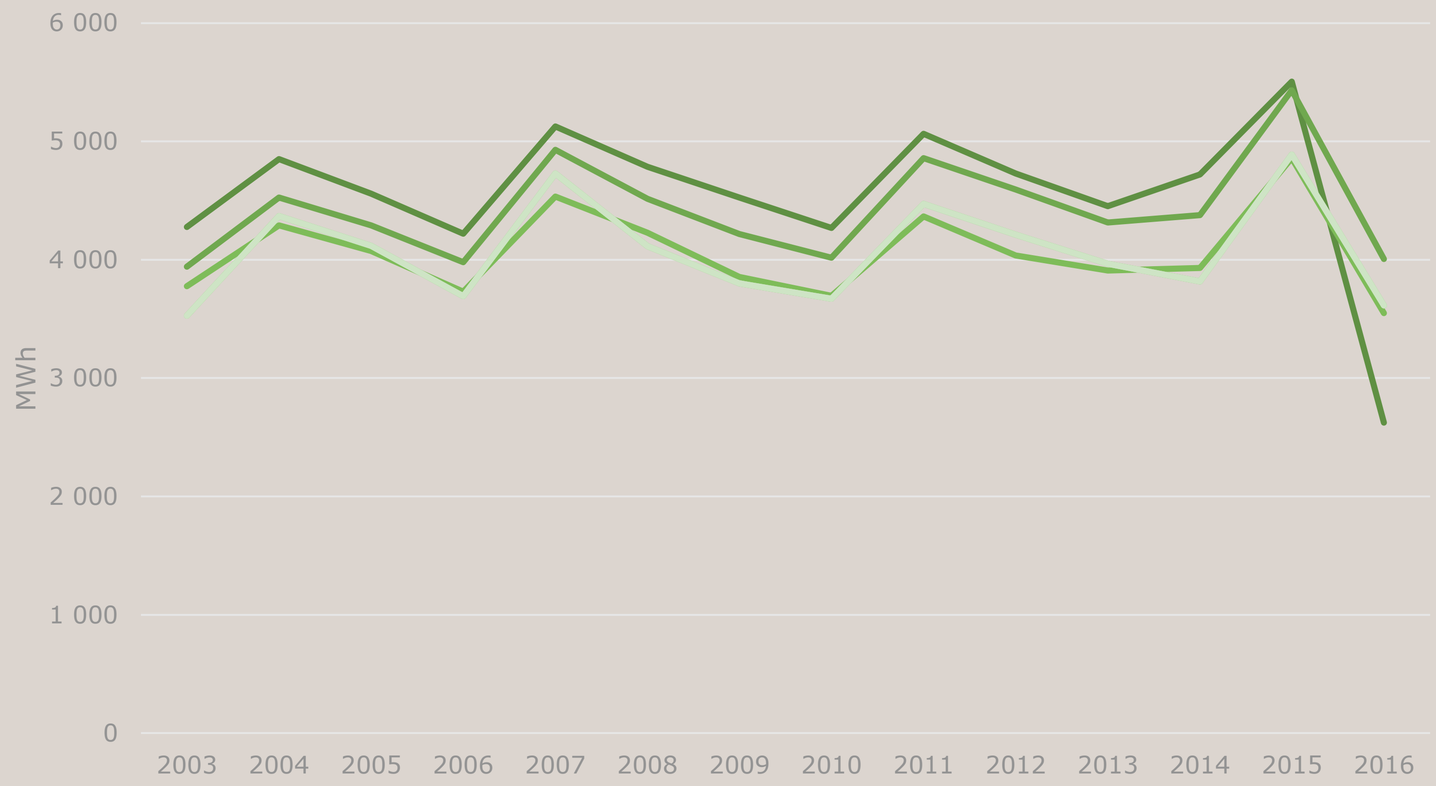


Calculating feasibility

- Not only taxes and tariffs are a challenge
- Diagram shows electricity price prognosis vs actual power prices

Wind energy production

Yearly electricity production from 6 neighboring windmills



- On a yearly basis, wind production can be rather stable
- Operational costs are well known
- Potential stable heat price, and
- many additional benefits

Benefits of wind connected to DH

Objectives

For mill owner		For grit owner		For DH owner				
Min. price sequrity (also when price support runs out)	Lifetime extension of existing wind turbine	Reduced electricity overflow	Reduced transmission costs (if own grit)	Tax free heat production	Tariff free heat production (if own grit)	Balancing CHP production	Cover own consumption of electricity (if plant connection)	Potentially balancing outskirts of DH grid

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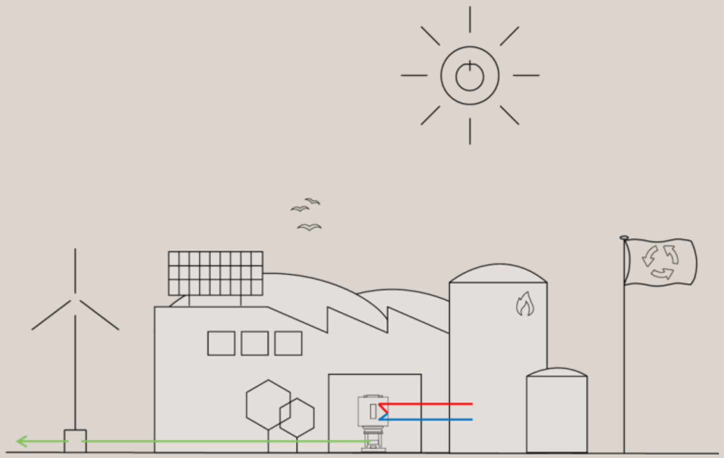
Connecting 6 neigbouring windmills

Future coupling with windmills



Demand to system:

- High level of control and stearing
- Agreement between parties
- Heat accumulation capacity

Outstading issues:

- Pricing of old mills?
- Electricity tax?
  - Ownership stucture
- Tariff structure?
  - Availability tariff
- EU legislation?
  - Parallel networks

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Energy Storage

- Joint accumulations capacity of 64 GWh in DK
- Equevilent to approx. 10 h full load electricity production from all wind mills in DK
- Larger is cheaper

50 GWh	4 units	1 unit	8 units
Tank Thermal Energy Storage (TTES)	Pit Thermal Energy Storage (PTES)	Borehole Thermal Energy Storage (BTES)	Aquafer Thermal Energy Storages (ATES)
5-95 C	5-95 C	-5-95 C	2-20 C
800-1500 DKr./m3 (+2000 m3)	150-300 DKr./m3 (+50000 m3)	150-300 DKr./m3 (+50000 m3)	40-250 Dk./m3
1-2 % heat loss pr. week	Heat loss: 15-30% year (<20% - 100000 m3)		

Dronninglund District Heating

60.000 m3 PTES, 35.000 m2 Solar Thermal Plant

Established	2013
Size	60000 m3
Investments	17 mio. DKr.
Temperature sets	10 – 90C
Capacity	5.570 MWh
Pumpe in / pumpe out Load	26,1 MW
Calculated heat loss year	2.260 MWh

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Thanks for your attention

Questions?

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