

Digital Twins for Energy Efficient Smart Buildings

IEA EBC Technical Day

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Background

Savings up to 30% on
the energy bill is readily
achievable in domestic
and public buildings

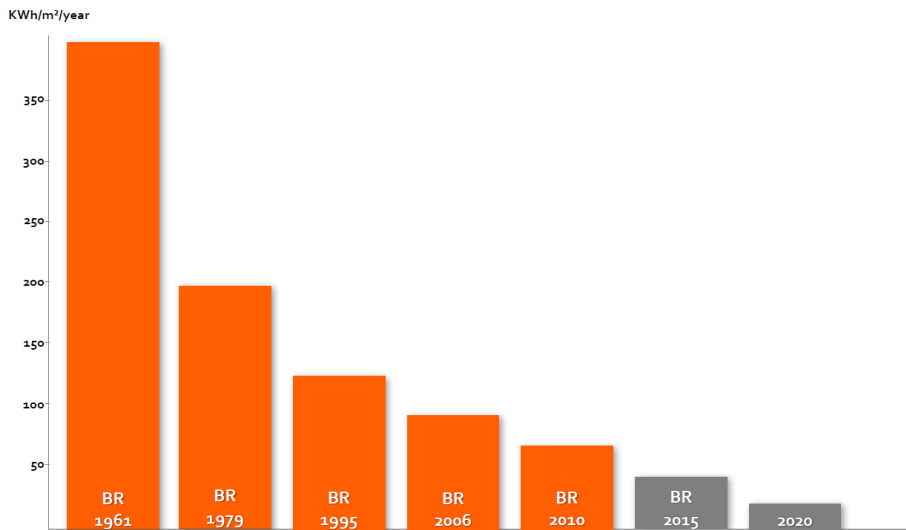
Energy cost, second
largest after staff cost in
non-residential
buildings

Higher performance
corresponds to better
thermal comfort and
indoor air quality and
higher productivity

Major hidden costs:
performance gap,
maintenance,
management...

Buildings are where our
majority of time is spent

Background



3

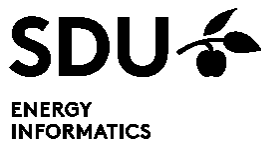
Background

- In future smart buildings, **DIGITALIZATION** is going to establish new levels of efficiency, security and comfort.



4

Twin4Build: A holistic Digital Twin platform for decision-making support over the whole building life cycle



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BIM



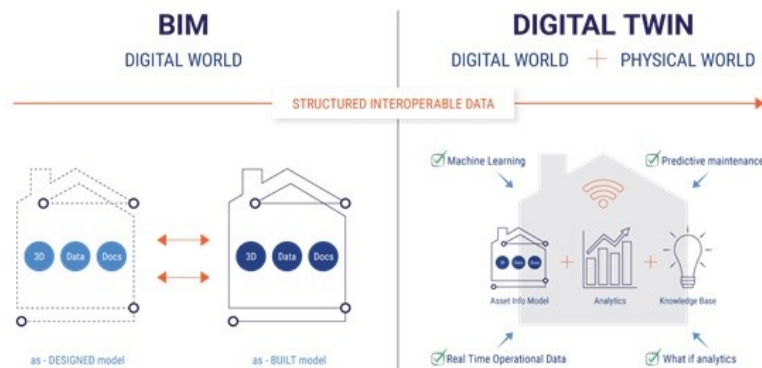
- **Building Information Modeling (BIM)** is one of the major drivers of building sector digitalization.
- On a global scale, studies predict that a wider BIM adoption will unlock **15-25% cost savings by 2025**. Even a 10% increase in cost efficiency in the European Market would save the industry €130 billion.
- In the current practice, BIM covers the minimum requirements set by guidelines and is put in a drawer after the building handover with **no or minimal use for facility operation and management**.

Project Objective

To harness the benefits of the building sector digitalization and to respond to the increasing demands for energy efficiency and comfort, we are proposing a Digital Twin platform allowing coordinated decision support over the whole building life cycle.

Project Objective

- The platform replaces the traditional static BIM with a living operational model combining flexible and adaptable dynamic energy models and real-time building data.



DT Services



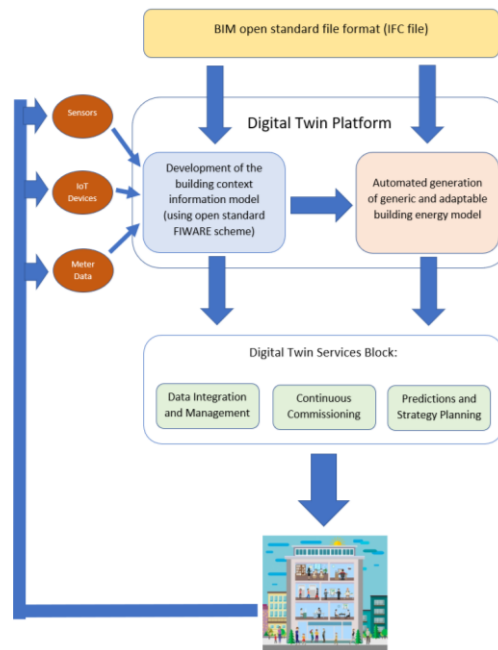
- The proposed DT will provide the following services:
 1. **Collecting, integrating and managing building data** within a flexible, effective and user friendly open standard context information model.
 2. **Real-time building performance monitoring and automated continuous commissioning** and fault detection enabling smarter operation and facility management along with performance optimization
 3. **Strategy and planning support** over the whole building life cycle through informing optimal decision and running 'What if?' scenarios in advance.

9

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Twin4Build Approach

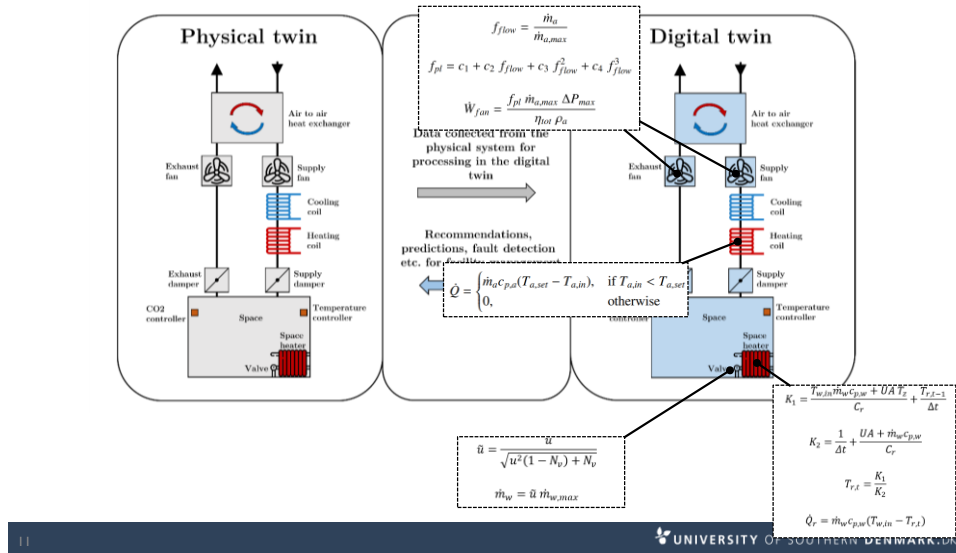
A simplified illustration of the proposed building digital twin framework and the main components



10

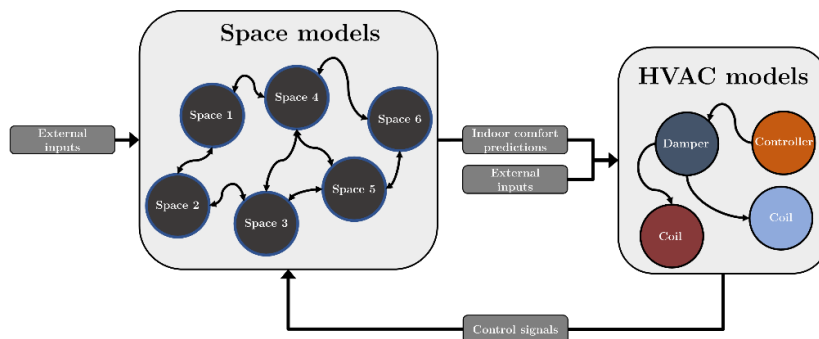
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Digital Twin Concept



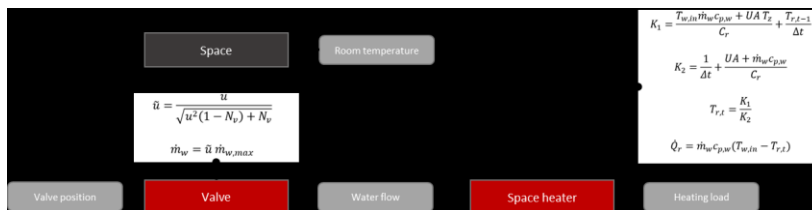
Component-based Energy Modelling

- The proposed simulation framework for the energy model divided into two general types of models, space models and energy systems models.



Component-based Energy Modelling

- To fit within a dynamic DT-environment, energy models must be scalable, modular and flexible.
- This is achieved through simple components that each have predefined inputs and outputs.
- The relationship between inputs and outputs for a given component is defined by either a grey or black box model, depending on the component and the information available



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DT Added Value

- The **Twin4Build** project will impact and improve energy efficiency in the building sector and provide an added value throughout the entire tool chain:
 1. Building owners and clients
 2. Facility and building managers
 3. Energy consultants and contractors
 4. City planners, authorities and decision makers

DT Added Value

- It is expected that the implementation of the proposed digital twin platform will:
 - ✓ Improve energy efficiency and allow up to **15% reduction on buildings' energy demand** during the operational phase
 - ✓ Provide smarter facility management and **generate up to 20% reduction on a building's maintenance and energy costs**
 - ✓ **Allow up to 25% reduction in CO2 and other greenhouse gas emissions** in buildings' construction and operational phases

15

 15
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DT Demo and Implementation

SDU
 ENERGY
 INFORMATICS

- To assess the potential of implementing the DT solution, three pilot buildings of different types, uses and location are chosen.
 1. A university teaching building in SDU Odense
 2. The Dokk1 public building in Aarhus Municipality
 3. A healthcare building in Helse Bergen hospital, Norway



16

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DanRETwin: A Digital Twin solution for optimal energy retrofit decision-making and decarbonization of the Danish building stock



ReMoni

EUDP



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Energy Retrofit



- Despite the demonstrated positive impacts of energy retrofitting, the weighted annual energy renovation rate in the EU is low with less than **1% of the building stock** per year.
- EU Commission triggered a **Renovation Wave for Europe** with the objective to at least double the annual energy renovation rate of buildings by 2030. To realize this, **35 million building units** are to be renovated by 2030.
- The existing building block constitutes over 97% of the overall building stock, and more than 75% of the current building stock in Denmark was **built before 1980**.

Project Objective



The project presents a timely and urgently needed intervention aiming to design, develop, and demonstrate a first of its kind Digital Twin solution 'DanRETwin', to serve as a basis for optimal energy retrofits decision-making, retro-commissioning and performance optimization of non-residential existing buildings.

DT Services



- The proposed DT will provide the following services:
 1. **Acquisition, storage, integration, management, and exchange of building data** from various sensors, meters and IoT devices
 2. **Energy retrofit decision-making support** and the capability of **testing and simulating various options, scenarios**, and systems integration
 3. **Post-retrofits retro-commissioning** of the energy systems and the automation and control system
 4. **Data-driven performance optimization** platform to drive building control and management

DanRETwin Approach

Current Retrofit Activities and Projects

- Based on Building-by Building approach
- static tools, tabulated approaches, and very large assumptions and generic inputs
- Retrofits when needed, or asked for, or based solely on building superficial condition and feedback from users
- Simple one-to-one calculations on the impact of each measure
- Large performance gap between promised savings and actual savings post retrofits
- Rely on whole building energy meter data
- Expensive and time and resources consuming

Proposed DanRETwin Solution

- A digital and scalable solution which can be easily adapted to multiple cases and buildings
- A holistic dynamic energy modeling approach relying on real and actual data for evaluation
- A systematic, data-driven approach with optimized retrofit process and selection of measures based on their dynamic impact
- A dynamic energy performance assessment of measures and packages of improvements
- Elimination of losses and errors employing systematic retro-commissioning
- Rely on meter data, along with clamp on noninvasive IoT sensors and BMS data
- Effective, flexible and allow efficient use of time and personnel

21

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DT Demo and Implementation

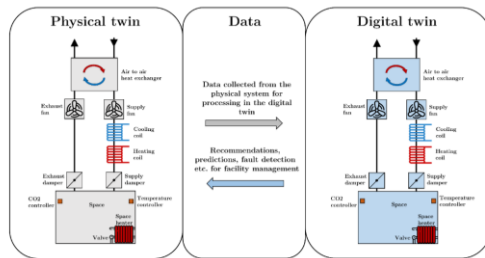


- To assess the potential of implementing DanRETwin solution, two pilot buildings of different types, uses and location are to be chosen in the municipality of Aarhus.
- The two buildings are from the municipality block of buildings which are set to be retrofitted, of different age and different uses.
- In this regard, an office building and a public school will be considered.



22

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Thank You ☺

