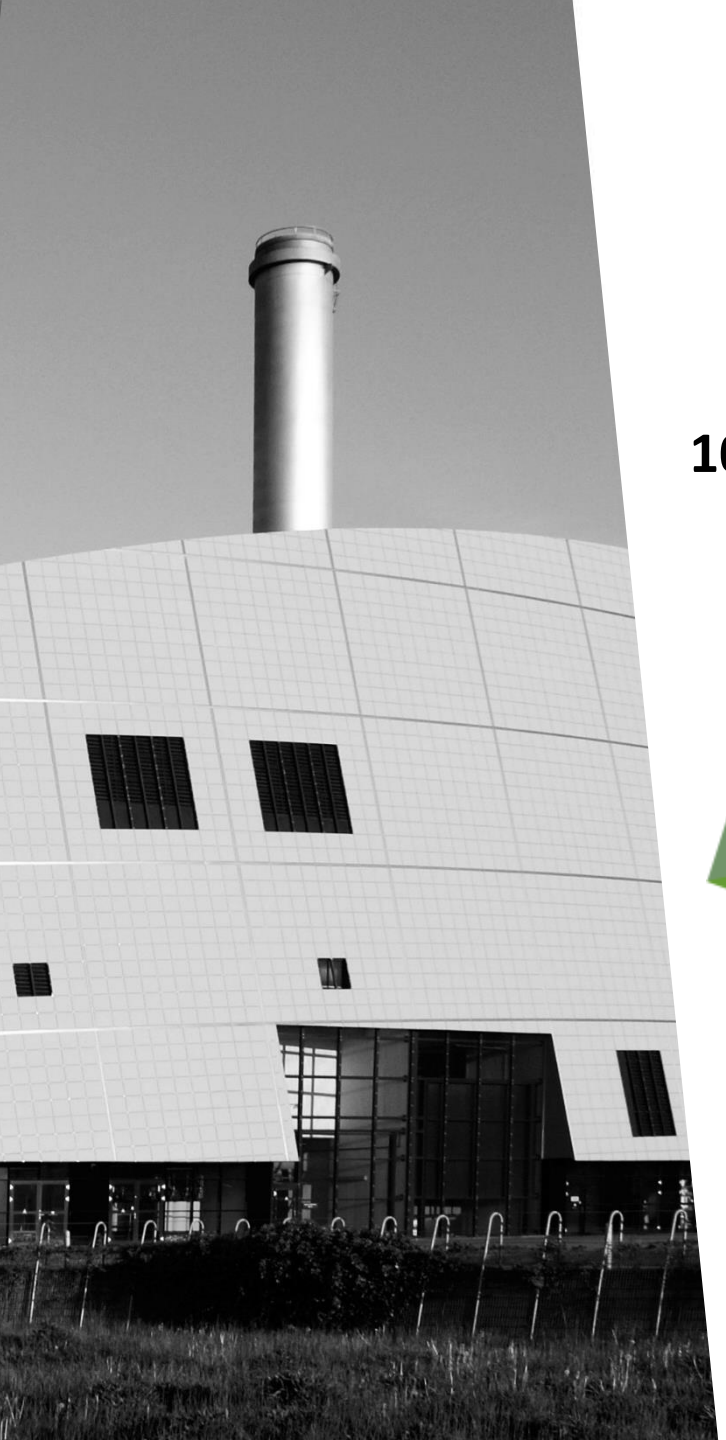


EMD´s bid on challenges for

100% Renewable Energy in Fukushima prefecture

7th of November 2018

Head of Energy Systems *Anders N. Andersen, ana@emd.dk*

EMD International A/S
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

windPRO

- 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

energyPRO

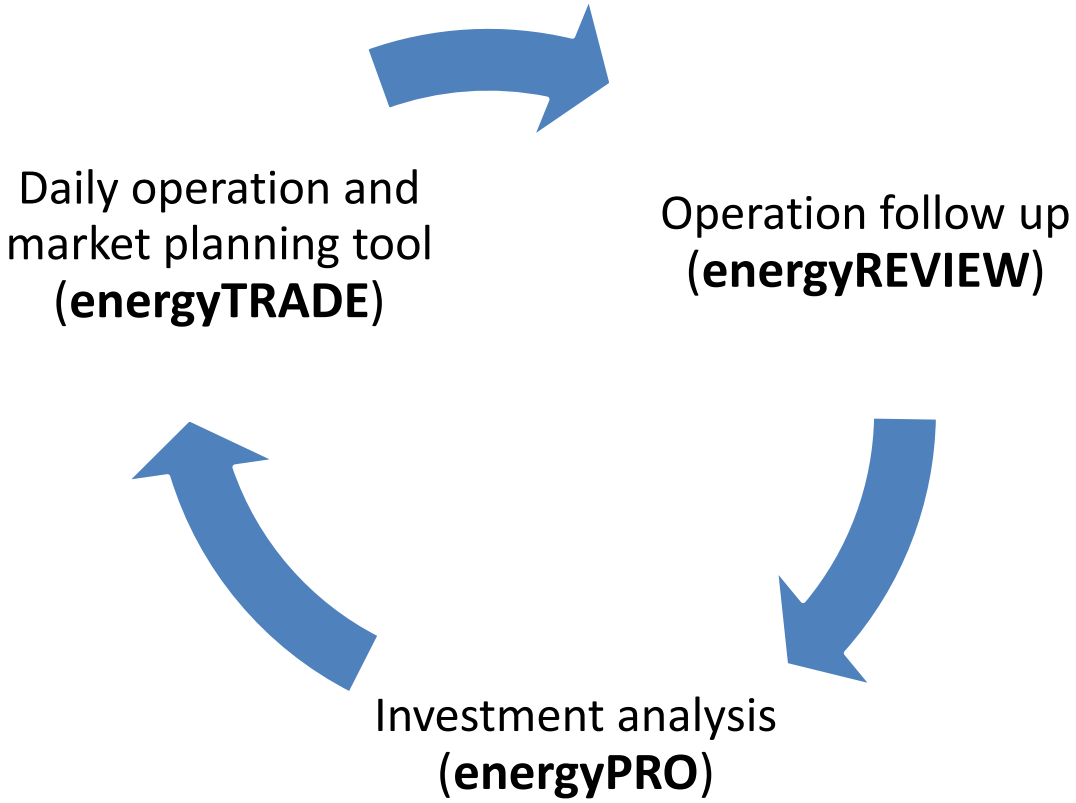
- combined techno-economic optimizations of energy systems
- Capability to model virtually any type of technology from well-known, fossil fuel-based production units to state-of-the-art renewables
- more than 400 users in the energy systems community
- See reference list at https://www.emd.dk/energypro/references/

Selected energyPRO References

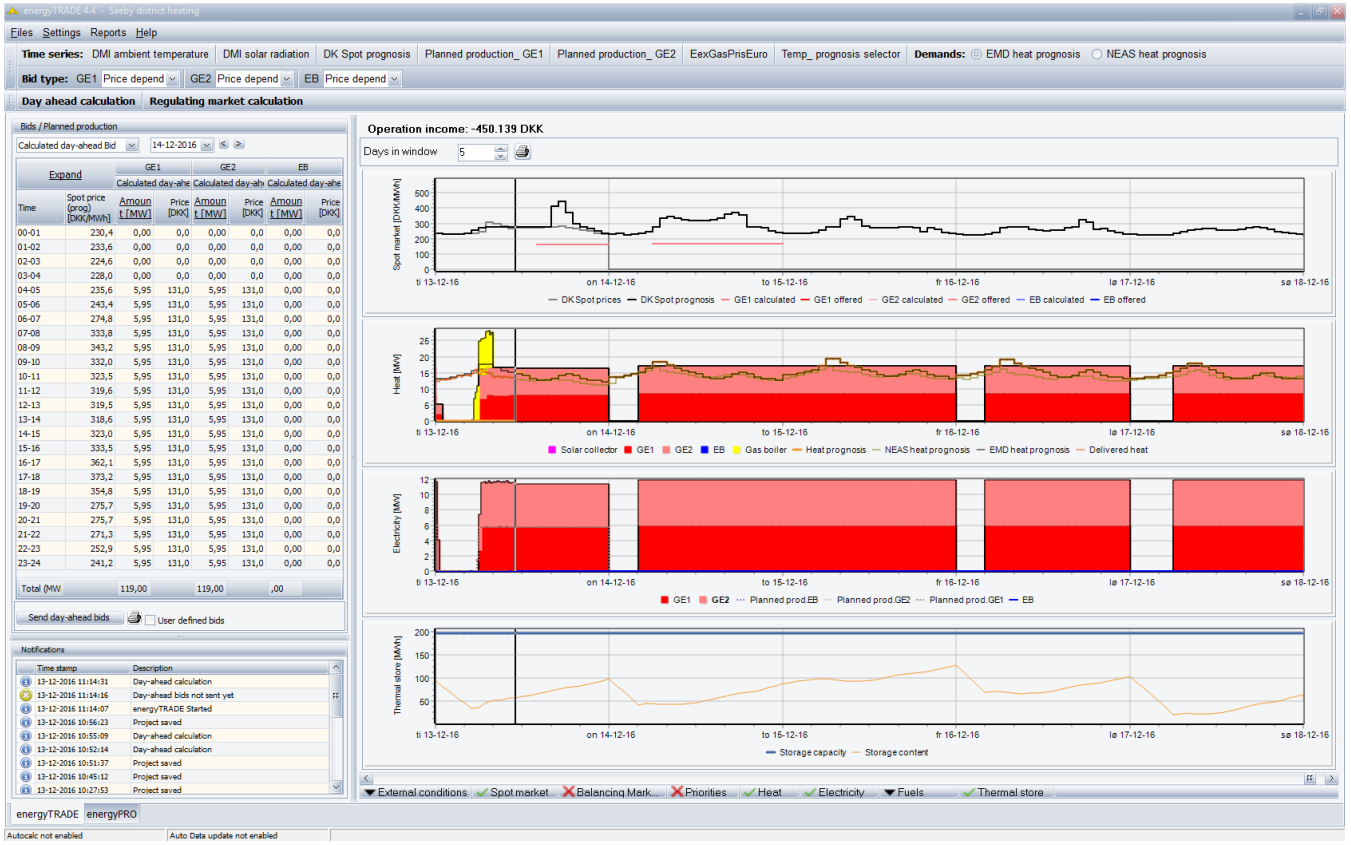
ENERGIE AUS DER MITTE

Danish Energy Agency

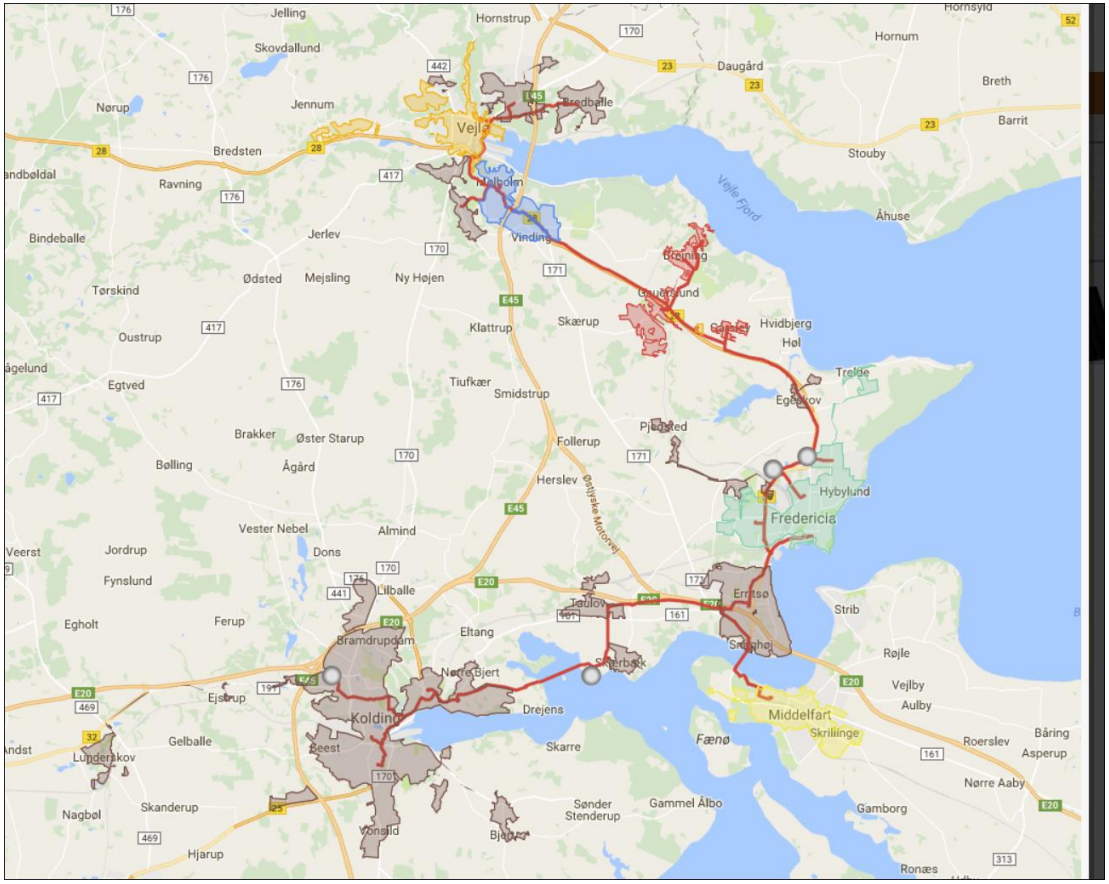
We offer the whole value chain to District Energy plants:



Daily operation and market planning tool (energyTRADE)



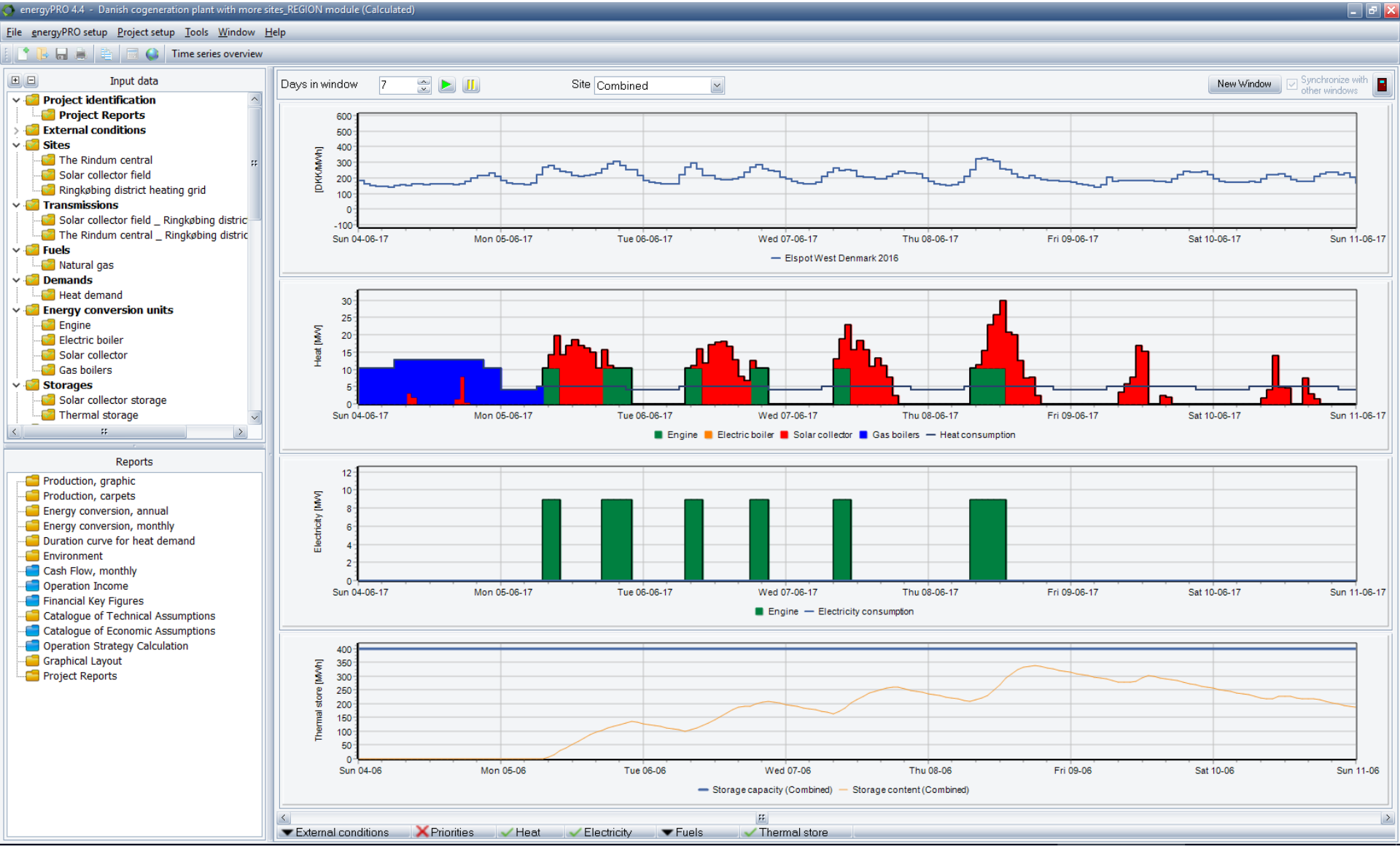
Daily operation and market planning tool (energyTRADE), also when limited transmission capacities between sites.



Operation follow up (energyREVIEW)

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

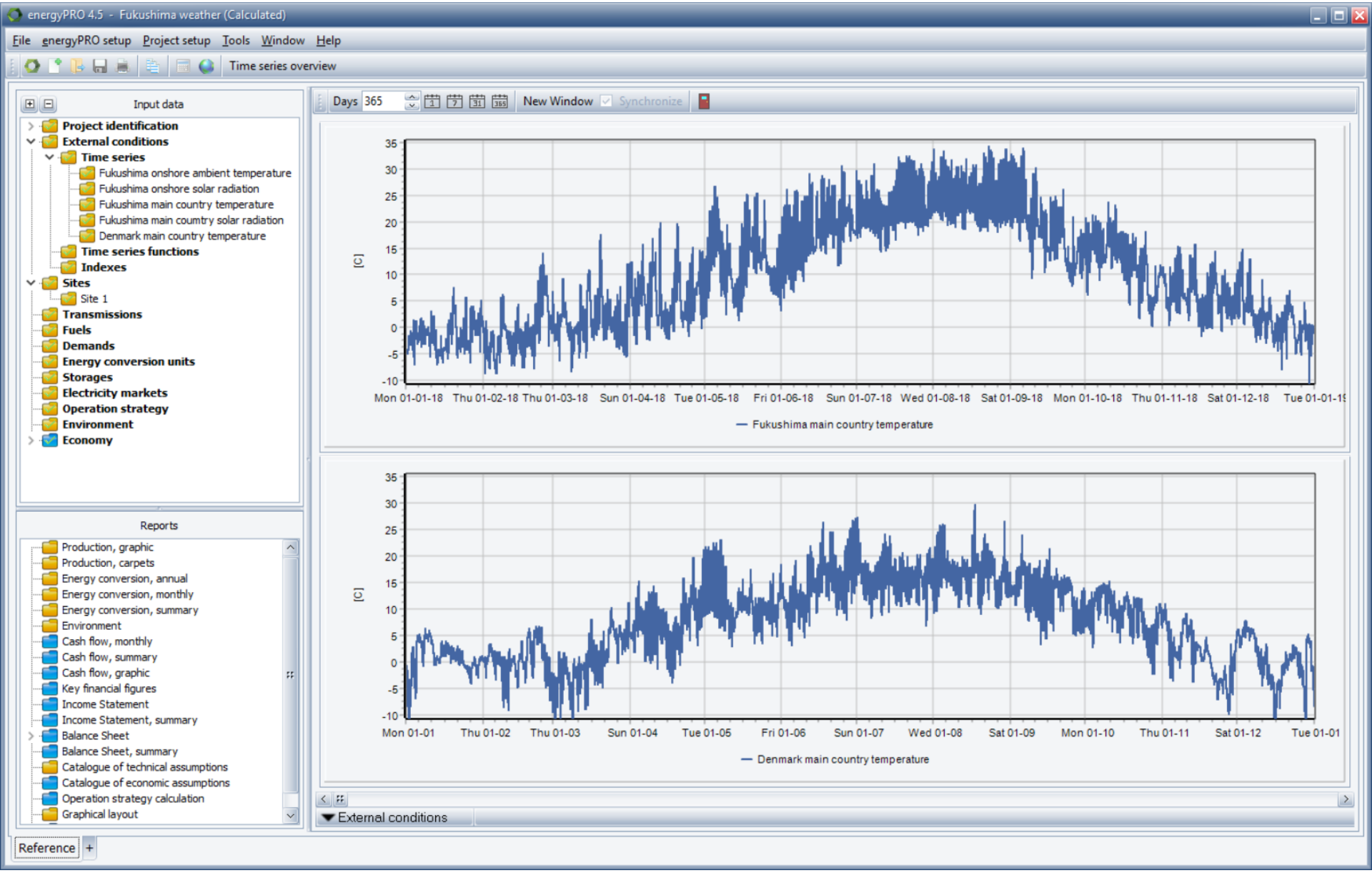
Investment analysis (energyPRO)



Comparison of Fukushima prefecture and Denmark

Conditions	Fukushima prefecture	Denmark
Area per capita (m^2/cap)	7331	7368
Average temperature (°C)	10	8
Yearly global radiation (kWh/m^2/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

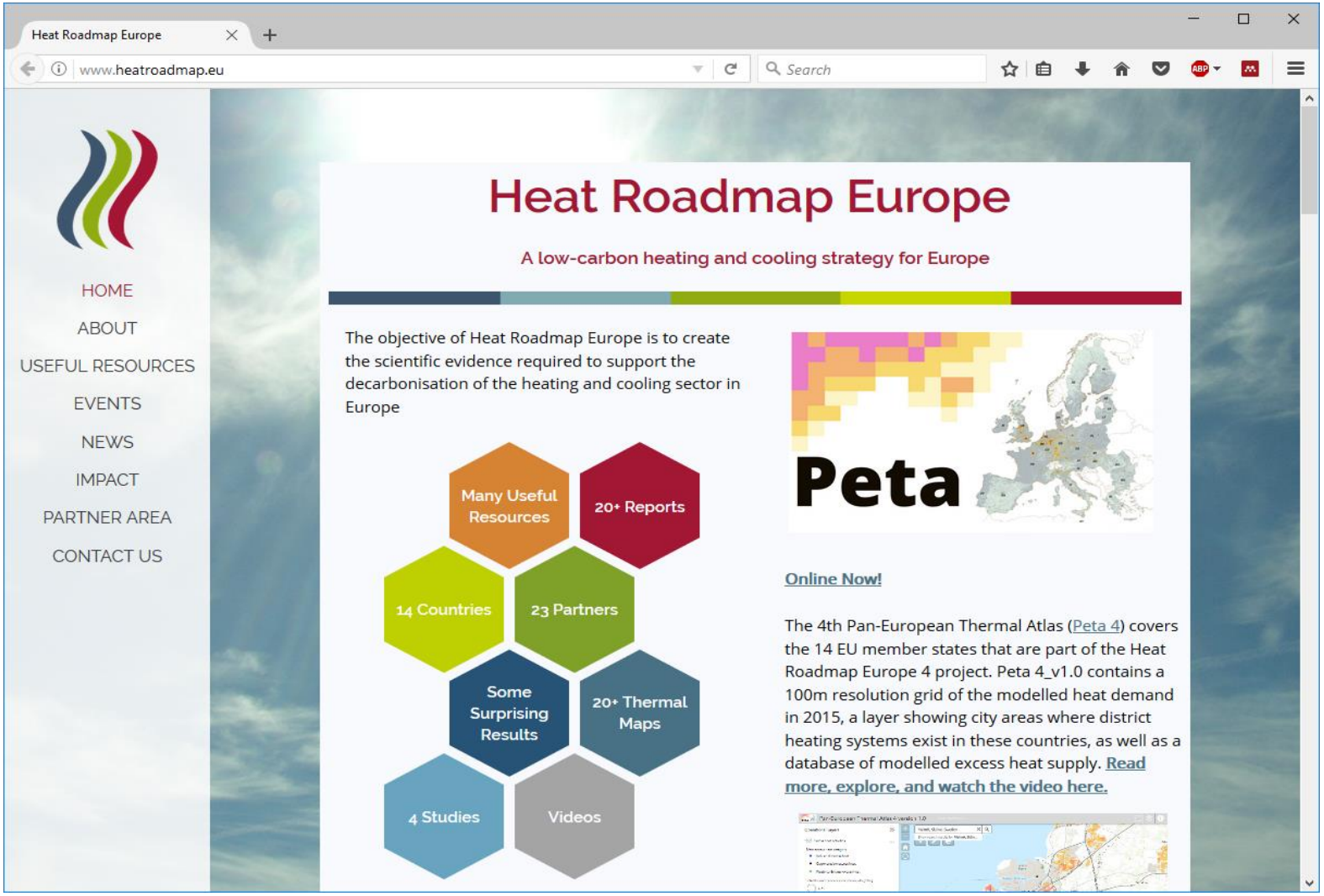
EU Horizon 2020 Work Programme 2016 – 2017 concerning the final energy consumption in Europe:
"Heating and cooling constitutes around half of the EU's final energy consumption and is the biggest energy end-use sector, ahead of transport and electricity"

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^2 or 60 TJ/km^2 ?

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.



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

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Booster heat pumps and central heat pumps in district heating

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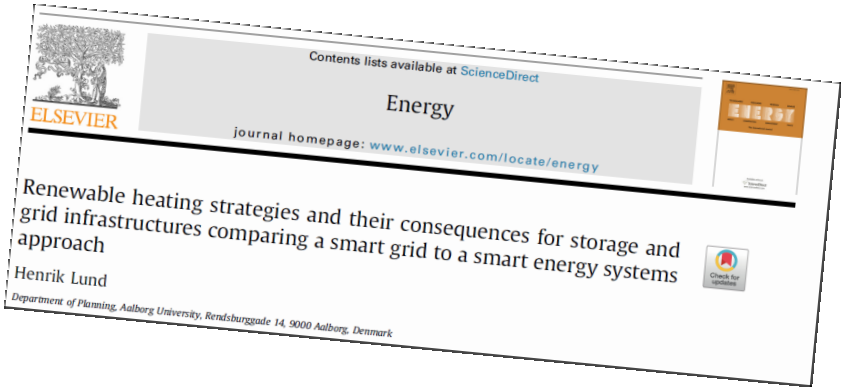
[b] EMD International, Niels Jernesvej 10, 9220 Aalborg Ø, Denmark

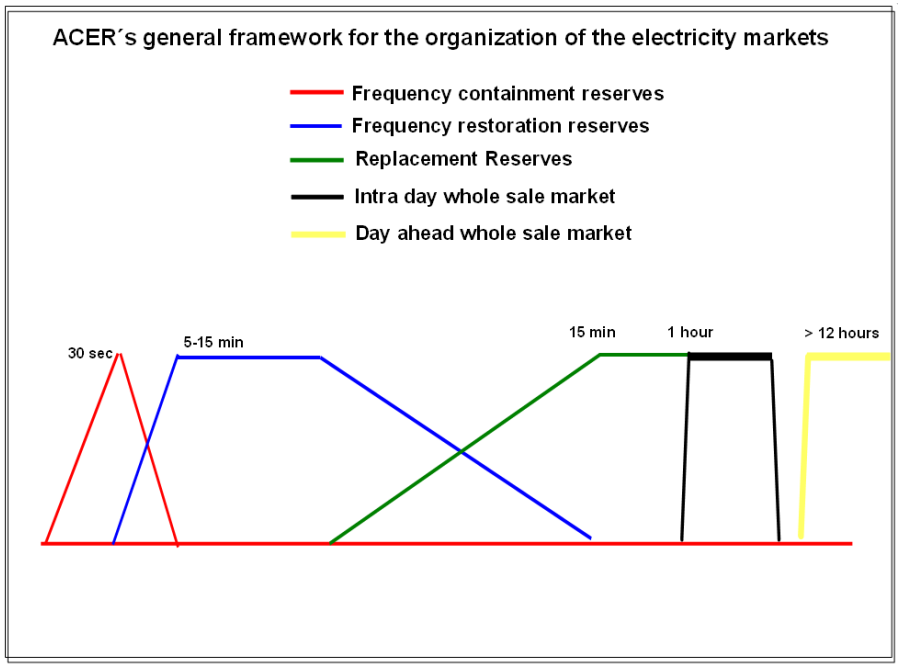
District Energy energy stores are the cheapest

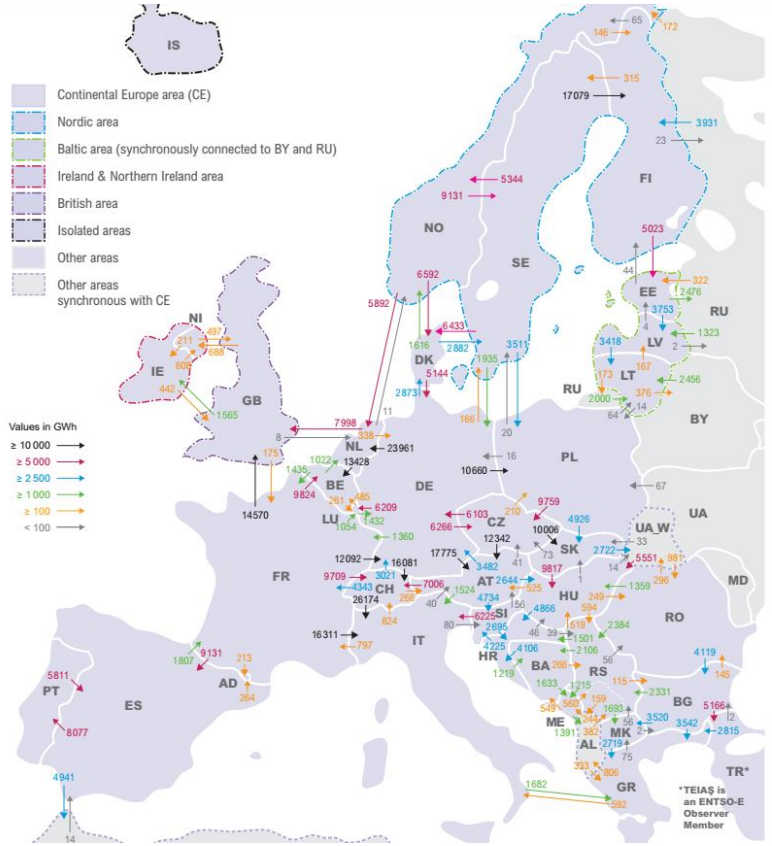
Table 1
Storage cost assumptions.

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[a]
Large thermal storage	500-2500	1500
Household thermal storage	24,000–180,000	20,000[a]
Large gas storage		60
Liquid fuel		20



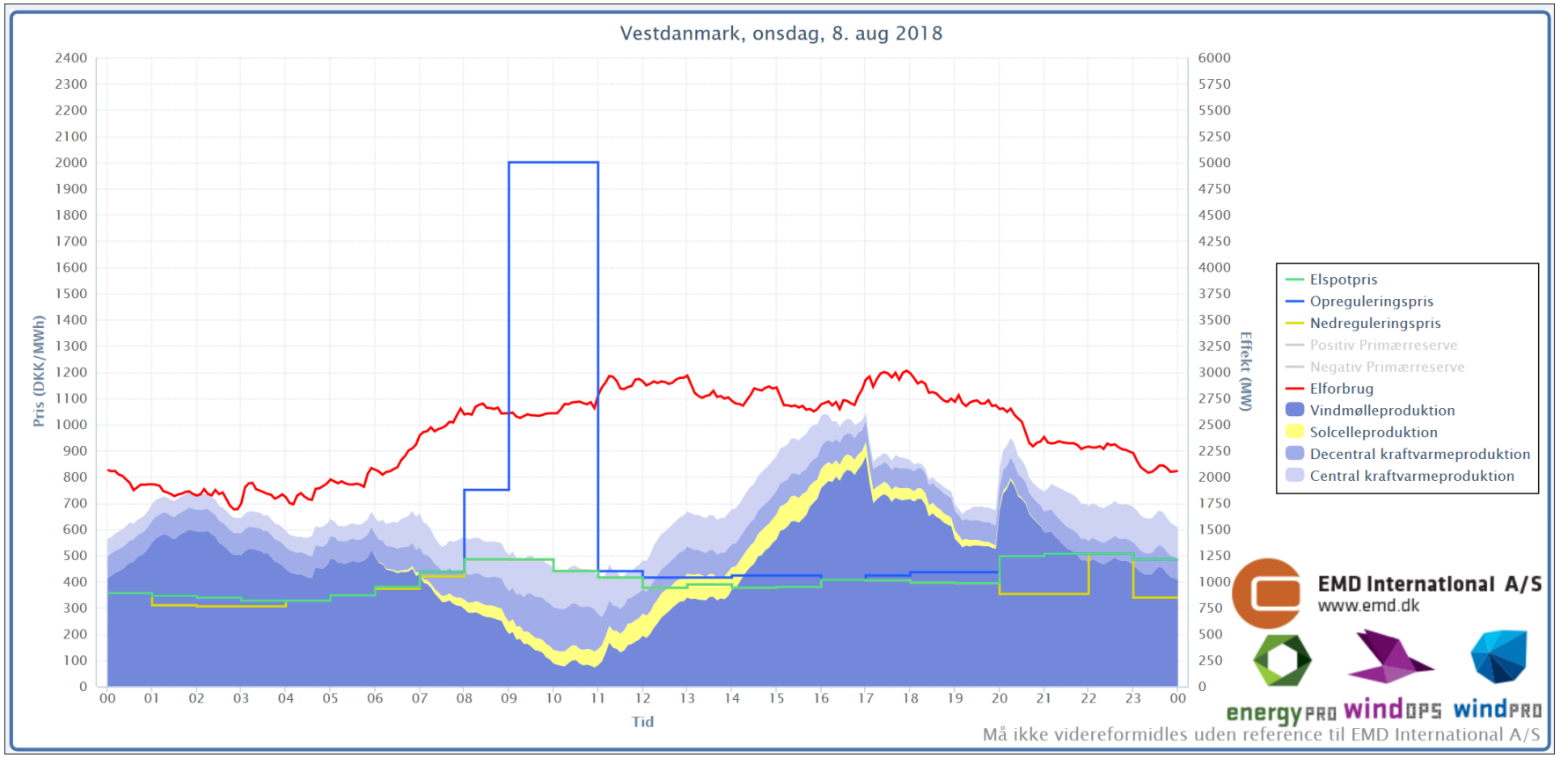
The 5 European electricity markets that are able to integrate intermittent production from photo voltaic and wind energy

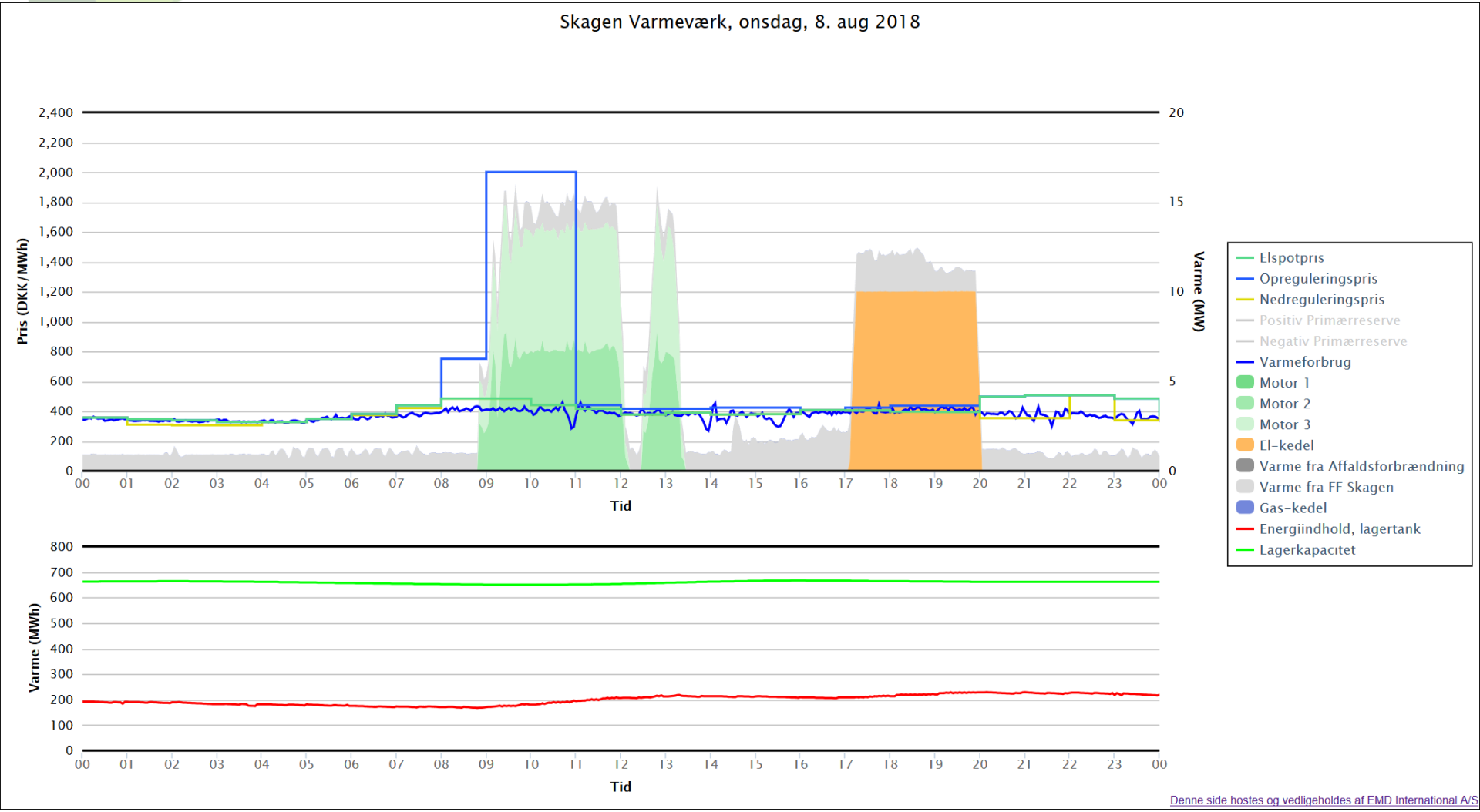




An example of market based operation

www.emd.dk/energy-system-consultancy/online-presentations




Skagen Varmeværk, onsdag, 8. aug 2018
Pris (DKK/MWh)
Varme (MW)
Tid
Elspotpris
Opreguleringspris
Nedreguleringspris
Positiv Primærreserve
Negativ Primærreserve
Varmeforbrug
Motor 1
Motor 2
Motor 3
El-kedel
Varme fra Affaldsforbrændning
Varme fra FF Skagen
Gas-kedel
Energiindhold, lagertank
Lagerkapacitet
Varme (MWh)
Tid
Denne side hostes og vedligeholdes af EMD International A/S

Thank you for your attention !