

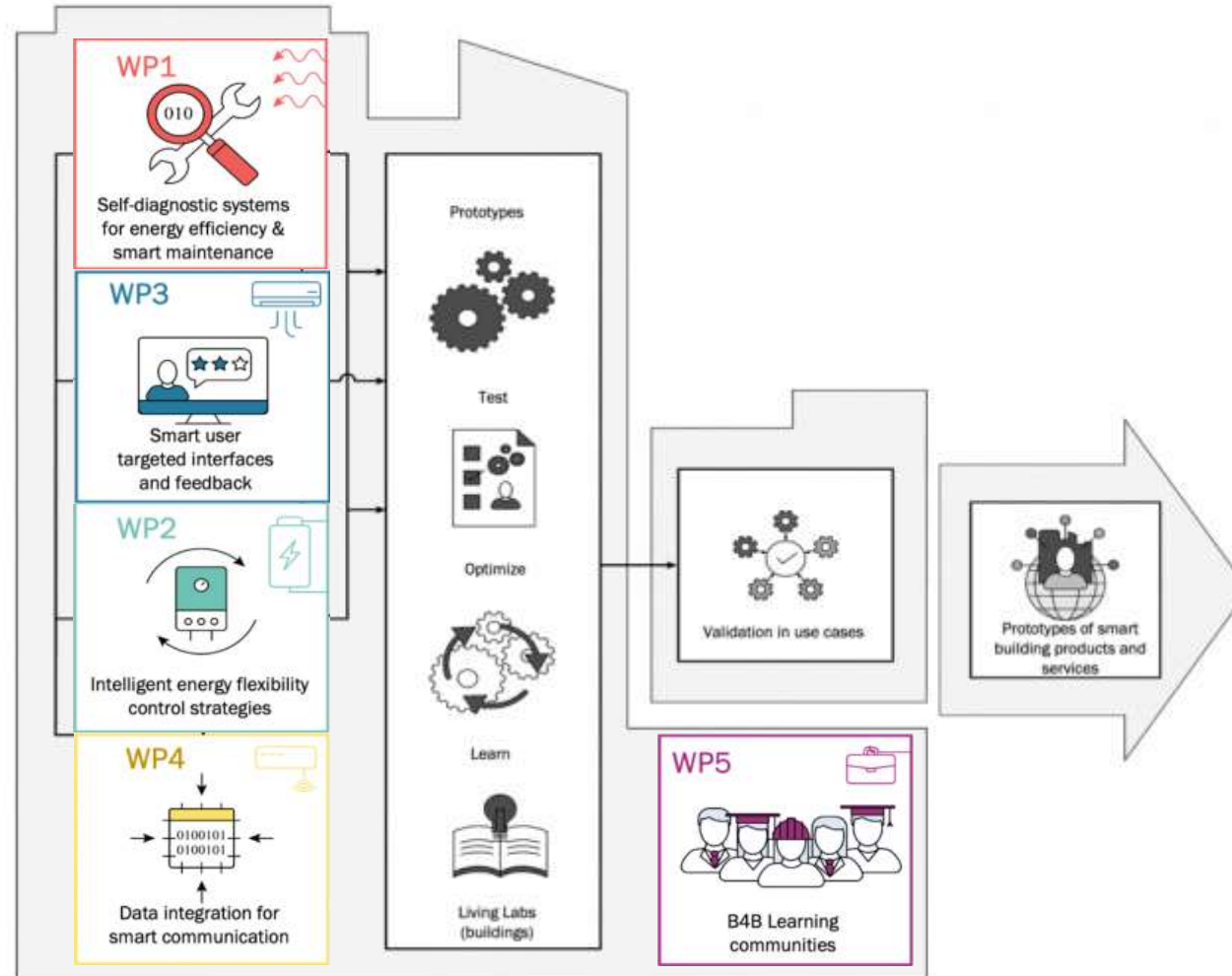
A photograph of a modern, multi-story glass building with a curved facade. The building is set against a clear blue sky with some light clouds. A network diagram, consisting of light blue circles connected by thin lines, is overlaid on the building's facade. The diagram is semi-transparent and appears to be a complex network structure. In the foreground, there is a metal railing and a road with a black and white striped curb. The overall scene is bright and clear.

Brains4Buildings: Knowledge platform and Roadmap for leveraging Smart Buildings

Martín Mosteiro Romero (TU Delft)

25 June 2024

Brains4Buildings



Learning Community

The B4B learning community encompasses various activities

1. Consortium meetings:

- 39 project partners (60–70 people)
- presentations and workshops

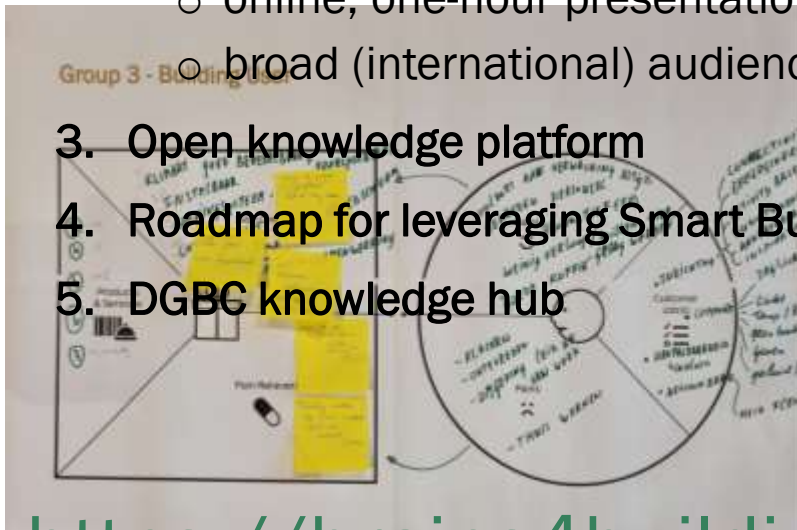
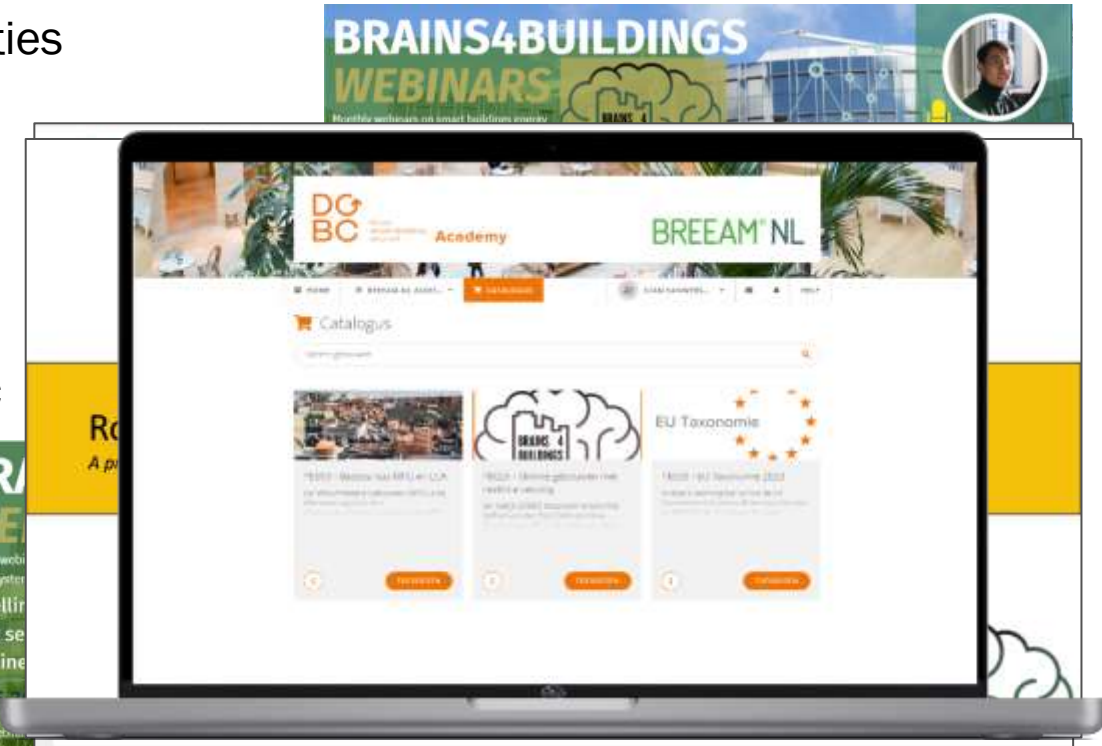
2. B4B webinar series:

- online, one-hour presentations open to the public
- broad (international) audience

3. Open knowledge platform

4. Roadmap for leveraging Smart Buildings

5. DGBC knowledge hub



<https://brains4buildings.org/learning-community/>

Overview Open Knowledge Platform



TU Delft TU Delft: TransACT01 Data and Machine Learning for HVAC Systems

mmosteiroromer

COURSE DISCUSSION PROGRESS WHO'S WHO

Data and Machine Learning for HVAC Systems

Search the course Search Resume Course

43% complete

Expand All

- Section 1: Introduction
- Section 2: For data scientists who want to know more about HVAC systems
- Section 3: For HVAC engineers who want to know more about data analytics for building operation
- Section 4: Commissioning and quick wins in optimization of HVAC systems operation
- Section 5: In-depth look at data labelling, pre-processing & integration
- Section 6: In-depth look at Data-driven prediction of energy use
- Section 7: In-depth look at Fault Detection and Diagnosis methods for HVAC systems

Course Tools

- Bookmarks

Important Course Dates

Today is Apr 22, 2024 15:34 CEST

Course Handouts

This Learning Community Site supports HVAC engineers who want to know more about the use of Building Energy Management System Data (BEMS) to optimize the operation of HVAC systems. It also aims at supporting data scientists who want to learn more on HVAC systems and want to understand BEMS data.

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Section 2: HVAC knowledge for data scientists



TU Delft MOOCs (4 weeks each)

ECObuild1x: Energy Demand in Buildings (started 16 April)

ECObuild2x: Energy Supply Systems for Buildings (23 April)

ECObuild3x: Comfort and Health in Buildings (starts 11 June)

ECObuild4x: Efficient HVAC Systems (16 April)



Examples
Standards
Data sources








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Section 3: Data science for HVAC Engineers

NUS MOOC (7 weeks)

Data Science for Construction, Architecture and Engineering



-  - Exceeding boundaries of a single screen (User needs to scroll)
-  - Fragmenting data into separate screens (multipage web apps)
-  - Displaying excessive details of precision (time up to milliseconds)
-  - Expressing measures indirectly (User needs to search for intended message)
-  - Introducing a meaningless variety
-  - Encoding quantitative data inaccurately (Bar plot: begin the scale at zero)
-  - Cluttering the display with visual effects (useless and destructing decoration)

Examples:

- Building energy prediction
- Fault Detection and Diagnosis
- Data labeling and preprocessing
- Data visualization

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Section 4: Commissioning & Quick Wins

Correct settings Air Handling Units

Measure	Description	Points of Attention	Comments
Make sure the inlet temperature is not higher than the room temperature. Pay attention to the setting of the Air Handling Unit.	<p>Set the maximum supply temperature (winter) back to approx. 19°C or a setting of a maximum of 18°C for the AHU from 5°C and lower, because the air still heats up through the fan and in the ducts before it reaches the grilles. Depending on the installation concept, the flow temperature at higher</p> <p>- all air constant volume with radiators (top cooling): Set 15°C at 14°C outdoors and above. The radiators can then be adjusted if they are used correctly.</p> <p>- Induction units for coil units: Set 15°C from 5°C outside. Possibly between 14°C and 20°C outside temperature, an increasing supply temperature, especially at higher</p>	<p>- In addition to a lot of energy savings, this measure results in (much) better comfort for offices, education and meetings.</p> <p>- Indoor rooms can become colder if there is no additional heating. Installing an (electric) heating element solves this. This usually does not concern workplaces because daylight is lacking in those indoor spaces. This can also be accepted for consultation or meeting functions, or short-term electrical heating will suffice.</p> <p>- Make sure that any dew point controls are functioning properly to prevent surface condensation.</p> <p>- Use as little as possible so-called compensation controls on the control</p>	<p>It does not matter whether the air in the rooms is heated by the local heating system or the air handling unit. That goes against the feeling, but quickly turns out to be correct if you think about it for a while. It is true that a higher inlet temperature than necessary results in unnecessary heating of the ventilation air.</p>  <p>The internal heat production and/or solar radiation is often more than sufficient to heat well-insulated buildings during a large part of the</p>

Tips and Tricks about setpoints (Ed Rooijackers)



Standards:

- ISSO 107

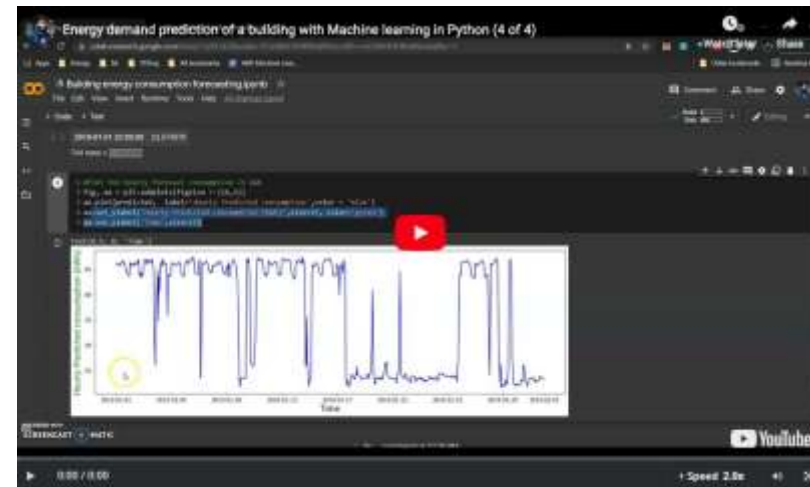
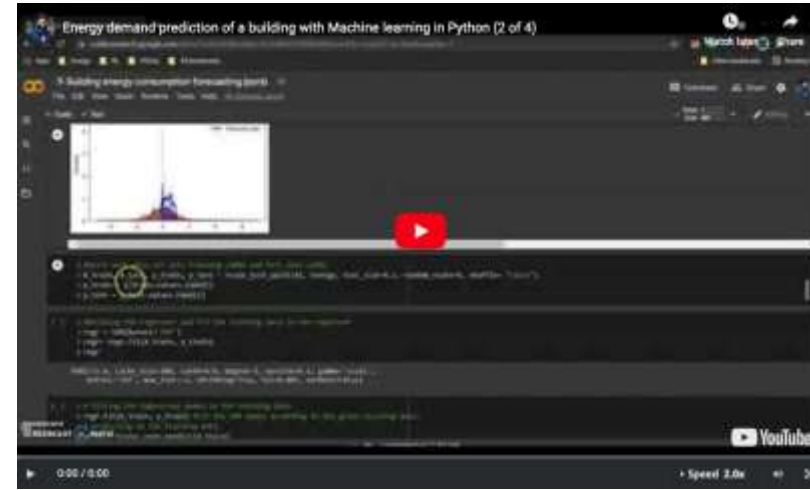
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Section 5: Data labelling, pre-processing and integration



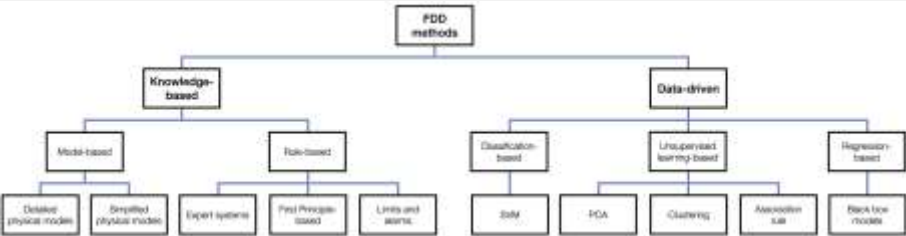
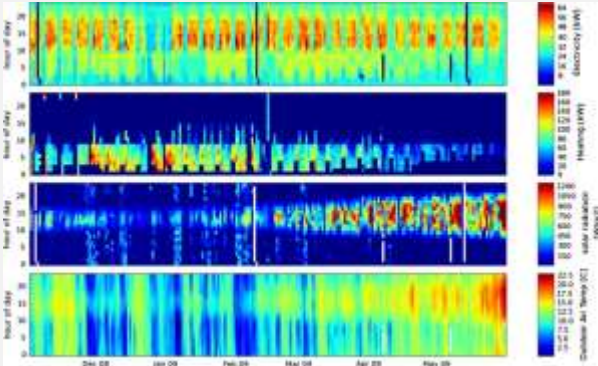
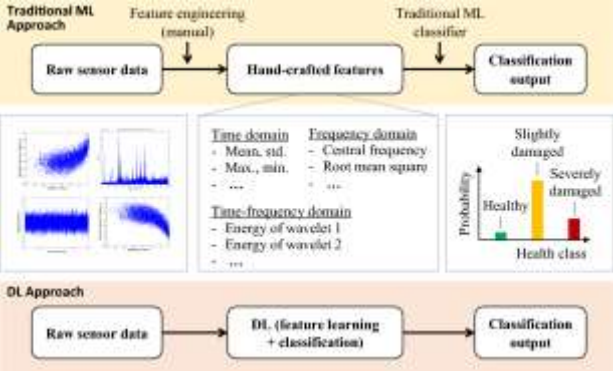
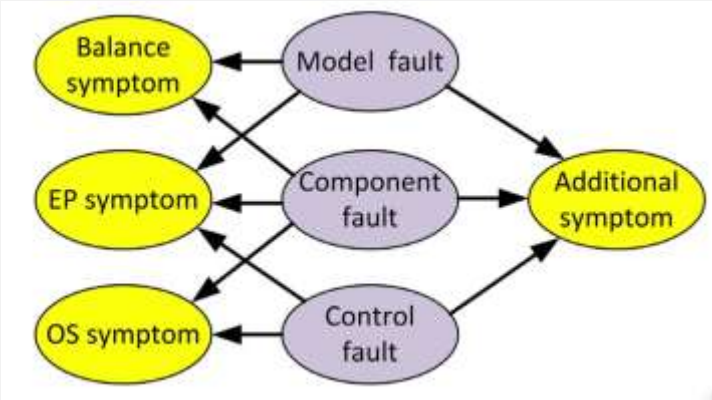
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Section 6: Data-driven demand prediction



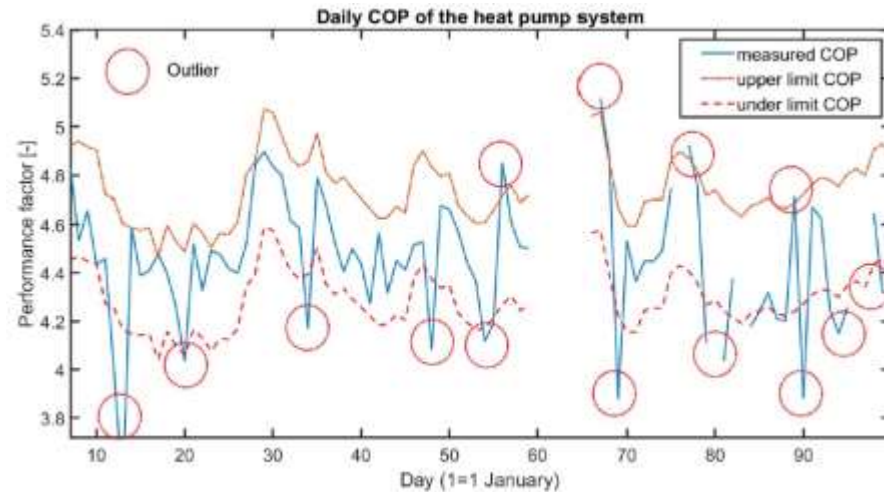
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Section 7: Fault Detection and Diagnosis

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Classification</p>  <pre> graph TD FDD[FDD methods] --> KB[Knowledge-based] FDD --> DD[Data-driven] KB --> MB[Model-based] KB --> RB[Rule-based] MB --> DPM[Detailed physical models] MB --> SPM[Simplified physical models] RB --> ES[Expert systems] RB --> FP[First Principles based] RB --> LWS[Limits and alarms] DD --> CB[Classification-based] DD --> UL[Unsupervised learning-based] DD --> RE[Regression-based] CB --> ID[IdM] CB --> PCA[PCA] UL --> CL[Clustering] UL --> AS[Association rule] RE --> BLM[Black box models] </pre>	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Pattern-based</p>  <p>The spectrograms show frequency content over time for different fault types: <ul style="list-style-type: none"> Top: Normal operation (low energy across frequencies) Second: Fault 1 (increased energy in higher frequencies) Third: Fault 2 (distinct vertical lines indicating impulsive events) Bottom: Fault 3 (increased energy in lower frequencies) </p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">ML-based</p>  <p>Traditional ML Approach: Raw sensor data → Feature engineering (manual) → Hand-crafted features → Traditional ML classifier → Classification output.</p> <p>DL Approach: Raw sensor data → DL (feature learning + classification) → Classification output.</p> <p>Feature engineering details:</p> <ul style="list-style-type: none"> Time domain: Mean, std, Max., min, ... Frequency domain: Central frequency, Root mean square, ... Time-frequency domain: Energy of wavelet 1, Energy of wavelet 2, ... <p>Health class probability distribution:</p> <ul style="list-style-type: none"> Healthy Slightly damaged Severely damaged 	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Bayesian networks</p>  <pre> graph LR MF((Model fault)) --> BS((Balance symptom)) MF --> EP((EP symptom)) MF --> OS((OS symptom)) MF --> AS((Additional symptom)) CF((Component fault)) --> BS CF --> EP CF --> OS CF --> AS CnF((Control fault)) --> BS CnF --> EP CnF --> OS CnF --> AS </pre>

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Section 7: Fault Detection and Diagnosis



Examples:

- Diagnostic Bayesian Networks
- 4S3F



Standards
Data sources



Roadmap for leveraging Smart Buildings

A practical roadmap for achieving asset management goals through data-driven building solutions

The goal of this roadmap is:

1. create **awareness** about the current challenges in the industry and how they can be tackled with data-driven solutions, and alternatively, how they can be tackled with low-tech solutions
2. to **illustrate** that a smart building is a tool (and not a goal in itself) to achieve a (set of) predefined asset management goal(s)
3. to provide a **practical step-by-step guideline** for achieving data integration to the different stakeholders involved in the value chain of smart buildings



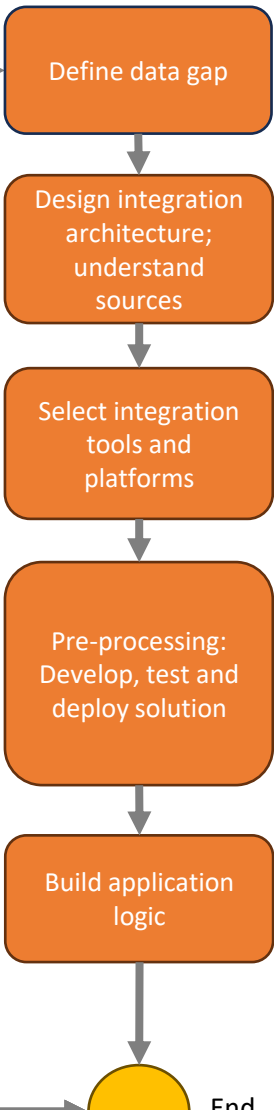
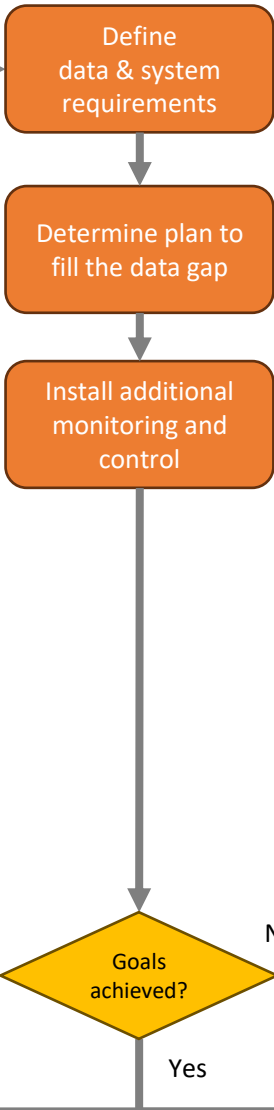
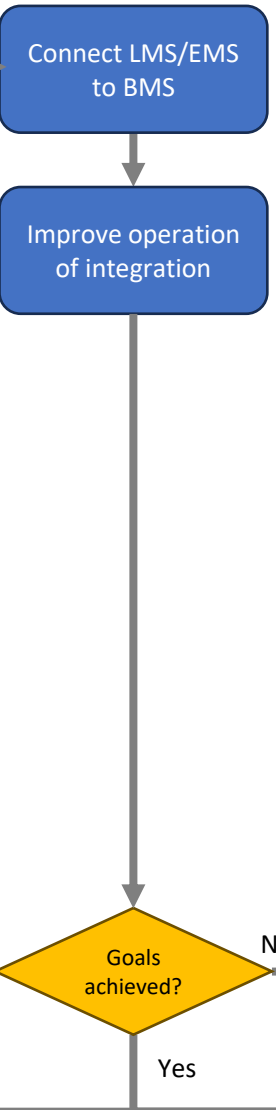
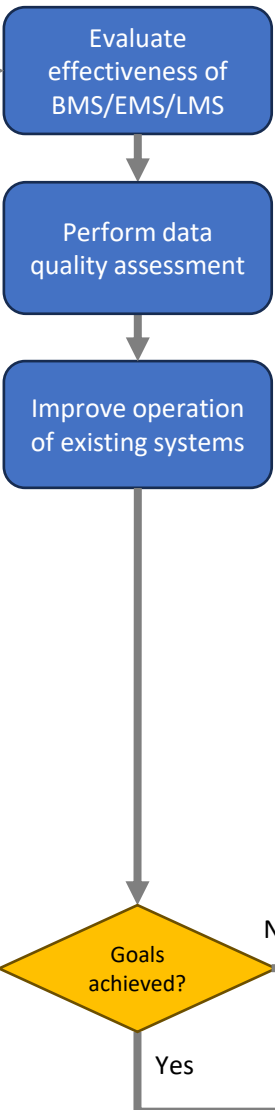
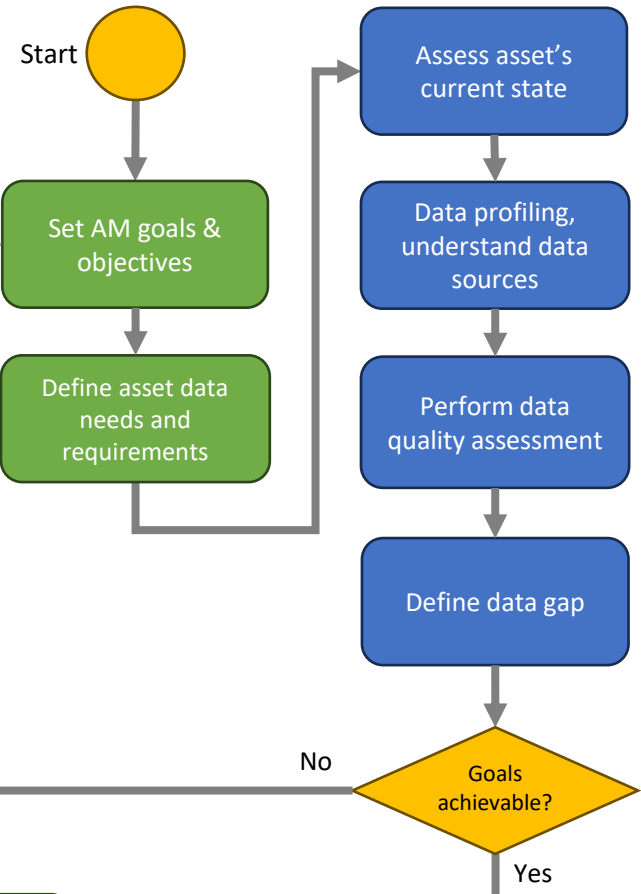
Evaluate

Improve

Integrate (1)

Extend

Integrate (2)






Legend

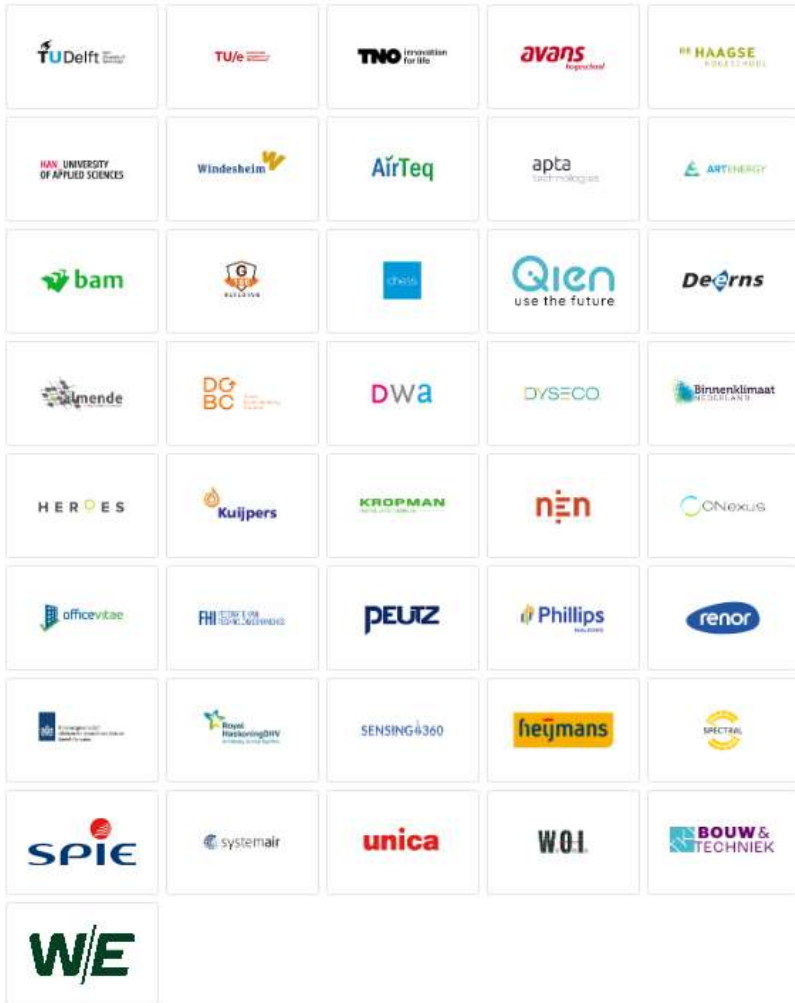
- Goals (Green box)
- Existing systems (Blue box)
- New systems (Orange box)

Stakeholder reading guide



 <p>A: Complex / high tech</p>		<p>Integrate</p>		<p>Integrate</p>	
 <p>B: Normal / mid-level</p>	<p>Integrate</p>	<p>Improve</p>	<p>Improve</p>	<p>Improve</p>	<p>Improve</p>
 <p>C: Simple / low tech</p>			<p>Evaluate</p>	<p>Evaluate</p>	
	<p>Academics & researchers</p>	<p>Product developers & consultants (Services & products)</p>	<p>Real estate owners (Strategic)</p>	<p>Building- & facility managers (Tactical)</p>	<p>Installers & technicians (Operational)</p>

DGBC Knowledge Hub



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Deliverables
Shared Resources
Website
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Knowledge transfer

What's happening out there?



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CO₂ Reduction

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Tracks

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PLANNED



More information

B4B Webinars



<https://brains4buildings.org/learning-community/>

Open Knowledge Platform



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DGBC Knowledge Hub



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Roadmap



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A photograph of a modern glass building with a network diagram overlay. The diagram consists of light blue circles connected by thin lines, forming a complex web. The building has a curved facade and is surrounded by greenery and a body of water in the foreground. A dark green triangle is in the top-left corner.

Thank you!

Martín Mosteiro Romero (TU Delft)

25 June 2024