

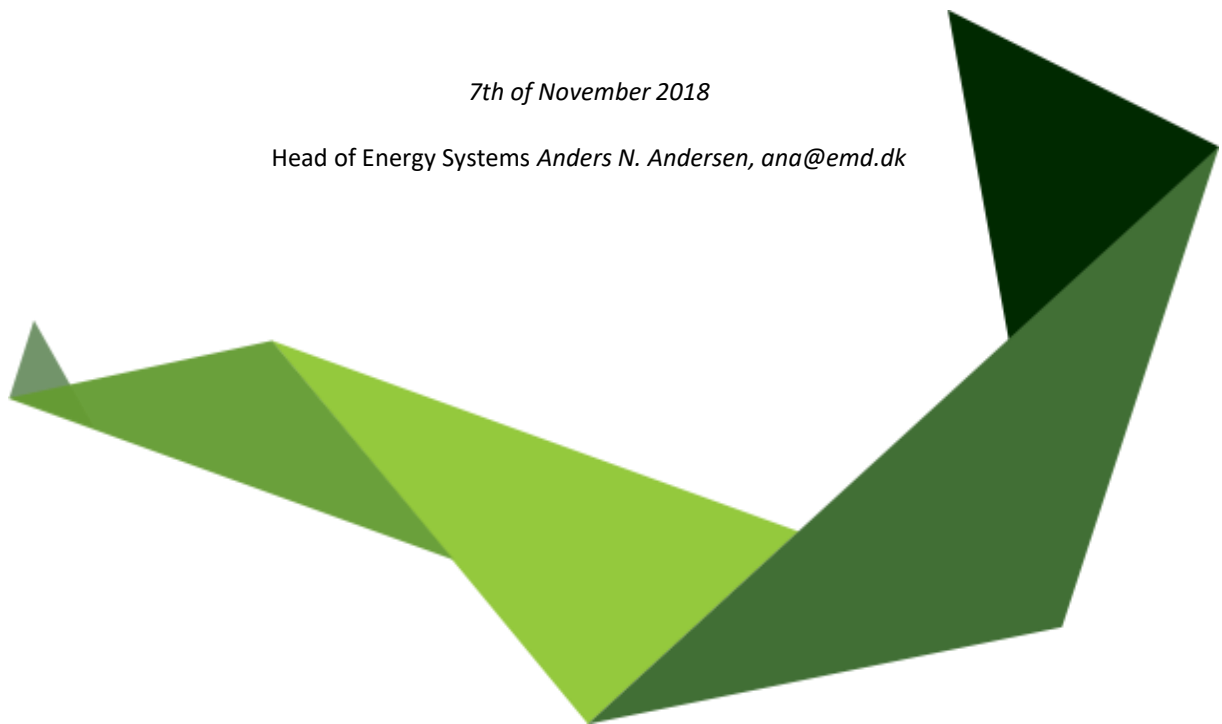


EMD's bid on challenges for

## 100% Renewable Energy in Fukushima prefecture

*7th of November 2018*

Head of Energy Systems *Anders N. Andersen, [ana@emd.dk](mailto:ana@emd.dk)*



**EMD International A/S**  
[www.emd.dk](http://www.emd.dk)



# My presentation

- Who we are
- Comparison of Fukushima prefecture and Denmark
- District Energy an important part of a 100% Renewable Energy System in Fukushima prefecture
- Intelligent operation of District Energy plants to integrate intermittent production from PV and wind energy



# Who we are?

## windPRO and energyPRO



- project design and planning of both single WTGs and large wind farms
- most used tool for wind energy project development
- more than 4000 users in the wind community
- See reference list at <https://www.emd.dk/windpro/references>



- combined techno-economic optimizations of energy systems
- Capability to model virtually any type of technology from well-known, fossil fuel-based production units to state-of-the-art renewables
- more than 400 users in the energy systems community
- See reference list at <https://www.emd.dk/energypro/references/>

## Selected energyPRO References



ARUP

*Danfoss*

RAMBOLL

COWI

WSP



sse  
Enterprise

NEAS ENERGY



ENERGIE AUS DER MITTE

*Vestas*®

UCDAVIS

*e-on*



Danish Energy  
Agency



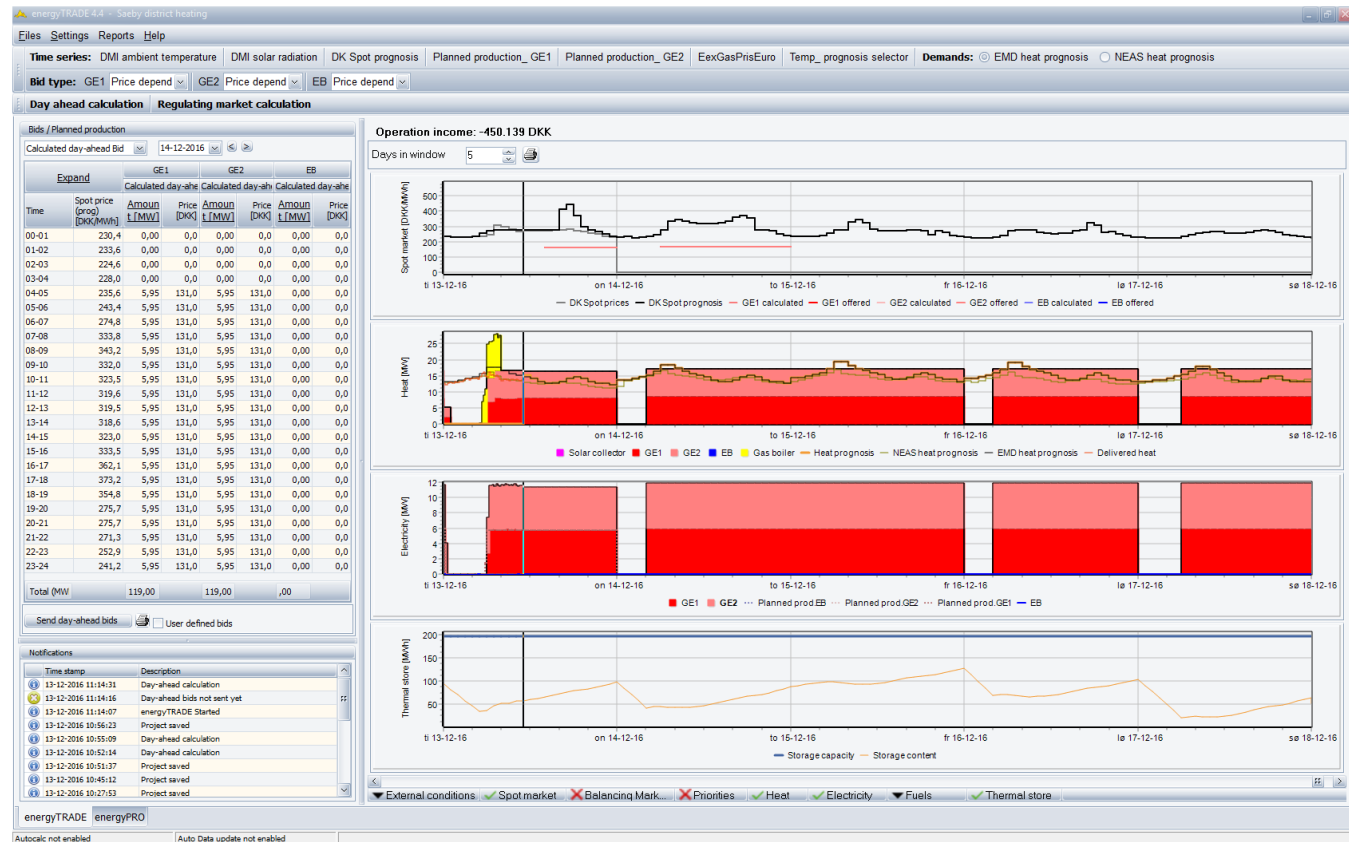
We offer the whole value chain to District Energy plants:

Daily operation and  
market planning tool  
**(energyTRADE)**

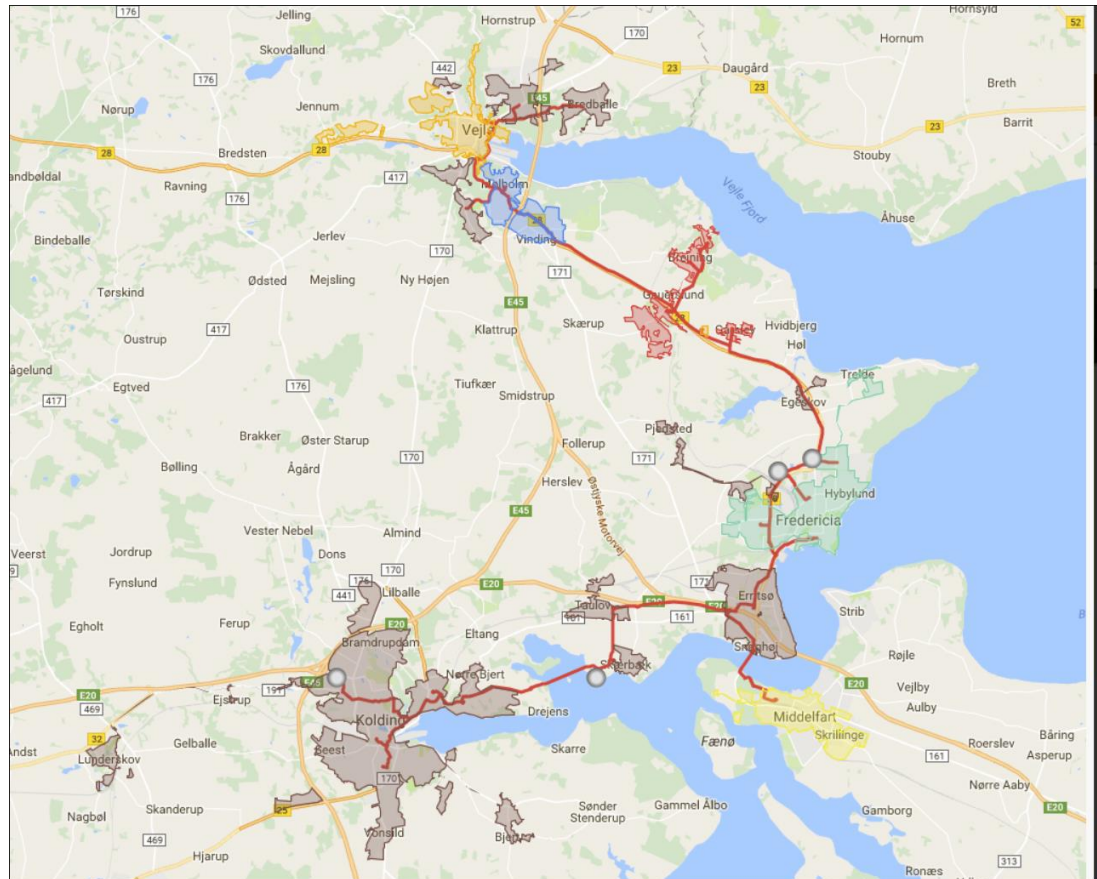
Operation follow up  
**(energyREVIEW)**

Investment analysis  
**(energyPRO)**

# Daily operation and market planning tool (energyTRADE)



**Daily operation and market planning tool (energyTRADE), also when limited transmission capacities between sites.**



## Operation follow up (energyREVIEW)

(see online operation at [www.emd.dk/energy-system-consultancy/online-presentations](http://www.emd.dk/energy-system-consultancy/online-presentations))





# Investment analysis (energyPRO)

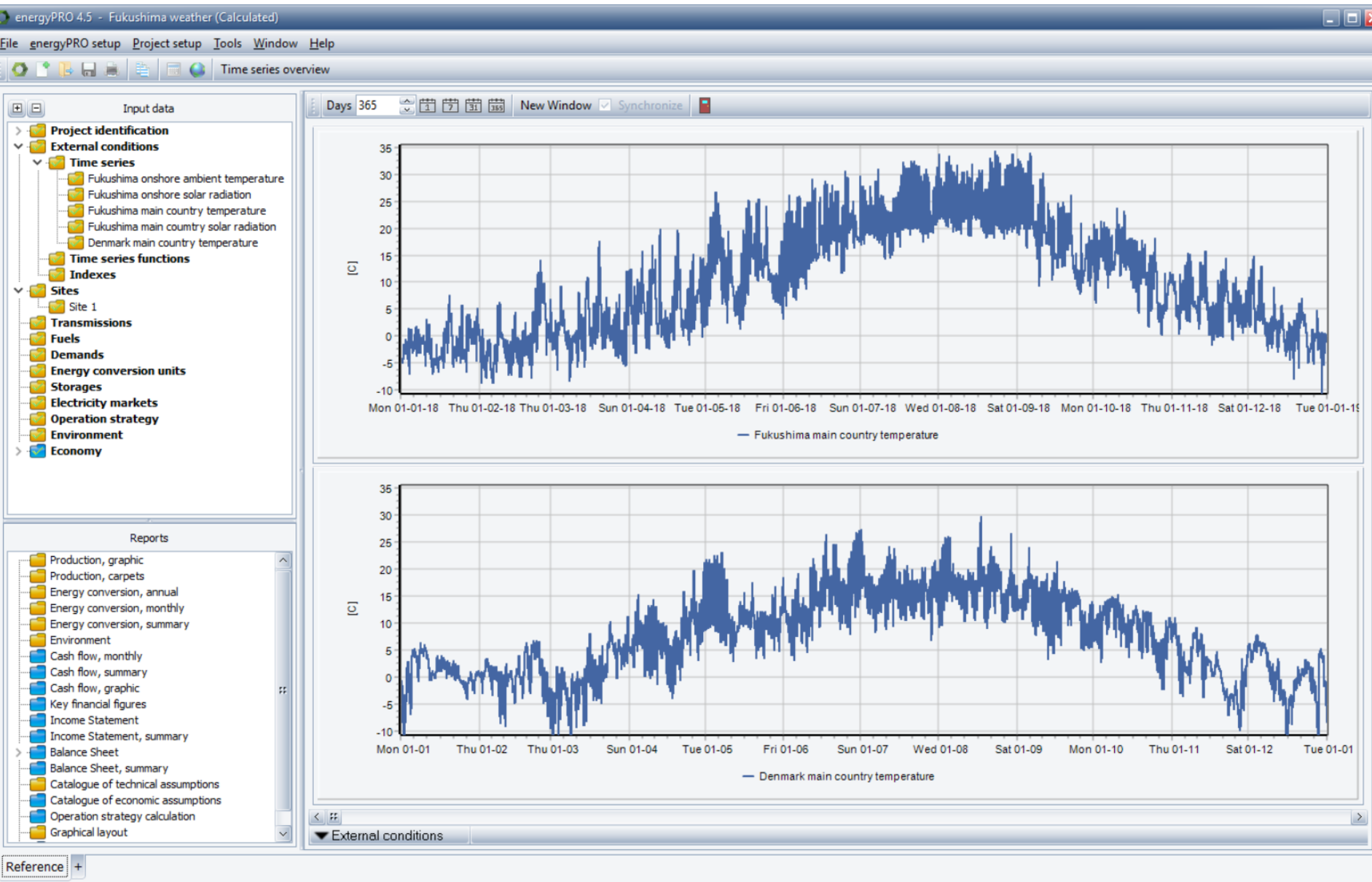




## Comparison of Fukushima prefecture and Denmark

Conditions	Fukushima prefecture	Denmark
Area per capita (m <sup>2</sup> /cap)	7331	7368
Average temperature (°C)	10	8
Yearly global radiation (kWh/m <sup>2</sup> /year)	1428	1016
Wind velocity	3,0	5,7

# Ambient temperature in Fukushima prefecture and Denmark from energyPRO weather database





## District Energy an important part of a 100% Renewable Energy System in Fukushima prefecture

### **Reasons for District Energy** *(to be modelled in energyPRO):*

- Exploitation of waste heat from power plants and industry
- Significant economy of scale-effect in solar collectors making communal systems much cheaper to build compared to solar collectors at each building
- Heat pumps gets access to a broader range of heat sources, e.g. heat from sewage systems
- Exploitation of geothermal energy
- More cooling sources becomes available, e.g. free cooling from lakes, rivers or seas.



## In which cities in Fukushima prefecture to implement District Energy

EU Horizon 2020 Work Programme 2016 – 2017  
concerning the final energy consumption in Europe:  
*"Heating and cooling constitutes around half of the  
EU's final energy consumption and is the biggest  
energy end-use sector, ahead of transport and  
electricity"*



In which cities in Fukushima prefecture to implement District Energy

**When you decide to develop a  
100% renewable energy system  
for Fukushima prefecture  
- identify the cities - where it is  
socioeconomic the cheapest to  
make district energy !**

*Is it cities with heating and cooling densities of  
120 TJ/km<sup>2</sup> or 60 TJ/km<sup>2</sup> ?*

Heat Roadmap Europe has dealt with that question, concluding that the overall heating and cooling demand in Europe should be reduced with 30%, half of the rest should be supplied from District Energy plants.

The screenshot shows the homepage of the Heat Roadmap Europe website. The browser address bar displays "www.heatroadmap.eu". The website features a navigation menu on the left with links: HOME, ABOUT, USEFUL RESOURCES, EVENTS, NEWS, IMPACT, PARTNER AREA, and CONTACT US. The main content area has a large title "Heat Roadmap Europe" and a subtitle "A low-carbon heating and cooling strategy for Europe". Below this, a text block states the objective: "The objective of Heat Roadmap Europe is to create the scientific evidence required to support the decarbonisation of the heating and cooling sector in Europe". A central graphic consists of eight hexagons containing the following statistics: "Many Useful Resources", "20+ Reports", "14 Countries", "23 Partners", "Some Surprising Results", "20+ Thermal Maps", "4 Studies", and "Videos". To the right, a map of Europe is shown with a color-coded overlay representing heat demand, with the word "Peta" in large text next to it. Below the map, a link "Online Now!" is provided, followed by a paragraph describing the 4th Pan-European Thermal Atlas (Peta 4) and its features. At the bottom right, there is a small thumbnail image of a software interface showing a map and various data layers.

Heat Roadmap Europe

A low-carbon heating and cooling strategy for Europe

The objective of Heat Roadmap Europe is to create the scientific evidence required to support the decarbonisation of the heating and cooling sector in Europe

Many Useful Resources

20+ Reports

14 Countries

23 Partners

Some Surprising Results

20+ Thermal Maps

4 Studies

Videos

**Peta**

[Online Now!](#)

The 4th Pan-European Thermal Atlas ([Peta 4](#)) covers the 14 EU member states that are part of the Heat Roadmap Europe 4 project. Peta 4\_v1.0 contains a 100m resolution grid of the modelled heat demand in 2015, a layer showing city areas where district heating systems exist in these countries, as well as a database of modelled excess heat supply. [Read more, explore, and watch the video here.](#)

**When electrifying heating and cooling demand – what is the right ratio between the central heat pump and booster heat pumps – the answer to be investigated by energyPRO**



**ELSEVIER**

Contents lists available at [ScienceDirect](#)

# Applied Energy

journal homepage: [www.elsevier.com/locate/apenergy](http://www.elsevier.com/locate/apenergy)



## Booster heat pumps and central heat pumps in district heating

Poul Alberg Østergaard<sup>a,\*</sup>, Anders N. Andersen<sup>a,b</sup>

<sup>a</sup> Aalborg University, Skibbrogade 5, 9000 Aalborg, Denmark

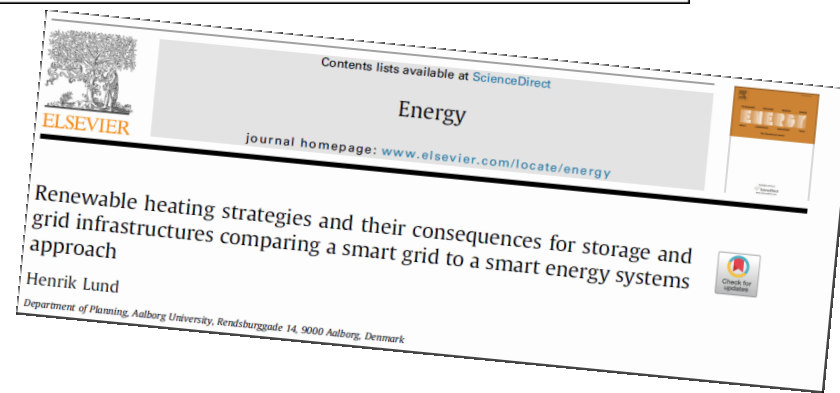
<sup>b</sup> EMD International, Niels Jernesvej 10, 9220 Aalborg Ø, Denmark



## District Energy energy stores are the cheapest

**Table 1**  
Storage cost assumptions.

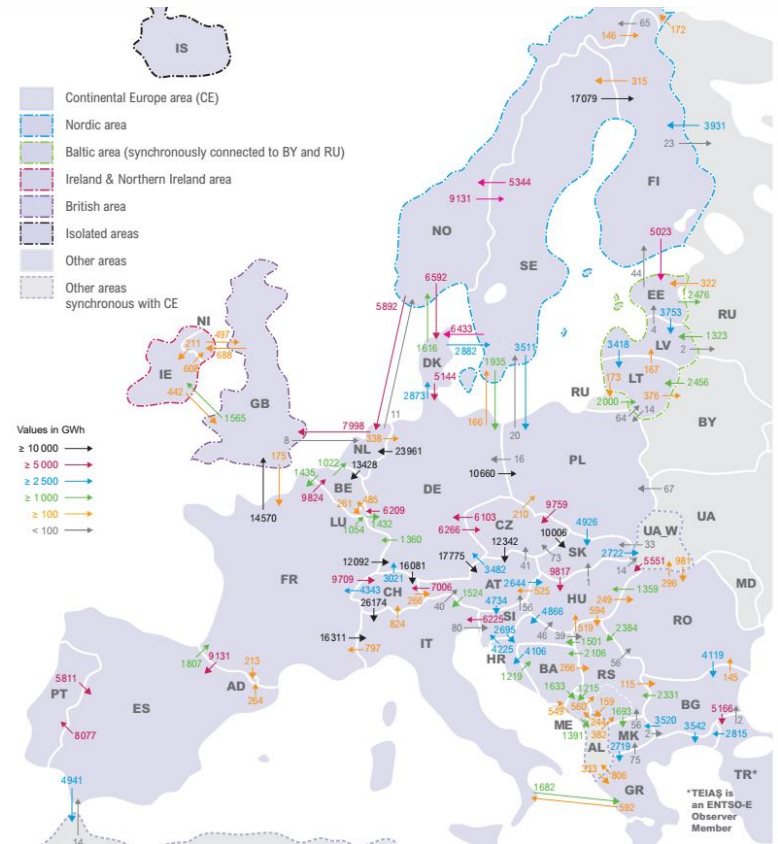
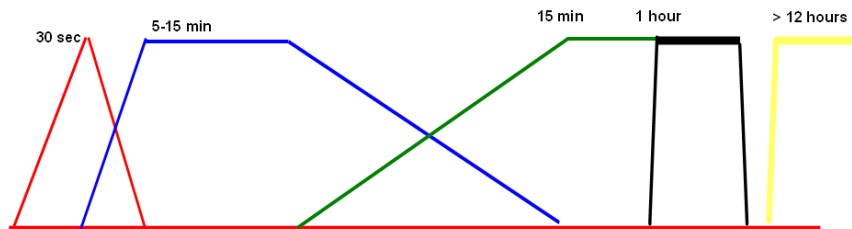
Storage type	Investment range [EUR/MWh]	Investment (chosen in this study) [EUR/MWh]
Large electricity storage (PHS)	125–600,000	200,000
Household electricity storage (Tesla)	600,000	300,000 <sup>a</sup>
Large thermal storage	500–2500	1500
Household thermal storage	24,000–180,000	20,000 <sup>a</sup>
Large gas storage		60
Liquid fuel		20



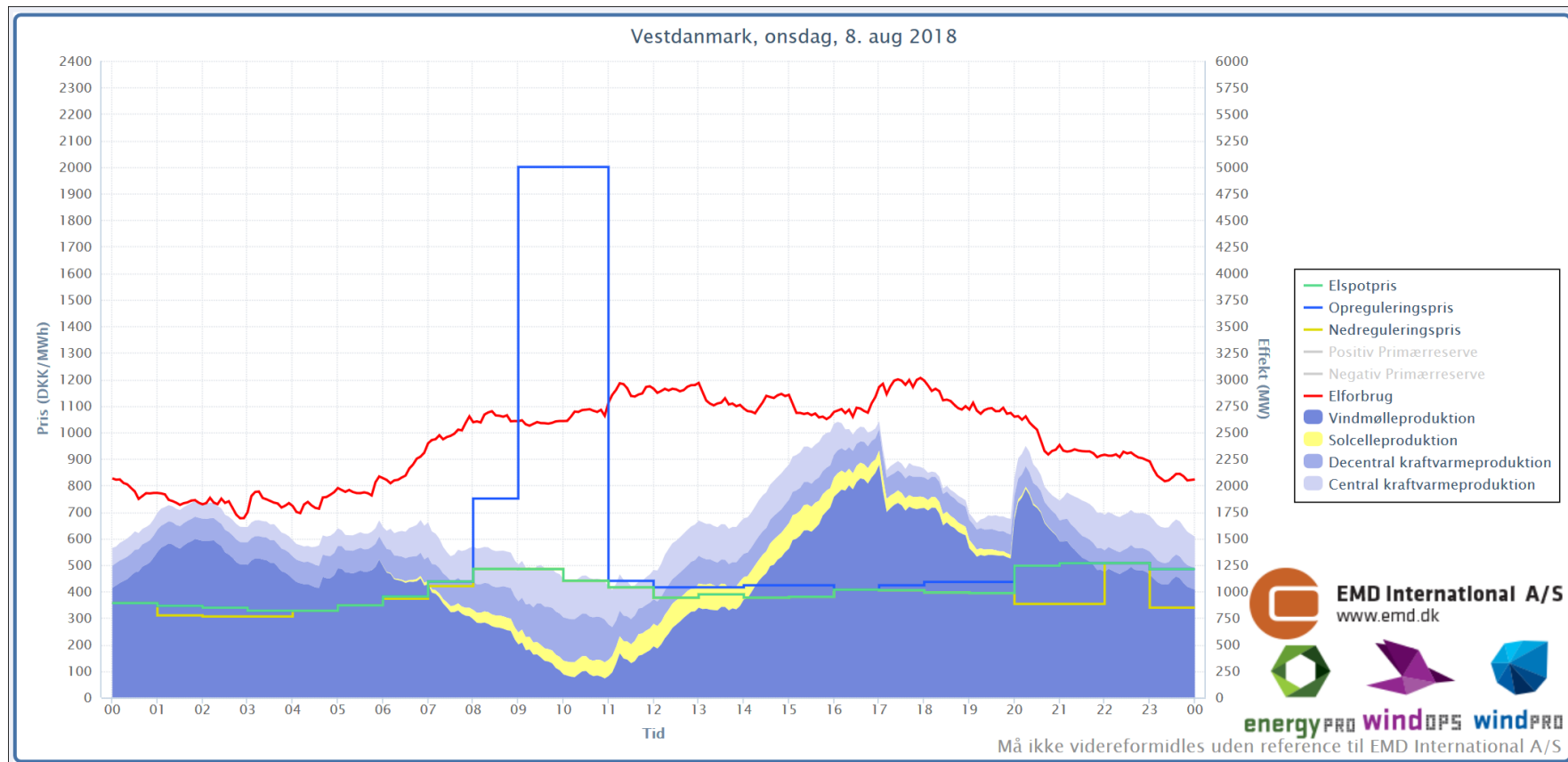
# The 5 European electricity markets that are able to integrate intermittent production from photo voltaic and wind energy

## ACER's general framework for the organization of the electricity markets

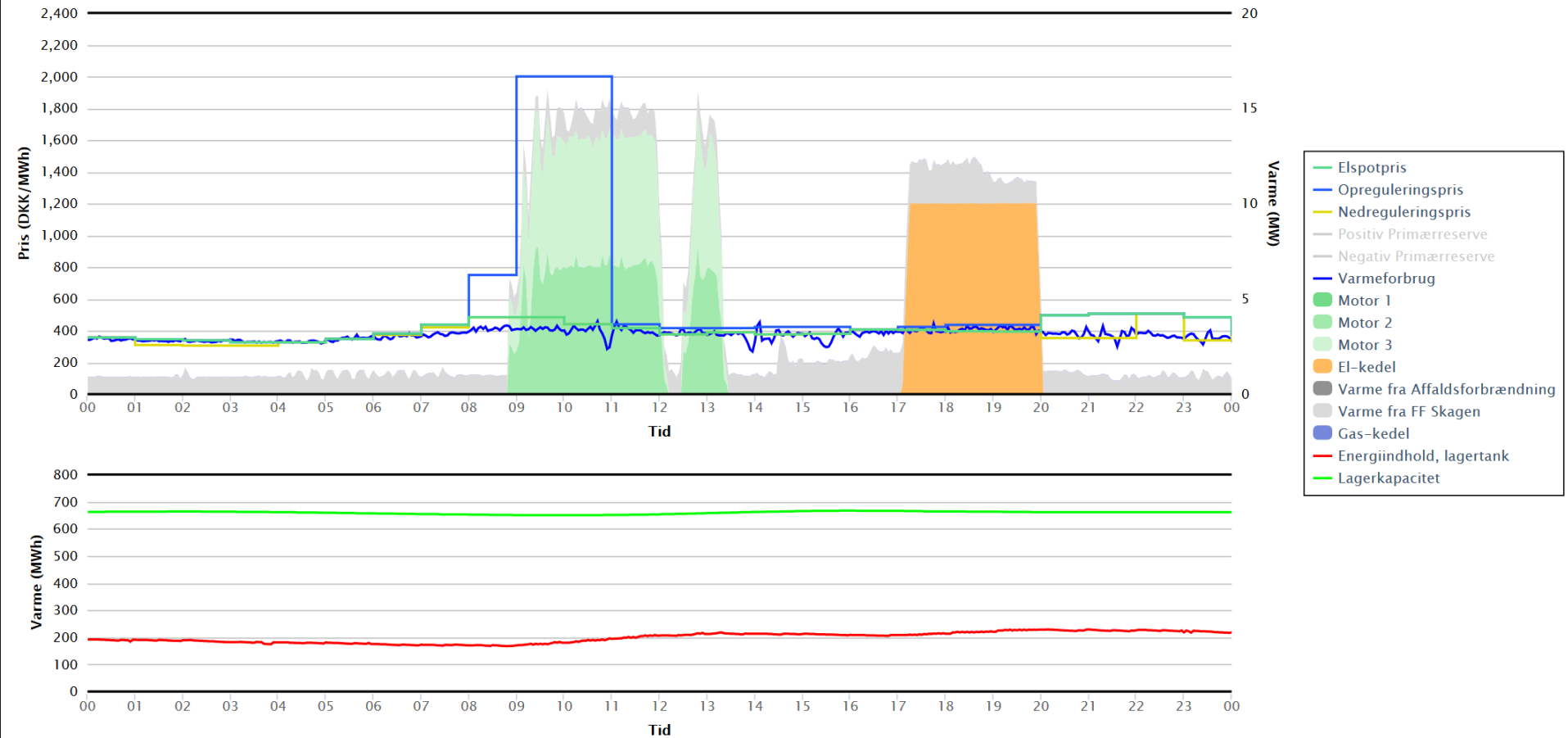
- Frequency containment reserves
- Frequency restoration reserves
- Replacement Reserves
- Intra day whole sale market
- Day ahead whole sale market



An example of market based operation  
[www.emd.dk/energy-system-consultancy/online-presentations](http://www.emd.dk/energy-system-consultancy/online-presentations)



# Skagen Varmeværk, onsdag, 8. aug 2018



Denne side hostes og vedligeholdes af EMD International A/S



Thank you for your attention !