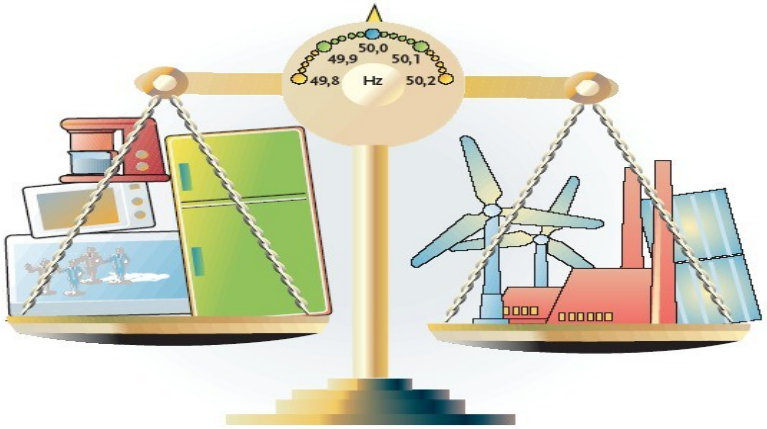
Energy Grids and Edge Computing

(Energy Center Denmark – Smart Energy Hub)



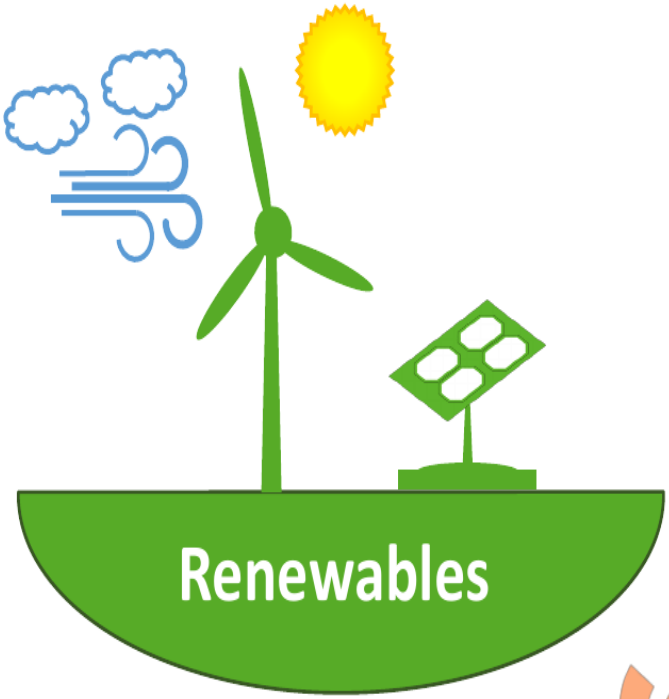
Henrik Madsen (DTU)

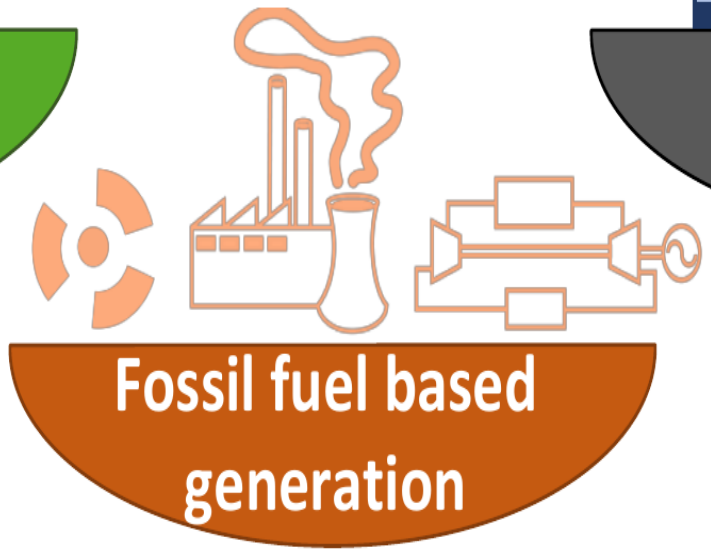
http://www.smart-cities-centre.org

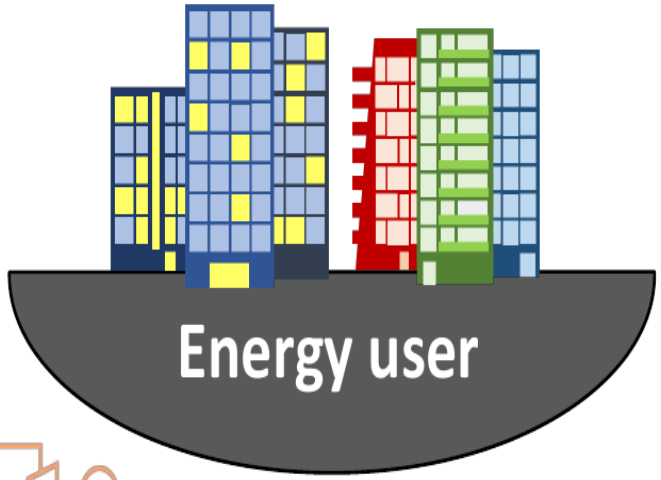
http://www.henrikmadsen.org

Challenges

The Challenge: Denmark Fossil Free 2050







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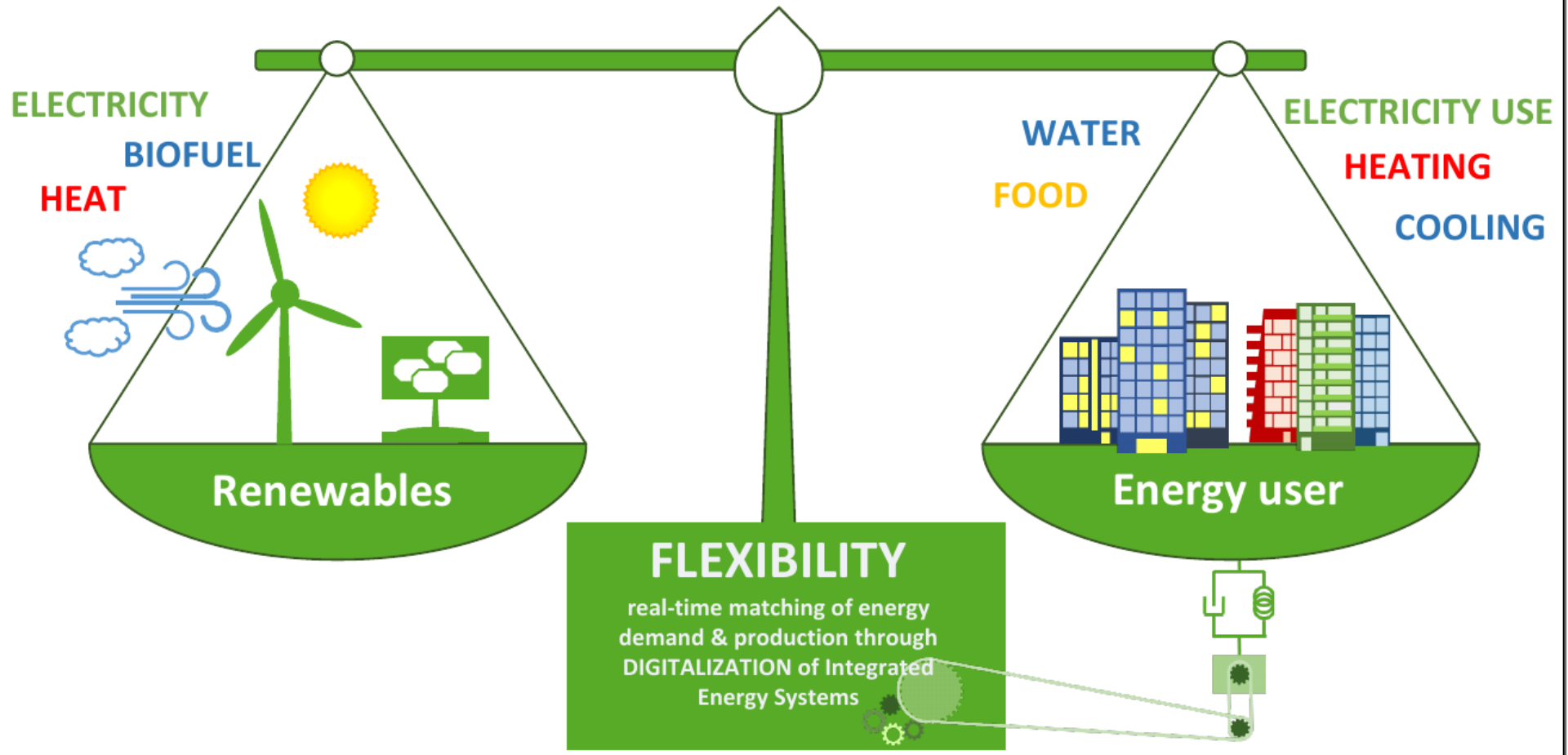
The Challenge: Denmark Fossil Free 2050



Challenges

Preparatory study on Smart Appliances

European Commission

Ecodesign Preparatory Study performed for the European Commission

Welcome | Project summary | Planning & Meetings | Documents | Register for website | Register for meeting | Contact & Consortium

Home > Project summary

Project Summary

The Ecodesign Preparatory Study on Smart Appliances (Lot 33) has analysed the technical, economic, market and environmental aspects with a view to a broad introduction of smart appliances and to develop adequate policy approaches supporting such uptake.

The study deals with Task 1 to 7 of the Methodology for Energy related products (MEErP) as follows:

- Scope, standards and legislation (Task 1, Chapter 1);
- Market analysis (Task 2, Chapter 2);
- User analysis (Task 3, Chapter 3);
- Technical analysis (Task 4, Chapter 4);
- Definition of Base Cases (Task 5, Chapter 5);
- Design options (Task 6, Chapter 6);
- Policy and Scenario analysis (Task 7, Chapter 7).

An executive summary of the project results can be downloaded here.

Throughout the study, new relevant aspects have come up which will be covered in a second phase of the Preparatory Study:

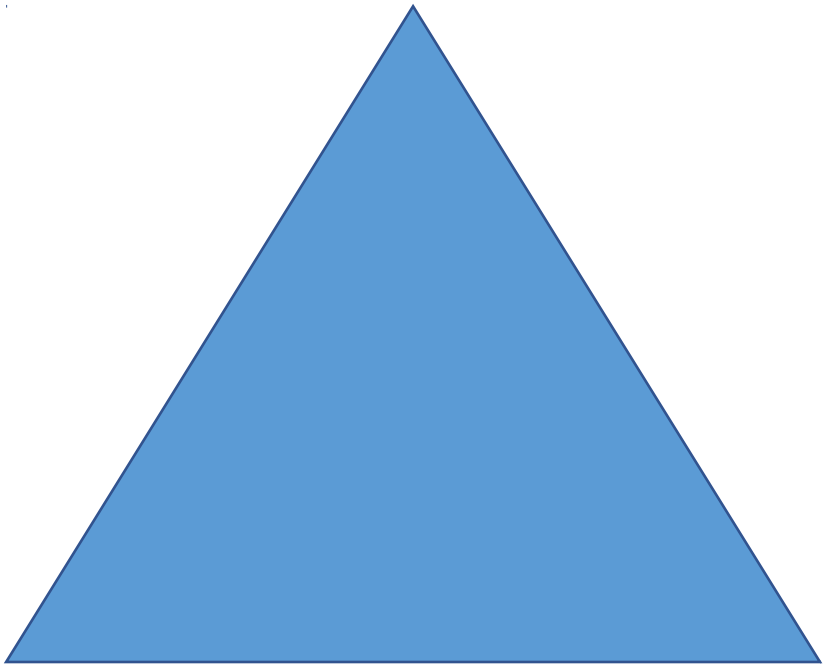
- Chargers for electric cars: technical potential and other relevant issues in the context of demand response.
- The modelling done in the framework of MEErP Task 6 and 7 will be updated with PRIMES data that recently became available, and with the EEA-countries.
- The development and assessment of policy options that were identified in the study will be further elaborated and deepened.

Almost no Flexibility

Space of Solutions

:

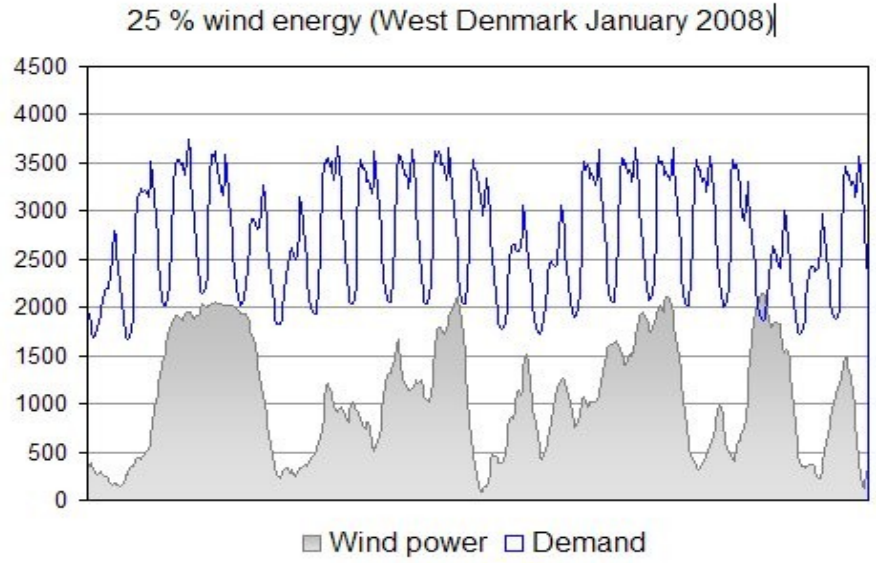
Flexibility (enabled by IoT and Edge Computing)

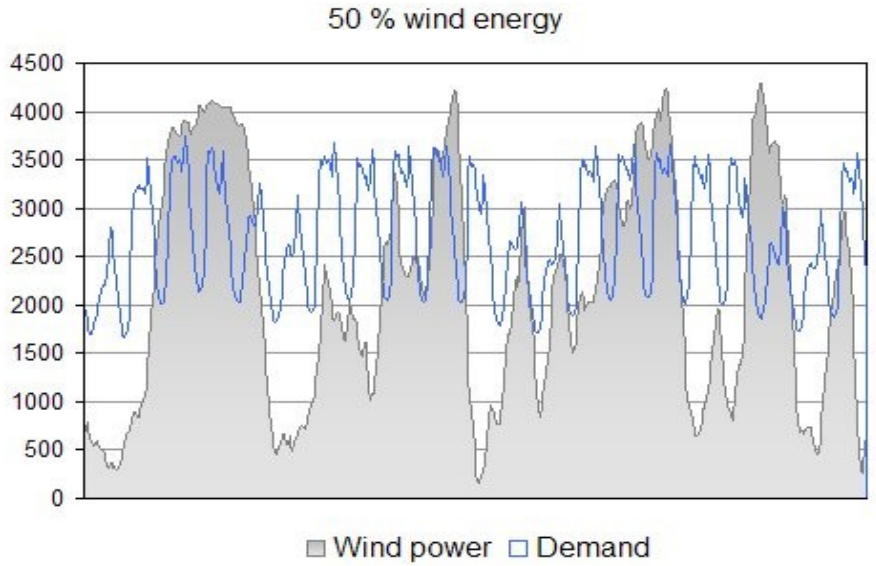


(Super) Grids **Batteries**

The Danish Wind Power Case

…. balancing of the power system





In 2008 wind power did cover the entire demand of electricity in 200 hours (West DK)

In 2020 Flexibility, IoT and Edge Computing are essential

That's the topic of 'Flexible Energy Denmark'

(For several days the wind power production is more than 100 pct of the power load)

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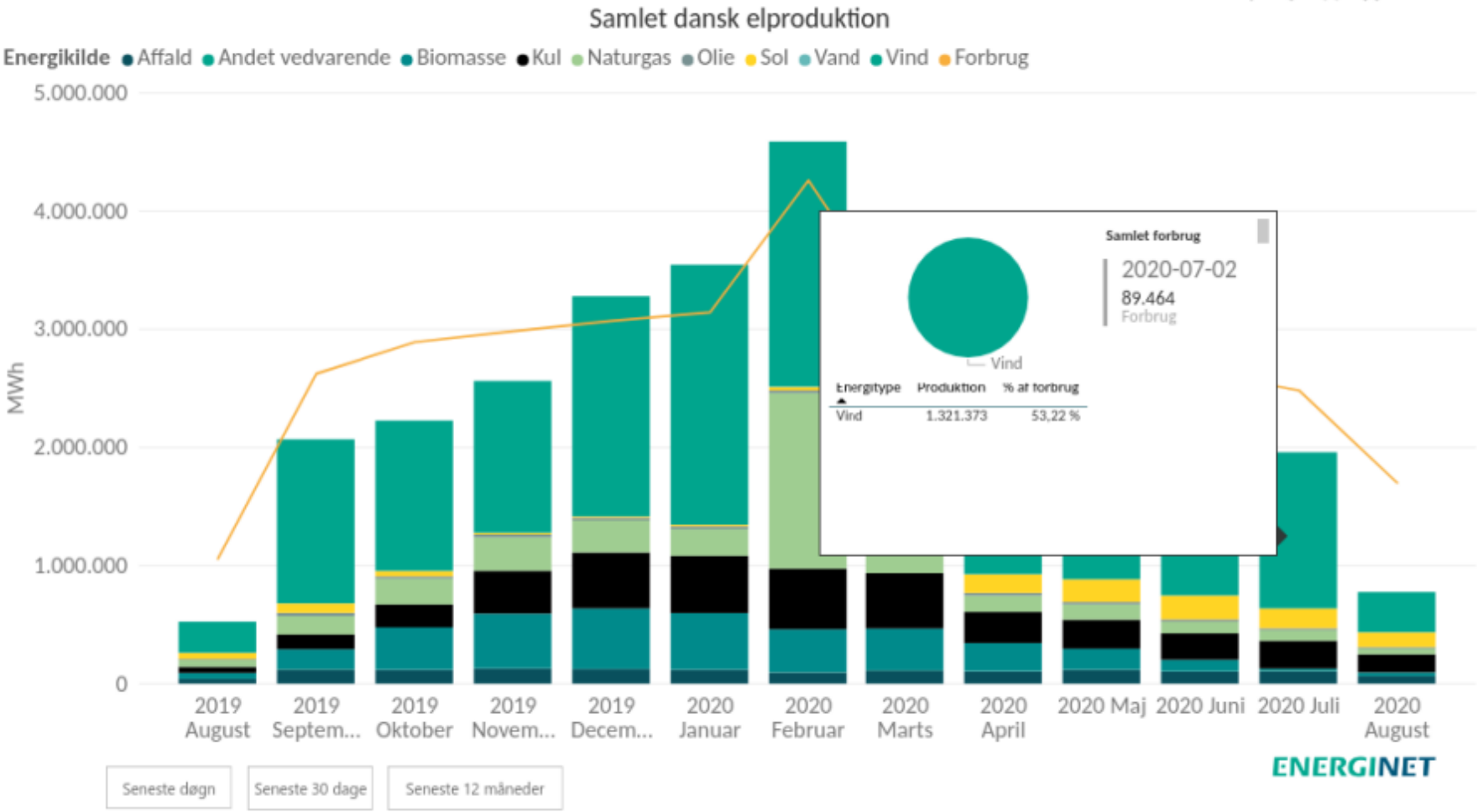
The Danish Wind Power Case



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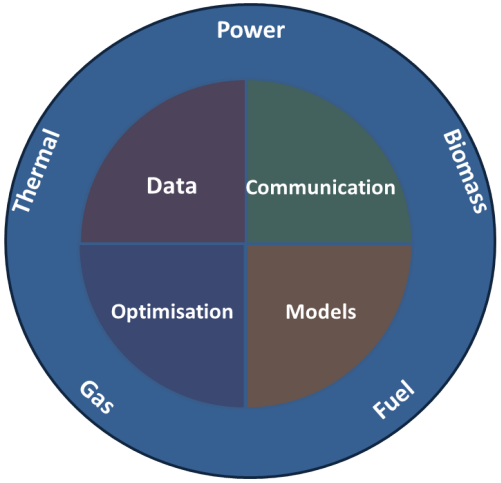
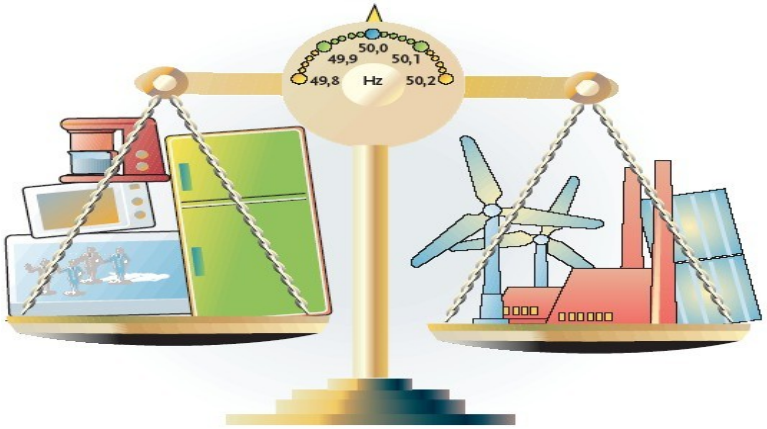
Use of IoT and Edge Computing

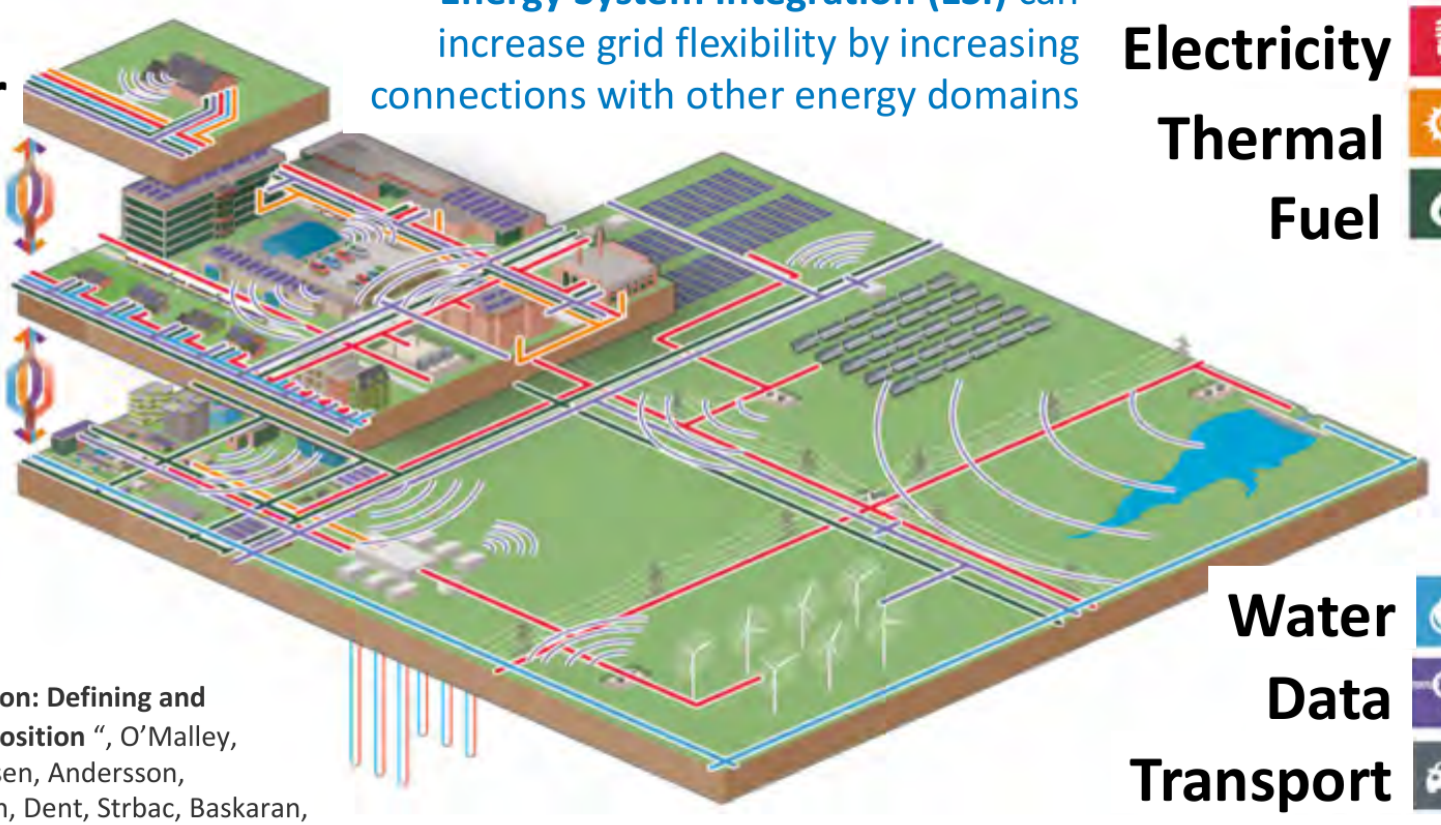




The **central hypothesis** is that by **intelligently integrating** currently distinct **energy** (heat, power, gas and biomass) and **water** components using **AI, IoT, Edge, Fog, Cloud computing** we can **unlock the flexibility** needed to **balance** very large shares of renewables - and consequently obtain substantial reductions in CO2 emissions.

Energy Systems Integration

Energy System Integration (ESI) can increase grid flexibility by increasing connections with other energy domains



"**Energy Systems Integration: Defining and Describing the Value Proposition** ", O'Malley, Kroposki, Hannegan, Madsen, Andersson, D'haeseleer, McGranaghan, Dent, Strbac, Baskaran, Rinker., NREL/TP-5D00-66616. June 2016

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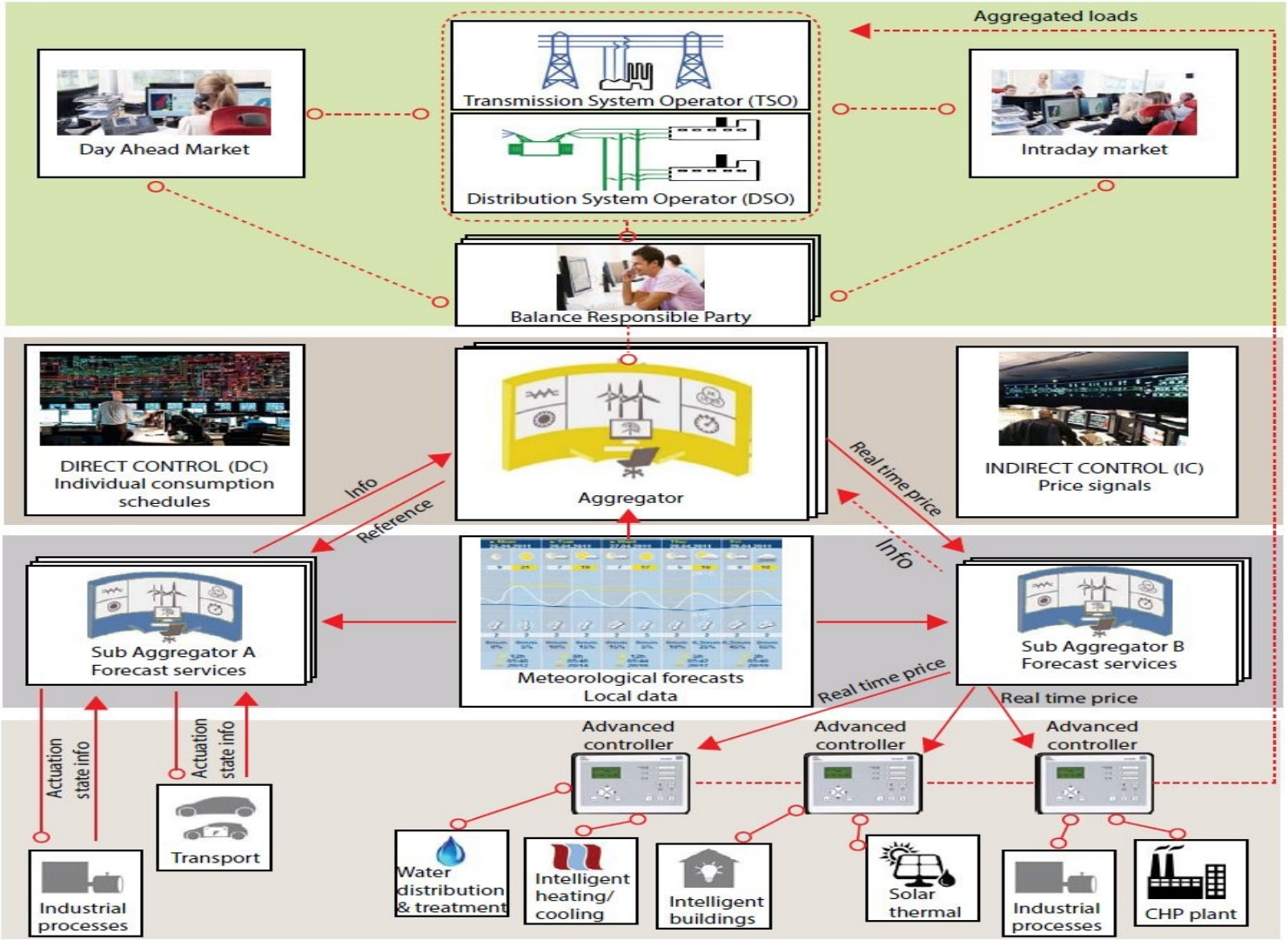
Smart-Energy OS



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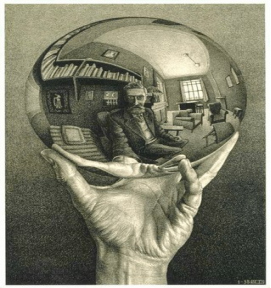
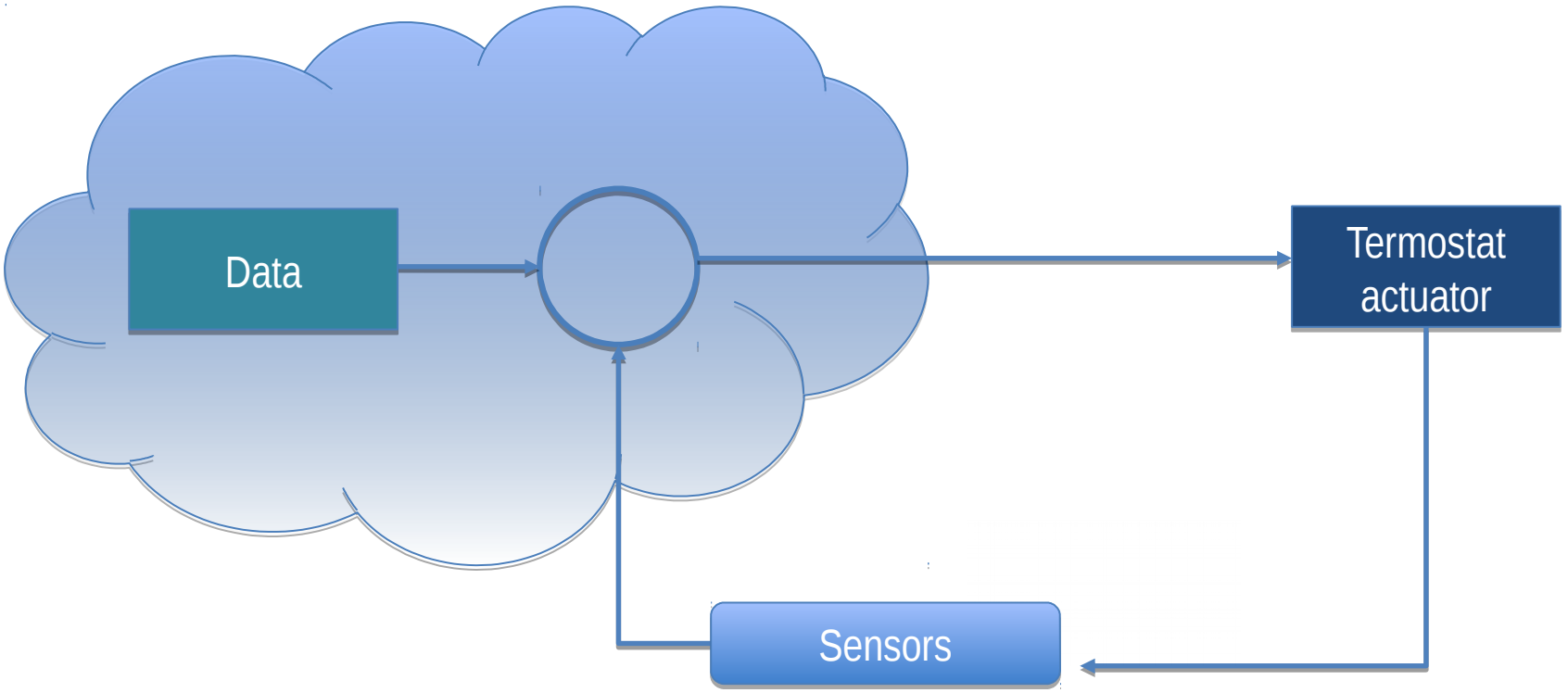
SE-OS Characteristics

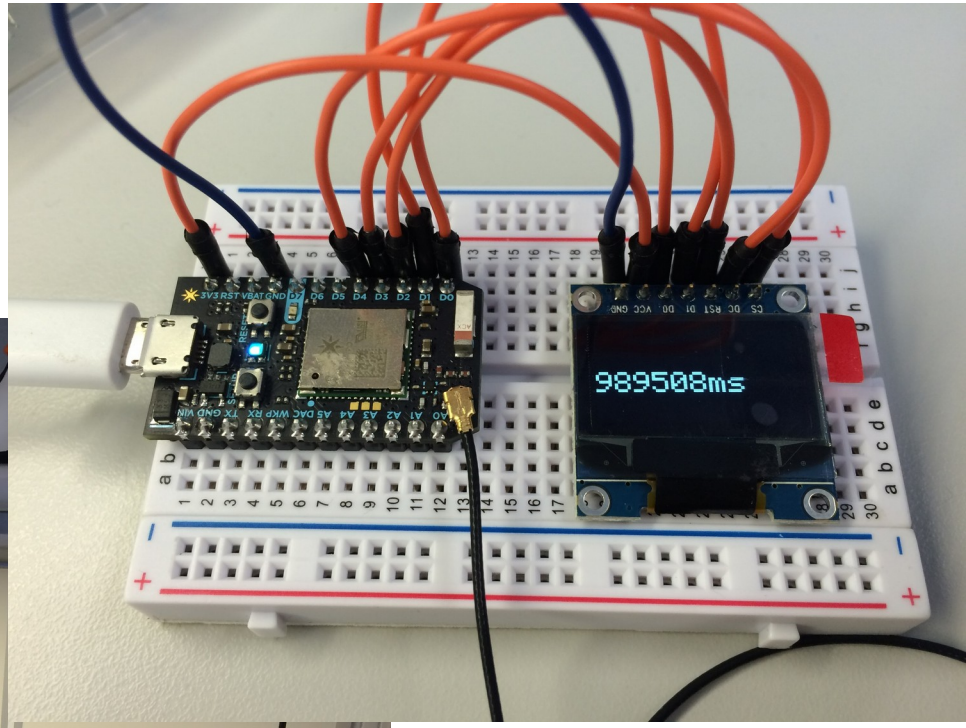
- Ordinary markets at higher levels
- Nested sequence of systems – systems of systems
- Hierarchy of optimization and control problems
- Cloud, Fog, Edge based (IoT, IoS) solutions
- One-way communication at lower level; robust by design
- Simple setup for the communication and contracts

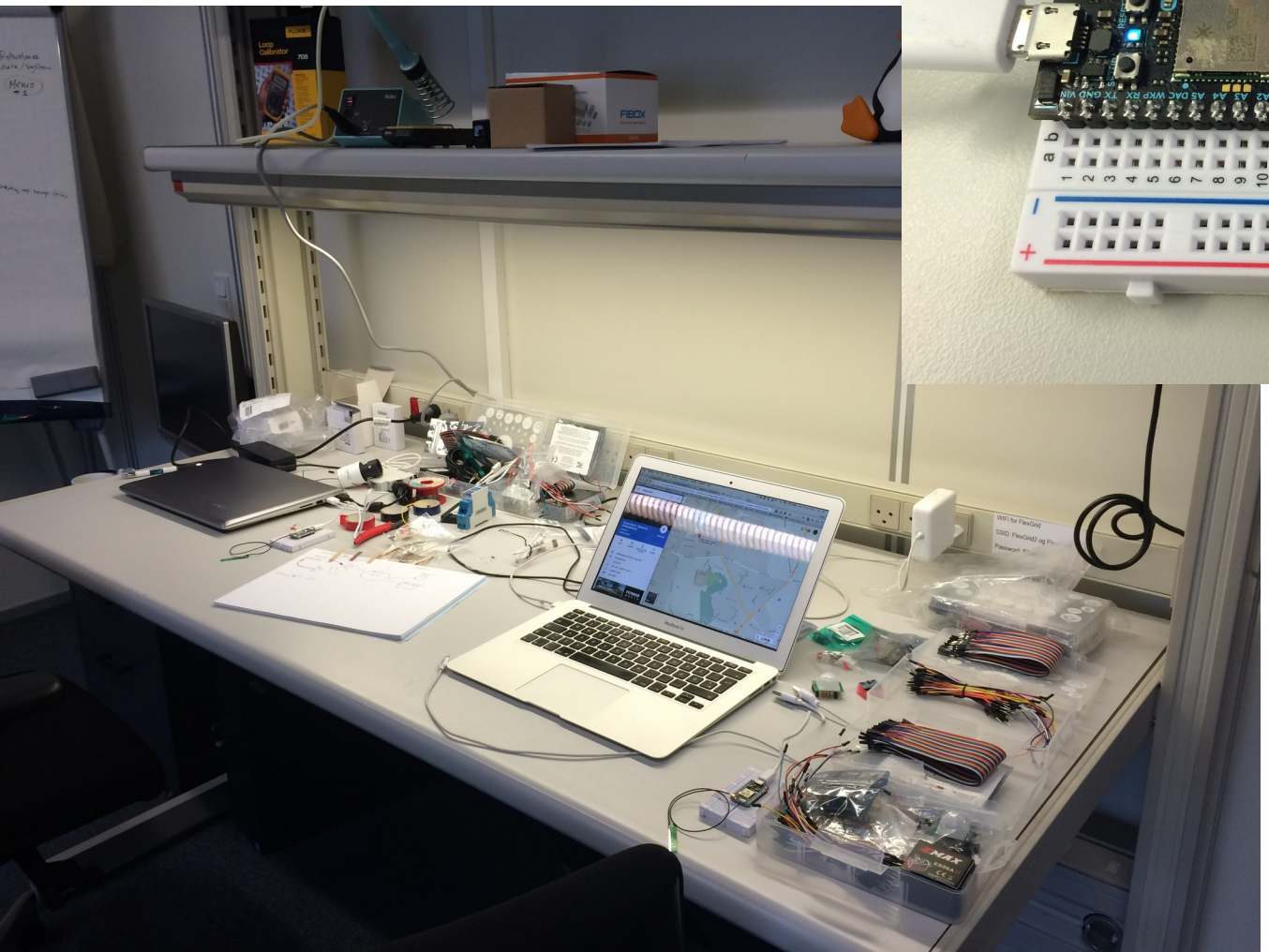


SE-OS – **Edge** level controllers
Control loop design – **logical drawing**

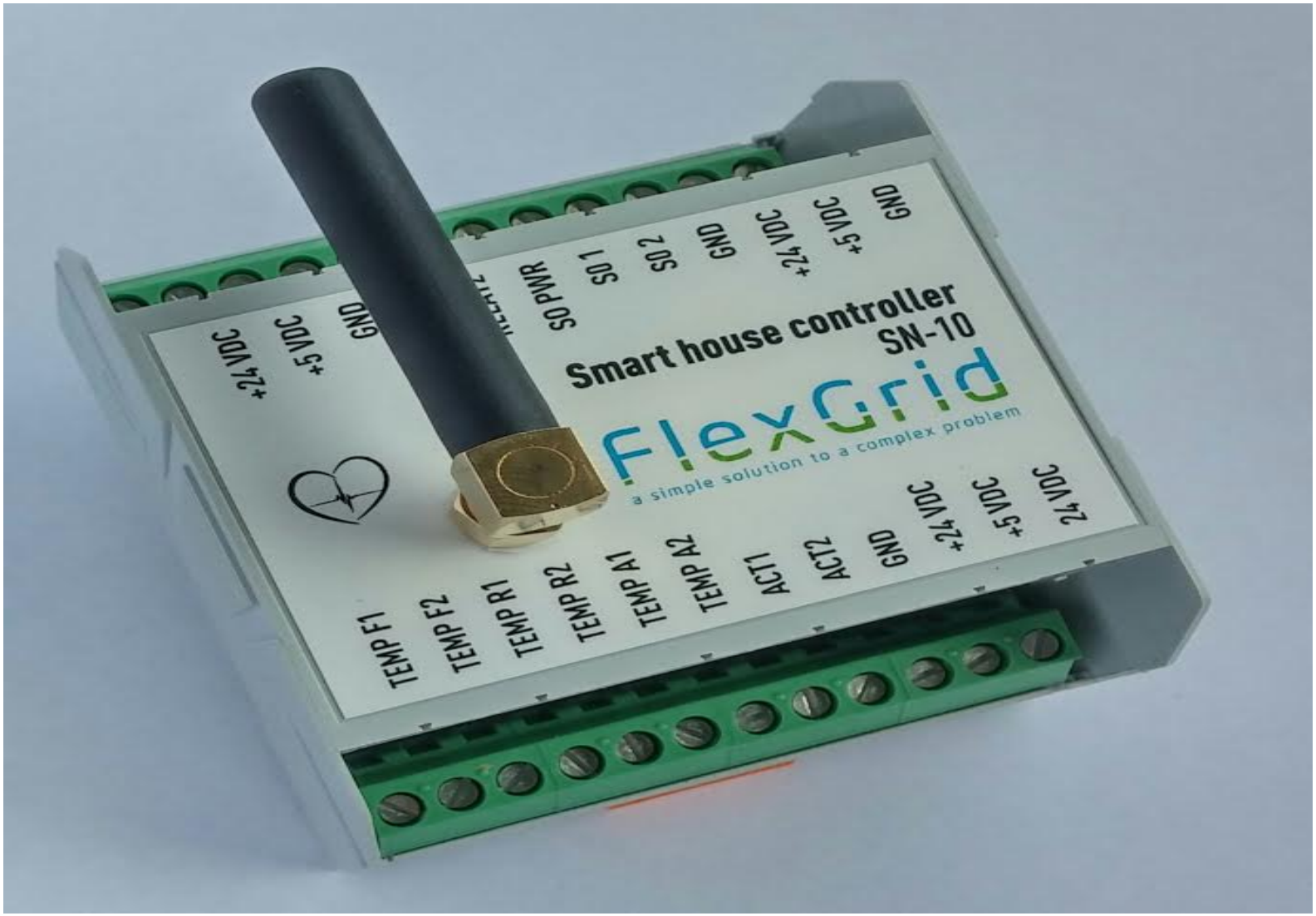


Lab testing ….





SN-10 Smart House Controller



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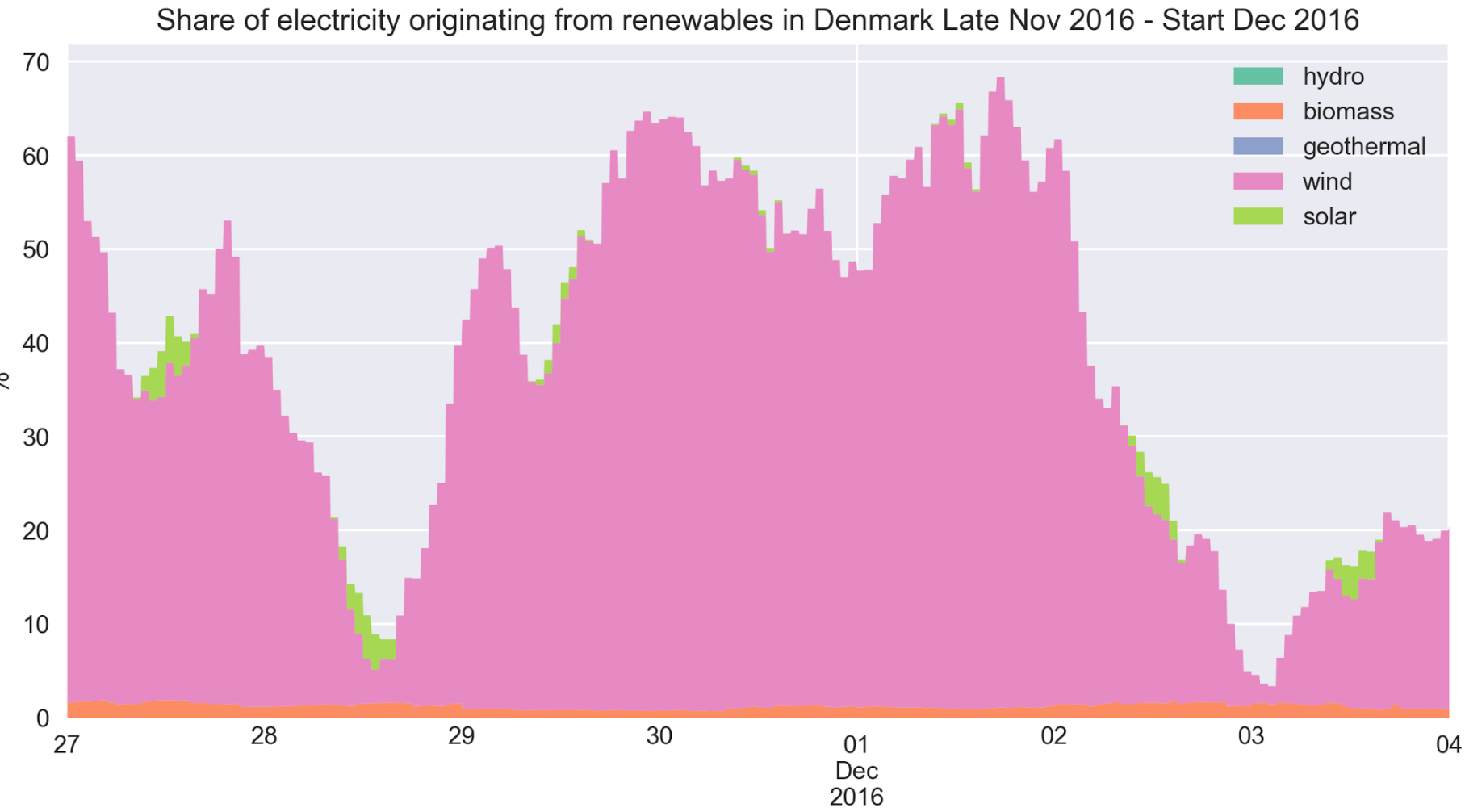
Case study

Control of heat pumps (Price / CO2 efficient control)



Source: pro.electicitymap.

How does it work?

Data measurement and information gathering

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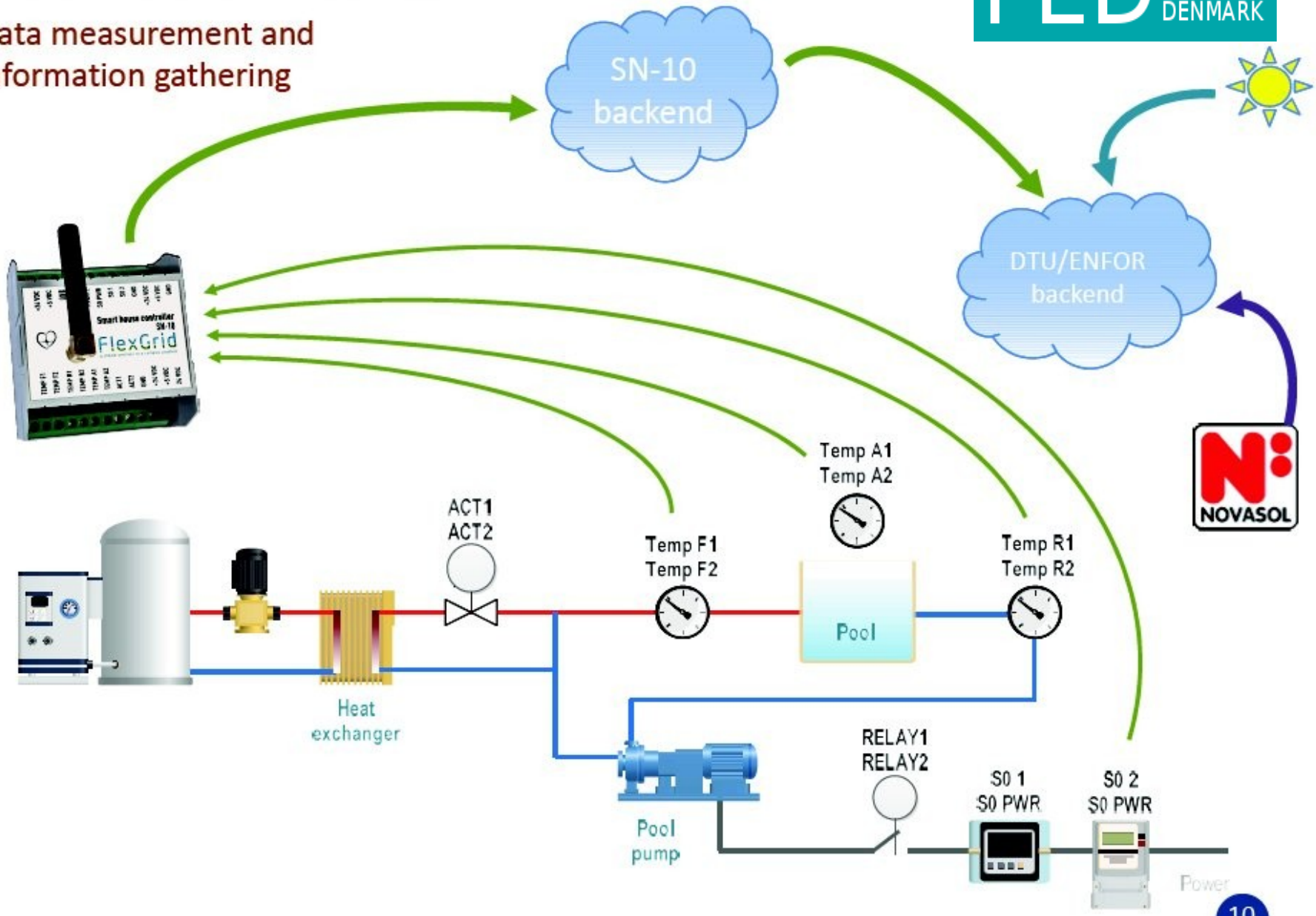

How does it work?

Price based Control

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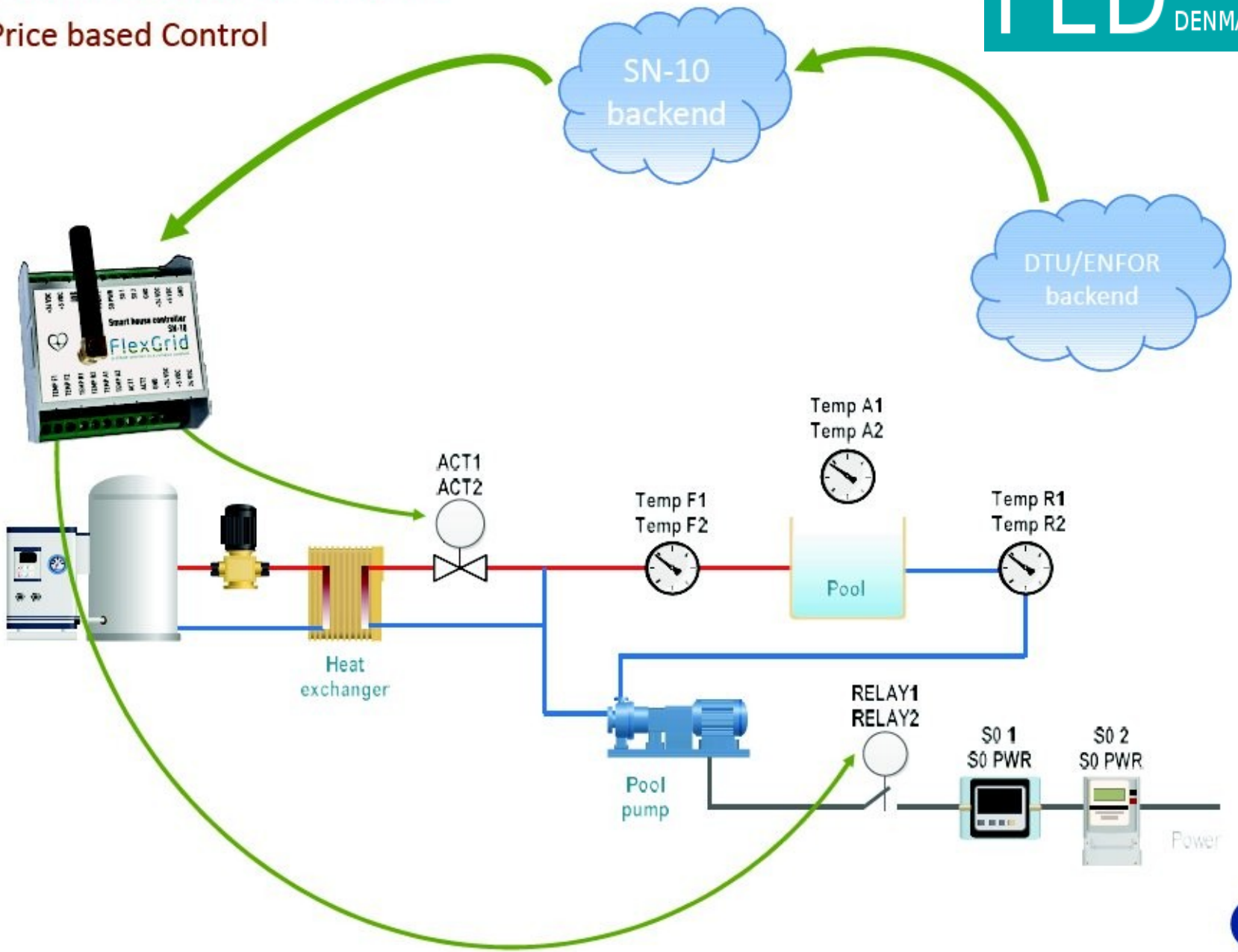

Example: CO2-based control (10-15 pct savings in CO2 e.)

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AI, IoT, Edge, Fog, and Cloud based solutions for unlocking the needed flexibility for large scale integration of wind and solar power

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CENTER DENMARK

Connect networks and data for a green world

Danmarks nationale Center

Fremme den grønne omstilling.
Samle og bygge bro, mellem forskning, teknologi, natur og formidling, på tværs af interesseorganisationer, virksomheder, skoler og universiteter.

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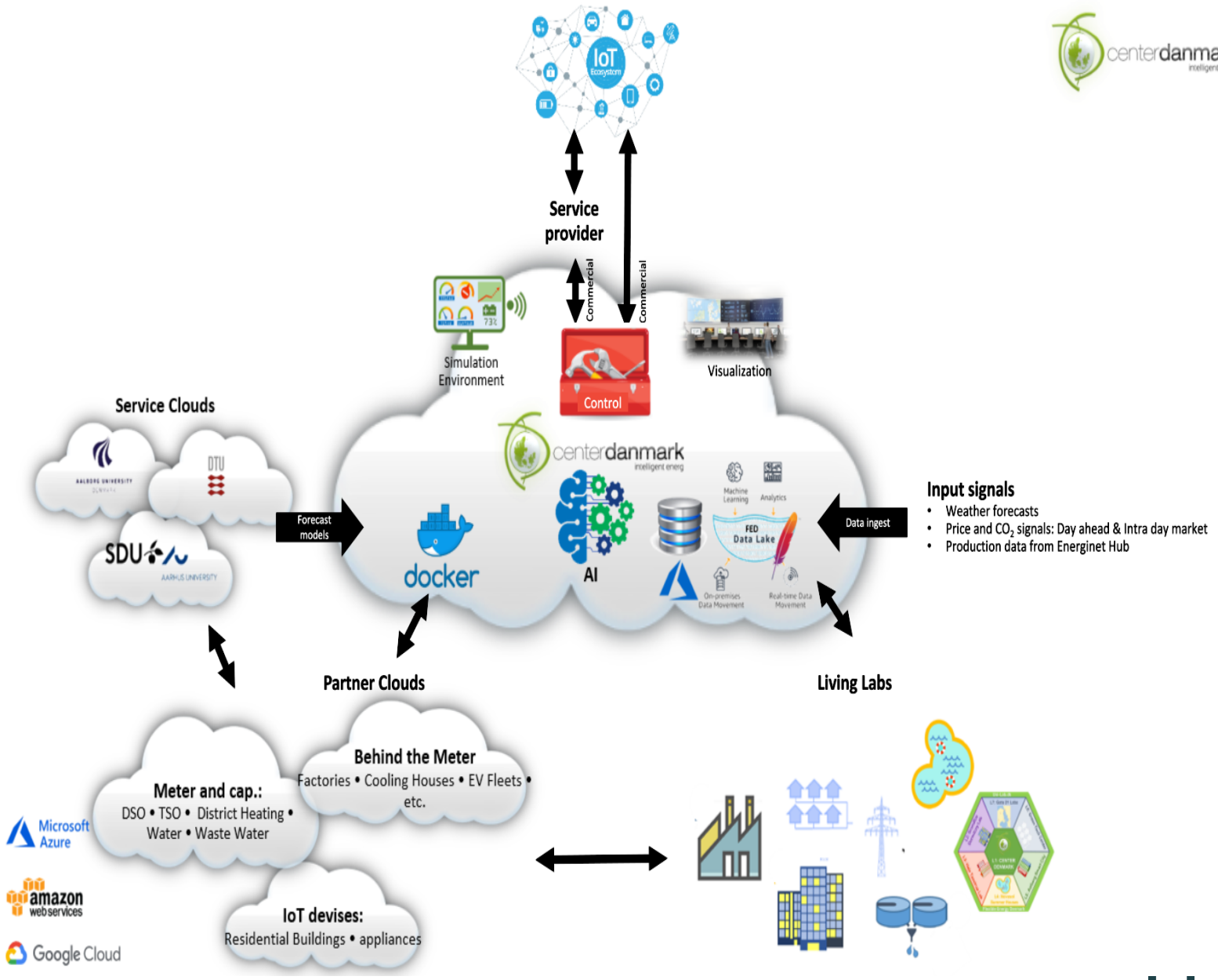
IoT
Ecosystem
Service provider
Commercial
Commercial
Simulation Environment
Control
Visualization
Service Clouds
AALBORG UNIVERSITY
DTU
SDU
AARHUS UNIVERSITY
Forecast models
centerdanmark
intelligent energy
docker
AI
Machine Learning
Analytics
FED Data Lake
On-premises Data Movement
Real-time Data Movement
Data ingest
Input signals
• Weather forecasts
• Price and CO_2 signals: Day ahead & Intra day market
• Production data from Energinet Hub
Partner Clouds
Living Labs
Meter and cap.:
DSO • TSO • District Heating • Water • Waste Water
Behind the Meter
Factories • Cooling Houses • EV Fleets • etc.
IoT devises:
Residential Buildings • appliances
Microsoft Azure
amazon web services
Google Cloud

For more information …

See for instance

www.smart-cities-centre.org

…or contact

- Henrik Madsen (DTU Compute)

  hmad@dtu.dk

Acknowledgements:

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