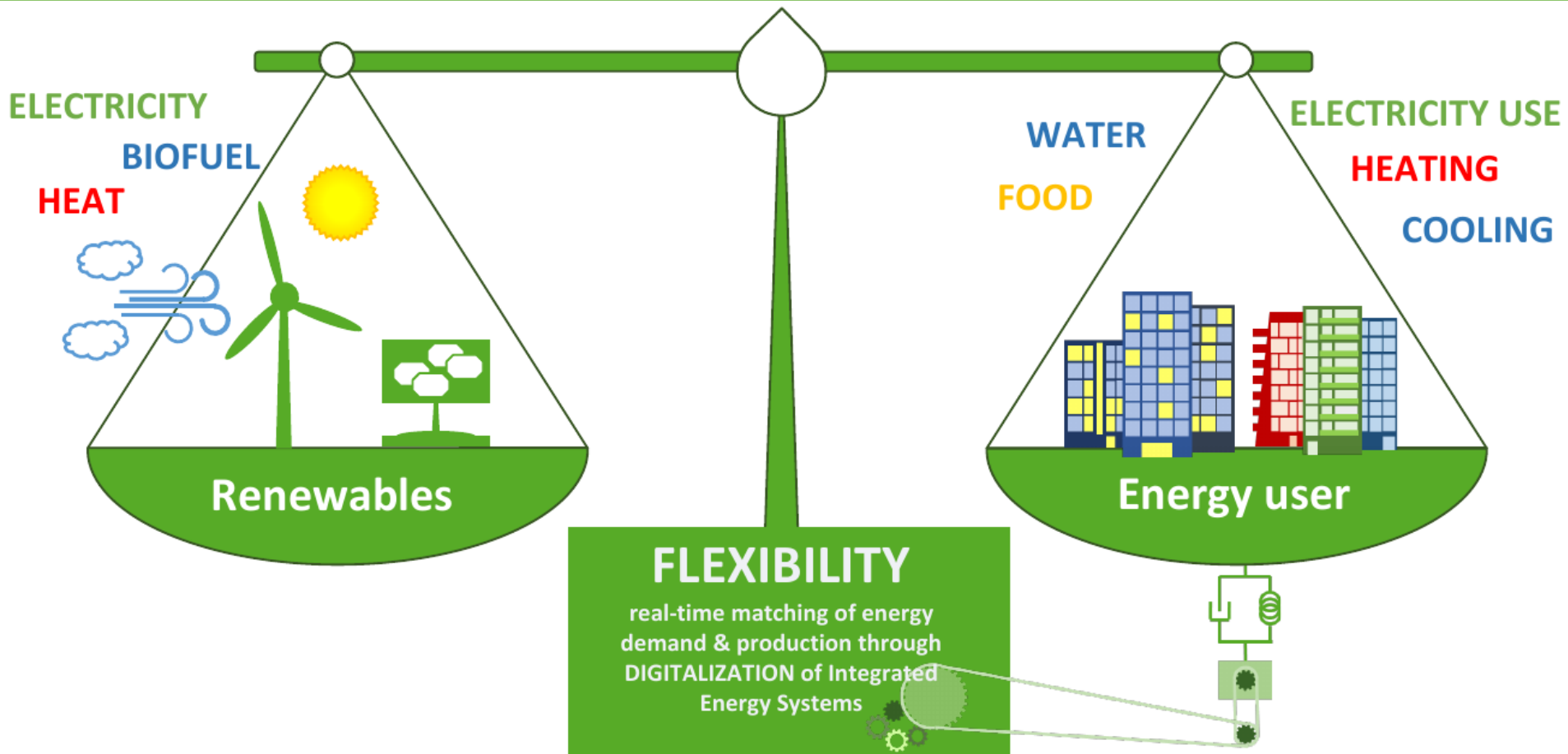GreenLab Summit 2022

Data-driven methods for Smart Energy Systems

Henrik Madsen, DTU Compute

(IFD projects: Flexibile Energy Denmark + Cool Data)
(EU/BRIDGE projects: ELEXIA + ARV + ebalance-plus)

DTU

FED FLEXIBLE ENERGY DENMARK

ebalanceplus
www.h2020-bridge.eu

This initiative is funded by

The Challenge: Denmark Fossil Free 2050

ELECTRICITY
BIOFUEL
HEAT

Renewables

WATER
FOOD

ELECTRICITY USE
HEATING
COOLING

Energy user

FLEXIBILITY

real-time matching of energy demand & production through DIGITALIZATION of Integrated Energy Systems

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Local Flexibility Markets
vs Classical Markets

- Static -> **Dynamic**

- Deterministic -> **Stochastic**

- Linear -> **Nonlinear**

- Many power related services (voltage, frequency, balancing, spinning reserve, congestion, ...) -> **Coordination + Hierarchy**

- Speed / problem size -> **Decomposition + Control Based Solutions**

- Characterization of flexibility (bids) -> **Flexibility Functions**

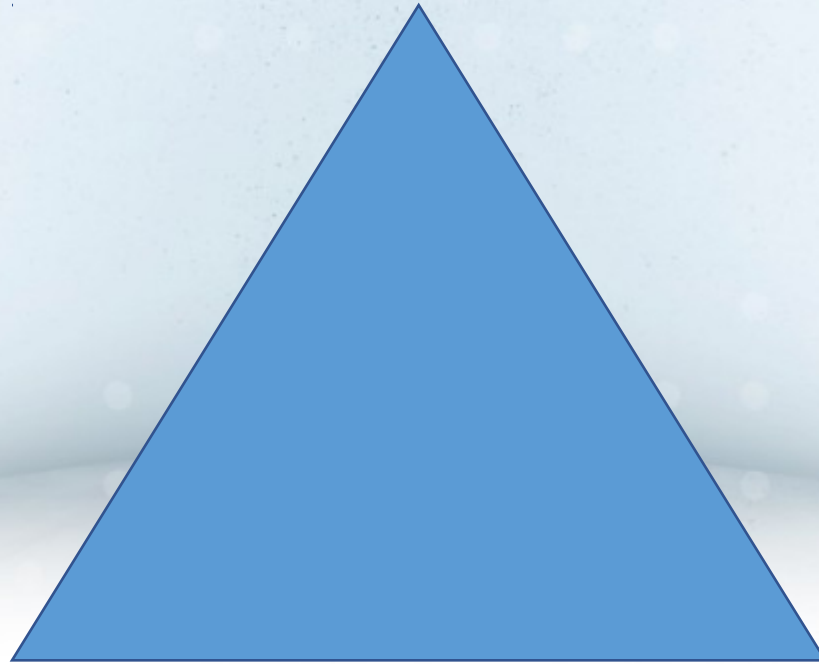- Requirements on user installations -> **One-way communication**

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Space of Solutions

Flexibility
(enabled by **AI, Digital Twins, Communication and IoT**)

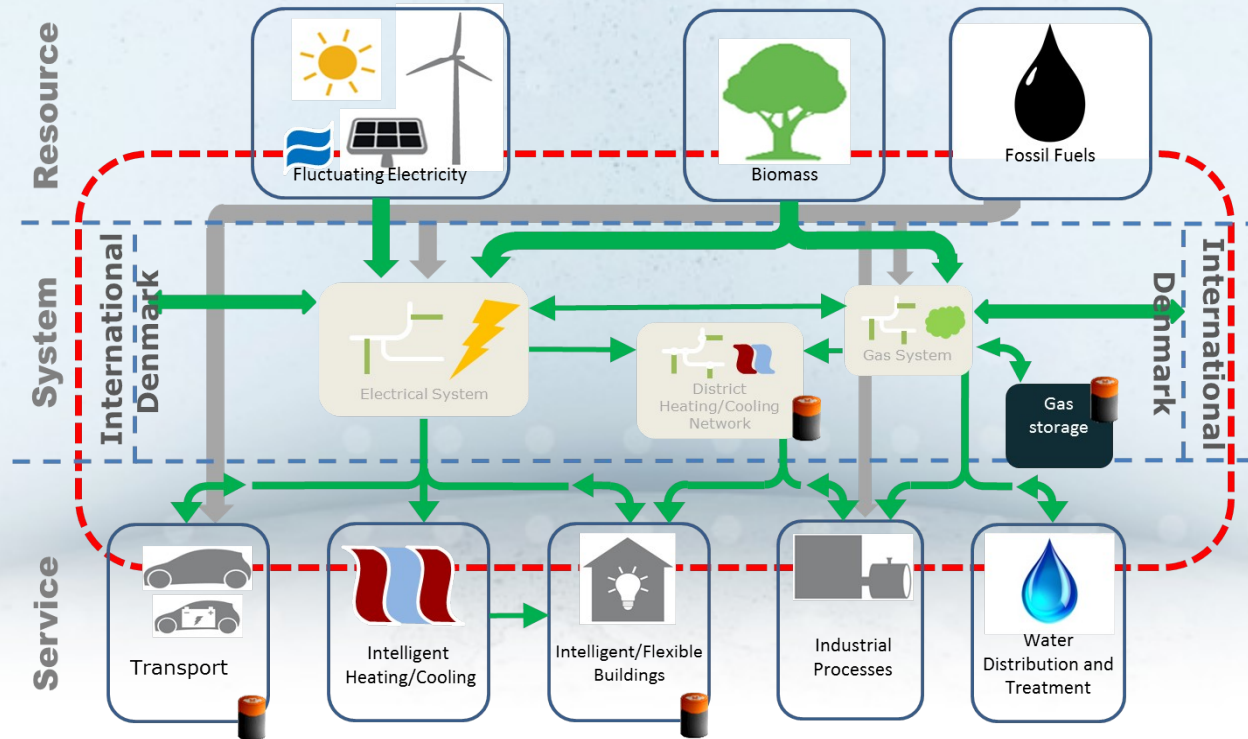**Grids**

Batteries

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Data-driven Digital Twins for Real Time Applications

Grey-box models are simplified Digital Twin models facilitating system integration and use of sensor data in real-time
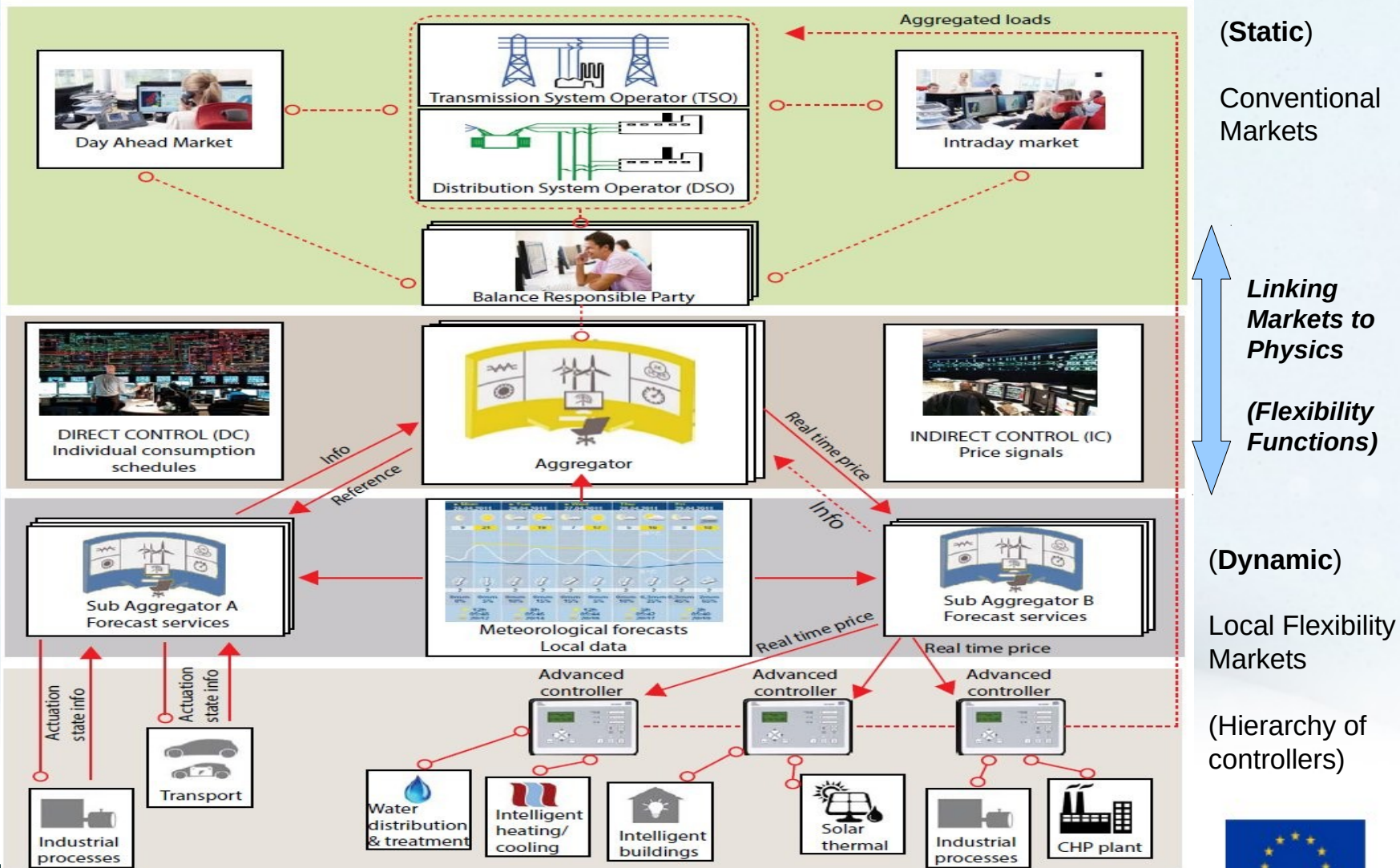
Temporal and Spatial Scales

A so-called *Smart-Energy Operating-System (SE-OS)* is developed in order to develop, implement and test solutions (layers: data, models, optimization, control, communication) for **operating flexible electrical energy systems** at **all scales**.
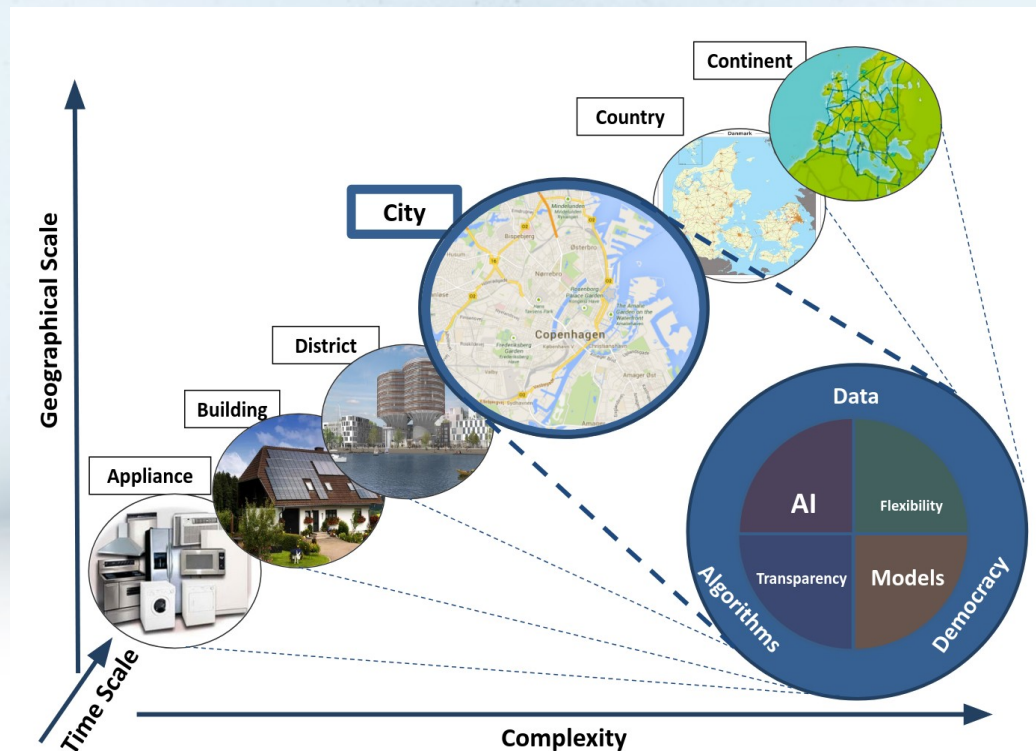
Smart-Energy OS
The Transformative Power of Digitalization

GreenLab Summit, 2022

Flexibility Function

The *Flexibility Function (FF)* is used to characterize and providing an interface between local and high-level markets
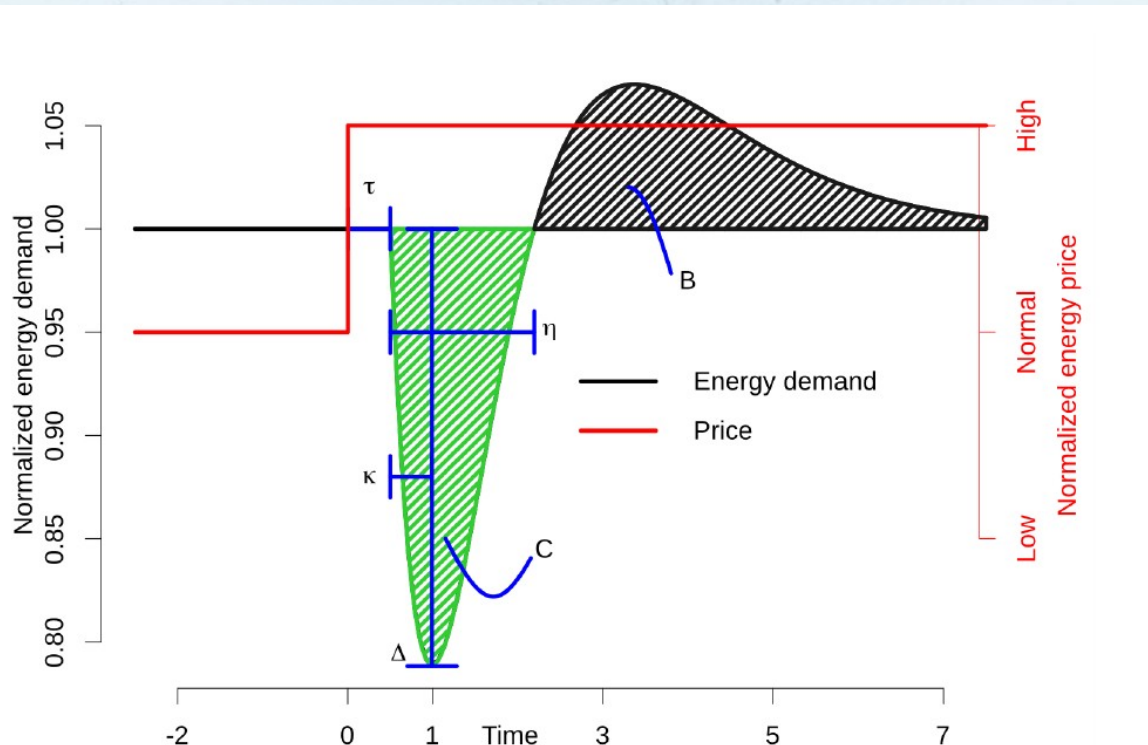
Flexible Users and Penalty Signals

Penalty Generator for, e.g.:

Voltage Control,
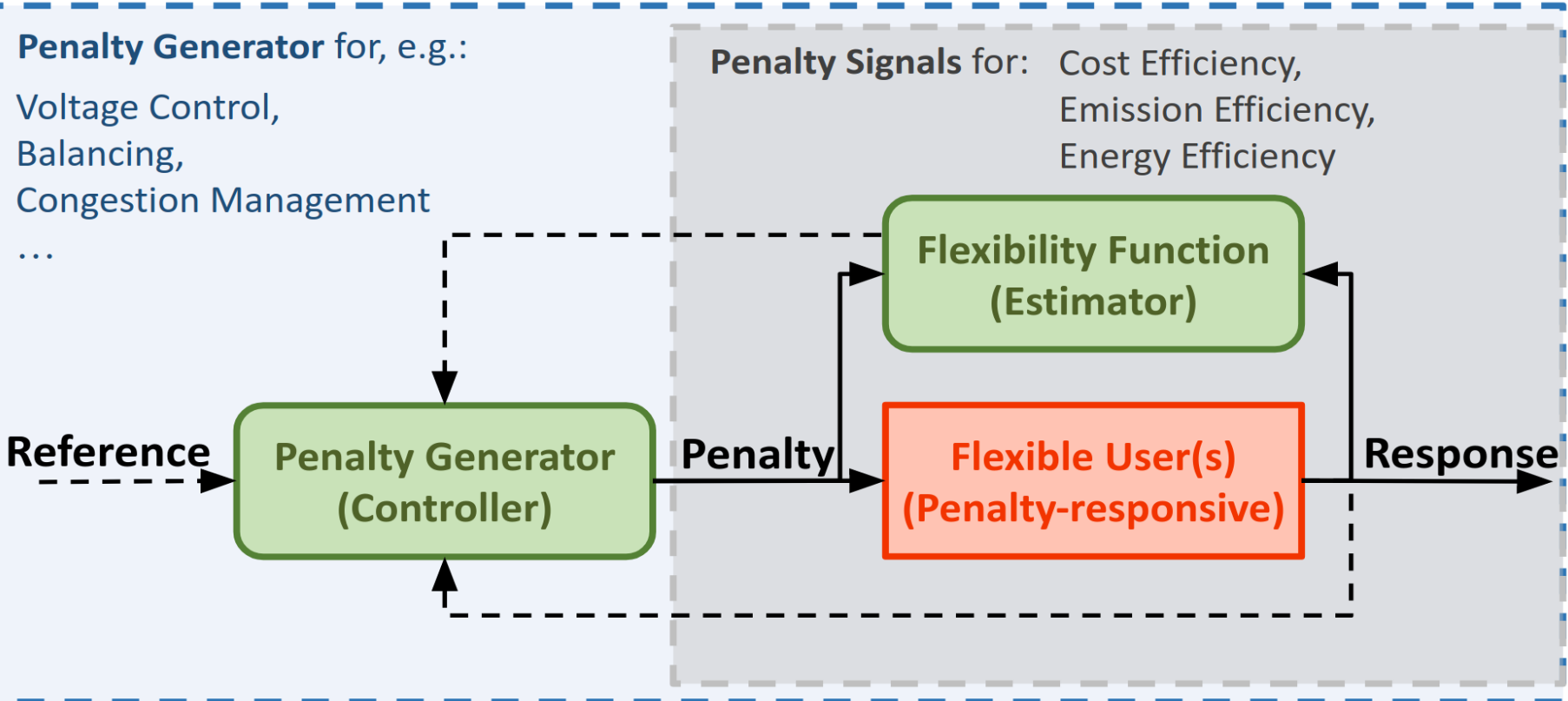Balancing,
Congestion Management

…

Penalty Signals for: Cost Efficiency,
Emission Efficiency,
Energy Efficiency

Flexibility Function (Estimator)

Reference

Penalty Generator (Controller)

Penalty

Flexible User(s) (Penalty-responsive)

Response

Center Denmark
Control Room and Data Space
Spatial–Temporal thinking

Center Denmark aims at enstablishing a trusted data-sharing data space which put priorities in cyber security and in empowering the users (industry and customers) such that they are able to provide flexibility without being subject to disproportionate technical requirements, administrative requirements, procedures and charges
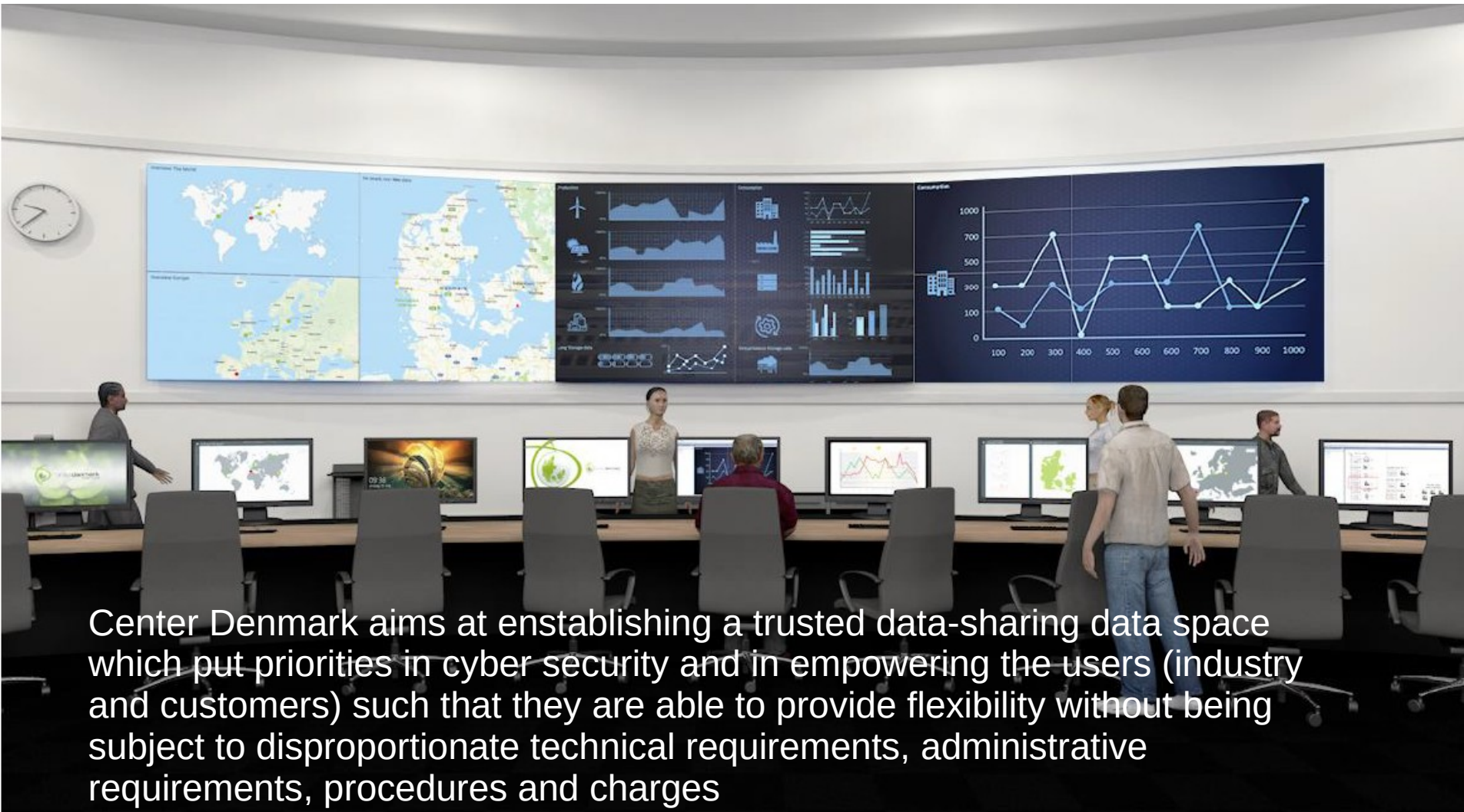
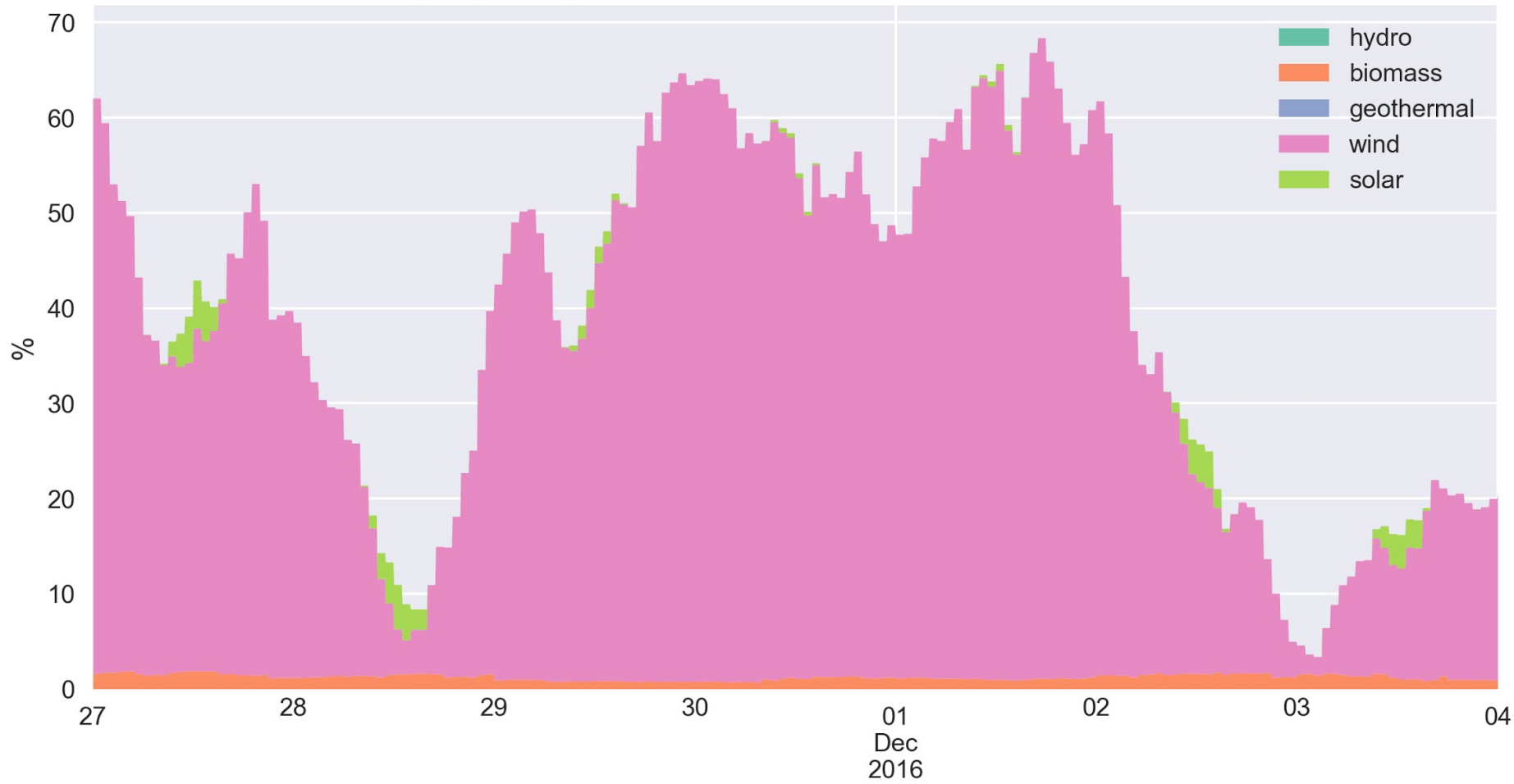# Case study

Summerhouses with a pool

Share of electricity originating from renewables in Denmark Late Nov 2016 - Start Dec 2016

Legend:
- hydro
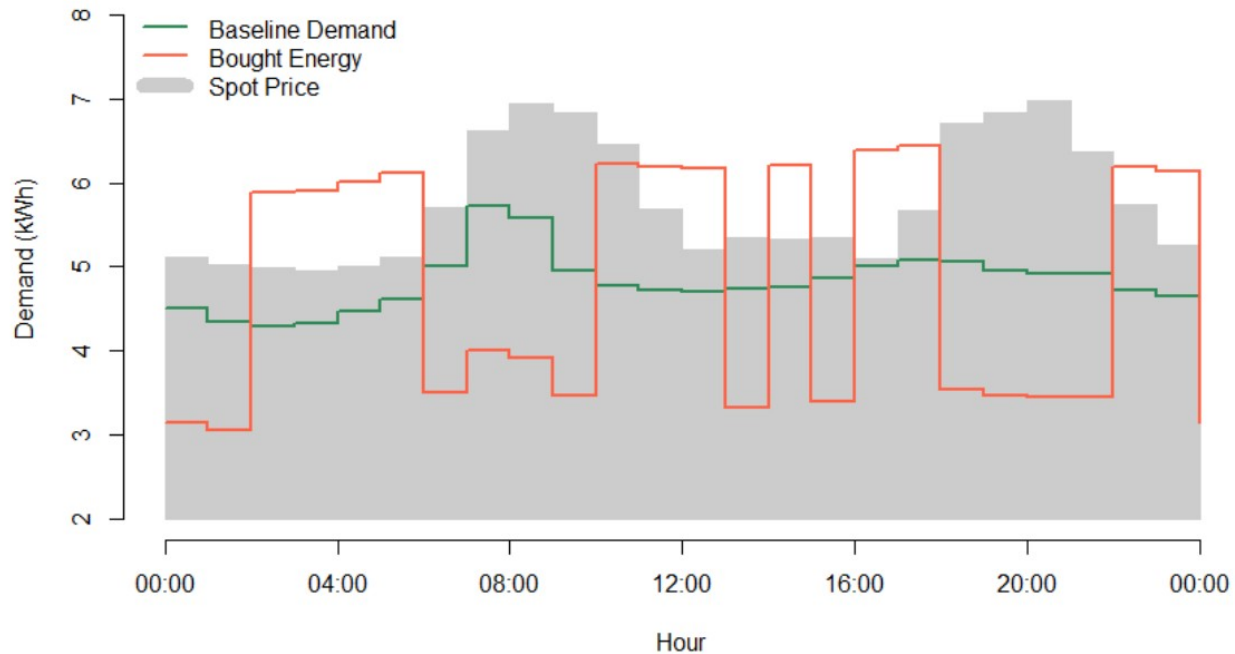- biomass
- geothermal
- wind
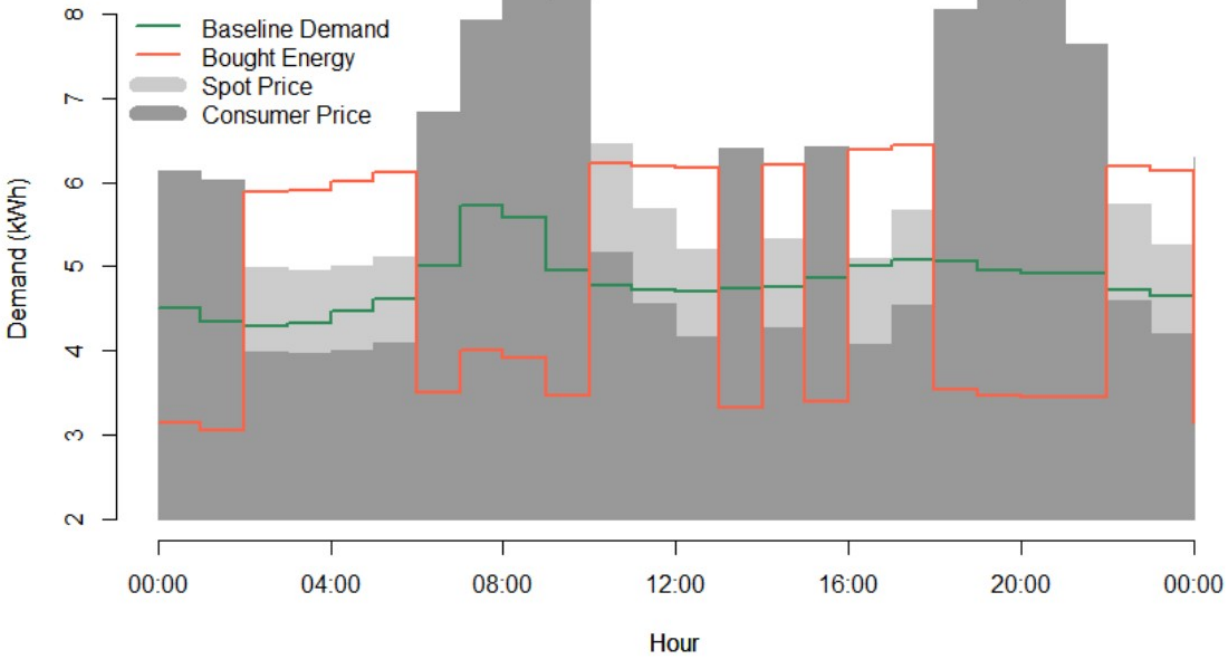- solar

Source: pro.electicitymap.org

Bidding Flexibility into Markets

- 4 hours intervals consisting of 30% of consumption with durations of 2 hours:

Bidding Flexibility into Markets

Solve FF(Price)=Bought Energy:

Summary

- An efficient implementation of the **future weather-driven** energy system calls for **data-driven Smart Energy Systems**

- We need **digitalization for enabling low-level flexibility markets**

- We need **transparent**, **safe, fair** and **democratic** solutions

- **It must be easy**. Industry should be able to participate in **flexibility markets** without being subject to disproportionate technical requirements, procedures and charges

- We have proposed to use **control-based methods for activating local flexibility (Smart-Energy OS)**

- We have indicated how to use **control-based methods for all type of grid services**

- Will be used in the **new (and large) InnoMission 2 PtX project (DynFlex)**

- Implemented at the **National Digitalization Hub, Center Denmark**

- **Savings** in summerhouses: 10 – 30 pct

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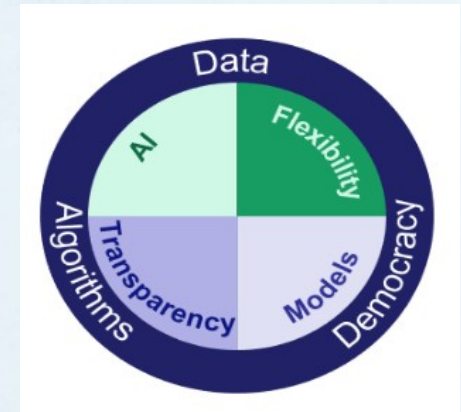
Thank you !

Connect – Share – Innovate

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@bridge_H2020

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