Contribution to the Campaign

电力规划设计总院
Electric Power Planning & Engineering Institute

ENERGINET

CNREC
国家可再生能源中心

Danish Energy Agency

Sharing our experience with coal-fired thermal power plant flexibility as a key contribution to the integration of increasing share of VRE

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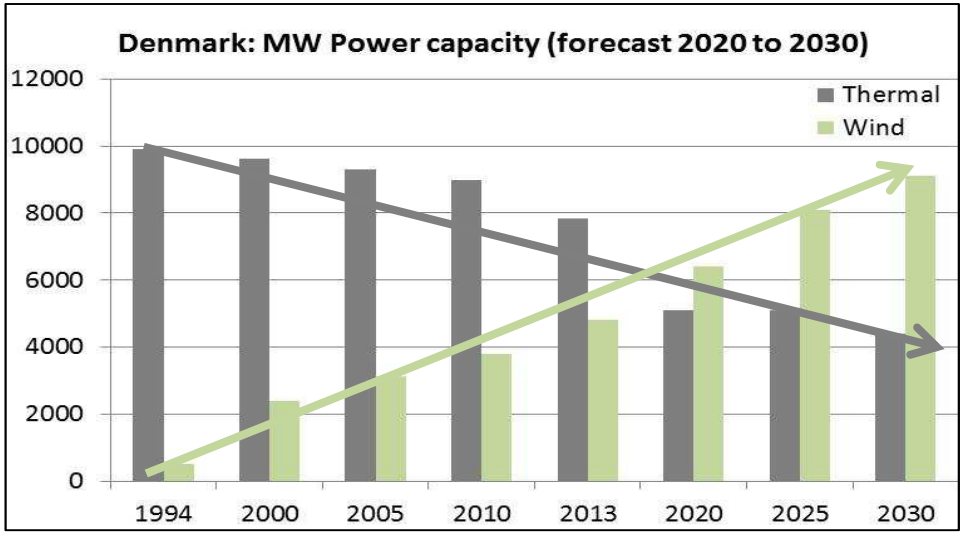
Agenda

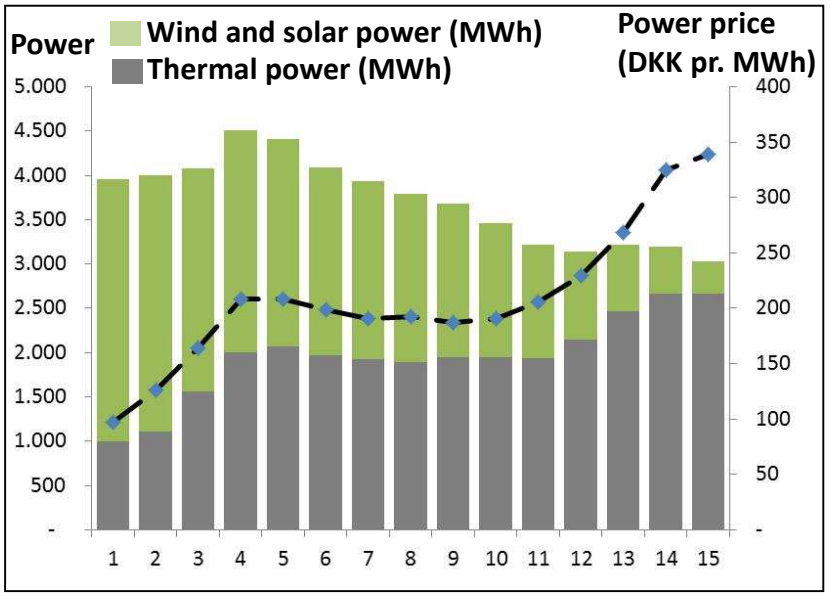
1. Advance power plant flexibility in Denmark's VRE integration
2. Large- scale integration of VRE in China and role of thermal power plant flexibility
3. Sino-Danish cooperation on advanced power plant flexibility
4. Possible contribution to the campaign

1. Advance power plant flexibility in Denmark's VRE integration

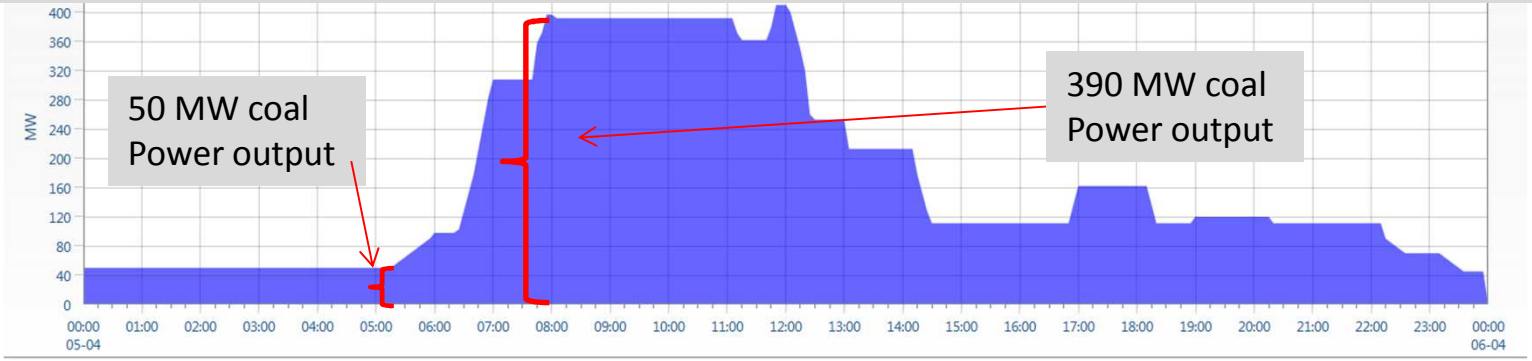
Thermal power capacity is no longer back-bone of production – but instead much more a provider of flexibility



Production and power prices during 14 hours period

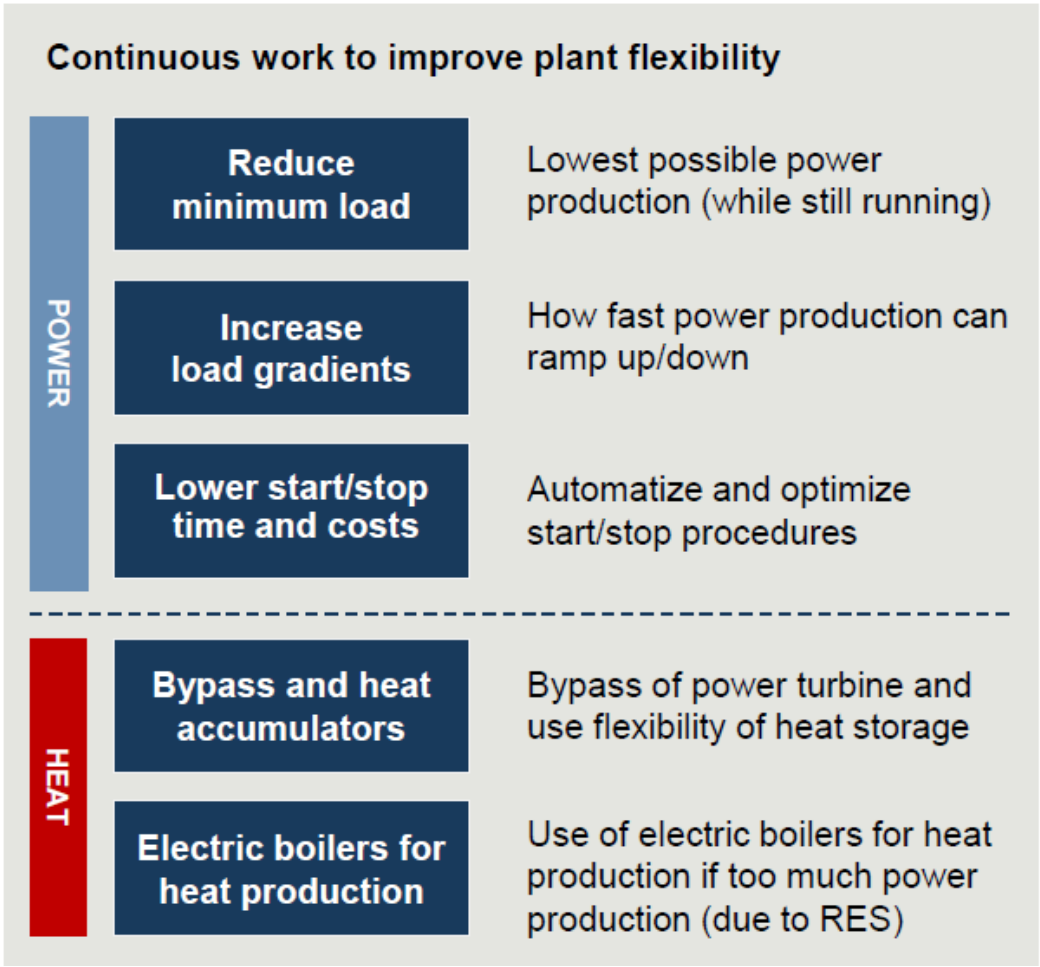


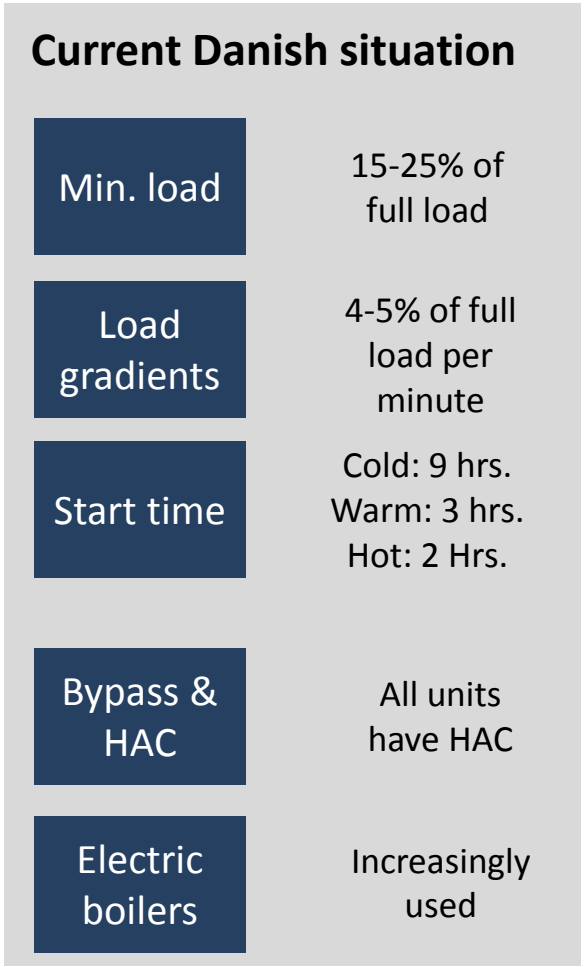
Power production on a Danish CPH plant during 24 hours



1. Advance power plant flexibility in Denmark's VRE integration

Improved flexibility of power plants can be obtained by minor or modest investments

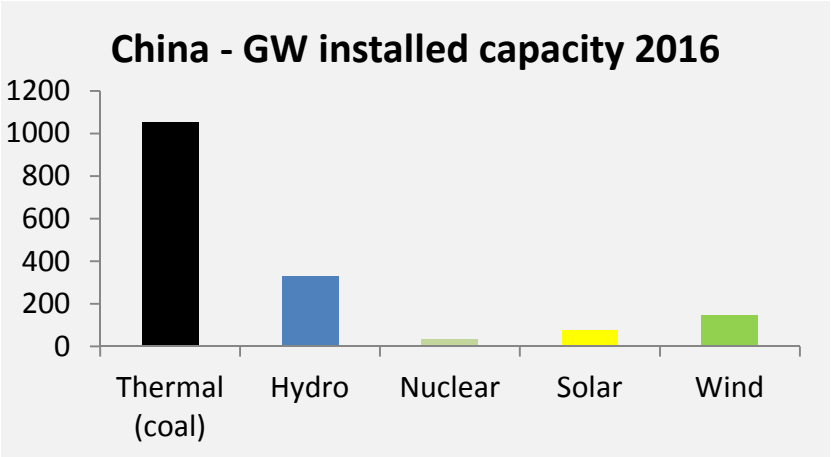




2. Large- scale integration of VRE in China and role of thermal power plant flexibility

VRE growth - and integration of it faces great challenges

- Installed capacities of wind power and solar power is targeted to reach 210 GW (150 GW in 2016) and 110 GW (77 GW 2016) respectively by 2020. (13th 5 year plan)
- The overall wind power curtailment between 2010-2015 amounted to 90 TWh
- In 2016, about 50 TWh wind & solar power was curtailed

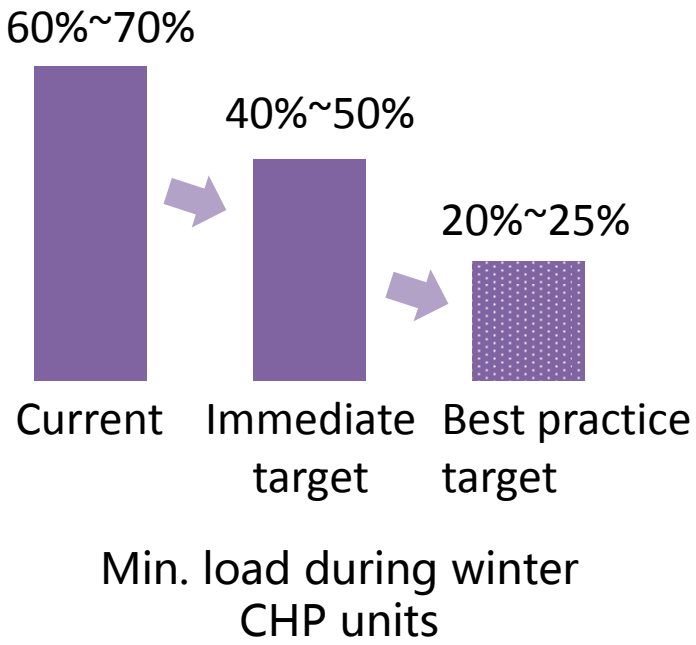


- Most of VRE integration challenges are in the 3 northern regions, where CHP production is wide-spread
- Combined-Heat-Power(CHP) plants will continue to increase in certain areas to replace small coal boilers.
- Northern regions will still lack conventional flexible power sources, such as pumped-hydro stations and gas turbines.

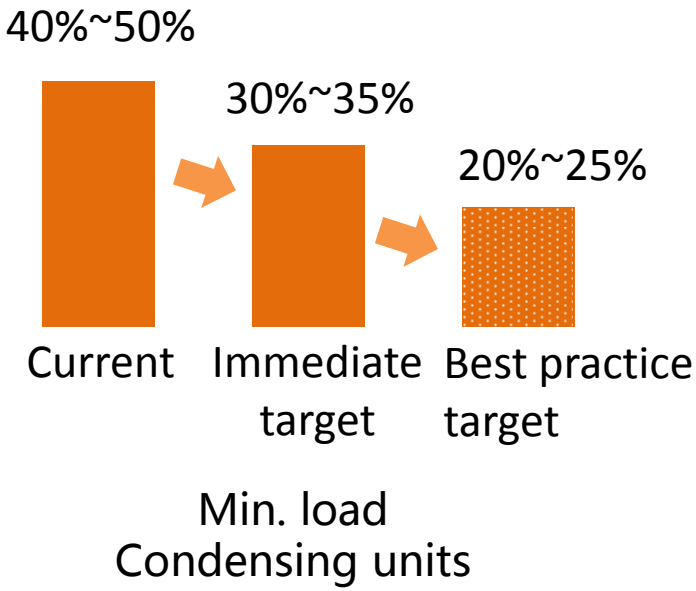
Need for Enhancing Thermal Power Flexibility

Unleashing the flexibility potential of the existing large coal power fleet in the 13th 5-year plan period (2015-2020)

- 130 GW CHP plants and 90GW power-only plants are targeted to be retrofitted by 2020
- After 2020 pumped-hydro stations gas turbines and battery can also contribute to the overall flexibility

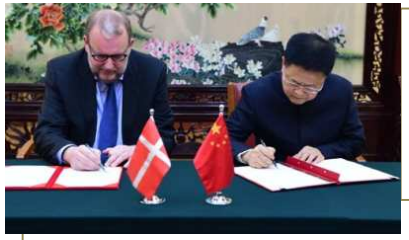


Min. load during winter CHP units



Min. load Condensing units

3. Sino-Danish cooperation on advanced power plant flexibility



January 2016: DEA and China National Energy Agency (NEA) signs MoU on thermal power plant flexibility

Chinese 13th 5 year plan on power sector aims at 220 GW retrofitted thermal power plant in 2020 with enhanced flexibility (+46 GW peak regulation)

China and Denmark co-lead CEM8 campaign on power plant flexibility until May 2018

Official launch of 22 demo projects in China

NEA launched "Enhancing power system regulation capability" project

Technical and market design workshops in Beijing with Danish experts

March 2016 | April 2016 | June | August 2016 | December 2016 | June 2017

EPPEI entrusted by NEA to lead work on thermal power plant flexibility

International Seminar on thermal power flexibility in Beijing

The 'big-5' Chinese power generator companies On study tour to Denmark and Germany

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Possible contribution from EPPEI to the campaign

Paper / report	Chinese situation and context	Background and reason for engaging in working with advance power plant flexibility
	Analytical method and process	How was the need for and cost-efficiency of enhanced power plant flexibility analyzed and assessed
	Market incentives	Incentive for enhanced power plant flexibility and to what degree is it adequate and how does it work
	Technical experiences from 22 demo projects	Effect and costs experiences from the demo projects and what are the key barriers to overcome
	Learnings based on Chinese experiences	Highlight key learnings and experiences from the last couple of years focus and work on advance thermal power plant flex.
Workshop	½ day workshop	Presentations highlighting technical learnings and market incentives
	1 day site visits	Visit one or two of the demonstration projects and possible provincial dispatch center or similar

Danish Energy Agency

Possible contribution from Danish TSO, Energinet (1/2)

ENERGINET

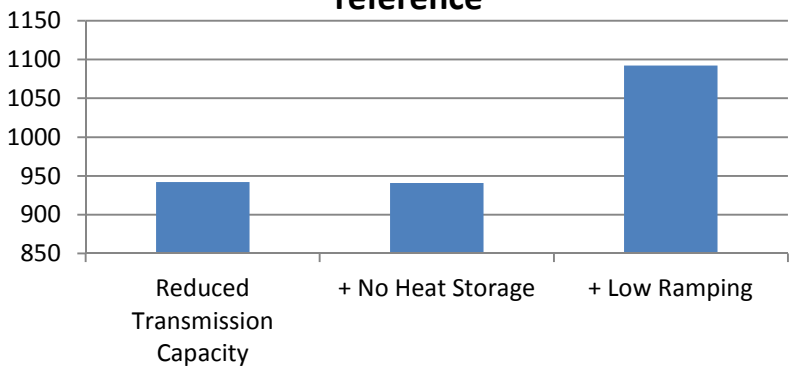
Paper / report
Model based analysis Input to paper on Danish experiences on impact and value of thermal power plant flexibility

Through Energinet's inhouse power system model illustrate what role the very flexible CHP plants in Denmark have on:

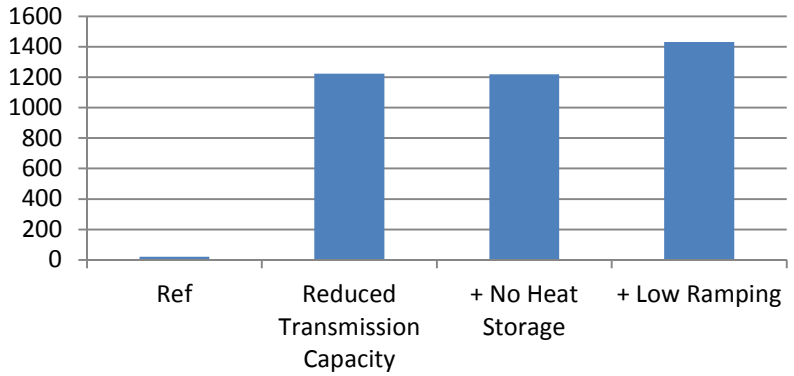
- Production effect in the power plant sector (FLH, stop/stop, achieved power prices etc.
- Physical system effects (VRE curtailment, import/export etc.)
- Economical system effects (whole sale price, achieved price pr. tech.)

Quick initial - and not validated results - for illustrative purpose

Socio-economic loss (million DKK/year) compared to reference



Wind + PV curtailment (GWh/year)



Danish Energy Agency

Possible contribution from Danish TSO, Energinet (2/2)

ENERGINET

Paper / report
Focus: Interplay between market design - and incentives for enhanced thermal power plant flexibility A report Danish experiences on impact and value of thermal power plant flexibility Input to an international best-practice manual on implementation of power plant flexibility

Share Danish experiences on how the different thermal power plant flexibility measures are incentivized in the different short term power markets (Day Ahead, Intraday and balancing market)

Provide insight into the general interplay between
(i) design of short term (Day-head, Intraday, balancing) power markets
(ii) incentives for providing generation side flexibility to the system and
(iii) a given power market's asset mix/types (hydro, VRE, thermal), size and types of units, weather patterns and other key factors of relevance for design of cost-efficient short term power markets

- How thermal power plants became more flexible over time - and particular what was the main drivers in this development
- How flexibility from thermal power plants is incentivized and used in each of the short term whole sale power markets.
- What type of power plant flexibility plays into which of the markets
- What conditions and regulation in the dispatch are critical to ensure cost-efficient use of - and incentives for - power plant flexibility

Possible joint contribution from CNREC, EPPEI, Energinet, and DEA

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Paper / report
Report on the energy system benefits from Chinese power plant flexibility Input to an international best-practice manual on implementation of power plant flexibility Seminar and dissemination activities in Beijing Dissemination at CEM9

Analysing the impact of increased power plant flexibility on a system level and on a stakeholder level by using advanced power market models developed as part of the ongoing Boosting RE in China Program approved by NDRC.

Analysing the impact on the different stakeholders of different policy measures for incentivising power plant flexibility, including efficient power market set-ups.

Contribute to preparing a best-practice manual, in cooperation with the IEA, for implementation of power plant flexibility as inspiration for other CEM members and presenting it at the CEM9 event in 2018.

Possible joint contribution from CNREC, EPPEI, Energinet, and DEA