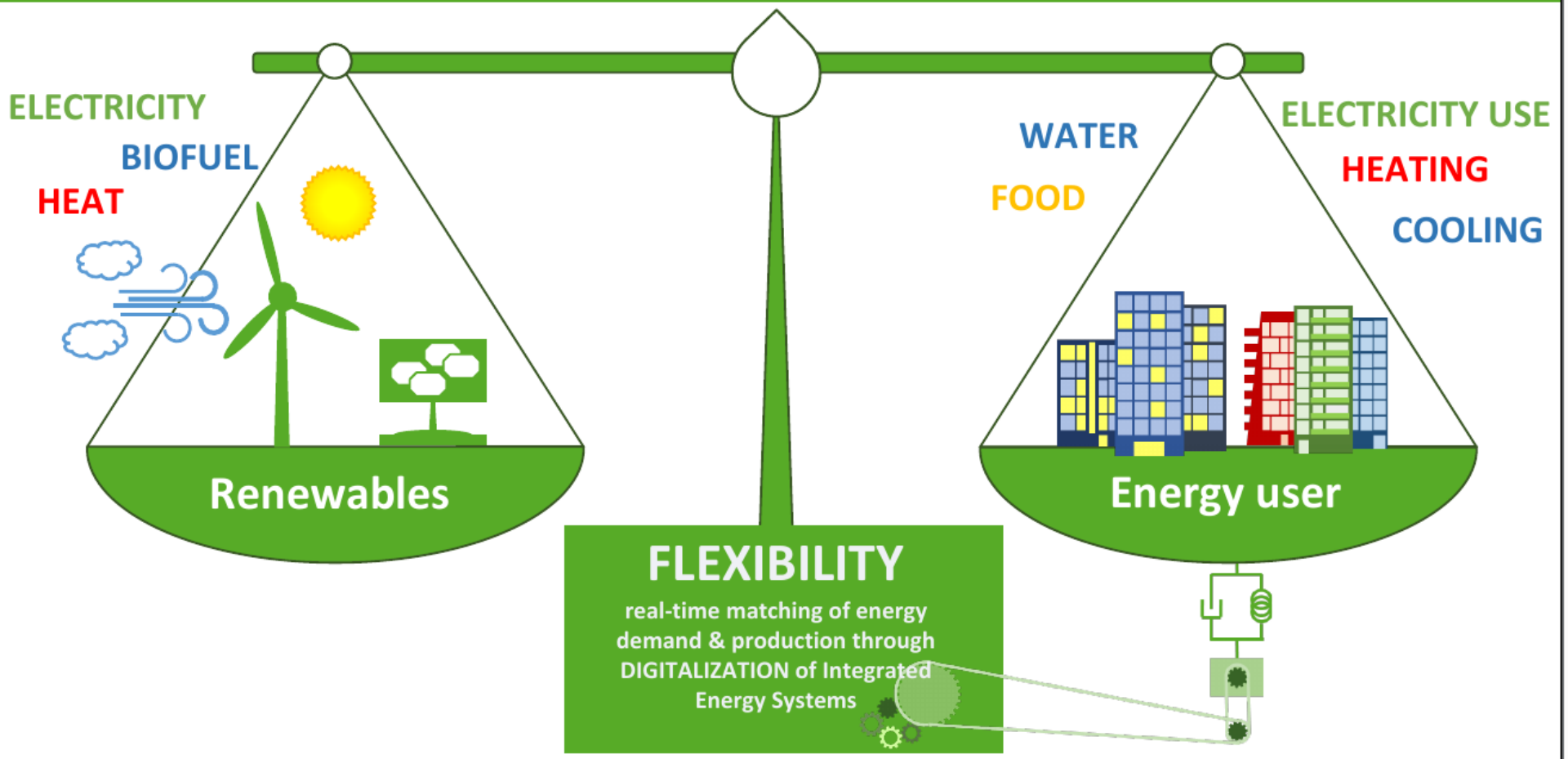
FED Contribution and Perspectives

Henrik Madsen

FED FLEXIBLE ENERGY DENMARK

Innovation Fund Denmark

The Challenge: Denmark Fossil Free 2050

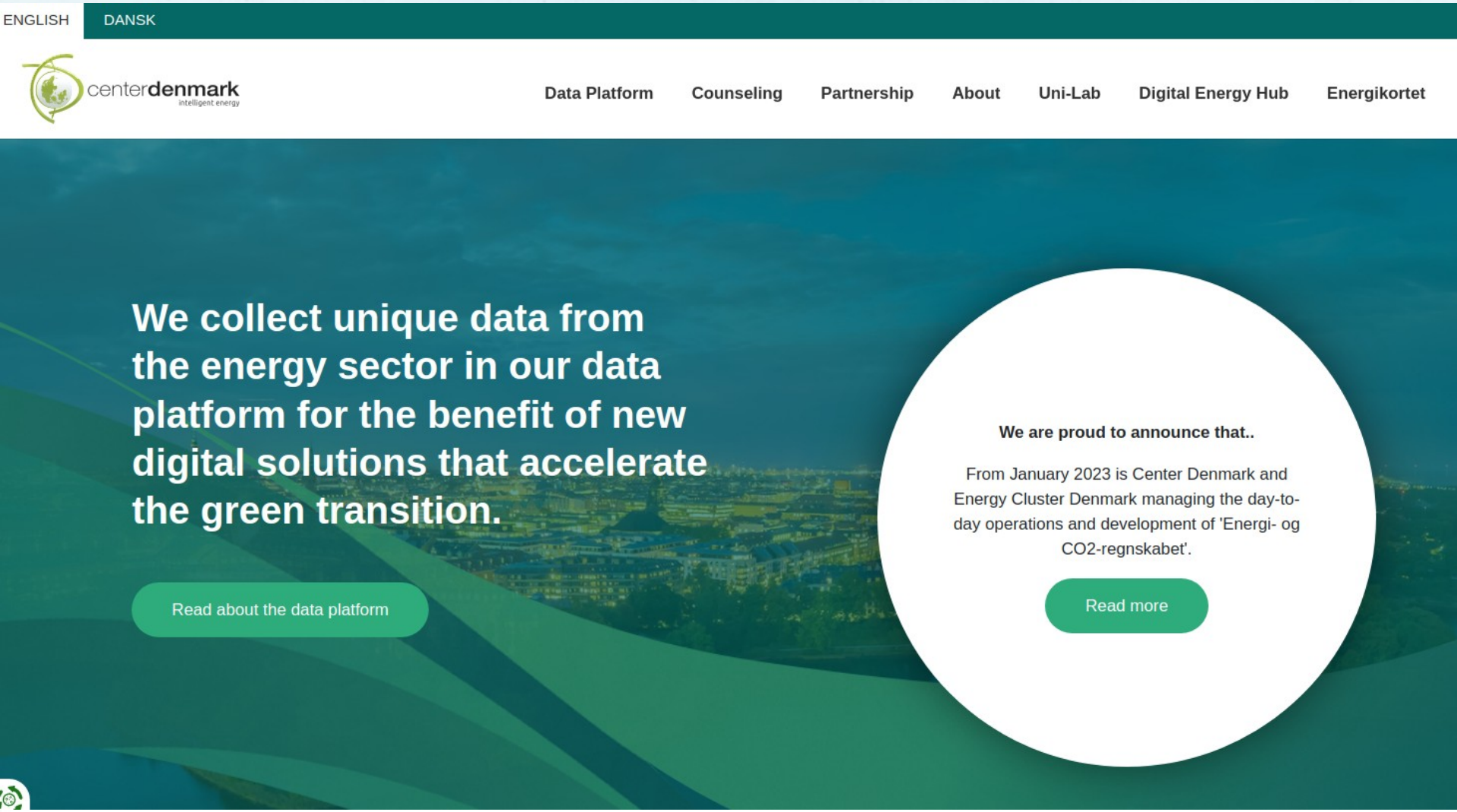


From the FED application:

Flexible Energy Denmark (FED) will:

- Offer **tools** and **solutions** for integrated energy systems
- Enable a **digitalization** of the energy grids, allowing for data collection and smart control
- Offer a representative and common **Living Lab** infrastructure to elaborate tools and solutions
- Establish a coherent **mathematical framework** for describing **flexibility**
- Describe how **flexibility** of e.g. building or wastewater systems can be used to provide grid **ancillary** and **balancing services**
- Provide guidelines for how to design the next generation of **energy markets** on **all spatial and temporal resolutions** and covering the entire spectrum of energy carriers

Center Denmark



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6 Living Labs

Establishment of 6 living labs

The FED project has established 6 living labs in which the tools and methods developed in the project are tested in real-world contexts. The 6 living labs represent central aspects of the energy system of the future:

Aalborg Forsyning (Aalborg) - Focus: Consumption-based regulation of local district heating loops and heat pumps in residential areas.

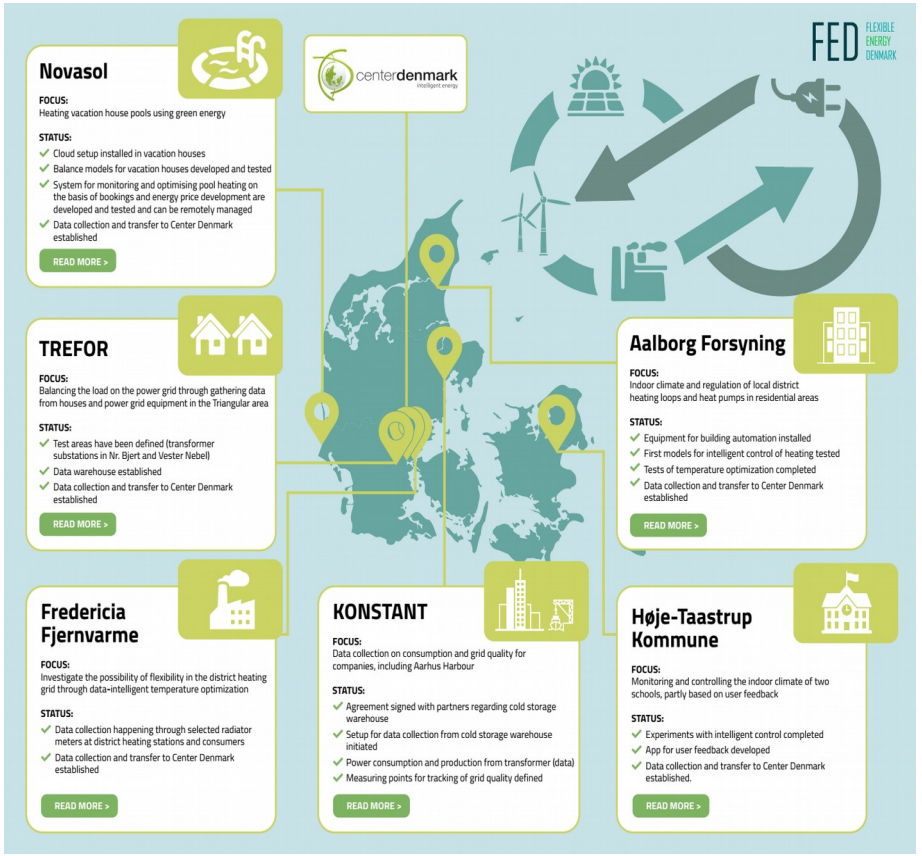
KONSTANT (Aarhus) - Focus: Data collection on consumption and grid quality for companies, including Aarhus Harbour.

Novasol (Blåvand) - Focus: Heating vacation house pools using surplus green energy ("virtual storage").

TREFOR (Triangle Area) - Focus: Balancing load in the power grid through collecting data from residential homes and power grid equipment.

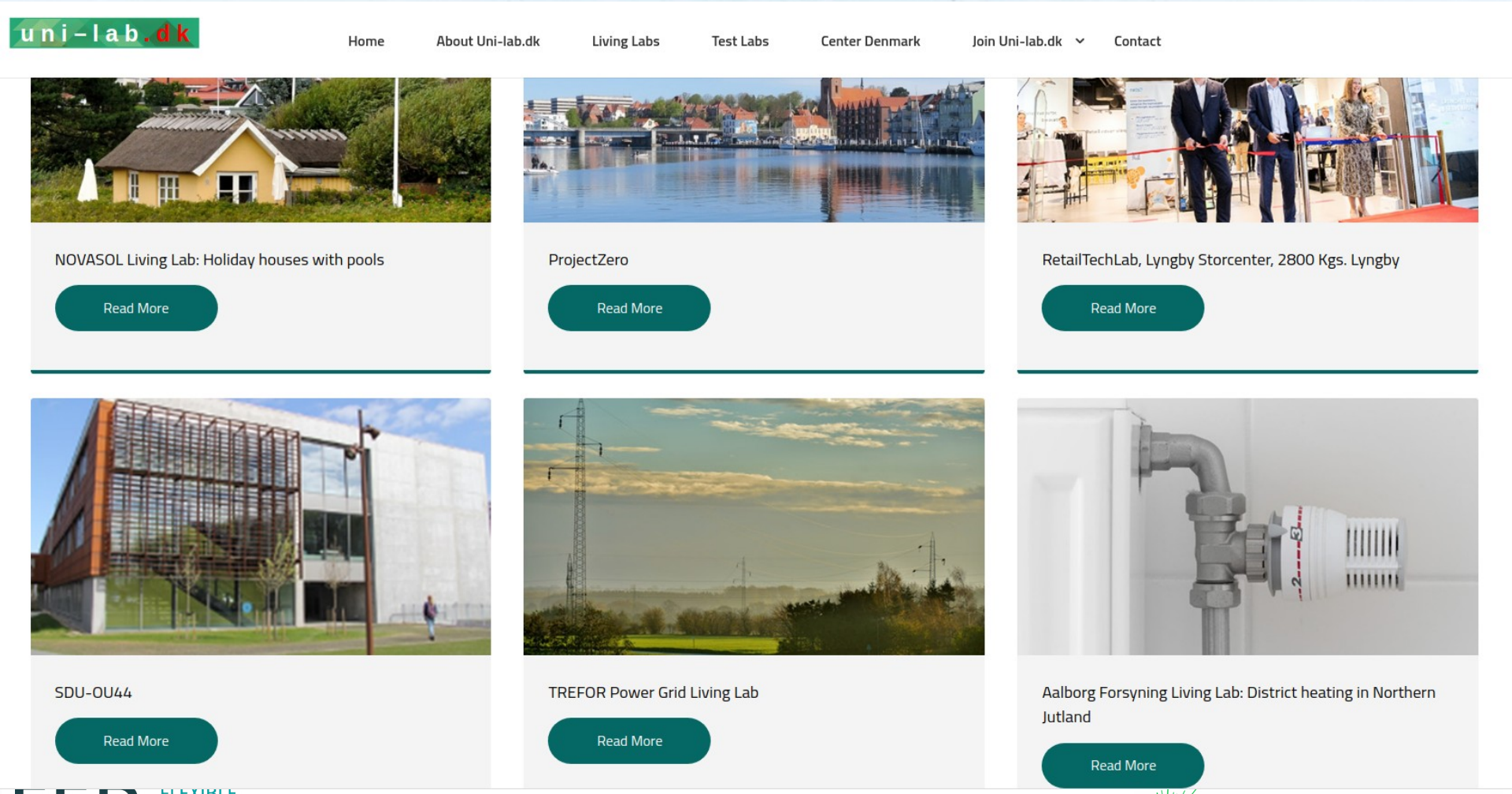
Fredericia Fjernvarme - Focus: Investigate potentials for flexibility in the district heating grid through data-intelligent temperature optimization.

Høje-Taastrup Kommune - Focus: Monitoring nad control of the indoor climate of two schools with consideration for user comfort, among other things on the basis of user feedback.



Uni-Lab.dk

Living Labs, Test Labs, HiL Facilities



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Major Results

- Established Center Denmark
- Established 6 Living Labs
- Established Uni-Lab.dk (both Living and Test Labs)
- Approx. 50 scientific papers (30 journal papers)
- State-of-the-art Data Lake established
- Virtual electricity storage using sector coupling and digitalization
- Data Spaces for energy and energy related data
- Methods for monitoring and digitalization of DSO grids (power and heat)
- Flexibility Functions suggested as one of the fundamental MIMs for Energy Systems
- Methods for using flexibility e.g. in buildings, districts and district heating
- New local flexibility markets and advanced bidding
- Methods established for linking the physics and the markets (ancillary services, balancing)

Some results from the Living Labs

- New methods for **wind power forecasting** for BRPs, TSO's and DSO's (Improvements 20 pct in DK1)
- New **optimal mixing loop controller**s based on forecasts (Return temperature on space heating reduced up to 10 degrees C)
- Data-driven Digital Twins for **Dynamic Transformer Rating** (Implies e.g. that wind farms can be expanded up to 60 pct without an upgrade of the transformer)
- New methods for **data-driven control of temperatures** in District Heating using meter data (savings 4 – 20 pct of heat loss)
- New methods for **heat load forecasting** in District Heating (improvements 10 – 40 pct)
- **Optimized heating control in summer houses** with a pool. Savings depend on the characteristics. For pool houses able to heat during the 6 cheapest hours the cost is reduced by 29 pct.
- New methods for **control of indoor climate** – 50 pct less dissatisfaction with the indoor comfort.
- **Controllers using the flexibility in buildings** lead to approx. 10 pct savings
- **Data-driven digital twins of freezing houses** are established. Method for optimal control using the DT model is under development.

FED results in National Reports

ENERGY EFFICIENCY IN BUILDINGS September 2022

DIGITALIZATION RELATED TO ENERGY CONSUMPTION IN BUILDINGS

Introduction

Digitization is the process of converting information into a digital (i.e. computer-readable) format. In relation to buildings, it is obtaining and processing of data for e.g. gaining insight into the energy consumption of a building, obtaining an overview of the energy efficiency and thermal characteristics of a country's buildings stock, controlling the energy consumption and the indoor environment in buildings, adjusting the energy consumption of buildings in order to improve the stability of the power grid, etc.

Digitalization will in the following be divided into three main areas based on the nature of the utilized data:

- Static and semi-static data
- Historic time series
- Real-time data

The document is not a thorough review of what digitalization in the built environment is, and possible can be in the future. The aim of the review is to give the reader an impression of the diversity and different levels of digitalization, and how it can be utilized. This will be done by describing specific examples, but the list of examples is not exhaustive.

Disclaimer
The document is partly based on materials by third parties, which not necessarily covers the viewpoint of Danish Energy Agency.

Danish Energy Agency

NIRAS

Analyse af digitalisering af eldistribution

Rapport

Energistyrelsen
Dato: 2. september 2022

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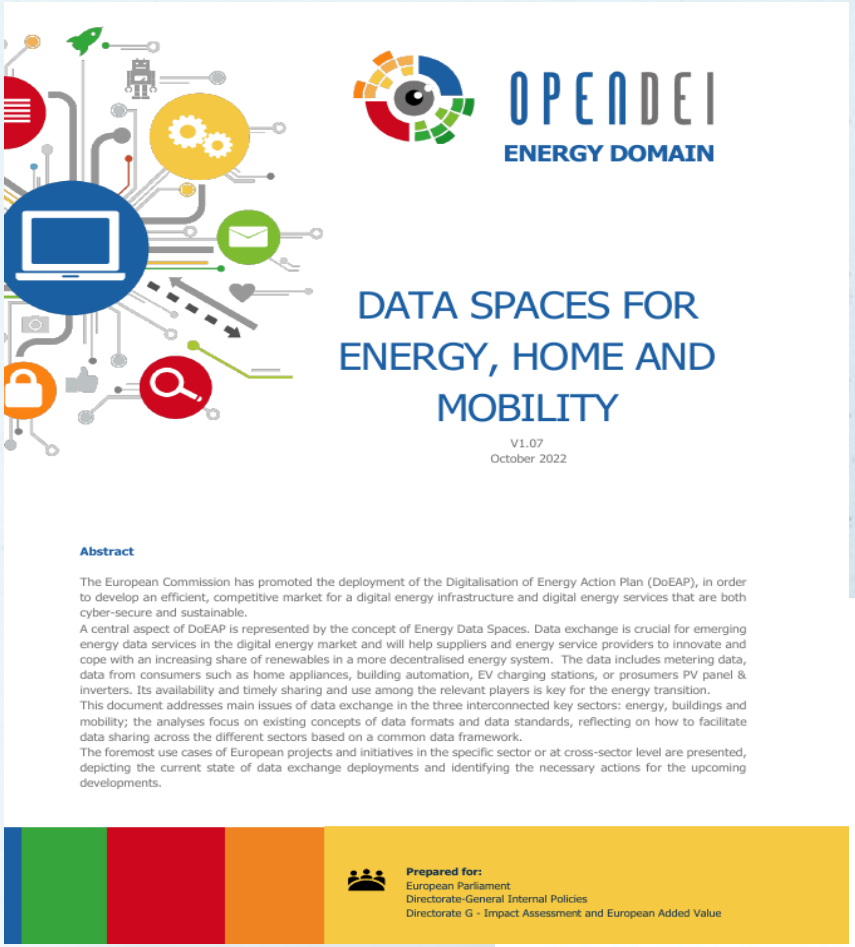
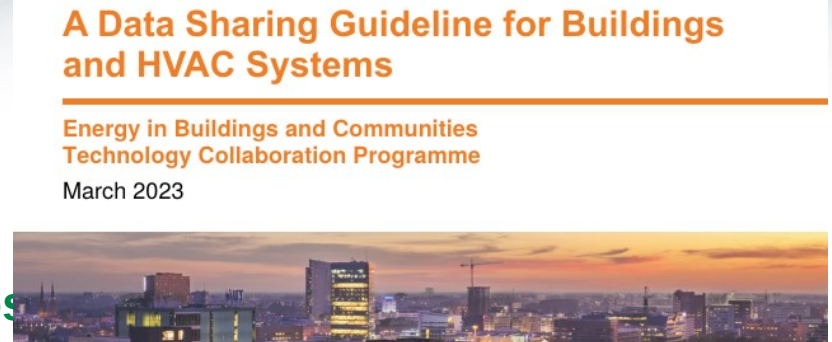
FED results in International Reports





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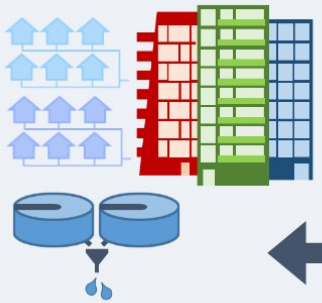
Perspectives

- Center Denmark is now a **Smart Energy European Digital Innovation Hub (EDIH)**
- Center Denmark plays an important role in the new **European TEF (Power, Mobility and Communication)**
- Improved **forecasting techniques** which ensure more precise forecasts and coherency between all stakeholders (BRP, TSO, DSOs, Aggregators, ...)
- **Uni-Lab** will be continued and expanded
- The methodologies can be used for design of new **dynamics net tariffs**
- Center Denmark is now providing **Data Space and Digital Solutions** for Municipalities, Energy Operators, and the Danish Energy Agency
- Center Denmark is now providing **cloud and data service solutions** for many national and European projects
- The **Flexibility Function** is a promising candidate for being the fundamental **MIMs** (Minimum Interoperability Mechanisms) for Energy Systems (linking physics to the markets)
- The methods for identifying **Data-driven Digital Twins** are now widely used
- **Trusted Data Sharing Environment** and **Data Spaces** for energy and energy related data

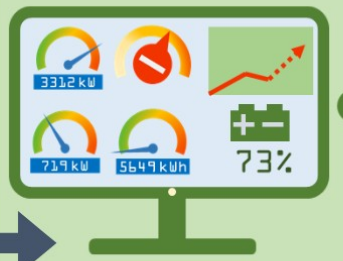
Business Ecosystem
From FED to the new EU TEF



uni-lab.dk

Union of the labs for energy research in Denmark. unilab.dk comprehends buildings (residential and non-residential, schools), supermarkets (and their refrigeration systems), water treatment plants, the energy infrastructure including production (through gas, wind, solar), storage (e.g. hot water storages for district heating networks), cooling, and distribution (gas, heat, power) and other facilities. unilab.dk is strictly related to the worldwide union of labs UNILAB.

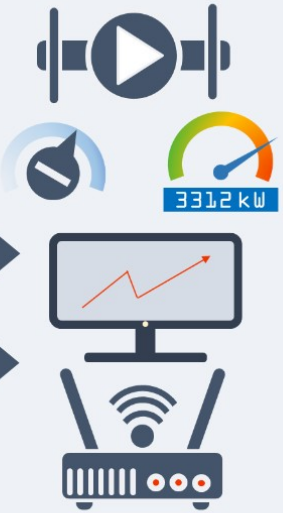
Wind turbine test center, Green Labs DK, Water Center Syd, AU Foulum, Aarhus Harbour, Energy Cities, ...



Solutions

Products and tools combined into solutions for the provision of services for data visualization, forecasting, flexibility provision, virtual storage provision, aggregation & control and new market set-ups

Industrial partners + Center Denmark



Products

Products from consortium partners aiming at providing flexibility using data, IoT, AI, Cloud/fog/edge Computing, etc.

Industrial partners

FLEXIBILITY

Accelerating Green Innovation through Data Intelligence & IoT Devices in Integrated Energy Systems

Living Labs

Three physical sites representing the building mass (residential, office, holiday, dormitory), selected industry, and further energy systems with embedded sensors and actuators

Living Lab partners

Data Lake

Cleansing, integration, and analysis of data from all Living Labs for fast and effective evaluation. Data organisation into a unique Data Lake

Center Denmark

Tools

A palette of tools for monitoring energy systems, data aggregation, prediction & forecasting. It includes also methods for cyber-physical modeling and for optimal set-up, operation & control of a flexible energy market

IT partners + Center Denmark

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Center Denmark
Integrated Energy Systems
Control Room and Data Space

Center Denmark aims at facilitating a trusted data space which put priorities in cyber security and in empowering the partners such that they are able to provide Digitalized and Efficient Solutions for People and Industry without being subject to disproportionate technical requirements, administrative requirements, procedures and charges