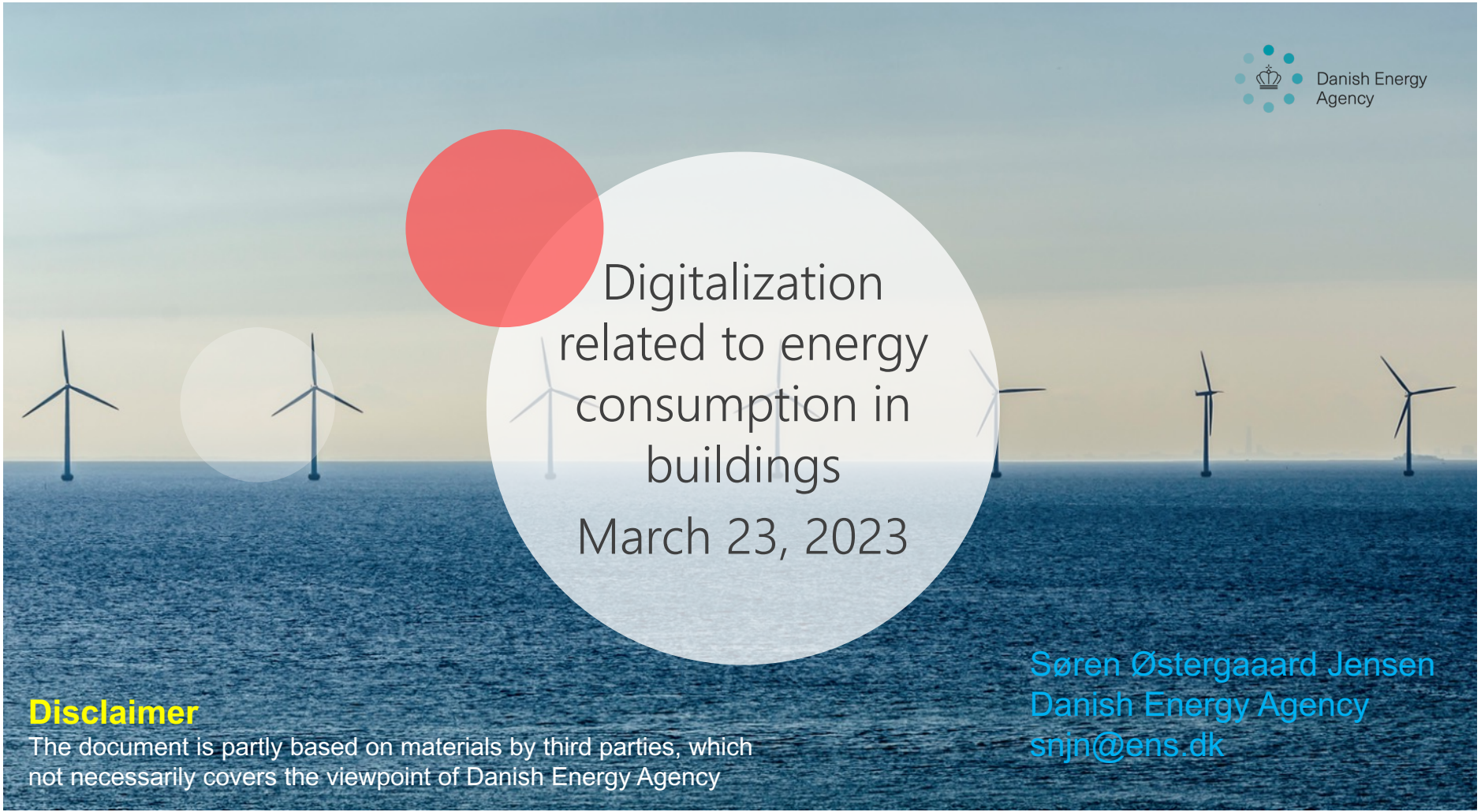

Danish Energy Agency

Digitalization related to energy consumption in buildings

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Disclaimer

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

Mix of Danish Energy Agency and DTU Compute

Switch in titles during the presentation

My main job is advisor in energy efficient (EE) buildings at the Danish Energy Agency, however, I do not deal with national legislation. I am situated in a center called Global Corporation where I corporate with UK, Germany, the Netherlands and France on EE in building.

However, I also have a small employment at DTU Compute, where I co-lead IEA EBC Annex 82 Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems (https://annex82.iea-ebc.org/)

Before that, I did lead IEA EBC Annex 67 Energy Flexible Buildings (https://annex67.org/).

What is digitalization

Digitization is the process of converting information into a digital (i.e. computer-readable) format.

In connection with buildings, it is obtaining and processing of data - e.g. storing information of a building, gaining insight into the energy consumption of a building hereunder detecting possible energy savings, obtaining an overview of the energy efficiency of a country's building 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 is many different things

Avoid misunderstanding

Digitalization in the built environment is thus many different things.

People often don't understand each other as they without knowing talk about different things.

The document to the left is an attempt to deal with this problem. It doesn't contain a thorough explanation of digitalization in the built environment. Instead examples are use to introduce different aspects of digitalization in relation to buildings.

Different types of data

In the following digitalization will 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

Static and semi-static data

Examples of static and semi-static data

- Building Information Models (BIMs)
- Energy Calculation/Simulation Models
- The Danish Building and Housing Register (BBR)
- Energy Performance Certificates (EPCs)
- EU Smart Readiness Indicators (SRI)

BBR and EPCs

Example of utilization of static data

The purpose of the BBR is to ensure a uniform registration of all Danish buildings and to make the information available as basic data for other databases.

BBR contains, among other things, information on floor area, location, use, installations (e.g. type of heating system), water and drainage conditions, kitchen conditions, number of toilets, exterior wall and roofing materials, etc.

The energy performance certificate (EPCs) shows the energy performance of a building and gives cost-effective recommendations for improvement of the energy performance of the building.

EPCs grade the energy performance of a building on a scale from A to G.

Possible energy savings

Estimate based on EPCs and the Danish Building and Housing Register (BBR)

A analysis has been carried out to estimate the energy savings to be expected until 2050 if buildings and building components are being upgraded according to the requirements laid down the in the Danish Building code 2010, when they have to be replaced or renovated for other reasons.

The result of the analysis was: that retrofitting Danish buildings due to termination of service life for the building components (thermal envelope), will by 2050 result in savings of about 30 % of the 2011 national energy use for heating in buildings.

If in addition balanced mechanical ventilation with heat recovery is implemented in residential buildings with a sloping roof (and enough free space in the attic to install the ventilation system) in combination with roof retrofit, the potential savings will increase to 47 %.

https://build.dk/Assets/Potential-heat-savings-during-ongoing-renovations-of-buildings-until-2050/sbi-2016-04-1.pdf

Historic time series

Examples of historic time series

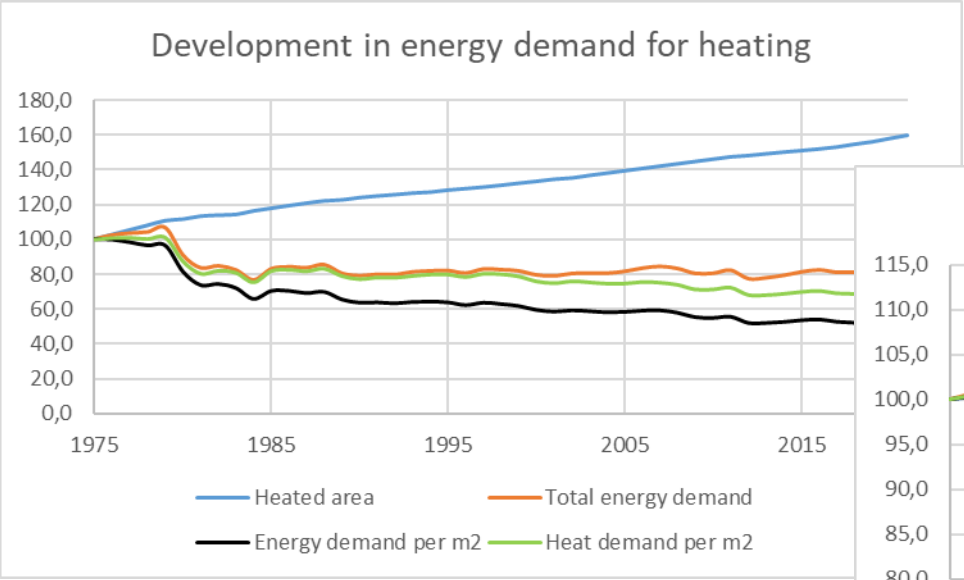
- Data hub
- Building hub - trial
- Any logged and stored data
  - Energy use
  - Temperatures
  - Weather
  - Control commands
  - Etc.

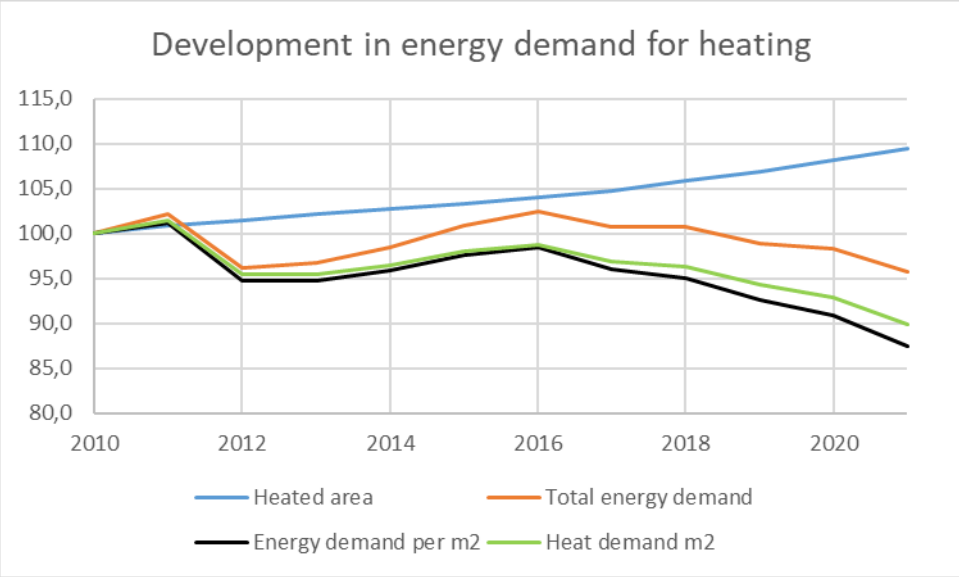
Examples on use of historic time series

- Display of time series of data
- Performance testing (BR18)
- Efficiency of e.g. heat pumps
- Energy signatures
- Development of simple data-driven low-order models

Development in the energy demand for heating of Danish buildings

1975-2021





Fault detection

Example: office building

https://www.buildvision.dk/pdf/characterization_and_optimized_control_by_means_of_multiparameter_controllers.pdf

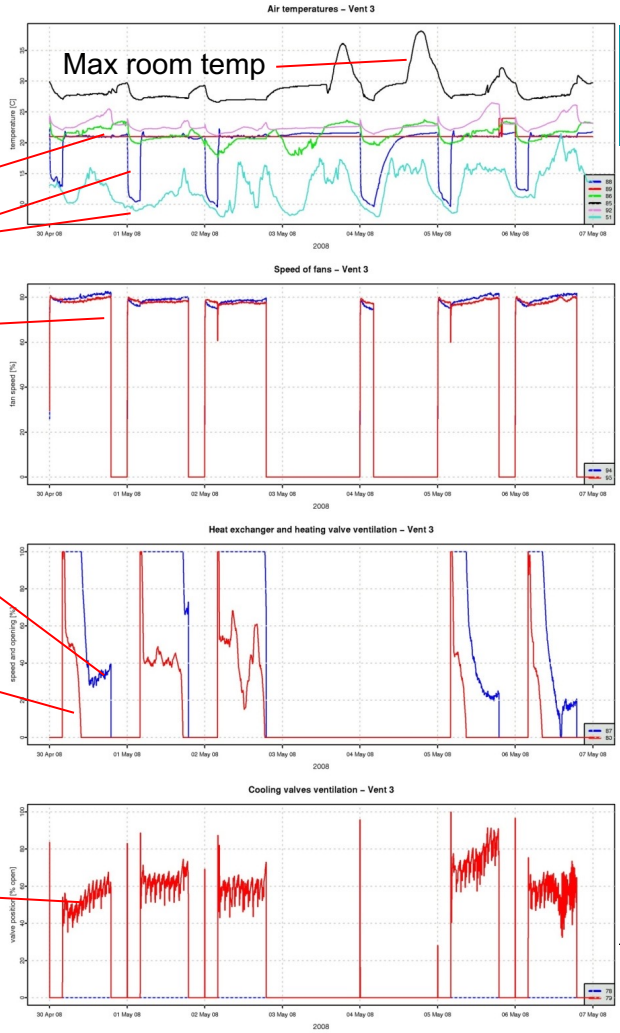
Heated floor area: 21,199 m²

Set point for fresh air (red)
Temp of fresh air to building
Ambient air temp

Speed of ventilation fans

Speed of rotating heat exchanger
Opening degree of valve for district heating

Opening degree of valve for cooling of rooms



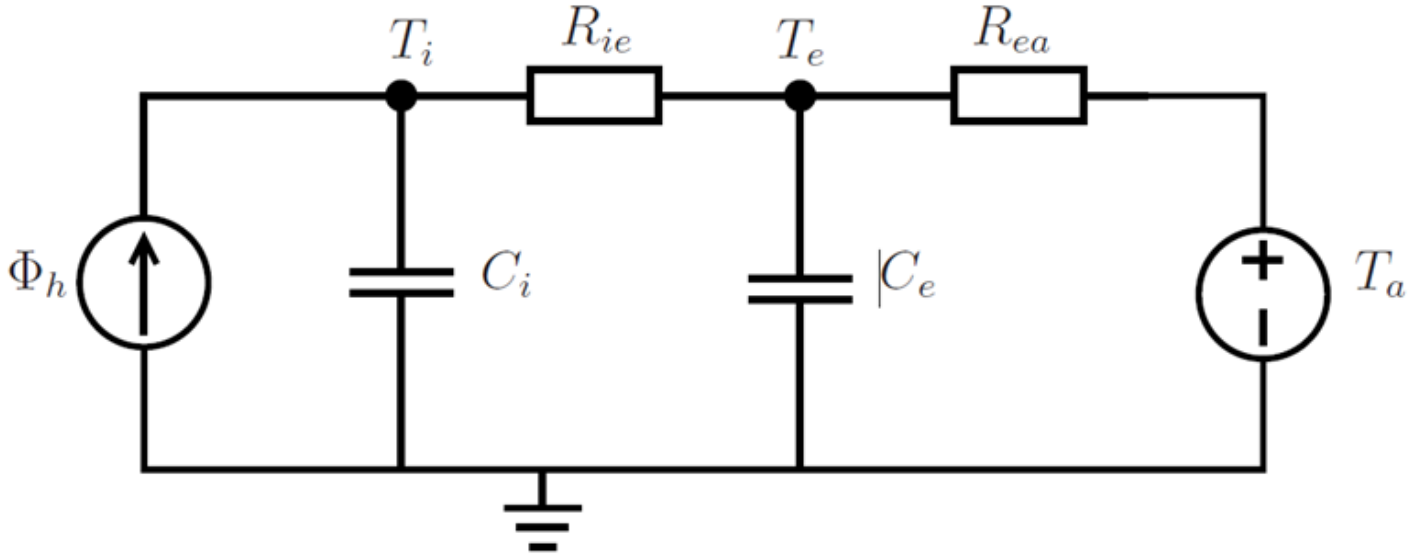
District heating is removed by the cooling system.

Online measurements can be used for automatic fault detection.

IEA EBC Annex 81 Data-Driven Smart Buildings (https://annex81.iea-ebc.org/)

Simple data-driven low order models

RC models – grey box models



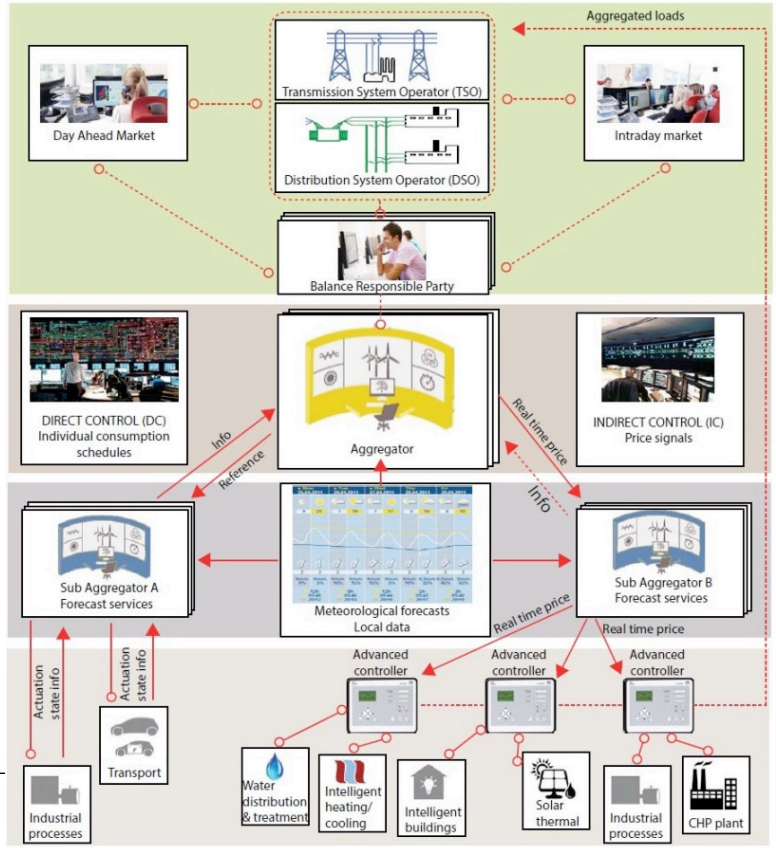
Historic data can be utilized for training a simple model to characterize a building. Grey box models have the advantage, that the parameters (here Rs and Cs) have physical meaning and can be utilized for energy optimization of the building

Real-time data

Real-time data are mainly utilized for control purposes.
Examples of control

- Rule-based control
- Model predictive control (MPC)
- Energy flexibility
- Advanced heat pump control

Energy flexibility



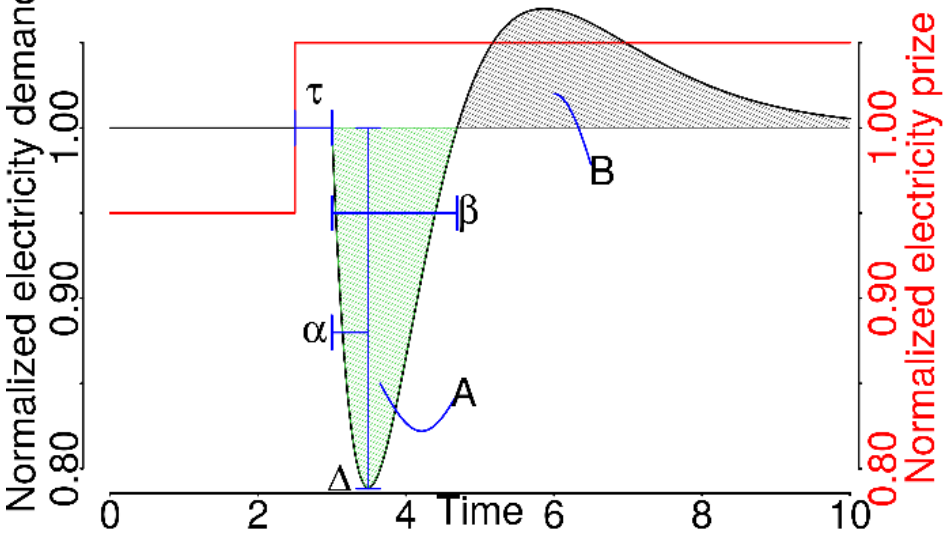
https://www.opendei.eu/wp-content/uploads/2022/10/OPEN-DEI-Energy-Data-Spaces-EHM-v1.07.pdf

High-level controllers aggregating the flexibility and determining which penalty signal to broadcast e.g. a price signal

Low-level controllers e.g. in the form of MPCs receiving a signal from an aggregator and enabling the energy flexibility from the building

Flexibility function – IEA EBC Annex 67

Characterization of the available energy flexibility



- *τ is the time from a signal is submitted to when an action starts,*
- *α is the period from the start of the response to the max response,*
- *Δ is the max response,*
- *β is the duration of the response,*
- *A is the shifted amount of energy, and*
- *B is the rebound effect for returning the situation back to the "reference" situation.*

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Characterizing the Energy Flexibility of Buildings and Districts.
https://www.sciencedirect.com/science/article/pii/S030626191830730X

Market Model 3.0

Inceased need for flexibility

- The transition of our electricity system to 100 % renewable energy leads to a need for increased focus on creating energy flexibility in the system.
- We are in the process of reorganizing the Energy Agency to create the framework for efficient and flexible energy use. Where efficient energy consumption becomes a more active component of the green energy system
- Energy efficient buildings is still a goal because we need to save resources – including renewable energy and the infrastructure needed to produce and transport energy. Going forward, however, it will also be important that buildings can offer energy flexibility.
- It requires more data and better access to data. However, an actual program for this awaits a new national digitization strategy.

https://ens.dk/sites/ens.dk/files/El/markedsmodel_3.0_afrapportering_juni_2021.pdf


Danish Energy
Agency
Thank you