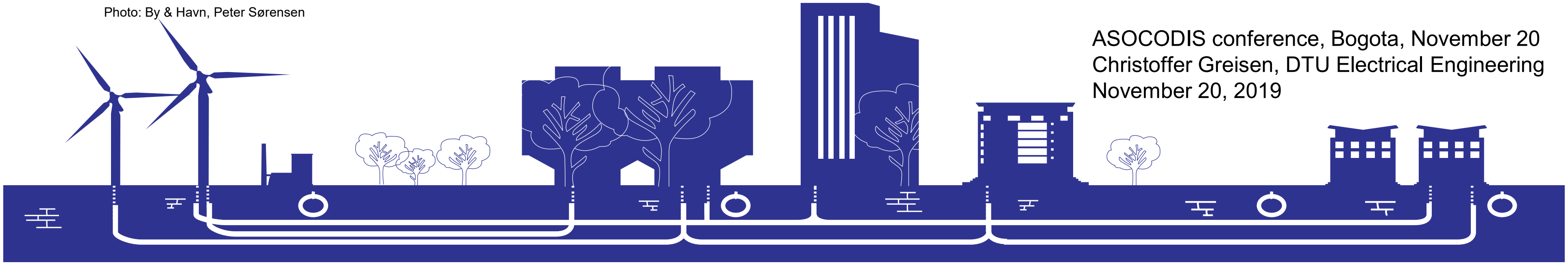
EnergyLab Nordhavn

Integrated Energy Infrastructures and Smart Components

Photo: By & Havn, Peter Sørensen



ASOCODIS conference, Bogota, November 20
Christoffer Greisen, DTU Electrical Engineering
November 20, 2019

Outline

- Introduction and background
- Project examples and results
- Conclusions and lessons learned

c_greisen
@EnergylabNordhavn

Our mission

”DTU will develop and create value using the natural sciences and the technical sciences to benefit society.”

H.C. Ørsted
Founder of DTU in 1829

Education

Innovation

Scientific advice

Research

DTU Electrical Engineering

Technical University of Denmark

- founded in 1829 by Hans Christian Ørsted

DENMARK

Key figures

Student body

11,221

- including PhD	1,300
- and int. MSc	1,500

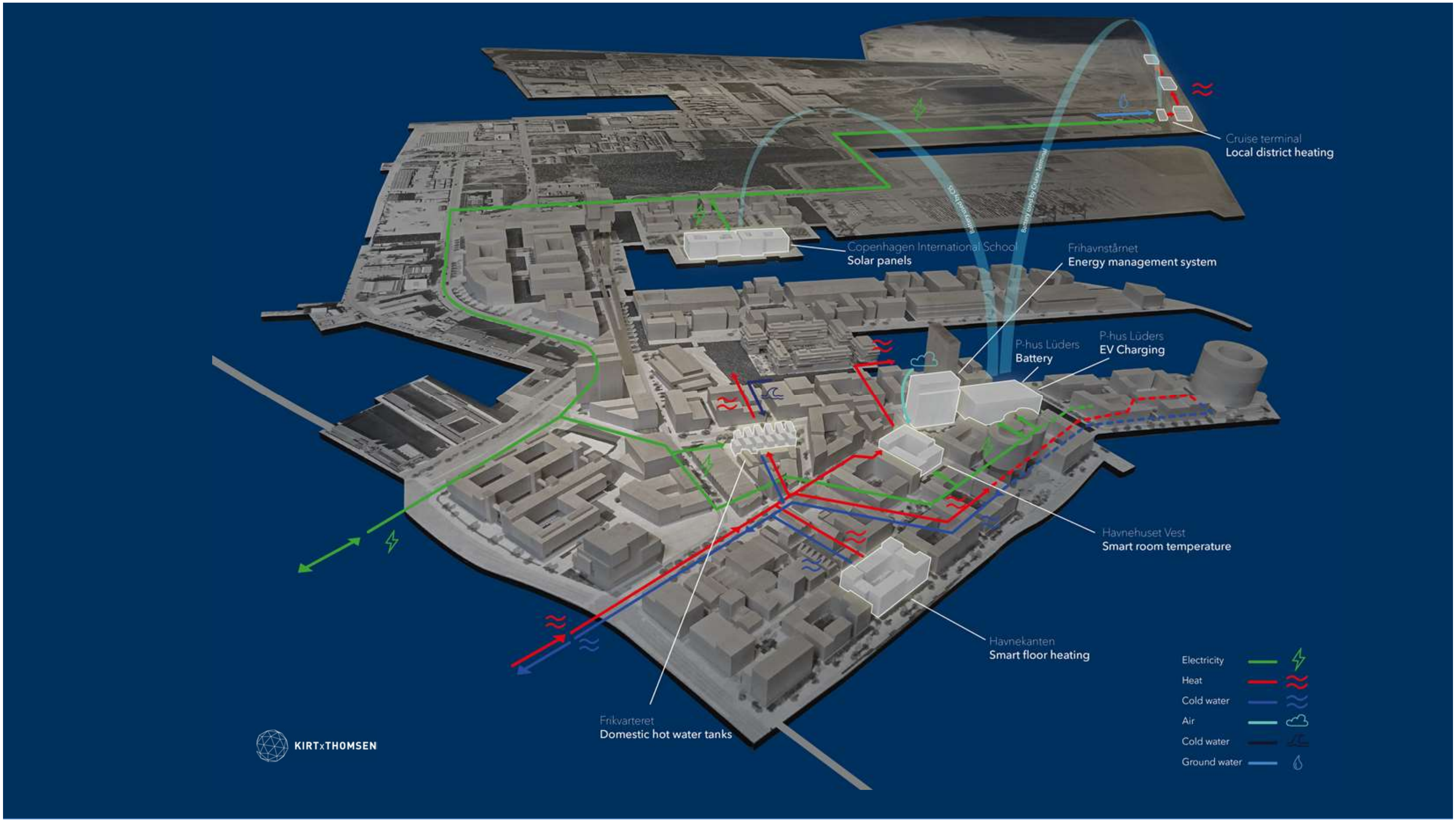
Research publications

5,700

Ranking

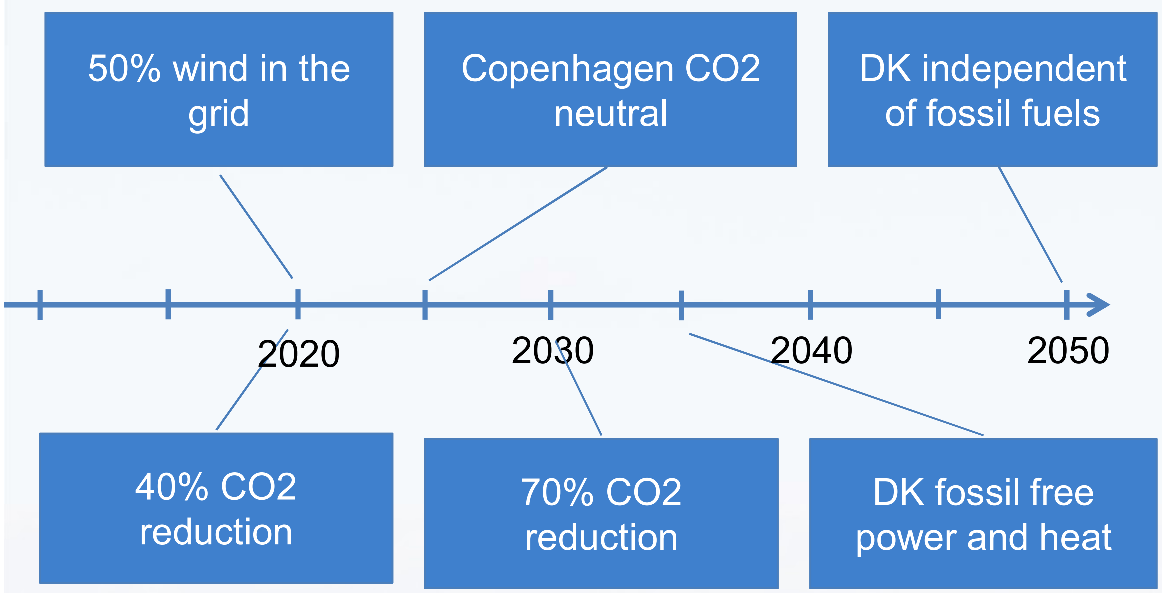
Leiden Ranking 2016:

No.1	in the Nordic region
No.41	in Europa



Cruise terminal
Local district heating
Copenhagen International School
Solar panels
Frihavnstårnet
Energy management system
P-hus Lüders
Battery
P-hus Lüders
EV Charging
Havnehuset Vest
Smart room temperature
Havnekanten
Smart floor heating
Frikvarteret
Domestic hot water tanks
Electricity
Heat
Cold water
Air
Cold water
Ground water
KIRTxTHOMSEN

National goals and SDG's supported



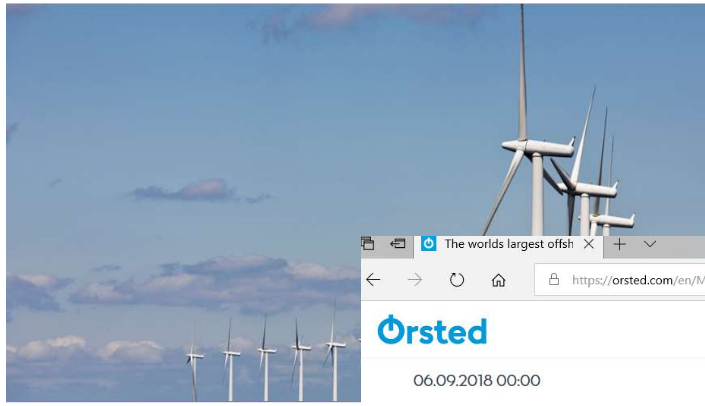
7 AFFORDABLE AND CLEAN ENERGY — Affordable and clean energy

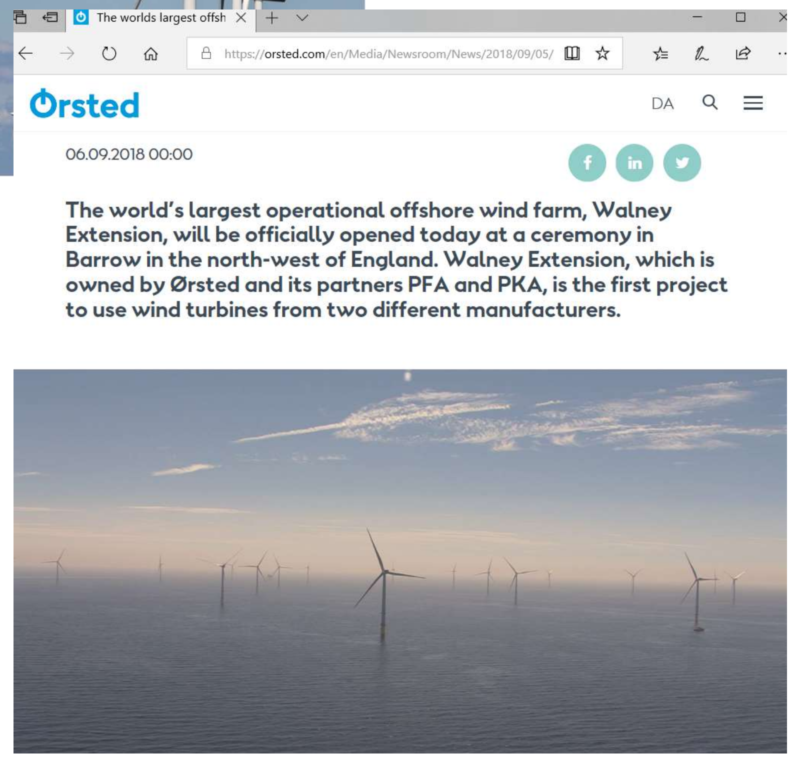
11 SUSTAINABLE CITIES AND COMMUNITIES — Sustainable cities and communities

12 RESPONSIBLE CONSUMPTION AND PRODUCTION — Responsible consumption and production

"Dad.. I'm scared about all that with climate change.. That there will no world for my kids to grow up in…"

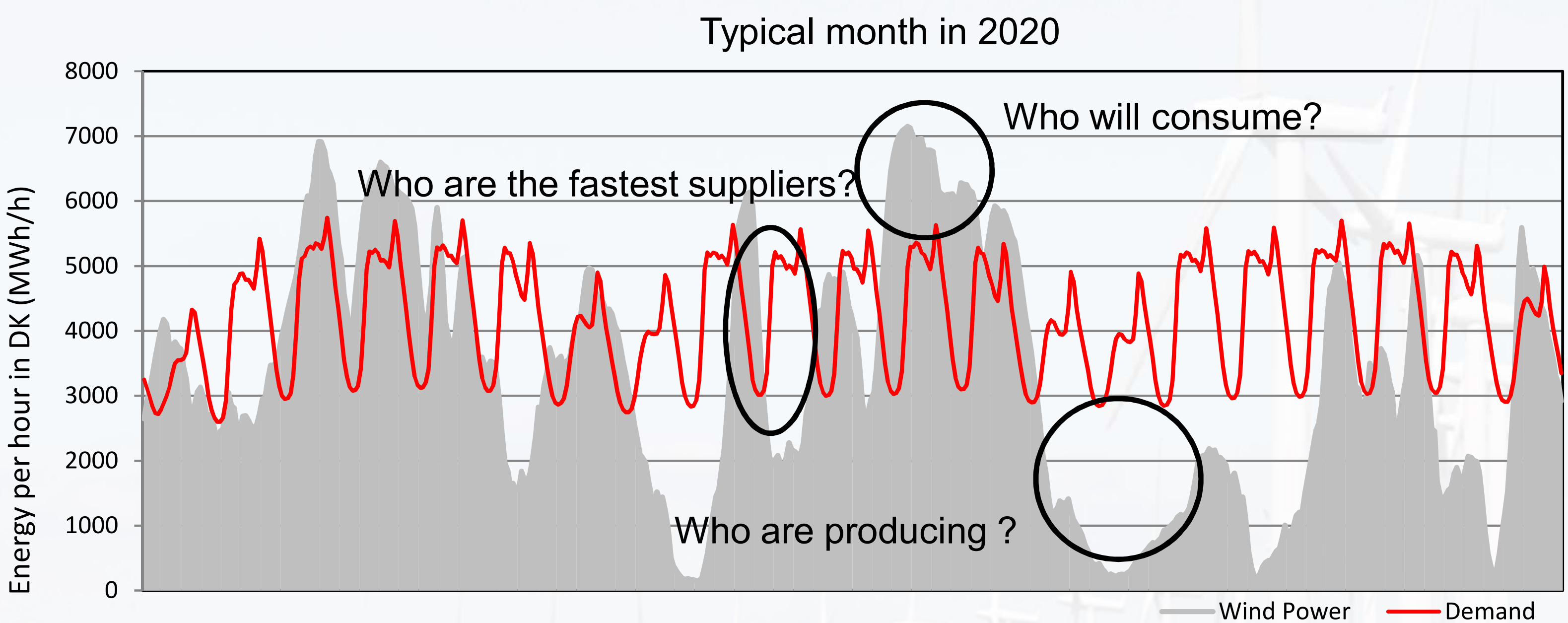
Juliane, 11 years, August 2019



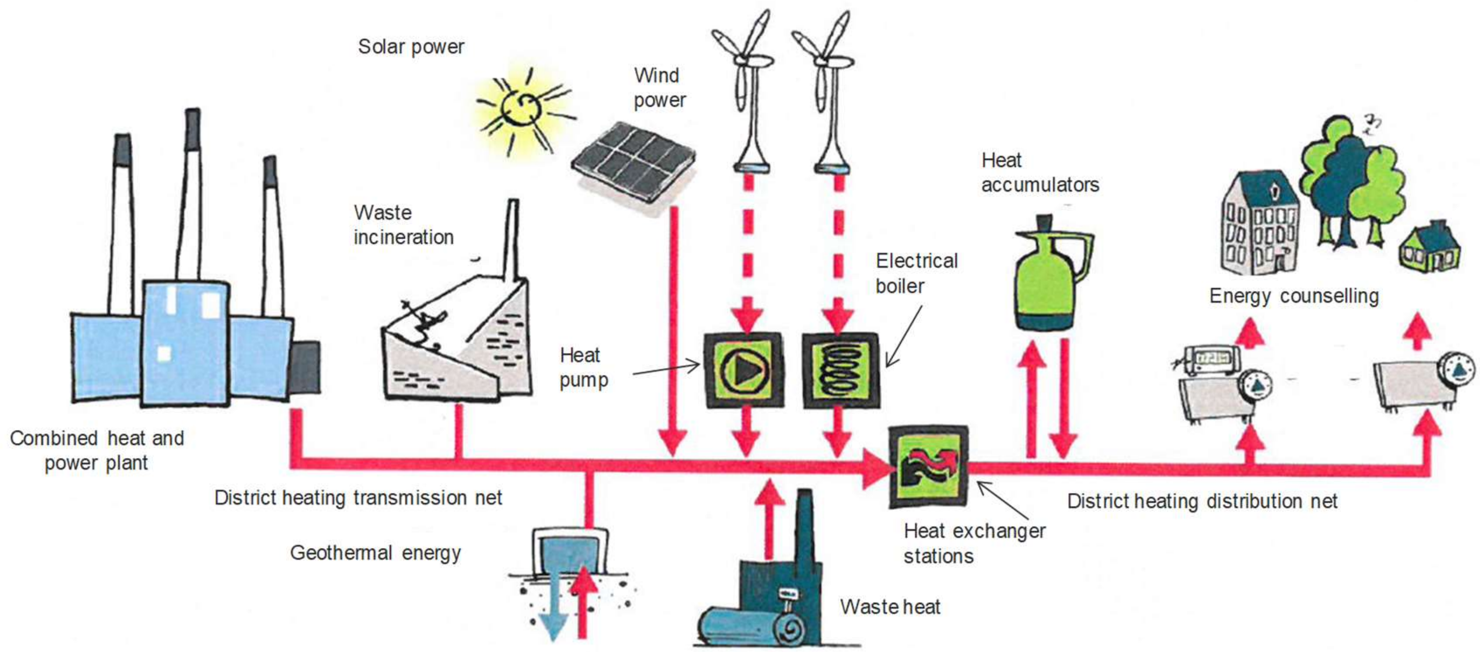


[From www.tvindkraft.dk]

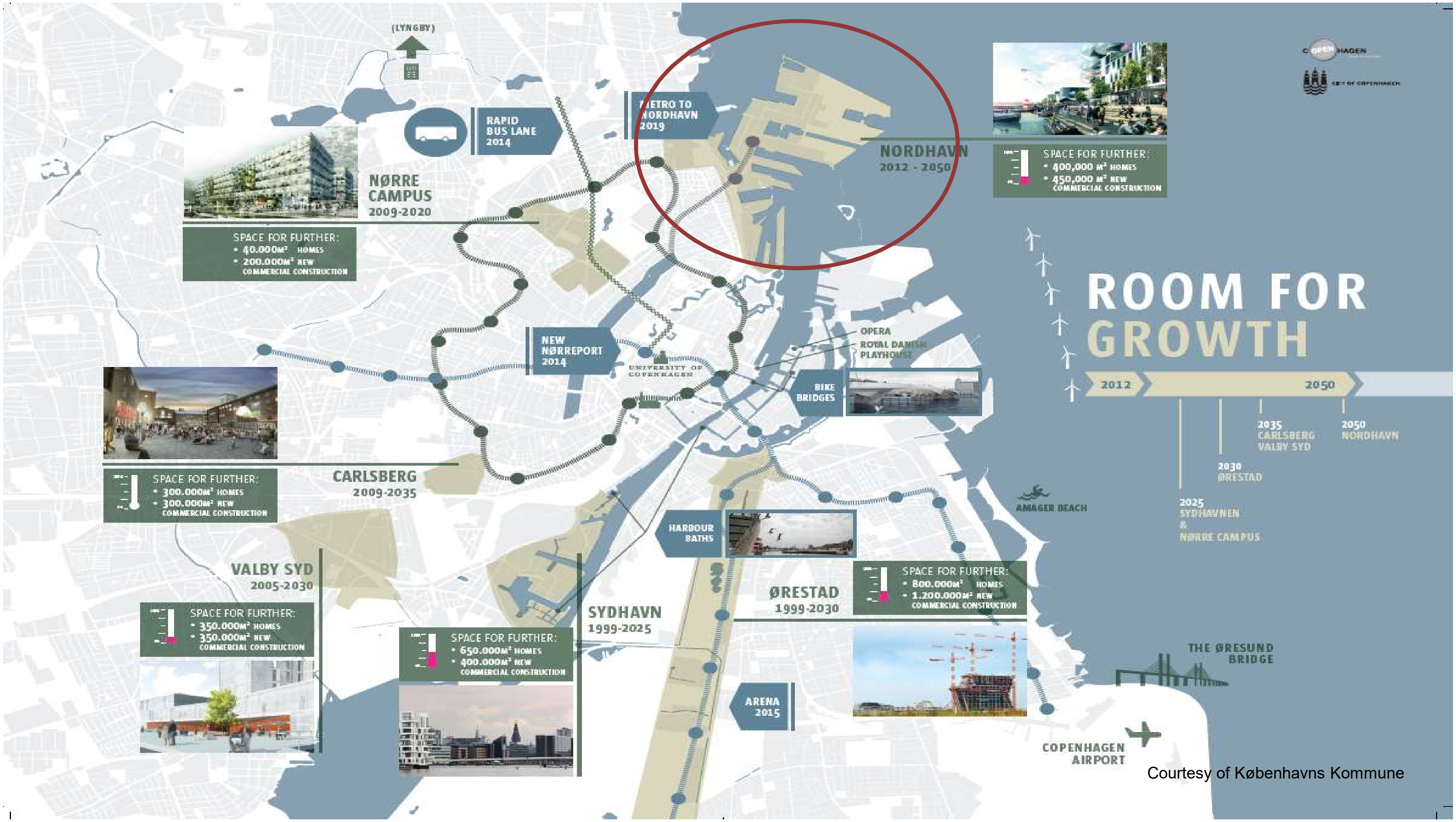
50% wind already in 2020



Flexibility and integration - district heating



Production → Distribution → Consumption



Courtesy of Københavns Kommune

Nordhavn – sustainable energy and transport

- Over the next 50 years, Nordhavn will develop into a **new district** with 40,000 residents and 40,000 jobs.
- The ambition is to become an **example of a future sustainable city**, supporting Copenhagens 2025 **carbon-neutrality** goal.
- This requires **innovation** in urban design - not least of energy infrastructure.

Courtesy of By & Havn

ISLETS AND CANALS
HOLME OG KANALER
CO2 FRIENDLY CITY
CO2 VENLIG BY
6 THEMES
FIVE-MINUTE CITY
FEM-MINUTTERS BY
IDENTITY AND HISTORY
IDENTITET OG KULTURSPOR
INTELLIGENT GRID
INTELLIGENT GRID
BLUE AND GREEN CITY
BLÅ OG GRØN BY
Courtesy of Københavns Kommune

Project mission

To develop

new methods and solutions

for design and operation of the future

cost-effective integrated energy system

based on Nordhavn as a

globally visible real-life laboratory.

Photo: Kontraframe

Partners from multiple sectors

Authority and city development	Energy Infrastructure	Industry and consulting engineers	University and data infrastructure

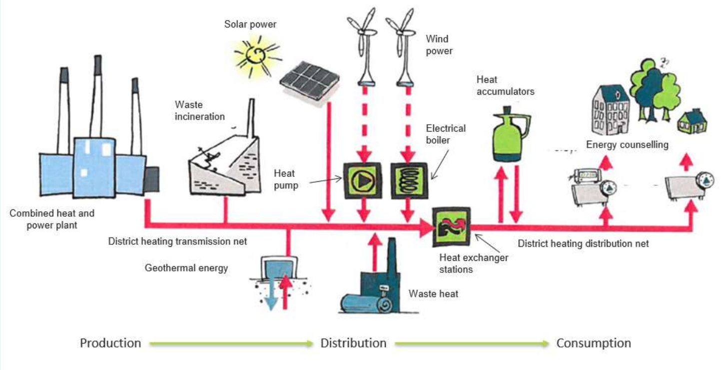
2015-2019, Budget 19 M€, Danish public funding 11 M€

Demonstrating in Nordhavn

Case – smart operation of a large heat pump

In the following we present:

- how the power system can use heat pump and storage in the district heating system, for both downward and upward regulation in the power system
- perspectives in combining heat pump in the district heating system with a battery



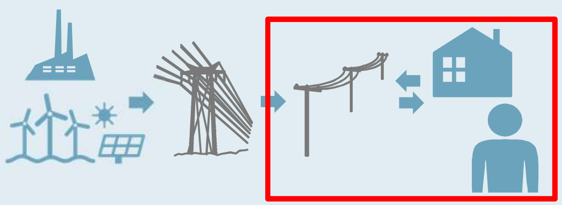
In conclusion:

- combining energy infrastructure system represent several ways of achieving flexibility.
- partnership between infrastructure utilities may be a way forward to mobilise flexibility

Originally presented by Poul Brath at ELN conference, october 2019

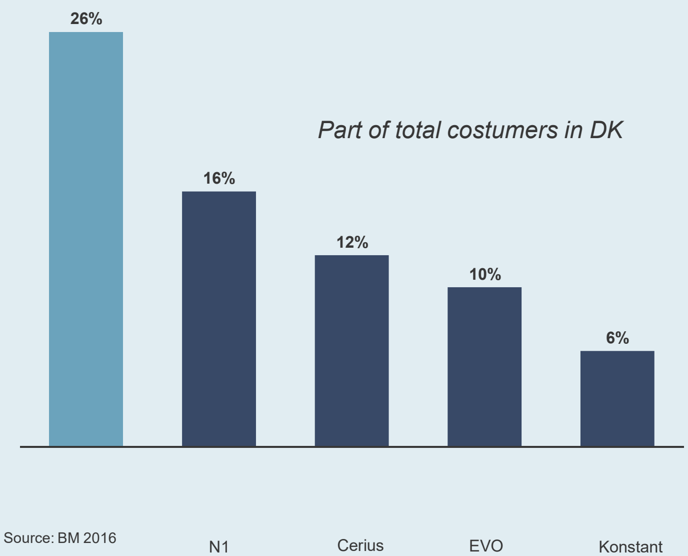
Radius is one of the largest power distribution facilities

Distribution is the last part of the energy chain toward the customers



Radius distributes power in Greater Copenhagen, North Zealand and part of middle Zealand

- Radius connect 26% of all Danish customers to the power system

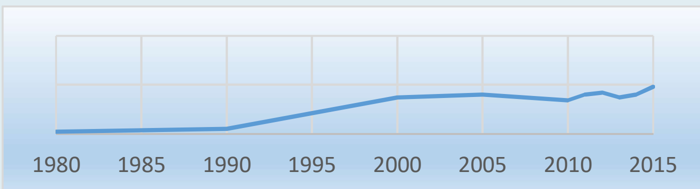


Source: BM 2016

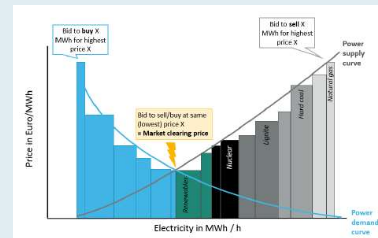
Originally presented by Poul Brath at ELN conference, october 2019

Flexibility is the key issue in the future power system

1. Organic growth in transport of electricity due to increasing electrification



2. Balancing between increasing renewable energy supply and consumption is solved increasingly by market.



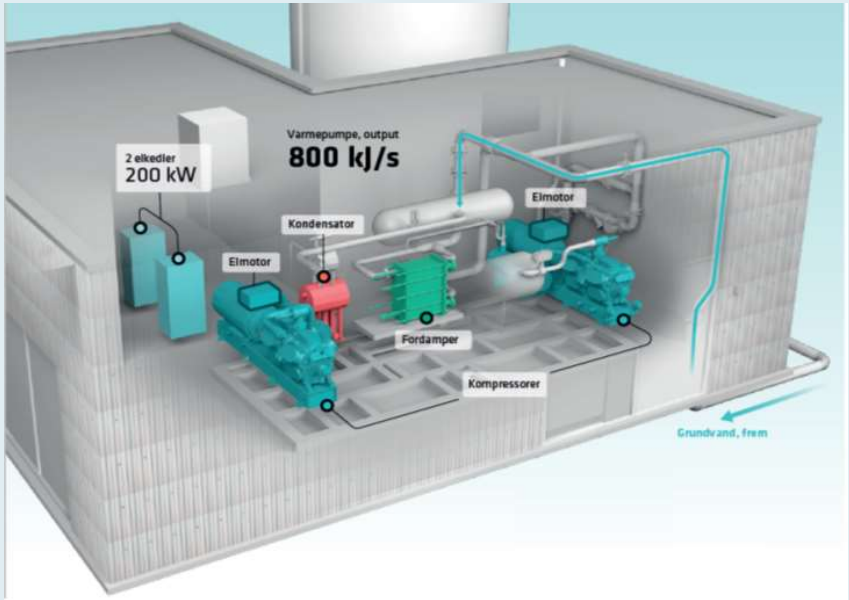
3. Increasing stochastic load due to new flexible technologies, growing energy managing, local renewable energy supply, and growing market solutions

4. New conditions and demands to DSO operation; primarily from EU

Radius

Originally presented by Poul Brath at ELN conference, october 2019

Heat pump as downward and upward regulation service



Purpose:

Suppling cruiser terminal and UNICEF storage with district heating.

Small island district heating system.

Essentially build for experiments with intelligent electricity consumption.

Owned by HOFOR

Electrical heat pump is the primary heat generator with additional electric boiler for flexibility. Backed up with oil based boiler.

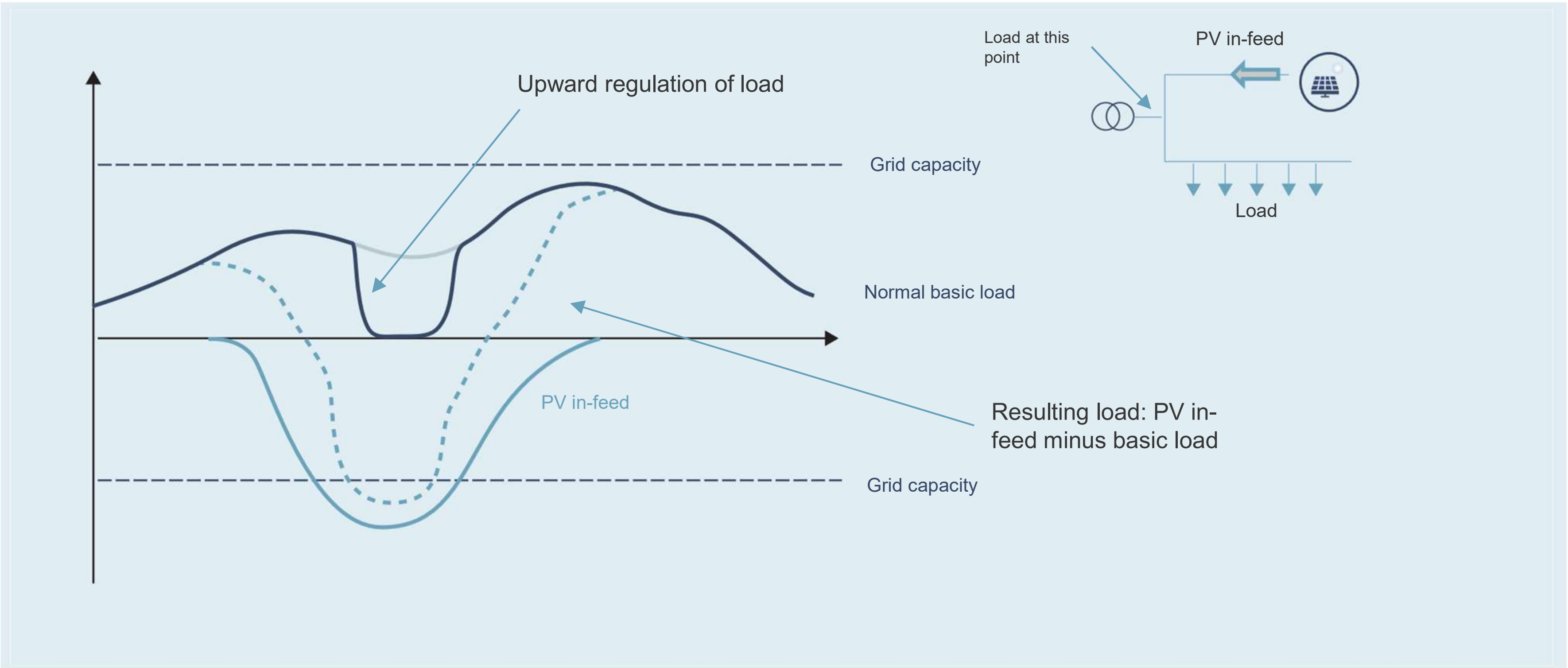
Heat pump 0.8 MW heat pump (heat side) ~ 0.2-0.45 MW power depending on COP

0.2 MW electrical boiler

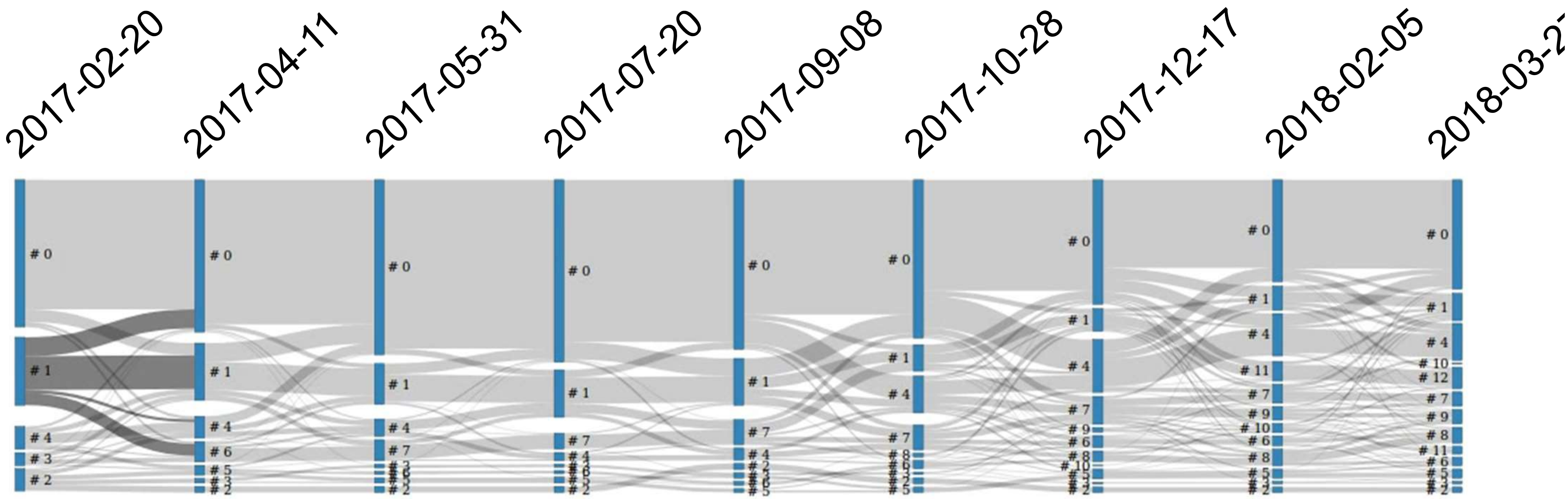
Heat source: ground water

Heat storage 100 m3 ~ 4-5 MWh

Case with RE input exceeding grid capacity but allowed due to expected basic load



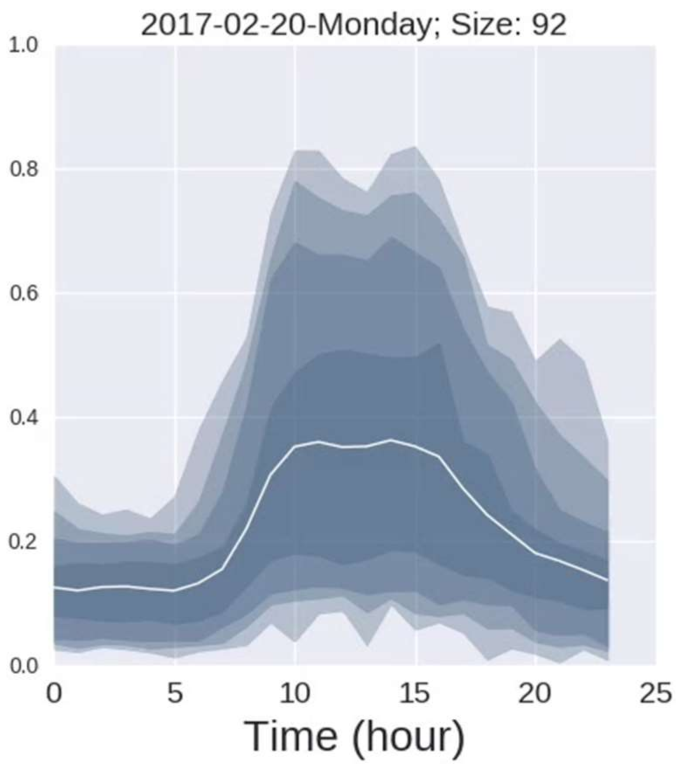
Case: Dynamic profiling



Customers can change cluster at each iteration (days)

From Guillaume le Ray, DTU Electrical Engineering

Dynamic profiling: Profile perspective



Profiles updated
using newly generated data from
assigned customers

From Guillaume le Ray, DTU Electrical Engineering

Outlook: Organization of consumer-centric electricity markets

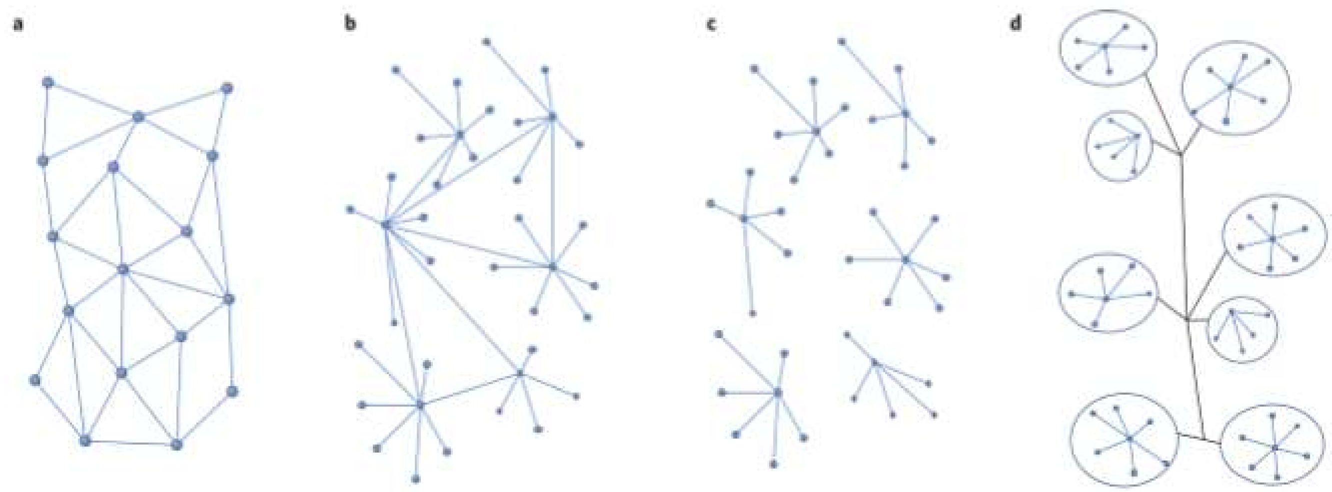
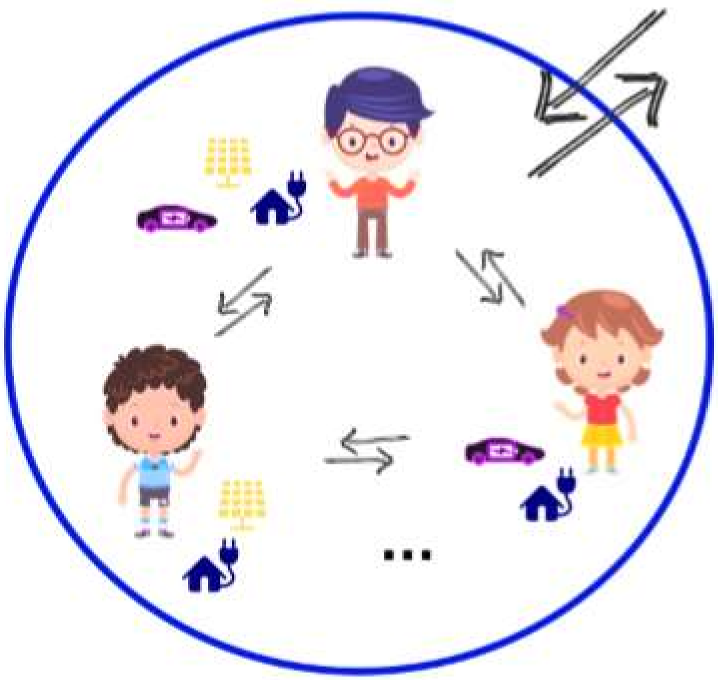


Figure 1 | Structural attributes of three prosumer markets. a, Peer-to-peer model, in which prosumers interconnect directly with each other, buying and selling energy services. **b**,**c**, More structured models involving prosumers connected to microgrids. These entail prosumer-to-interconnected microgrids, in which prosumers provide services to a microgrid that is connected to a larger grid (**b**), or prosumer-to-islanded microgrids, in which prosumers provide services to an independent, standalone microgrid (**c**). **d**, Organized prosumer group model, in which a group of prosumers pools resources or forms a virtual power plant. Dots represent prosuming agents; lines represent a transaction of prosuming service; circles represent an organized group of prosumers.

Pierre Pinson, at DTU High Tech summit, 2019

An example – Energy Communities



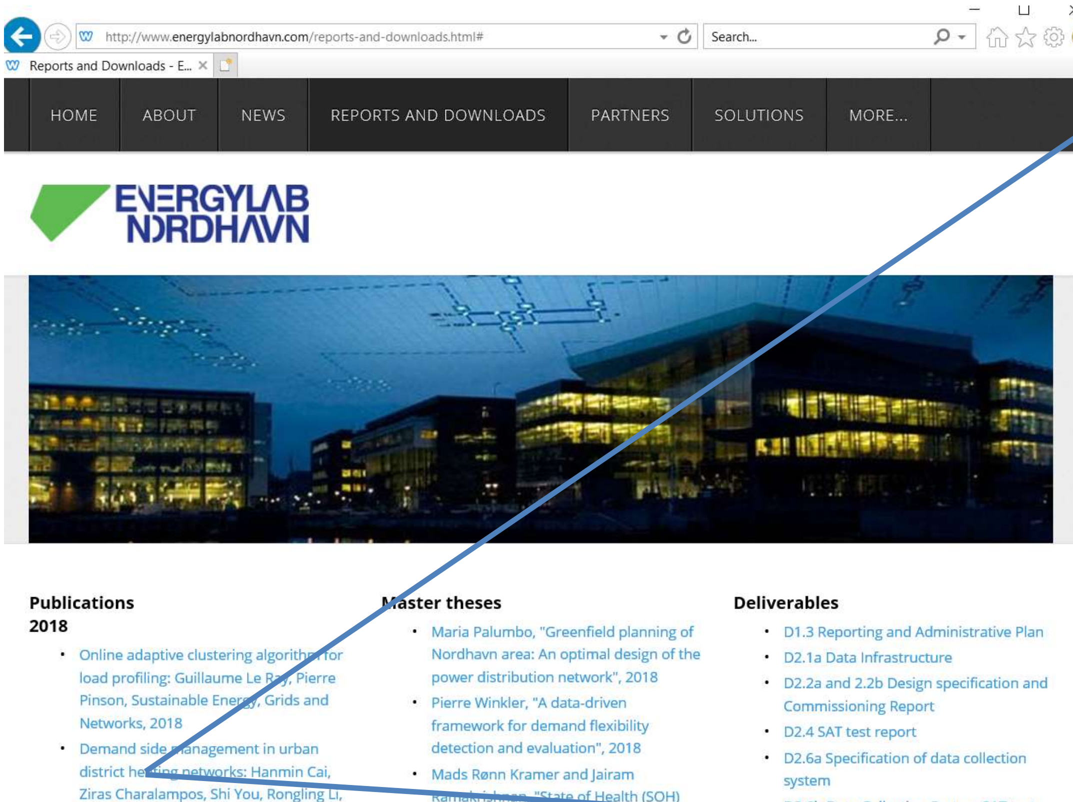
[Characters designed by freepik.com]

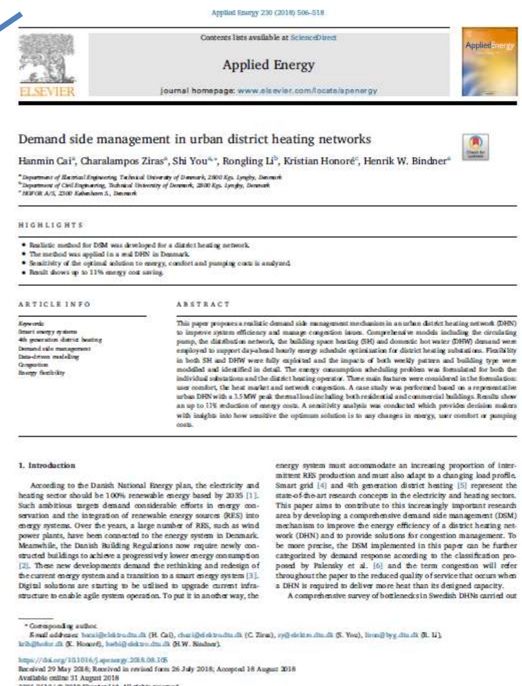
- Aidan, Eamonn, Niamh, etc., chose to gather in an *Energy Collective*
- They traditionally bought energy from the grid and sold their production back at a disadvantageous rate...
- They work at optimally matching their production and consumption
- They decide on how to share costs and benefits from import/export
- Exchanges within the community do not have to be settled against monetary transactions, but e.g., against a service or simply for free

Co-creating tomorrow's energy system

- Co-creation space, conference or co-working
- 5000 guests in H1
- Researchers, as well as politicians and business developers from all over the world
- EnergyHub for smart city companies

Learn more





Applied Energy 230 (2018) 506–518

Applied Energy

Demand side management in urban district heating networks

Hanmin Cai, Charalampos Ziras, Shi You, Rongling Li, Kristian Honoré, Henrik W. Bindner

HIGHLIGHTS

ARTICLE INFO

ABSTRACT

1. Introduction

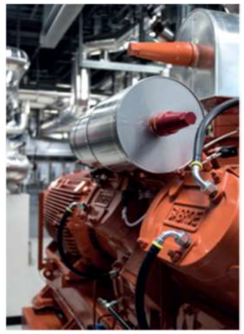
Conclusions and selected learnings

- Significant flexibility in the heating system can be unlocked, using home automation
- It is possible to accomodate much more renewable energy than today.
- Power sector is unbundled – Heat sector is not > organizational aspects are just as relevant as technology
- DSO products go through a lengthy approval process, and bandwidth at regulator is small > slowing innovation.
- Shared observability in real time
- Very different interpretation of personal data legislation in different organizations
- Service stacking is key
- Demonstration is necessary – also for finding regulatory barriers
- A combined showroom, physical presence and innovation space brings cross-organizational innovation and co-creation about.

The consumers shall co-build the energy system,

Knud Pedersen, Radius Elnet, 2018

ENERGYLAB NORDHAVN



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