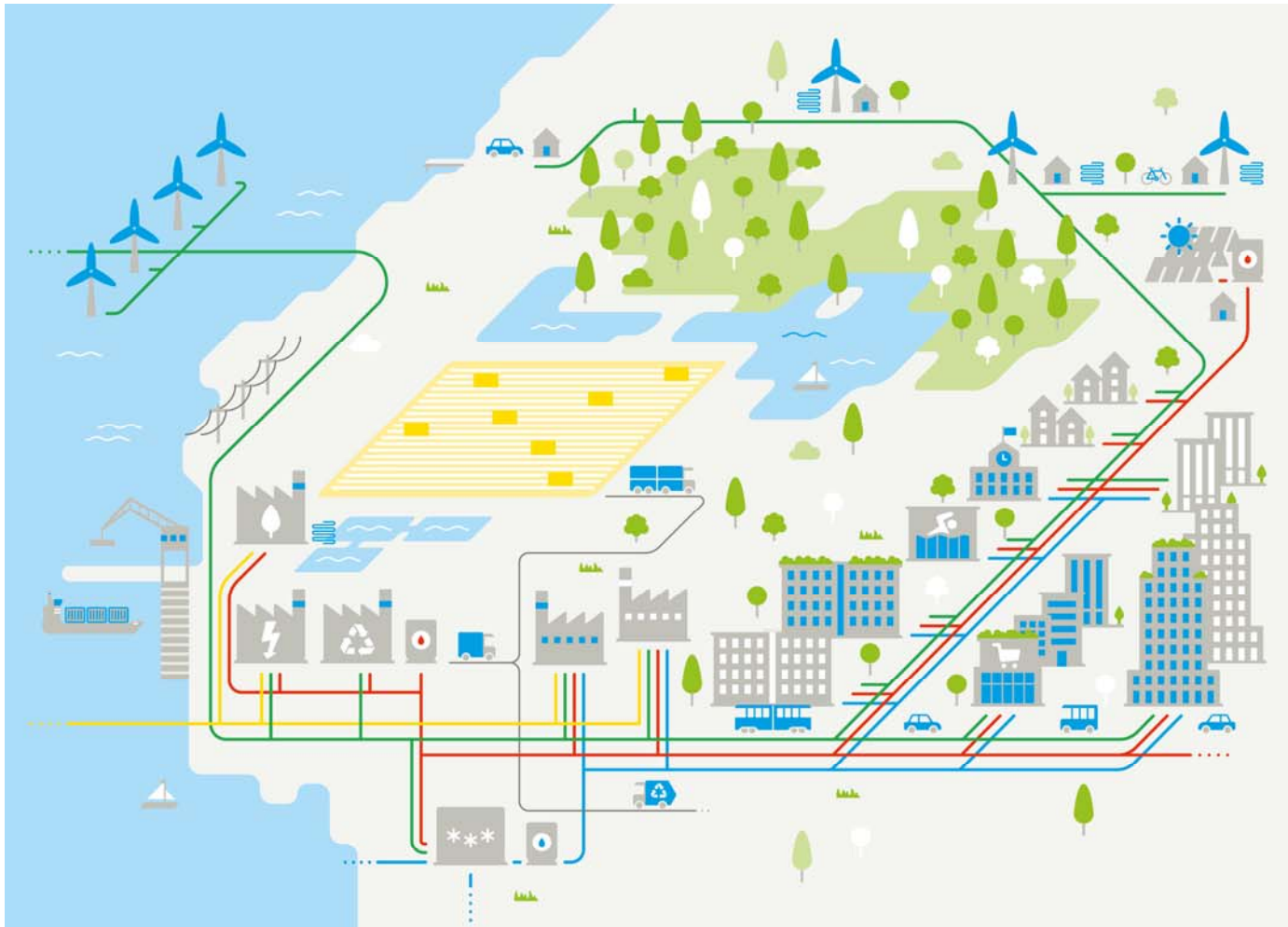




THE SMART ELECTRICITY STORAGE DISTRICT HEATING AND COOLING WITH THERMAL STORAGES

OUR VISION

Creating liveable cities – smart solutions for the citizens



- Surplus biomass for CHP plant
- Surplus straw for CHP plant
- Offshore wind farm
- Large commercial / residential building
- Small residential building
- Harbour, unloading of biomass
- Wastewater treatment, heat pump, biogas and sludge incineration
- Solar heating plant and heat storage
- Solar PV plant
- Distant building w/solar PV
- Outskirt building w/heat pump, solar PV and wind turbine
- CHP plant fuelled by gas, straw, wood, city waste + heat storage
- District heating/cooling plant + cold water storage
- Industry with process energy and surplus heat
- Electricity
- District heating
- District cooling
- Gas

STRUCTURE OF THE PRESENTATION

- Today's energy system
- The future smart energy system
- Virtual battery
- Case study: Gram Fjernvarme
- Case study: Favrholt
- Final remarks

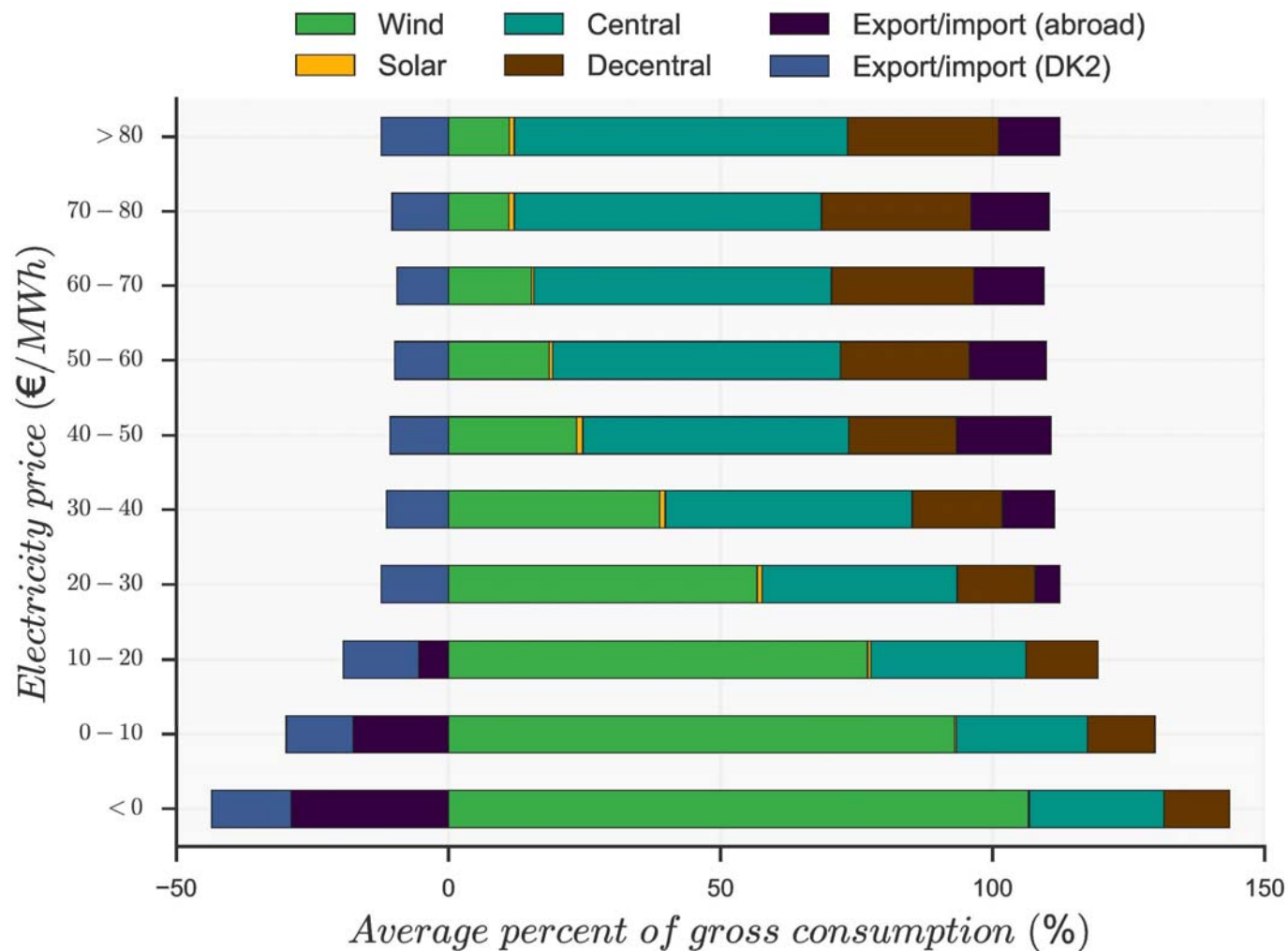




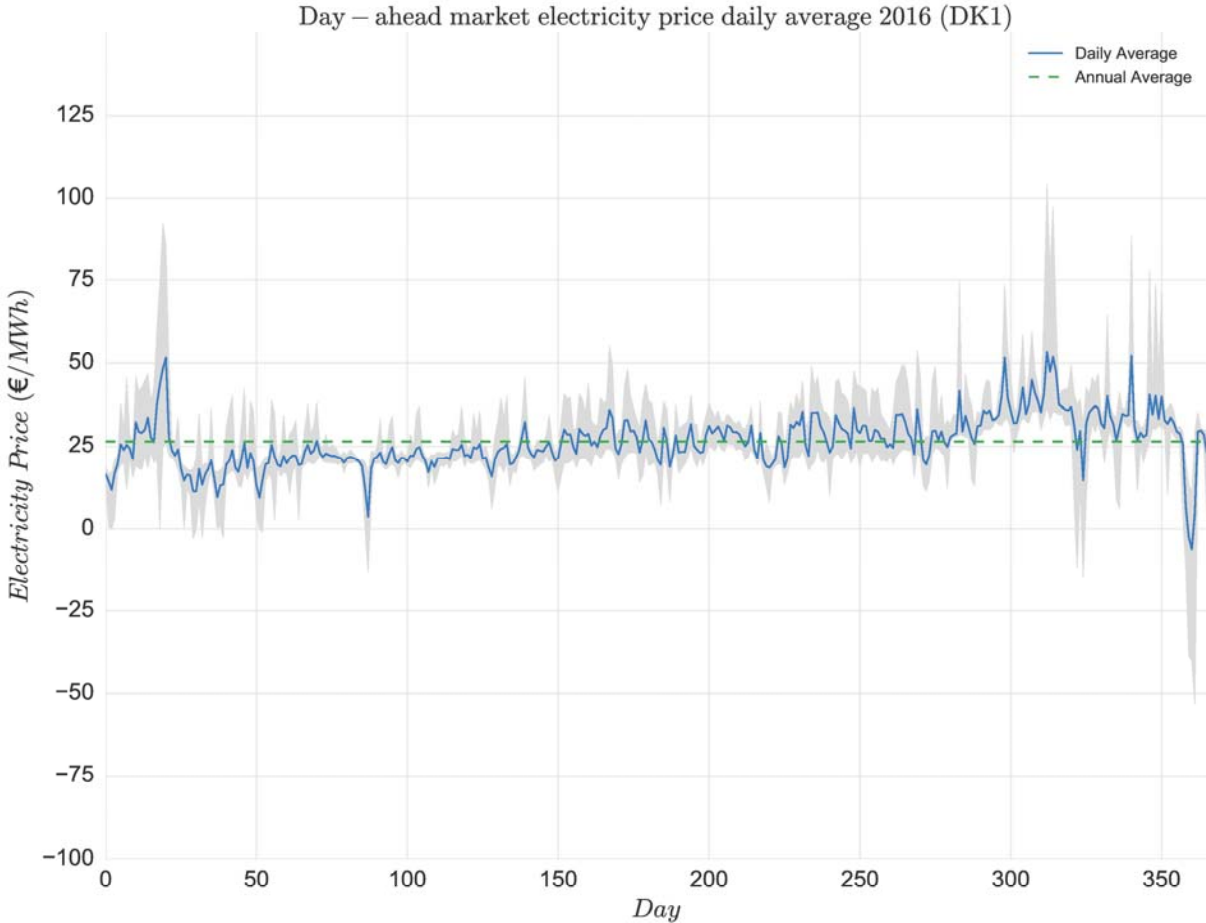
TODAYS ENERGY SYSTEM

- Starting point in DK1 (Western part of Denmark)

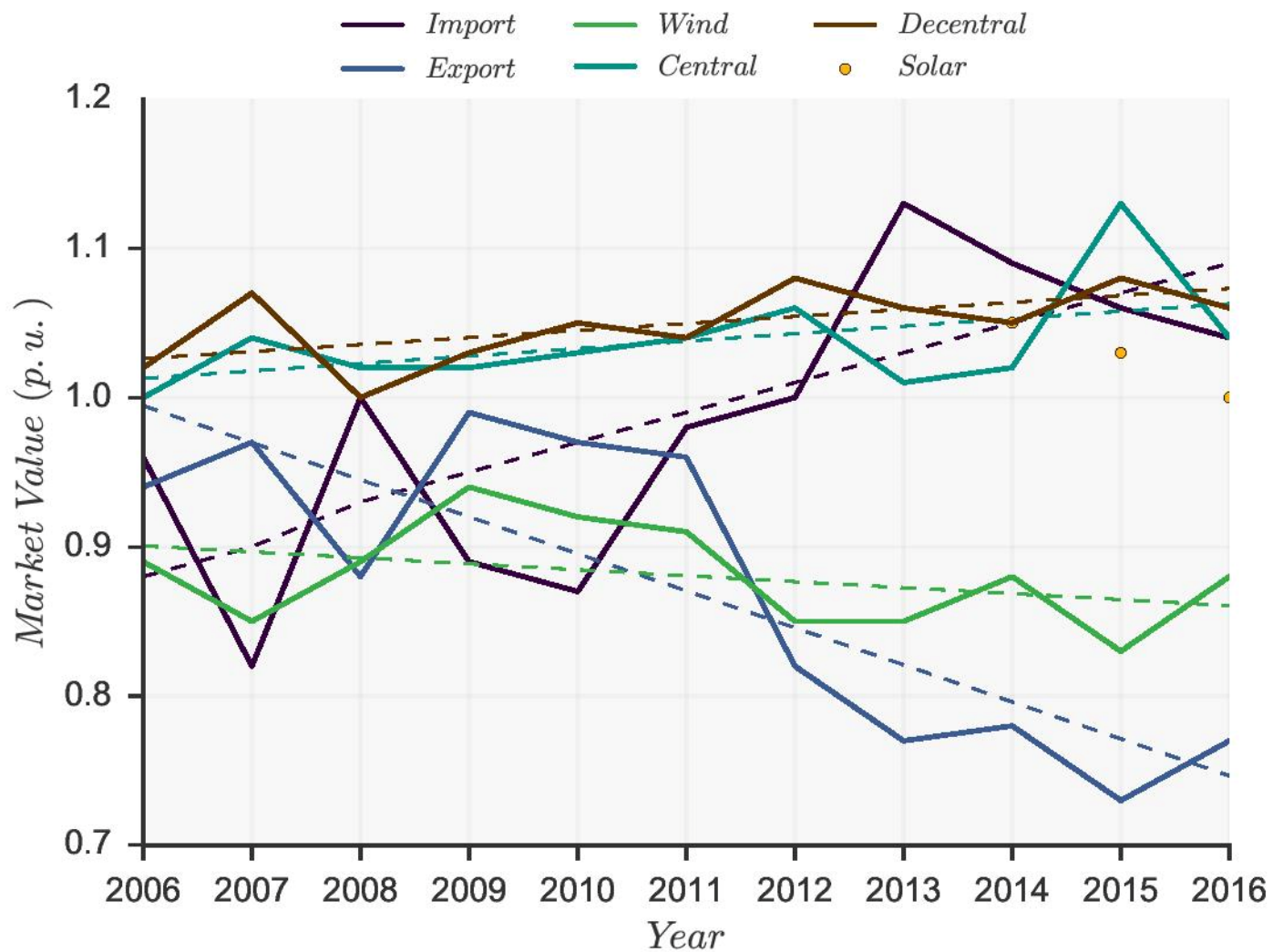
PRODUCTION DISTRIBUTION (2010 – 2016)



ELECTRICITY PRICE 2016

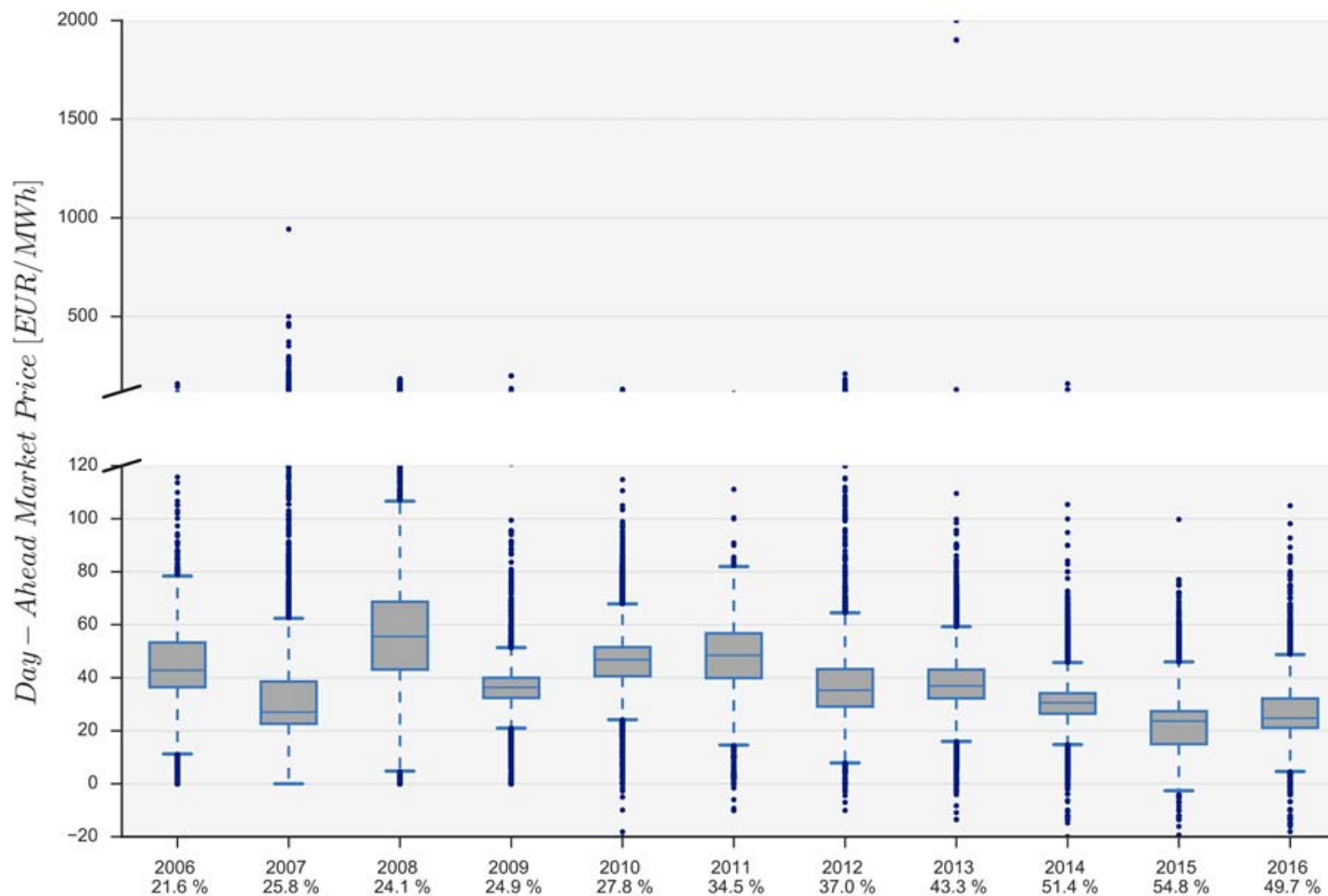


MARKET VALUE OF ELECTRICITY



ELECTRICITY PRICE AND WIND PENETRATION

Day – Ahead Price vs. Wind Penetration (DK1)



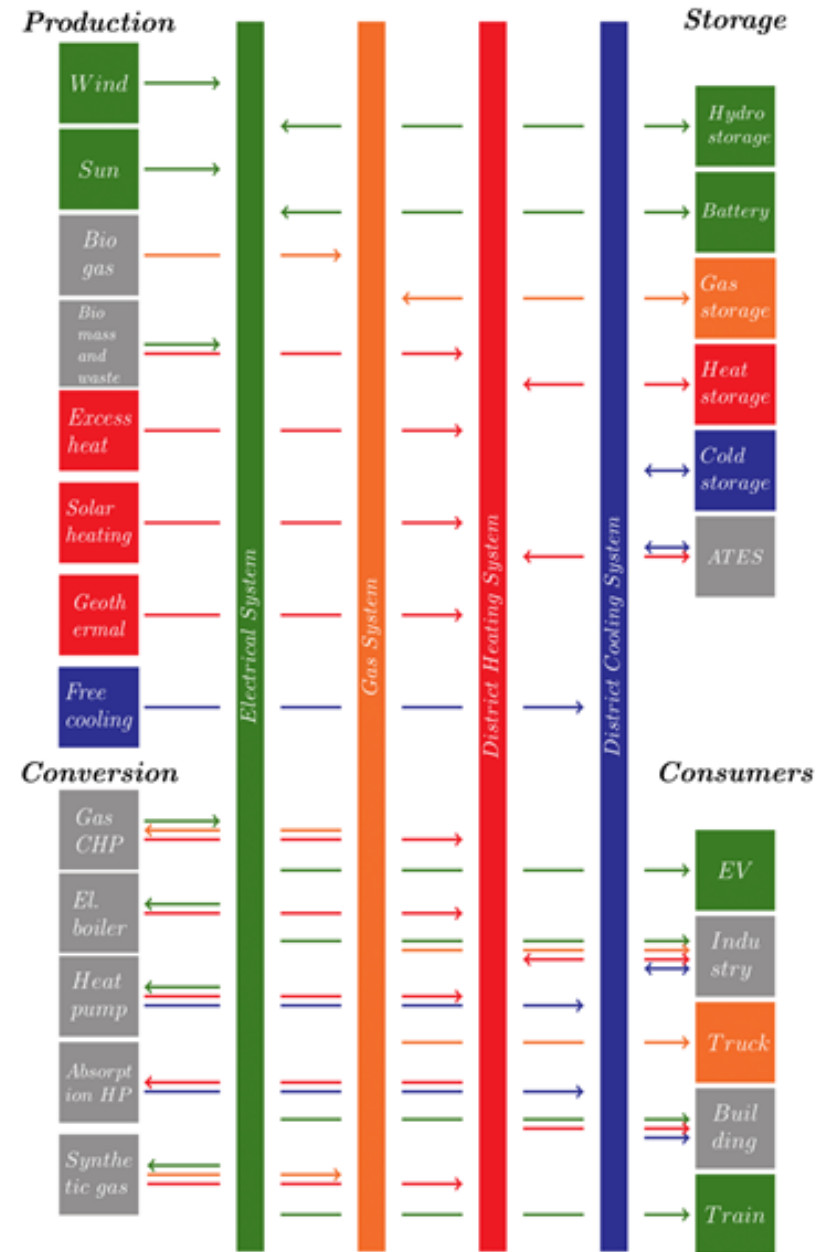


THE FUTURE SMART ENERGY SYSTEM

- Based on the *Smart Energy Barrier and Solution Catalogue*

STRUCTURE OF SMART ENERGY SYSTEMS

- *Smart Energy Barrier and Solution Catalogue* outlines the benefits and roadmap towards a renewable energy system
 - Integration between sectors
 - Sectoral suboptimal planning must be avoided
 - 4th generation district heating
 - Thermal storages



THE VIRTUAL BATTERY



THE VIRTUAL BATTERY

“Thermal storages with electricity producing/consuming units can provide the same flexibility as electric batteries, but at a much lower cost”

RAMBOLL



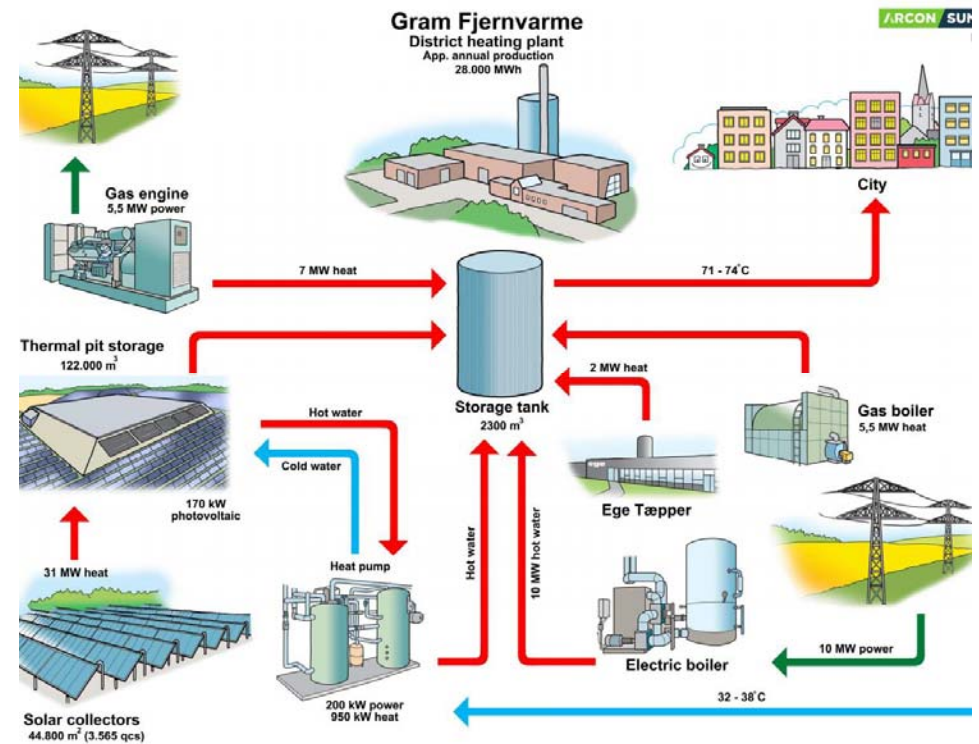


CASE STUDIES

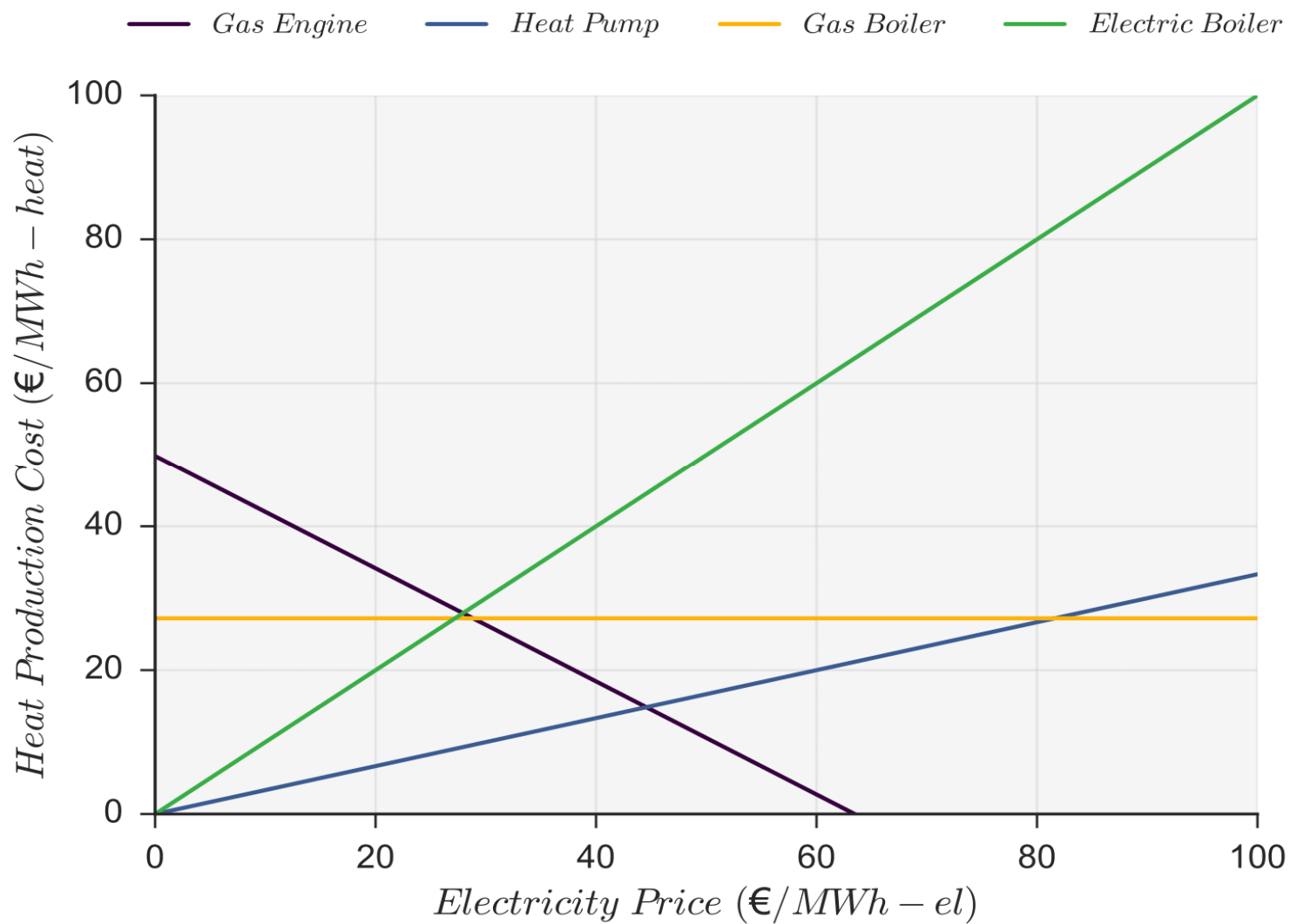
- Gram Fjernvarme
- Favrholm

GRAM FJERNVARME

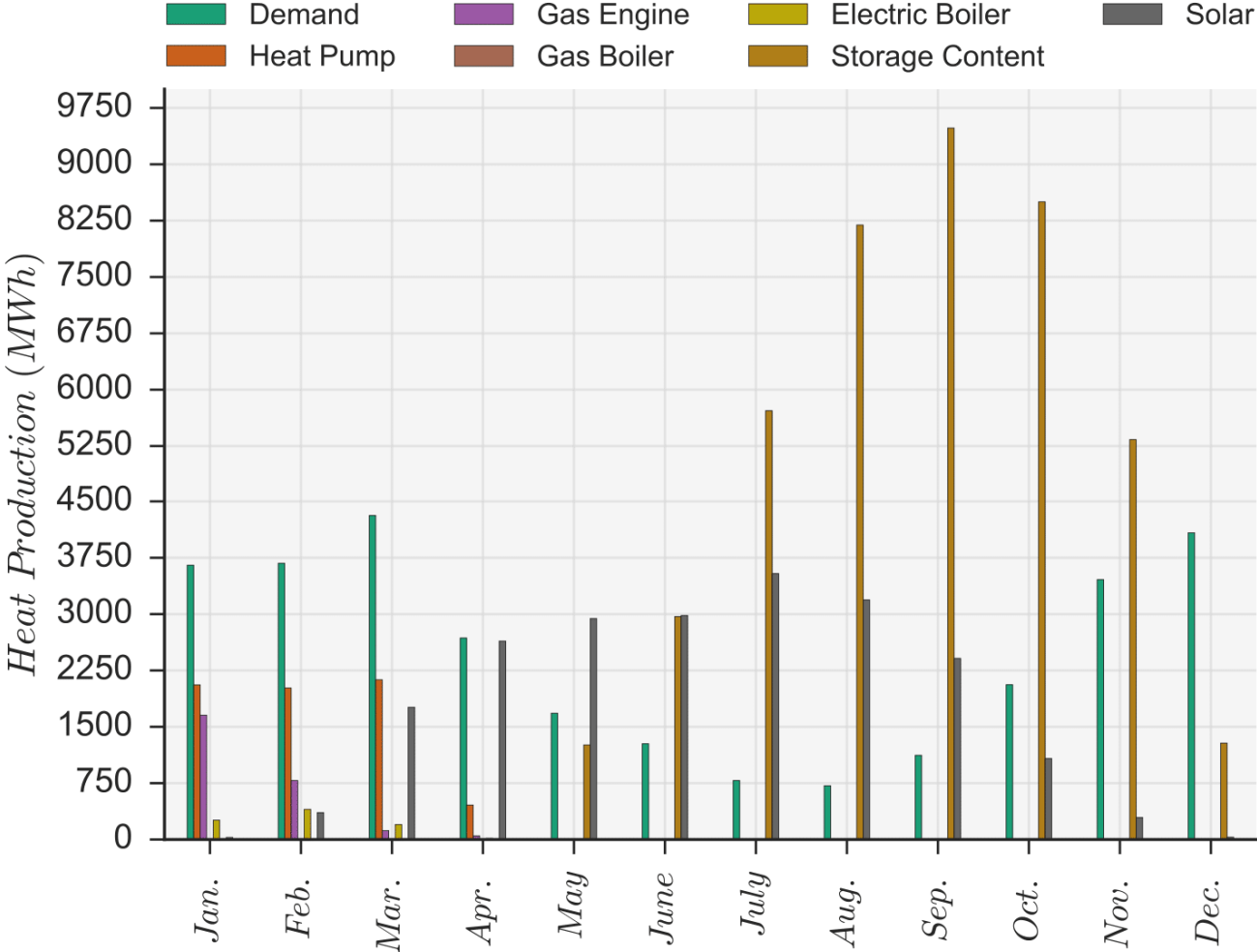
- Multiple production units
- Thermal storage



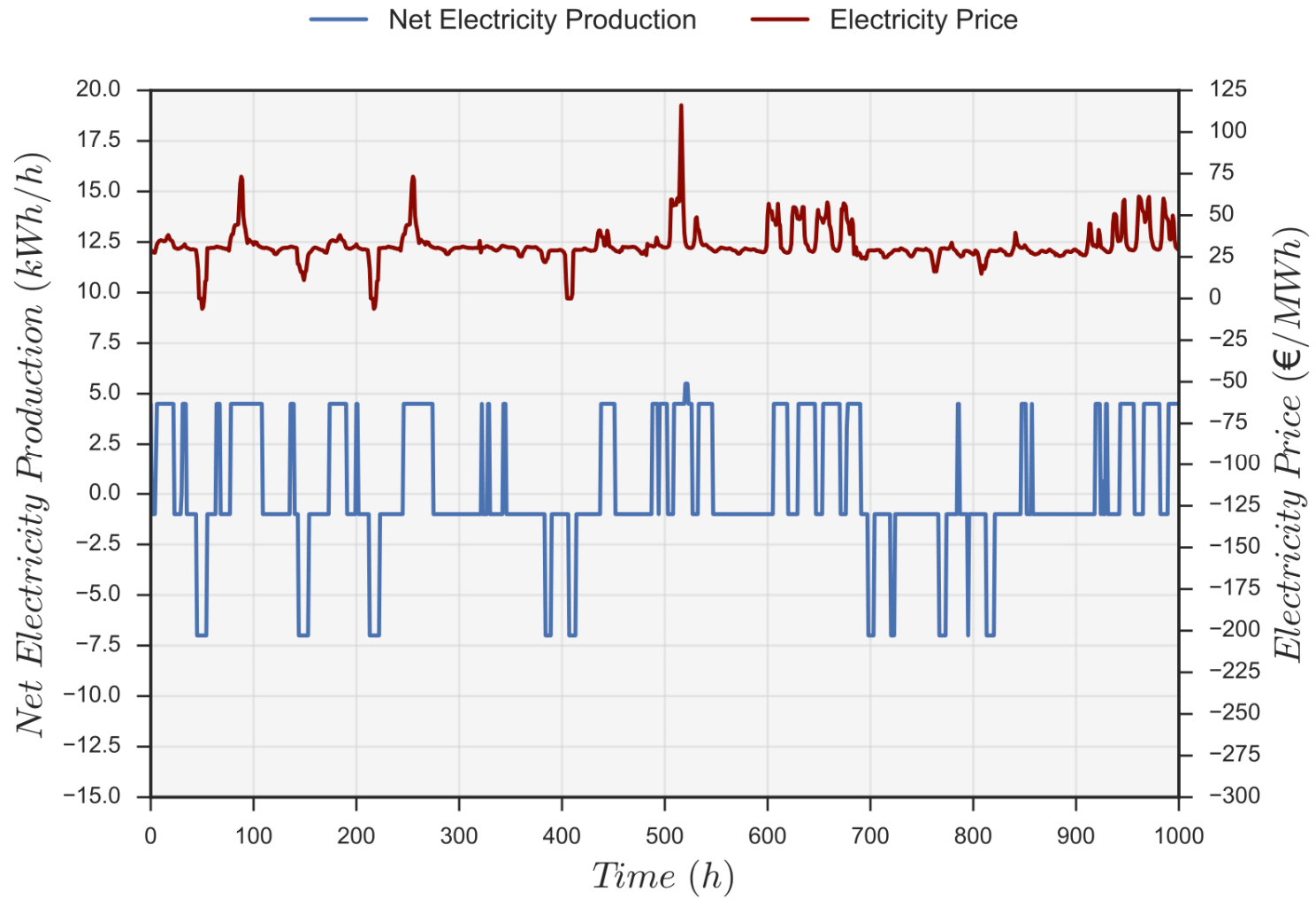
HEAT PRODUCTION COST



DISTRICT HEATING PRODUCTION DISTRIBUTION



NET ELECTRICITY PRODUCTION



FAVRHOLM (HILLERØD)

- Development area
- DH&C a profitable option
 - 660,000 m² heated floor area
 - 13 MW peak
 - 470,000 m² cooled floor area
 - 9 MW peak

Projektscenarie

Fjernvarme ved 100 % tilslutning

Fjernkøling med 80 % tilslutning

I alt

Lokalsamfund

159 mio.kr.

65 mio.kr.

224 mio.kr.

Samfund

124 mio.kr.

55 mio.kr.

179 mio.kr.

Lav tilslutning

Fjernvarme ved 70 % tilslutning

Fjernkøling ved 60 % tilslutning

I alt

107 mio.kr.

31 mio.kr.

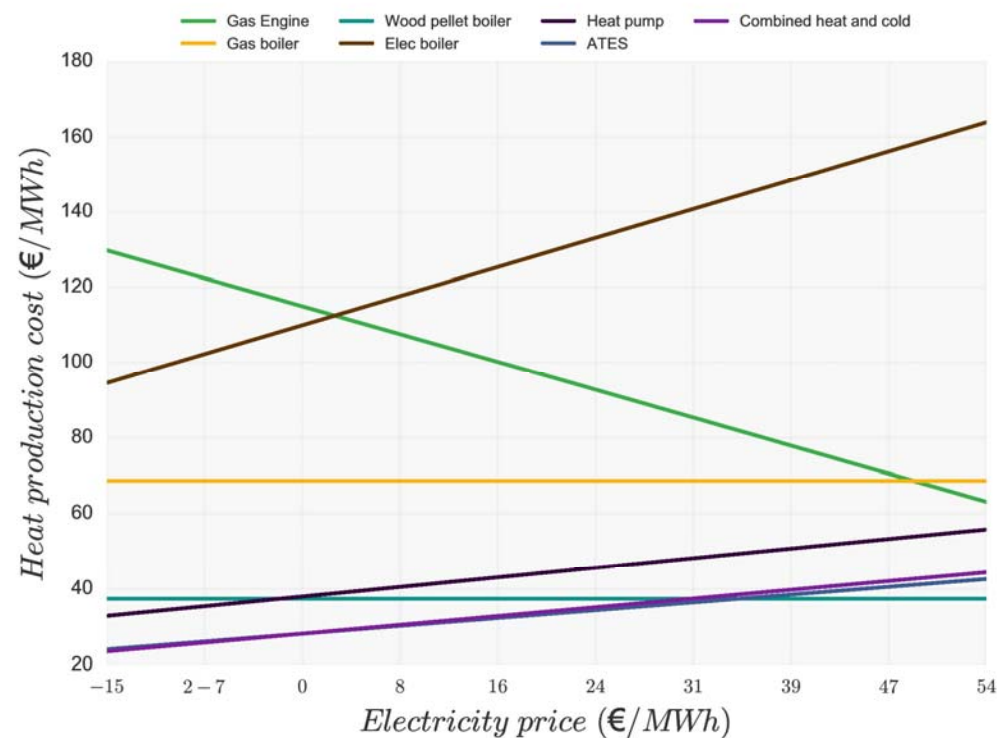
138 mio.kr.

73 mio.kr.

18 mio.kr.

91 mio.kr.

RAMBOLL

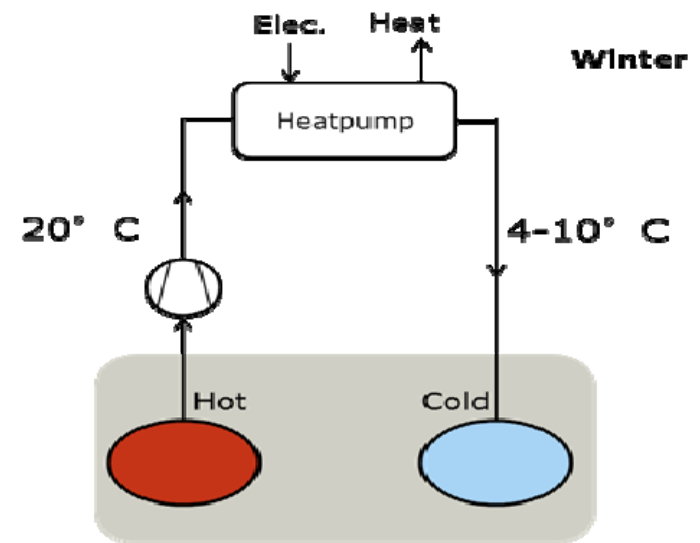
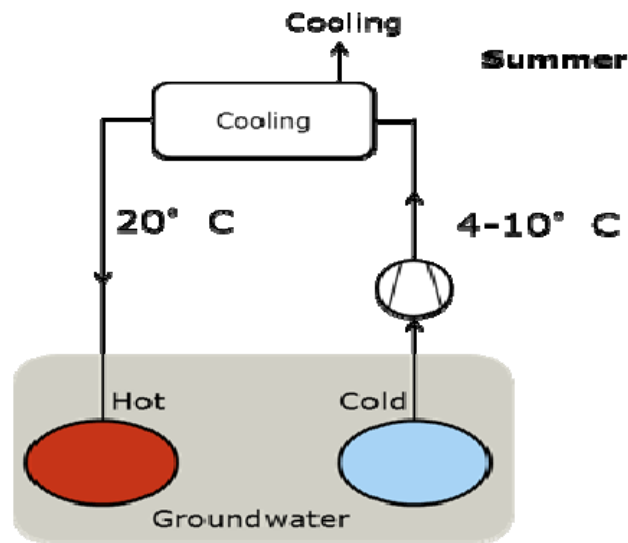
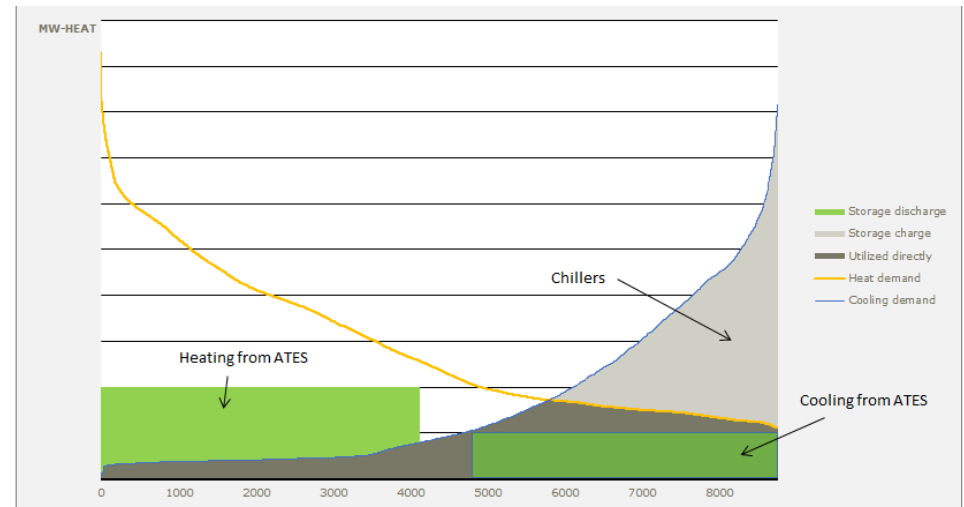


THE DH&C SYSTEM

DH&C SYSTEM:

- ATEs
- Heat Pumps
- Thermal Storage

ATES AS SEASONAL STORAGE



FINAL REMARKS

- The virtual battery is available for free
- DH&C systems provides great flexibility to the electricity system (demand response)
- Variable electricity prices (and tariffs) favours flexible operation
- District cooling holds great future potential for development

THE LIVEABLE CITY

“Common solutions provides cheaper energy to the local community, and additional benefits to all of society”

THANKS FOR YOUR ATTENTION!

**SØREN MØLLER THOMSEN
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[HTTP://WWW.RAMBOLL.COM/ENERGY](http://www.ramboll.com/energy)**