Integrating human needs in building automation by Artificial Intelligence

Activities and Perspectives

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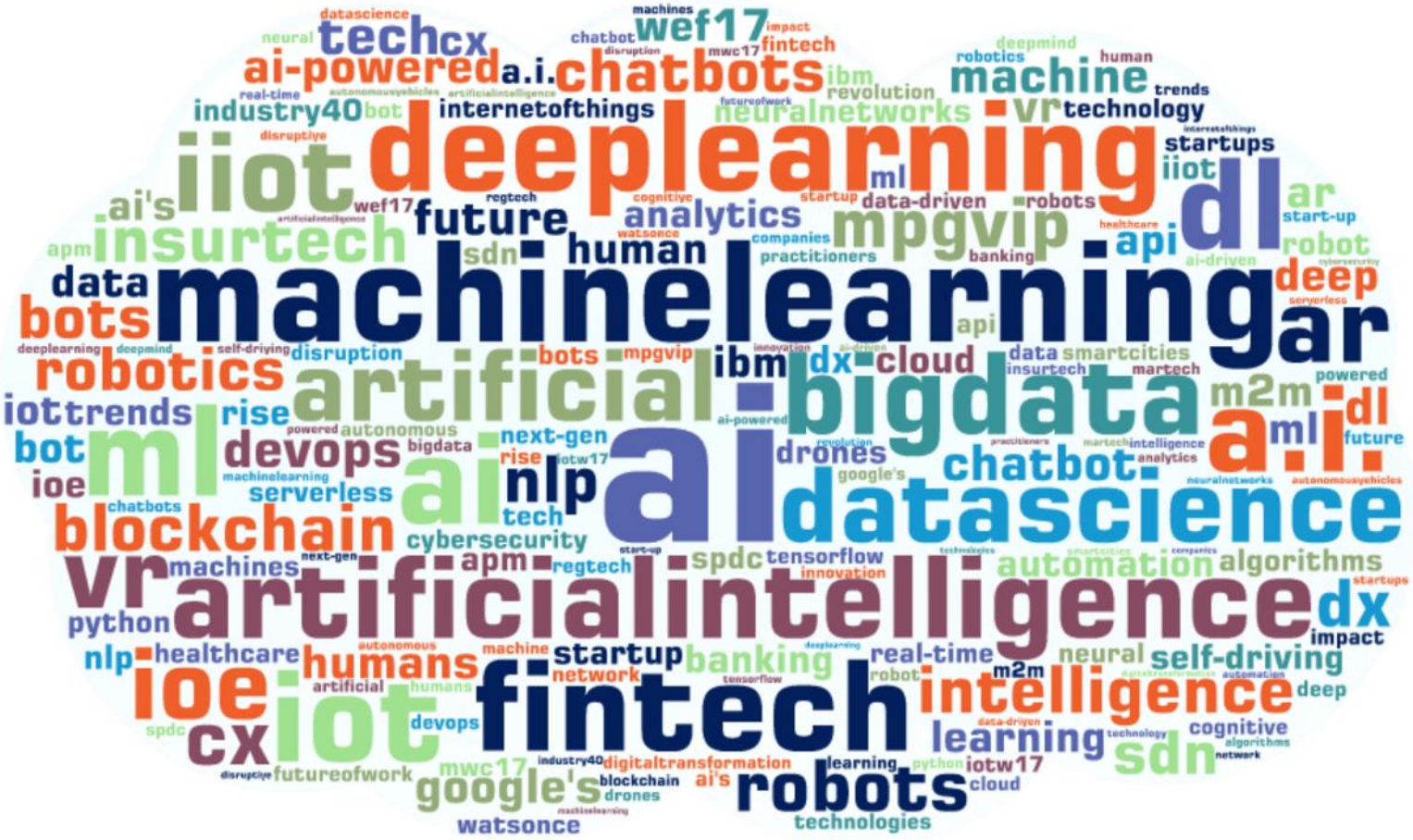
The project received funding from Dutch Ministry of Economic Affairs and Climate Policy and Ministry of the Interior and Kingdom Relations under the MOOI program

AI and ML for the future?



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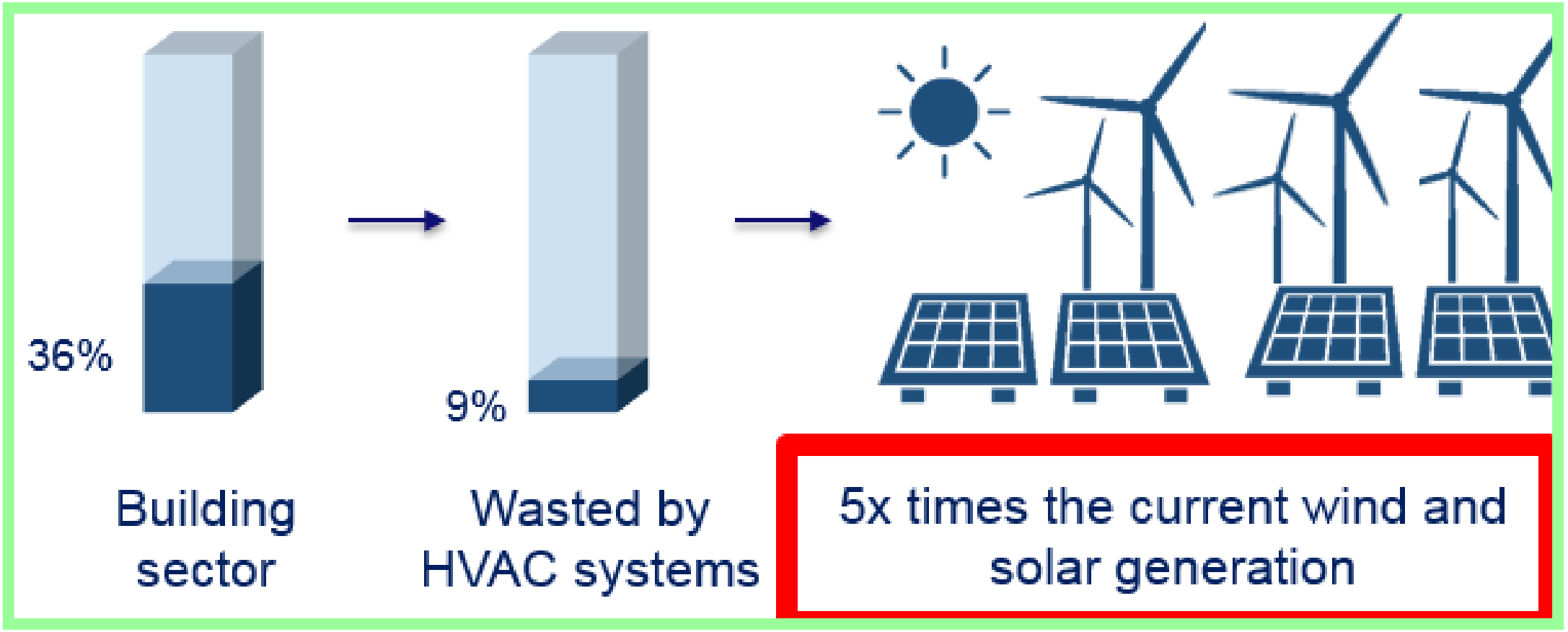
Or solve real problems that exist today?

70% of HVAC systems use on average **25% more energy** than strictly necessary conform the design.

The so-called *performance gap.*

Or solve real problems that exist today?

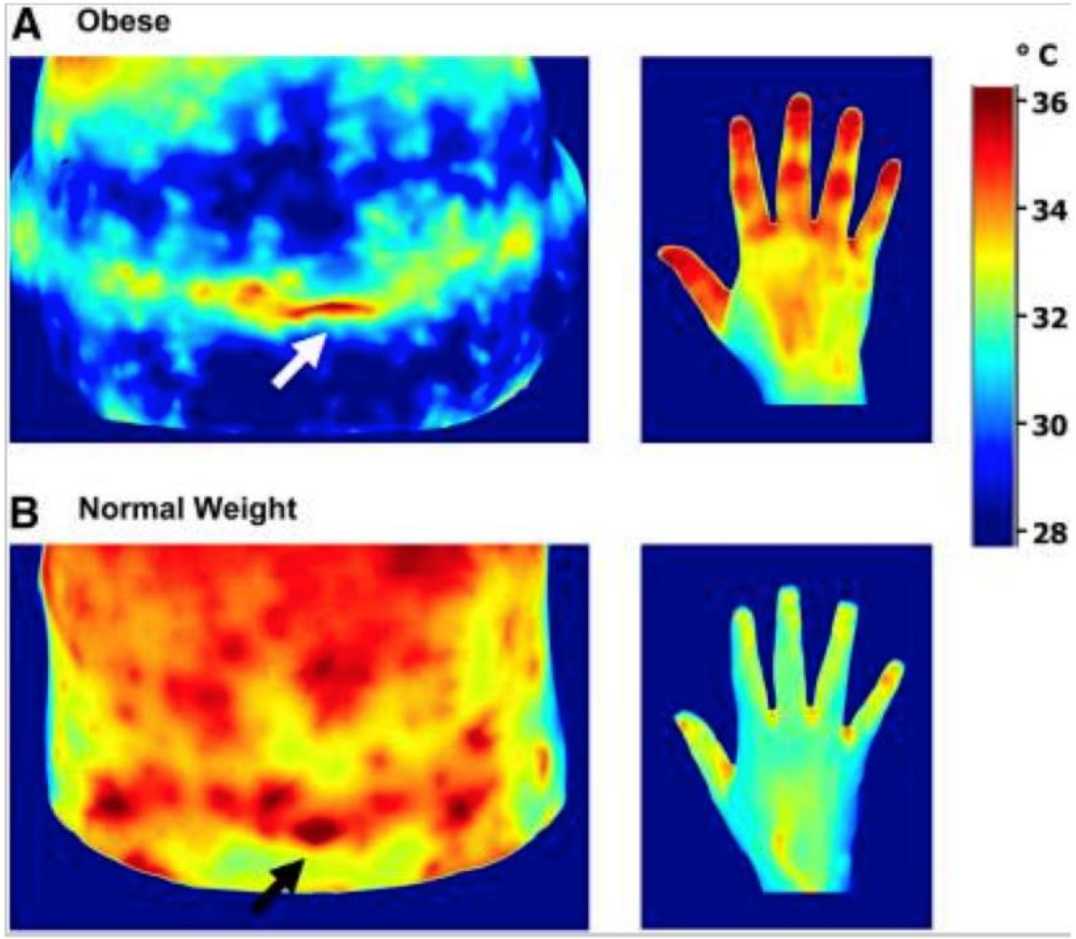
To put that into perspective for NL:



Or solve real problems that exist today?

Moreover, energy wastage because of mismatch with user preferences

- Large inter-individual differences
- Dissatisfaction & Complaints

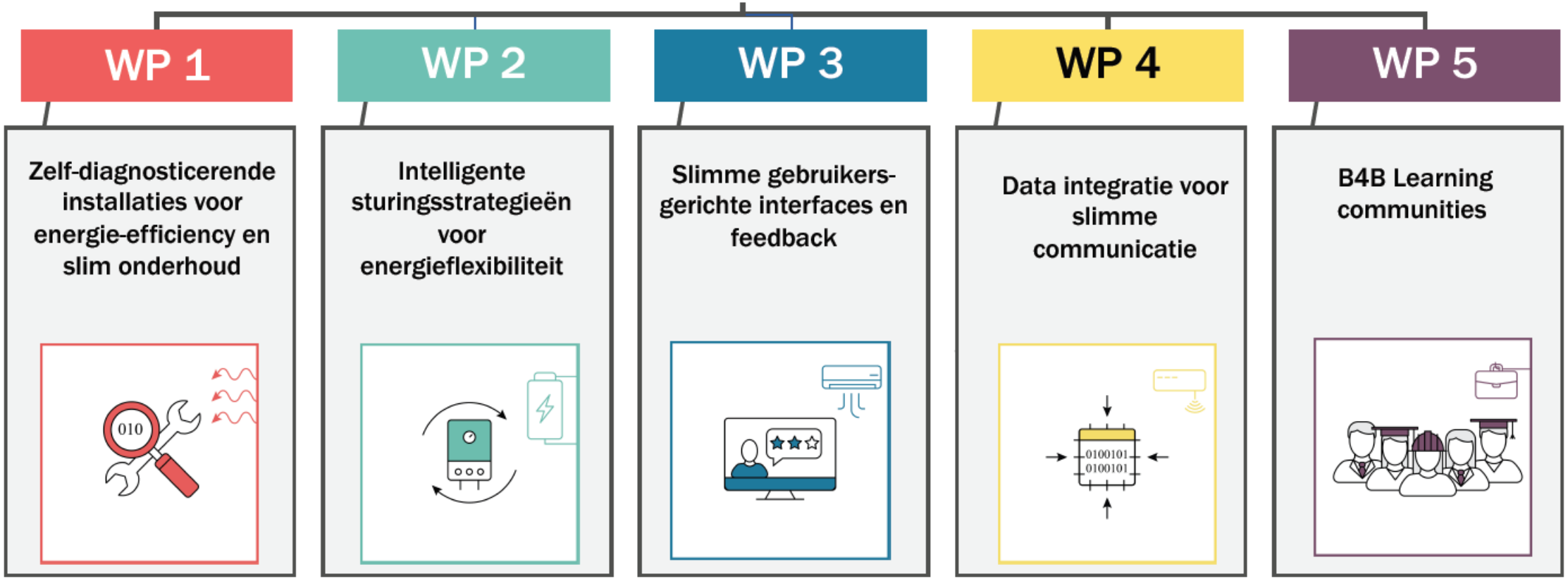


Savastano et al., AJCN 2009

RVO MOOI Brains4Buildings

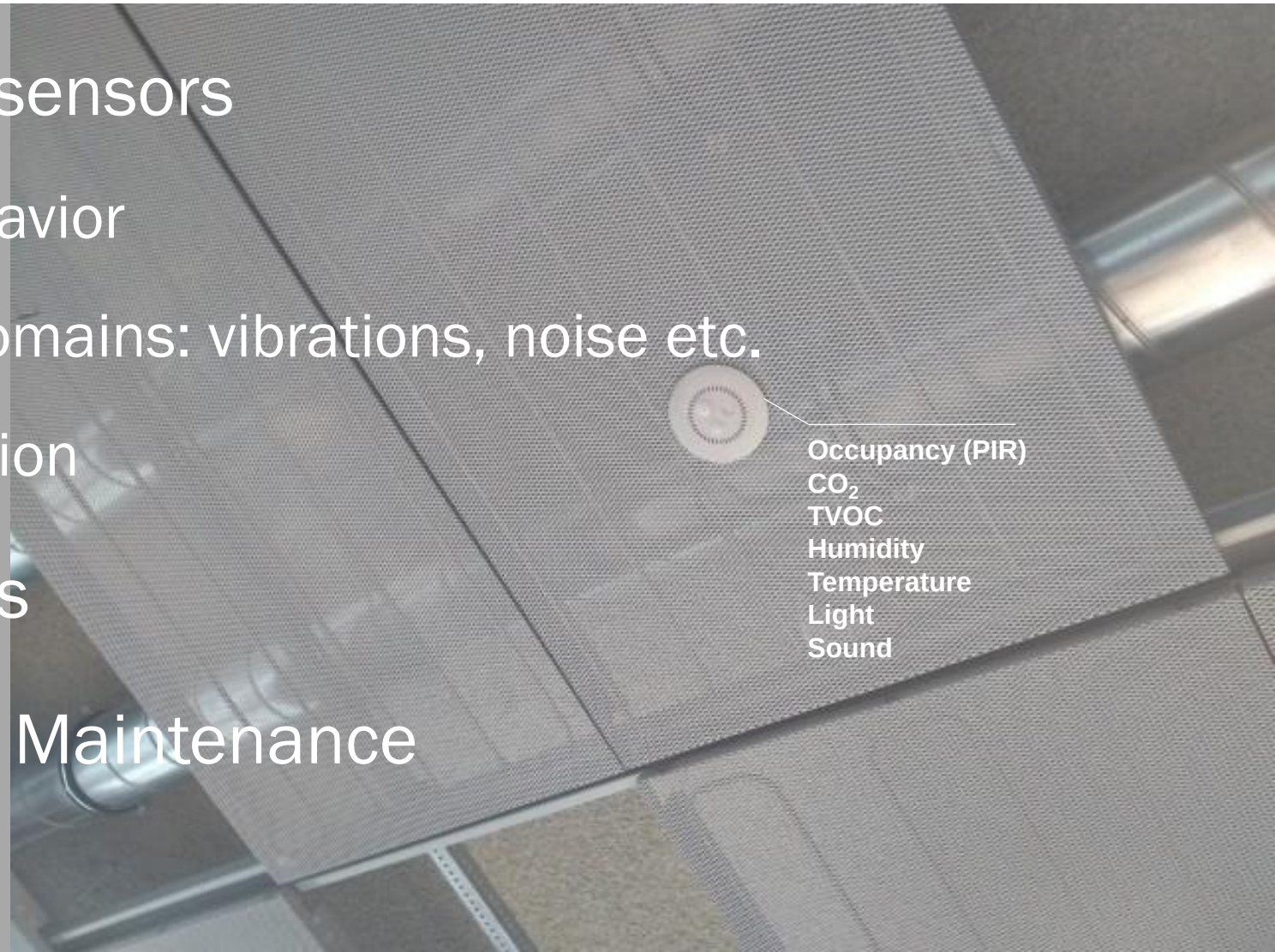
Missiegedreven Onderzoek, Ontwikkeling en Innovatie

Project leader: Prof.dr. Laure Itard (TU Delft)



Brains 4 Buildings: Goals

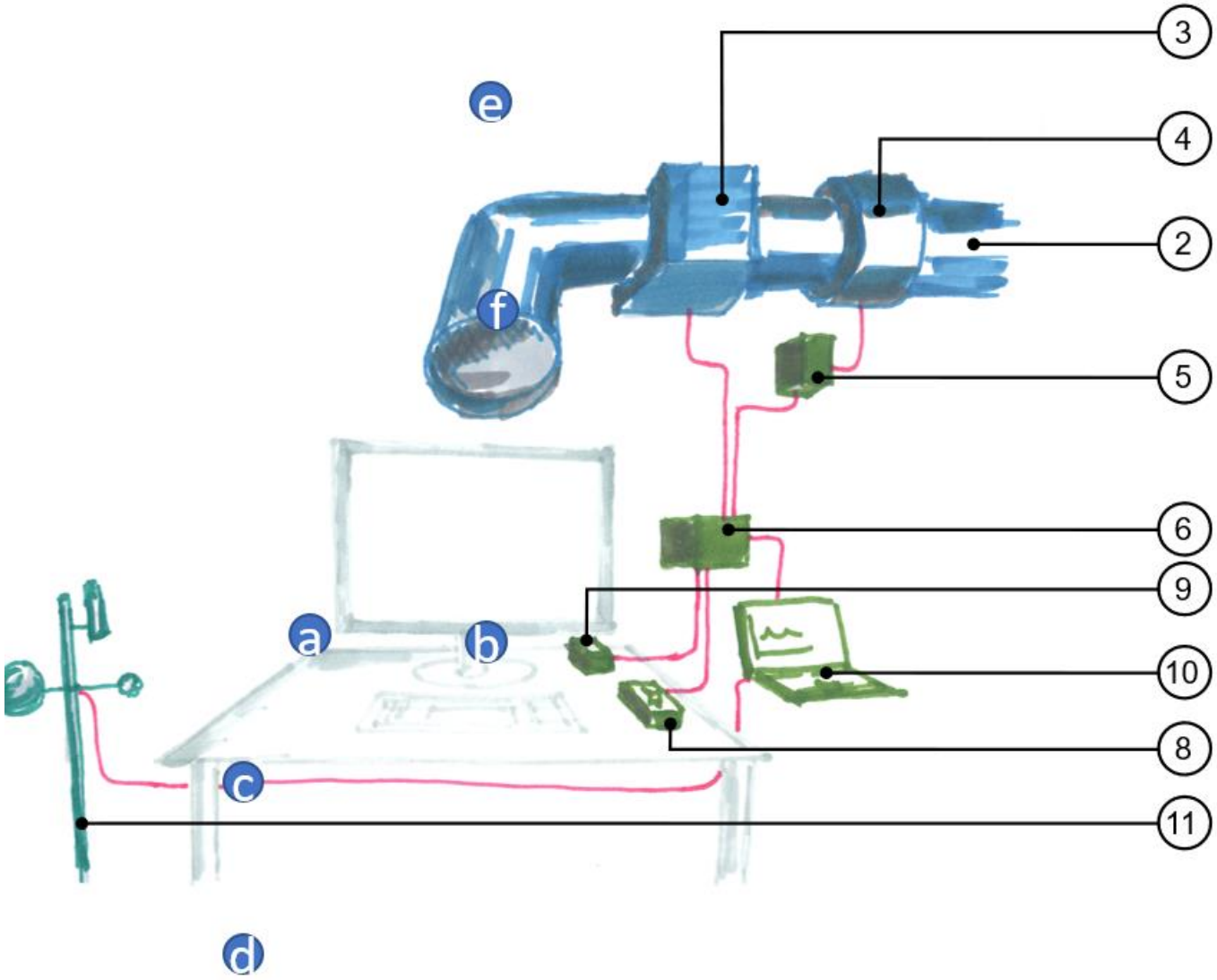
- Reliable & robust low cost sensors
  - Occupancy detection & behavior
  - Apply sensors from other domains: vibrations, noise etc.
  - Virtual sensors and calibration
- Fault Detection & Diagnosis
- Condition based predictive Maintenance



Climate Chamber Experiments

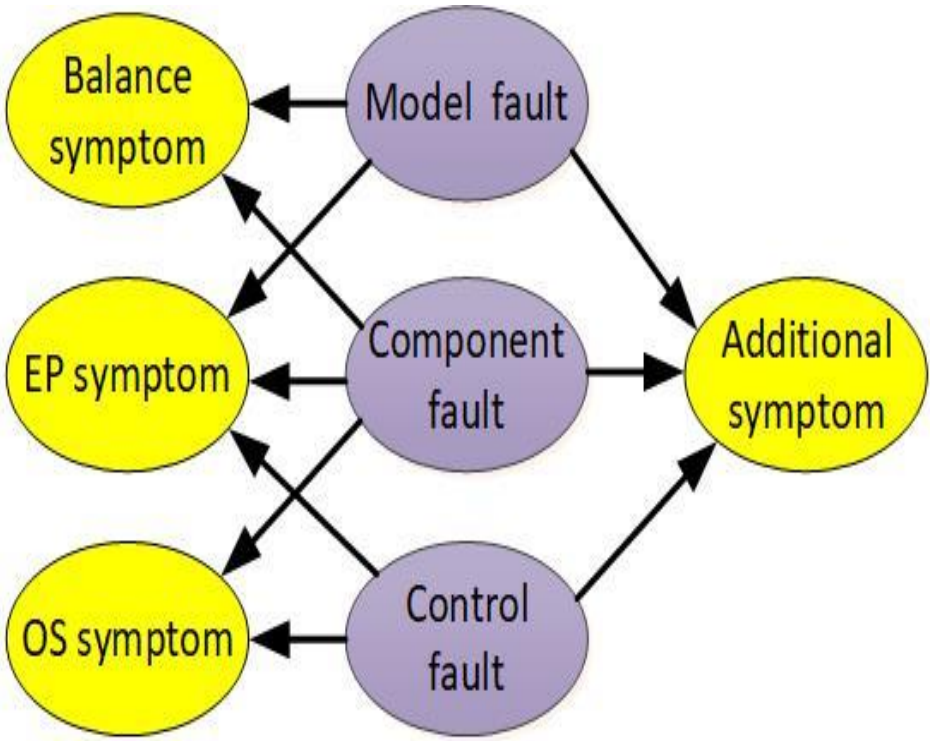
From first experiments on self-calibration to full scale measurements in the climate chamber

Correct positioning of sensors w.r.t. the occupants



FDD based on DBN

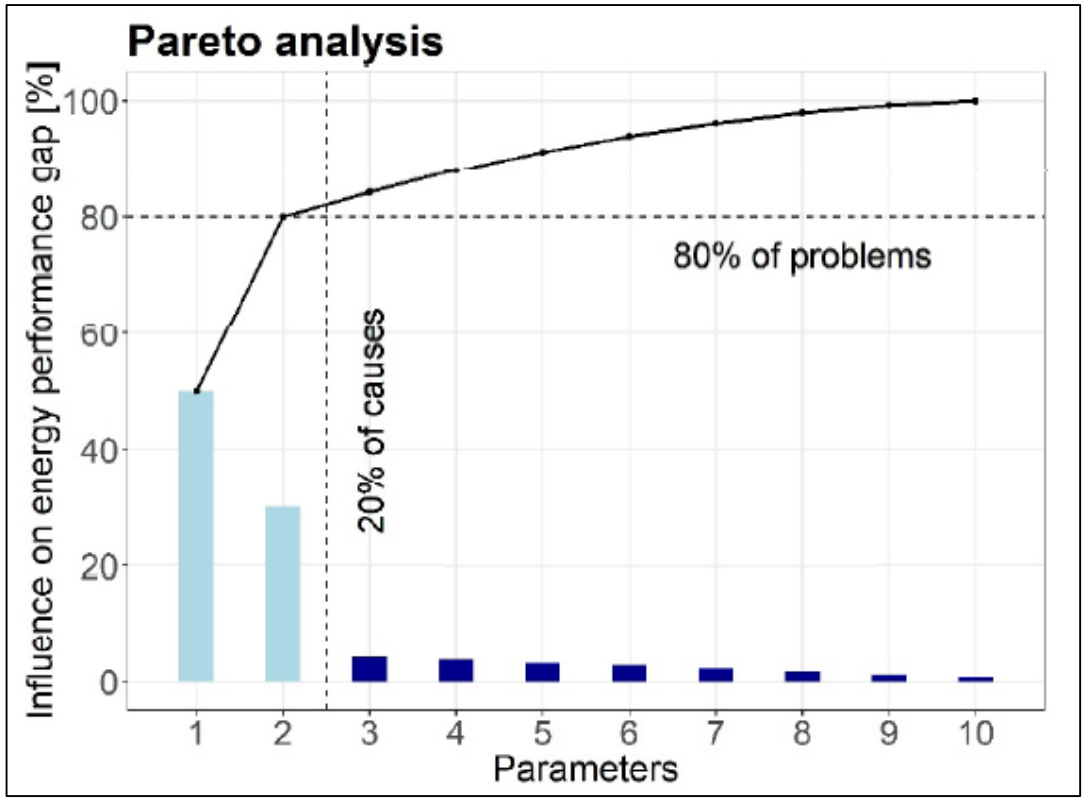
- DBN-method based on P&ID (Process and Instrumentation Diagrams, NL: principeschema's)
- DBN will be used to test FDD on BMS data



OS= Operational state, EP= Energy Performance

The 4S3F structure *(Source: Taal et al. (2020)).*

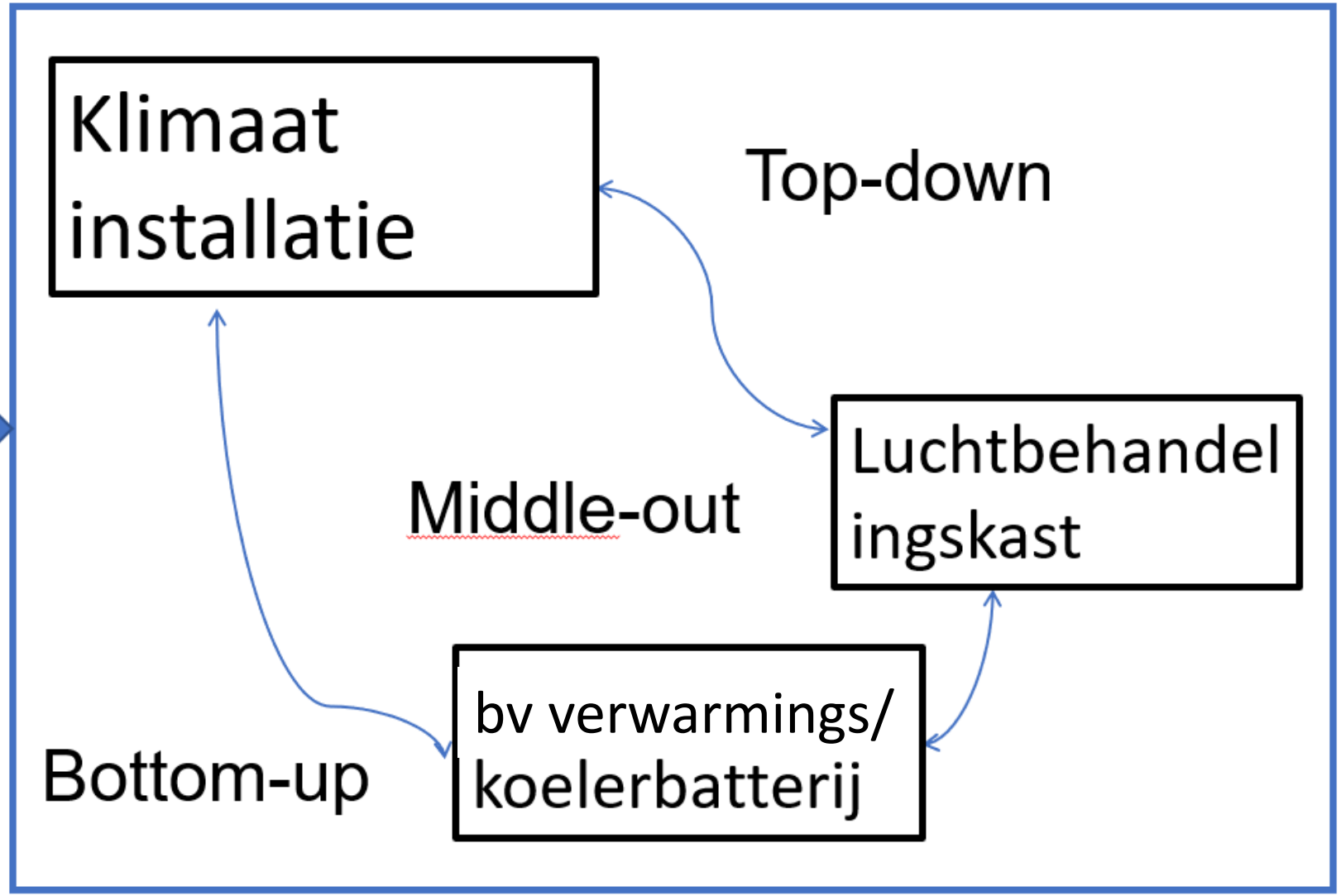
Downscale problem: Pareto LEAN



A schematic of Pareto Analysis (Corten et al.,2019).

Models based on first principles knowledge to select most important parameters (Pareto-LEAN Analyse)

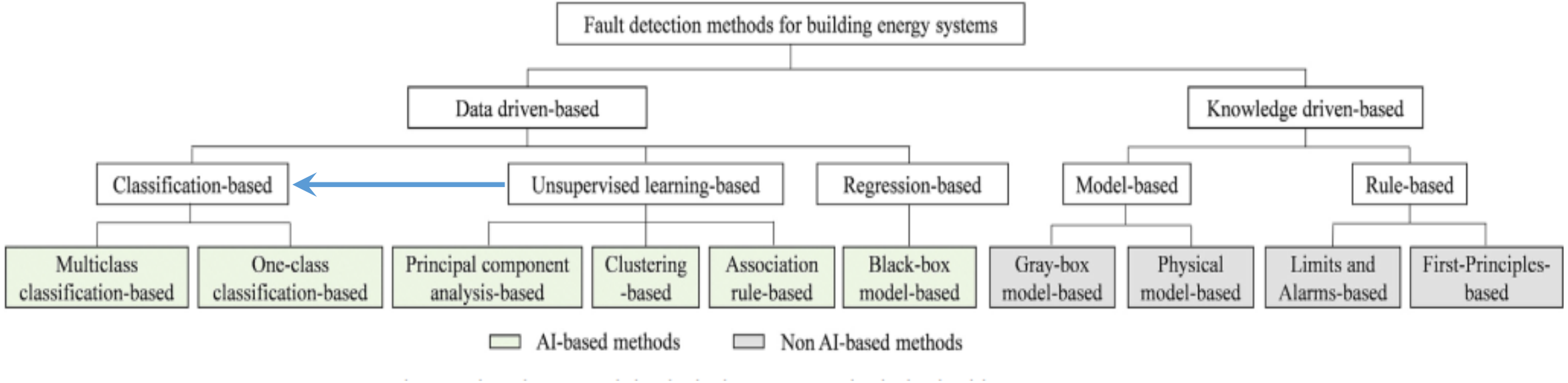
Downscale problem: System thinking



Automated FDD: Machine learning approach

From unsupervised to classification-based:

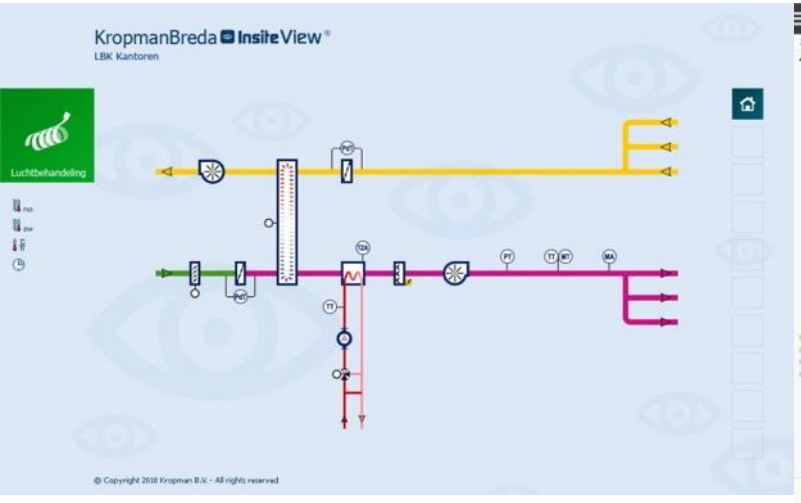
- Challenge: classification requires labelled data (labour intensive)
- Approach: starting with unsupervised -> efficient labelling -> classification

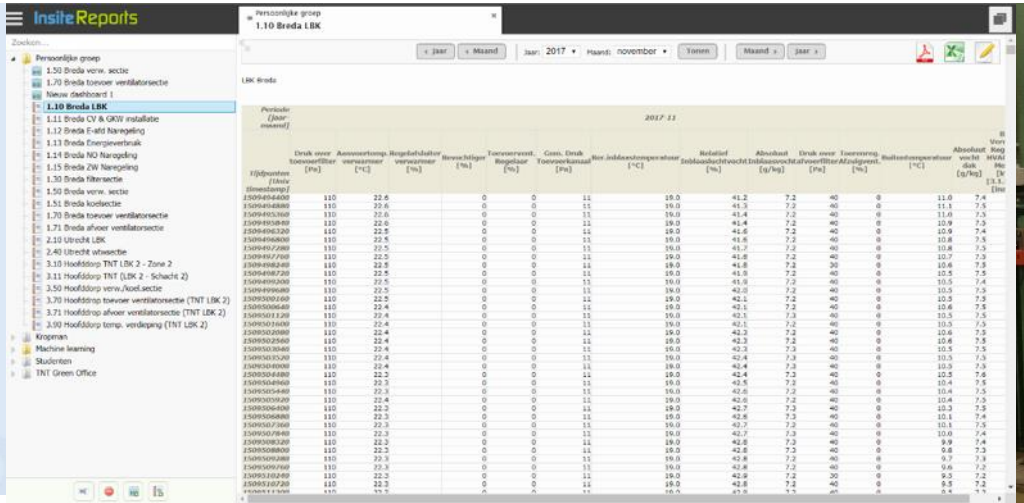


Zhao, Y. et al. (2019) Artificial intelligence-based fault detection and diagnosis methods for building energy systems: Advantages, challenges and the future. Renewable and Sustainable Energy Reviews vol. 109.
https://doi.org/10.1016/j.rser.2019.04.021

Not just theoretical performance

- Living labs:
  - Kropman, HHS Delft
- Case studies:
  - TU Delft, Strukton, TNO, Cloud Energy Optimizer
- Validation Studies:
  - TU Delft, Kuijpers, RHDHV, BAM





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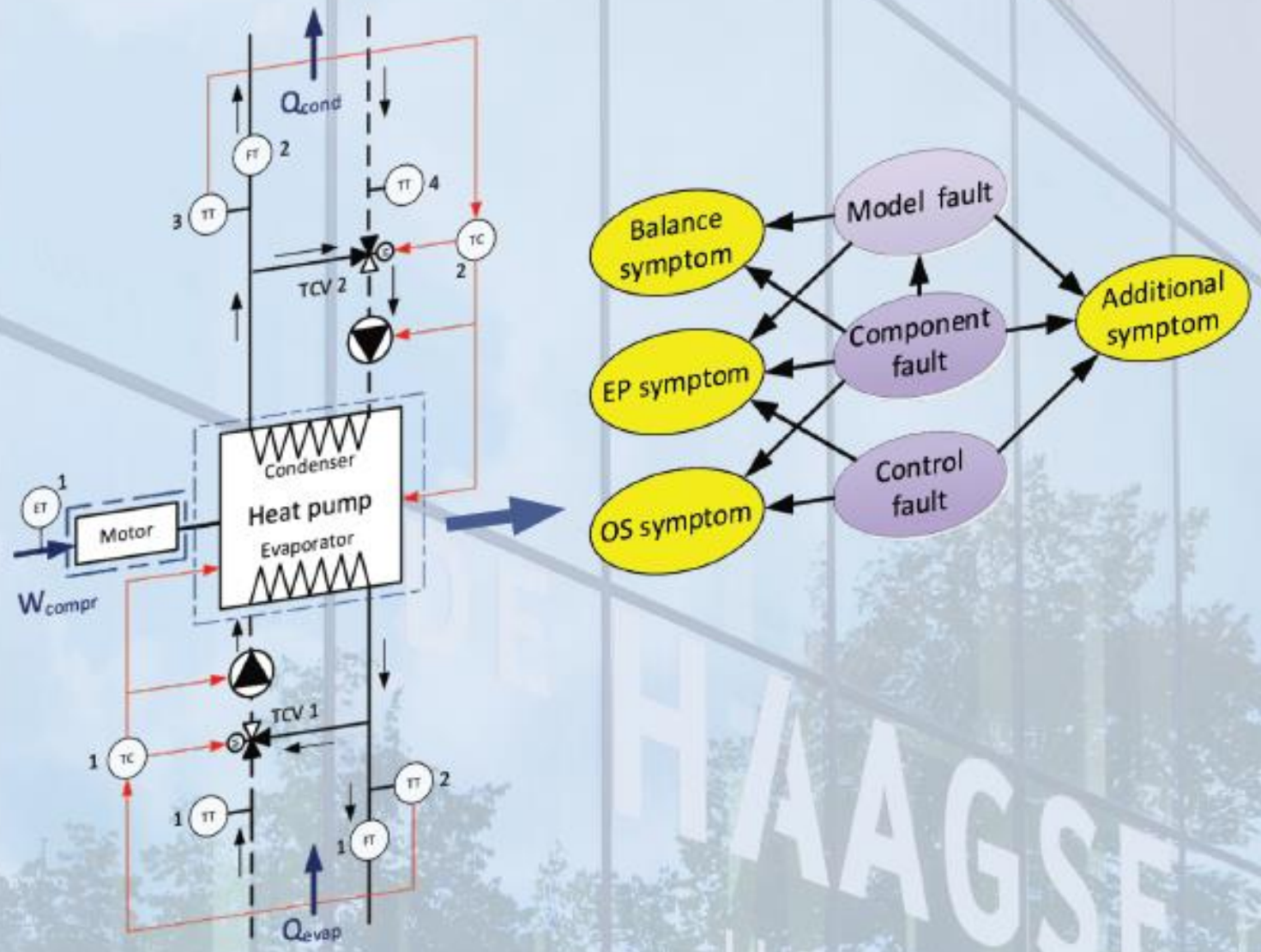

Uitnodiging

tot het bijwonen van de openbare verdediging van mijn proefschrift

A new approach to automated energy performance and fault detection and diagnosis of HVAC systems: Development of the 4S3F method

op dinsdag 23 november 2021 om 13.30 uur.

De promotie zal plaatsvinden in ruimte 0.710 van het Atlas gebouw van de Technische Universiteit Eindhoven.

Aansluitend aan deze plechtigheid zal een receptie plaatsvinden waarvoor u van harte bent uitgenodigd.

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BRAINS 4 BUILDINGS

DE HAAGSE HOGESCHOOL TU Delft TU/e

Thank you! Questions?

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