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Lead beneficiary	TU Delft (Mirjam Harmelink, Laure Itard)
Project partners	Technische Universiteit Delft (lead), Technische Universiteit Eindhoven, Stichting Hoger Beroepsonderwijs Haaglanden, Nederlandse Organisatie voor Natuurwetenschappelijk Onderzoek TNO, Stichting Hogeschool van Arnhem en Nijmegen, Stichting Avans, Stichting Christelijk Hogeschool Windesheim, Air-teq, Apta Technologies, Art Energy , BAM Techniek Energy Systems , Building G100, Chess Wise, Qien (Cloud Energy Optimizer), Deerns Nederland , Almende , Stichting Dutch Green Building Council, DWA , DYSECO , Binnenklimaat Nederland, Kropman Installatietechniek , Stichting Nederlands Normalisatie Instituut, O-Nexus , OfficeVitae , FHI, Federatie van Technologiebranches, Peutz , Philips, Renor, Rijksvastgoedbedrijf, Royal Haskoning DHV Nederland , Sensoring360 , Simaxx , Spectral Enterprise , Spie (Strukton Worksphere) , Unica Installatietechniek , W/E adviseurs, Stichting ter Bevordering van Wetenschappelijk Onderwijs en Onderzoek (WOI), Heijmans
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PREFACE

With this report, we close the B4B (Brains4Buildings) project—a shared effort of 39 partners working together over four and a half years. Our common goal was clear: to make buildings smarter, more energy-efficient, and better for the people who use them.

Looking back, we are proud of what we achieved together. We developed and tested new solutions for smart monitoring, fault detection, energy flexibility, and user-friendly building interfaces. These innovations showed strong results, including the potential to reduce energy use by 20–30% while improving comfort, health, and overall building performance.

One of B4B's greatest strengths was the close cooperation among partners. Throughout the project, there was strong and steady involvement in living labs, real-life use cases, and regular meetings. Even during challenging periods, knowledge sharing remained active. The final conference, with more than 200 participants, showed the wide interest and impact of our work.

We also made sure that what we learned will continue to be useful. Our results are publicly available through open platforms and guidelines, helping others to build on our work. Many companies have already continued developing the tools, and several follow-up projects have started. In addition, many researchers moved into industry roles, strengthening the connection between research and practice.

Together, we have taken important steps toward smarter buildings by developing and applying new technologies and approaches. This report marks the end of the project, but also the beginning of further progress built on what we have achieved together.

Laure Itard

Mirjam Harmelink

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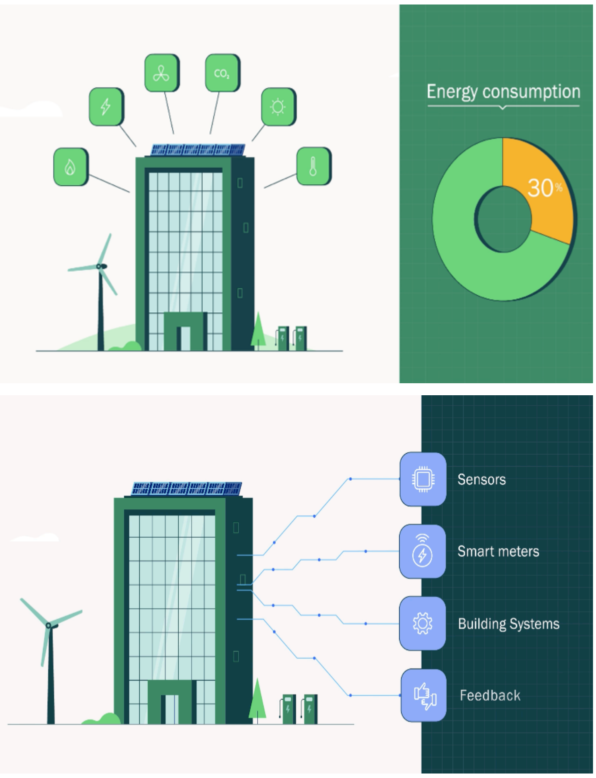
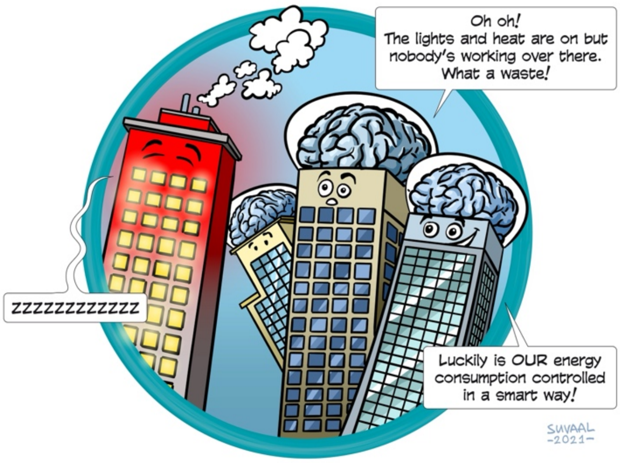
1 BACKGROUND

1.1 The grand challenge

Even in the most modern non-residential buildings, 10-30% of energy is wasted due to malfunctioning installations and unexpected user behaviour. In many cases, indoor air quality needs improvement, and maintenance & operating costs are high.





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Smart meters, building management systems and the Internet of Things allow the collection of large amounts of data. Using these data is seen as promising to

- Get rid of a systematic 10-30% energy wasted
- Shift energy demand and peak loads to match renewable supply
- Respond flexibly to user behaviour and comfort & health needs
- Save on the costs for installation and maintenance

Real-time analysis and use of large amounts of data require Machine Learning and Artificial Intelligence. However, current models and algorithms are not yet fast and efficient enough to make buildings "smarter", and implementation is cumbersome and time-consuming. The grand challenge we worked on in the B4B project was to develop scalable building smartness.

1.2 B4B Objectives

The main objective of the B4B project is to add operational intelligence to buildings to support a transition towards energy-efficient, flexible buildings. Derived objectives are to develop:

- Validated integrated prototypes of software plug-ins for smart monitoring and fault diagnostics in buildings and installations, resulting in a 20-30% reduction in energy consumption & lower maintenance costs
- Prototypes of control systems increasing the use of self-produced (renewable) energy and enabling adjustable energy flexibility regarding the heat/cold/electrical grid.

- Validated prototypes of data-driven and user-centric user interfaces that contribute to user comfort, health and well-being.
- Methods, guidelines, and standards for data integration in smart building infrastructure, with an associated open data platform and Smart Readiness Indicators, while ensuring ethics, privacy, and security.
- A Learning community to share/exchange knowledge on self-learning software for smart buildings and the link to the smart grid
- Reducing costs for smart building control systems and improving business cases for facility managers, building owners and service providers that capture the value of the entire energy system in the built environment.

1.3 Highlights

- Continuous engagement of project partners: Throughout the project, virtually all 39 consortium partners remained actively involved in living labs, use cases, and consortium meetings. The periodic consortium meetings consistently attracted 60–70 participants.
- Sustained knowledge sharing through platforms: All deliverables, webinars, data structures and design guidelines remain publicly accessible through 1) the DGBC Knowledge Centre and 2) the Brains4Buildings Open Knowledge Platform. Both platforms serve as long-term repositories for project results. Main results about data integration architecture and privacy and security framework were included in the actualisation of ISSO guideline 115.
- Final conference: Successful final B4B conference with over 200 participants from research, industry and government.
- Market dissemination: The project contributed extensively to knowledge dissemination. We published our findings in 42 public deliverables and 55 publications in scientific journals and sector journals, including a series of articles in a REHVA special issue. Furthermore, the results were presented in 24 webinars, with attendance ranging from over 100 participants for webinars organised during the COVID pandemic to approximately 20-40 participants, and with extensive viewership of the recordings.
- Successful testing in living labs and validation in use cases: The methodologies were tested in 7 living labs and validated in 7 industry-led use cases. Additionally, more than 15 companies have further developed their own tools.
- Talent Transfer from Academia to Industry: Multiple PDEng and PhD researchers transitioned into positions at consortium companies such as Peutz, Unica, SPIE and TNO, underlining the project's contribution to capacity building and knowledge transfer.
- Successful follow-up projects: Several projects have been started and funded that directly build on B4B outputs, including DBN models, AFDD methodologies, sensor innovations, data architectures and interface concepts.
- Creation of new knowledge: Tangible contribution to international advances in Smart Buildings and interfaces, through participation in IEA Annex 81 “Data-driven smart buildings”, and the publication of more than 50 papers in international scientific journals, conference proceedings and technical journals.

To conclude, we have all together developed, demonstrated and applied technologies and approaches for Smart buildings in the fields of Fault detection and diagnosis, Energy flexibility, Smart Interfaces and Data infrastructure, setting the necessary steps for future upscaling.

1.4 Approach: five integrated work packages

The project was organised around five work packages, in which we collaborated on 10 results. In this report, the results are presented per work package. In four work packages, work was integrated into the required development of smart building control. Figure 1 provides an overview of the work packages and results. The activities were organised around open living labs and use & validation cases. Methods, models, and algorithms developed in the work packages were first tested in one or more living labs and then validated in use and validation cases. The fifth work package, 'B4B Learning Communities', focused on knowledge dissemination.

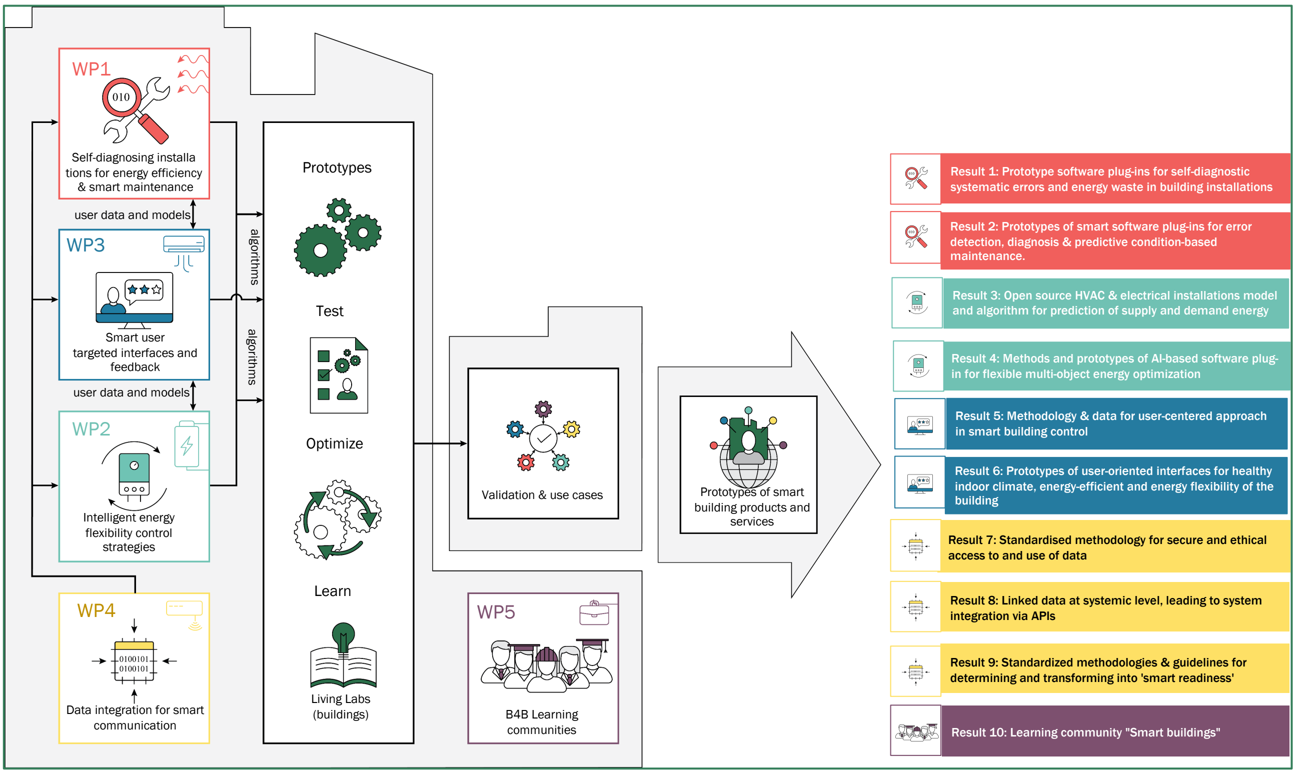

Figure 1: Five work packages organised around living labs & use/validation cases leading to 10 tangible results.

1.5 Reading guide

- Chapter 2-6: The results are described per work package. Each result starts with a summary of the work package's core focus, activities, results, and deliverables.
- Chapter 7: Describes the spin-off resulting from the B4B project in and outside the sector
- Chapter 8: Provides an estimate of the potential contribution of the B4B results to the objective of the MOOI program.

Annexes

- Annex 1 holds the full list of deliverables (Annex 1). The deliverables are also available on the B4B website. The "DGBC Kenniscentrum" serves as the long-term repository for all results, ensuring they remain accessible after the B4B project is completed.
- Annex 2 provides an overview of articles published in scientific journals and trade publications.
- Annex 3 presents the list of available webinars.
- Annex 4 lists the national and international conferences at which the B4B project results were presented.
- Annex 5 provides an overview of the media outlets where the B4B project was presented.
- Annex 6: Summary of the publicly available code and data that are shared through the Brains4Building Github page.

2 WP 1: SELF-DIAGNOSING INSTALLATIONS FOR ENERGY EFFICIENCY AND SMART MAINTENANCE

The main aims of WP1 were to:

1) Develop further the 4S3F Bayesian Network-based (DBN) approach for Fault Detection and Diagnostic (FDD) in Air Handling Units (AHUs), as DBNs are considered the most promising.
2) Extend the fault diagnosis framework from AHUs to total HVAC systems
3) Investigate the capabilities of 4S3F FDD in Model Predictive Control, as used in energy-flexible buildings
4) Test the implementation in real systems
5) Research the capabilities of Machine Learning approaches to fault detection
6) Develop FDD methods for predictive maintenance

Points 1 to 4 belong to Result 1, and points 5 to 6 belong to Result 2. The highlights in this work package are:

- Demonstration in practice of the DBN-FDD method in 2 living labs (Kropman Building and TUDelft)
- Method tried out by 2 companies (Kropman and Spie)
- Guidelines for the needed number and types of sensors
- Further refinements of the method, including libraries
- Use of LLM to automatically construct the DBN from P&ID
- Inventory and prioritization of faults in AHUs and their effect on comfort and energy usage
- 10 companies have advanced their own platforms for performance analysis of sensor data and systems

2.1 Result 1: Prototype Bayesiaan Network-based software plug-ins for self-diagnostic of errors and energy waste in building installations

Core focus

Developing and validating a Bayesian Network–based diagnostic approach for automated detection of systematic errors, suboptimal operation and energy waste in building installations, with a primary focus on Air Handling Units in HVAC systems in non-residential buildings.

Key activities

- Development of the 4S3F diagnostic framework linking observable symptoms to underlying faults and performance issues.
- Design and implementation of Diagnostic Bayesian Network (DBN) models representing causal relations in HVAC systems and components.
- Translation of system descriptions, P&IDs and expert knowledge into DBN structures, including a Large Language Model (LLM) based approach.
- Development of data pre-processing and post-processing methods for use with operational BMS data.
- Testing of DBN-based diagnostics using historical and near-real-time data from living lab buildings.
- Analysis of sensitivity and robustness, including the role of prior and conditional probabilities.
- Stepwise extension of the framework towards indoor climate quality, user-related effects and energy-flexible control contexts.

Key results

- A Bayesian Network–based diagnostic methodology for HVAC installations, enabling structured reasoning from measured symptoms to probable fault causes, including LLM approach (D1.08b, D1.01).
- Prototype DBN models for common HVAC components and subsystems, suitable as reusable building blocks (D1.03a, D1.03b).
- A standardised diagnostic framework (4S3F) supporting systematic identification of faults, control issues and energy waste mechanisms (D1.01, D1.02a, D1.02b, D1.03b).

- Validated diagnostic performance under controlled conditions, demonstrating correct fault identification for selected fault types and limited false positives (D1.01, D1.03b).
- Documented insight into uncertainty handling, including the influence of prior knowledge and data quality on diagnostic outcomes (D1.04a).
- Extensions of the framework addressing indoor climate quality issues, user-related effects and suboptimal control strategies in energy-flexible buildings (D1.05a, D1.05b, D1.05c).
- A set of prototype-level software components and model libraries, forming a basis for further turnkey deployment (D1.01, D1.02a, D1.02b, D1.03a, D1.03b).

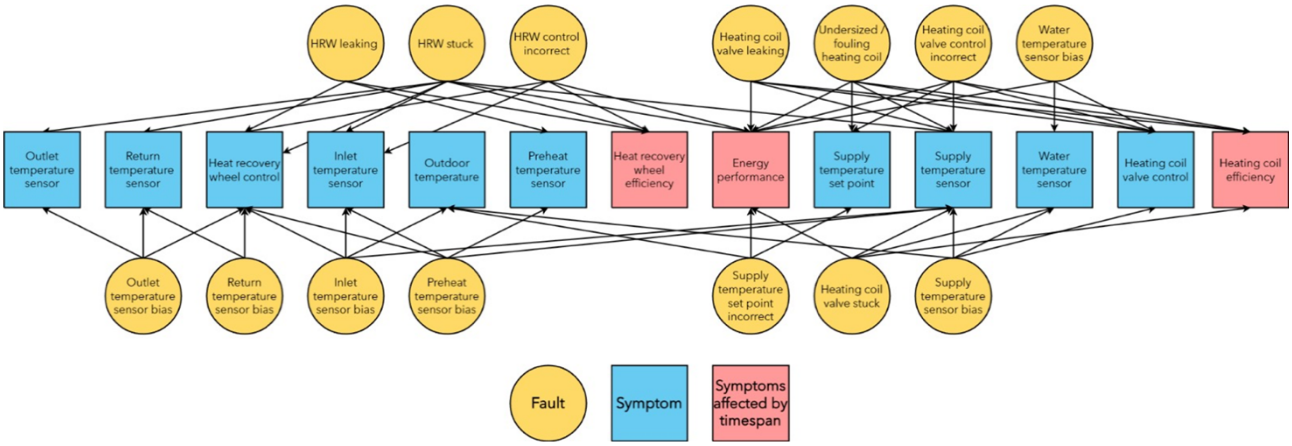

Figure 2: DBN of AHY Building 28 for real-time diagnosis

Contributing partners

TUD, TU/e, HHS, DWA, Kropman, Qien (Cloud Energy Optimiser), Spie, Sensing 360, Peutz, WOI, Building G100

Deliverables

- D 1.01 Real-time implementation of part of the 4S3F method in two living labs.
- D 1.02 a Use-cases data processing for pre- and post-processing (Basic preprocessing).
- D 1.02b Use-cases data processing for pre- and post-processing (Advanced preprocessing and sampling).
- D 1.03a Open library of standardized DBN models for the most common components & sensors / models / control in installations.
- D 1.03b Standardized DBN model libraries: Impacts of sensor numbers and configurations.
- D 1.04a Impact of prior and conditional probabilities in DBN.
- D 1.05a Extension of the 4S3F HVAC B28 framework to account for end-user and indoor climate quality.
- D 1.05b Extension of the 4S3F AHU framework for identifying undefined end-user use and poor indoor climate quality, analysing subject live data.
- D 1.05c Extension of the 4S3F framework for identifying suboptimal controls in energy-flexible buildings (Controls).
- D1.08b2 State of the art DBN for Building energy systems
- 🧠 Software code: DBNs for real-time FDD
- 🧠 Software code: Sensor selection code

2.2 Result 2: Prototypes of ML- and knowledge-based software plugs-ins for error detection, diagnosis & predictive condition-base maintenance

Core focus

Developing and validating prototype software plug-ins that combine machine-learning methods and knowledge-based approaches to support error detection, diagnosis and prioritisation in building installations, with condition-based maintenance explored as a complementary application area.

Key activities

- Development of fault-detection and diagnosis methods that combine data-driven techniques with expert knowledge.
- Design of fault-prioritisation approaches, linking detected faults to estimated impact and relevance for operations and maintenance.
- Analysis and processing of operational data and maintenance records, including text-based maintenance logs.
- Development and testing of machine learning models to detect anomalies and degradation patterns in HVAC components.
- Integration of diagnostic results with energy impact assessments to support decision-making.
- Exploration of condition-based maintenance concepts for selected components, using available data and sensors.
- Validation of methods in living lab and operational building contexts, under realistic data and organisational constraints.

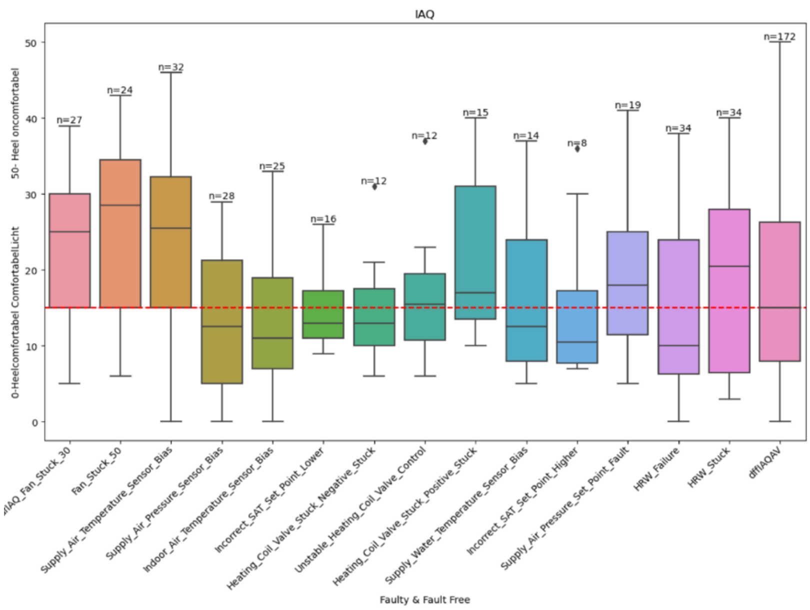

Figure 3: Effect of HVAC faults on thermal comfort

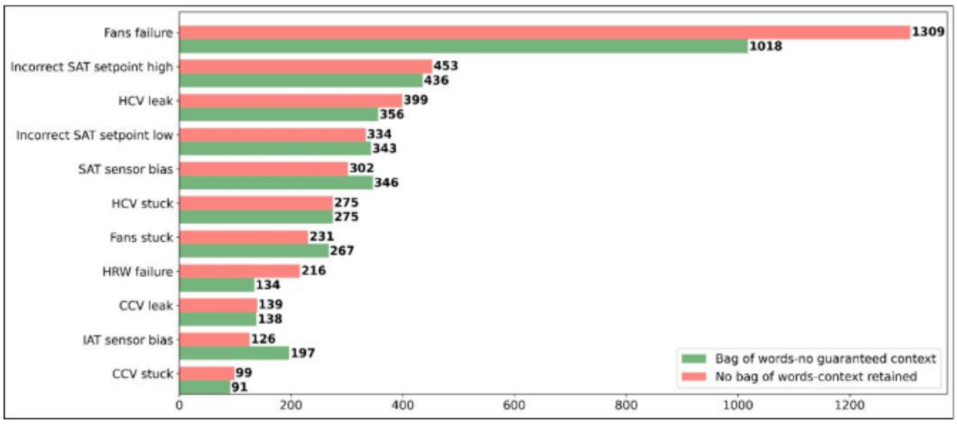

Figure 4: Results for fault frequency occurrence obtained through network clustering for both cases (with and without applying the bag of words feature).

Key results

- Prototype ML- and knowledge-based fault detection methods capable of identifying deviations from normal operation in building installations (D1.04b, D1.07, D1.08a).
- Diagnostic approaches that combine data-driven detection with system knowledge, supporting interpretable fault identification (D1.08a, D1.10).

- A fault prioritisation framework linking detected issues to operational relevance and potential energy impact (D1.06).
- Processed and structured maintenance data sets, enabling analysis of fault occurrence and maintenance patterns (D1.06, D1.10).
- Validated proofs-of-concept for combining diagnostic outputs with maintenance decision support (D1.06, D1.07, D1.08a).
- Exploratory condition-based maintenance models for selected components, demonstrating feasibility under specific data conditions (D1.07, D1.08a).
- Documented boundary conditions related to data quality, sensor availability and transferability between buildings (D1.07, D1.10).
- A set of prototype-level software components and methods, suitable as a basis for further development rather than direct deployment (D1.06, D1.07, D1.08a).

Contributing partners

TU/e, TUD, TNO, Avans Hogeschool, AirTeq, ArtEnergy, BAM Energy Systems, Building G100, ChessWise, Qien (Cloud Energy Optimizer), DWA, DYSECO, Kropman, Kuijpers, Peutz, Renor, Sensing360, Spie, WOI.

Deliverables

- D1.04 b: expansion of the method with additional data from building management and expert knowledge
- D 1.06 Tools for Continuous Commissioning with a) Pareto LEAN energy analysis and b) data trends of continuous monitoring, for detection and GBS plug-ins.
- D 1.07 Evaluation Machine Learning algorithms, applying new sensors & possibilities, dynamic air conditioning.
- D 1.08a Overview of approaches to ML & system-based diagnosis and conclusions on the beta design of a software module (First approaches)
- D1.08 b1: Overview of approaches to ML & system-based diagnosis and conclusions on the beta design of a software module (Final)
- D 1.10 Overview of existing knowledge and inventory of existing products with potential for application
- Software code

Next to the listed deliverables, several companies involved in WP 1 drafted separate reports detailing the results they achieved and their progress on the project. These include reports from

- AirTeq
- Almende: Crownstone IPS for smart offices
- Chesswise: Engineering a new concept room ceiling sensor
- Dyseco: Towards automatic fault diagnosis under dynamic climate conditions for effective buildings' energy flexibility
- Peutz: Research on sensor data interpretation through a hybrid inverse modelling approach and fictitious sensors
- Qien
- Renor: Verspillingsanalyse
- Sensing 360: Research and evaluation for low-cost vibration sensors on the HVAC for early fault detection
- SPIE Building Solutions: PULSE Core
- TNO & SPIE: Virtual Sensing & Data Driven Detection

3 WP 2: INTEGRATED ENERGY FLEXIBILITY AND CONTROL

The goals of WP2 were to:

1) Develop Building Energy Models to be used for/support Model Predictive Control (MPC)
2) Define Energy flexibility and choose which flexibility to study
3) Develop algorithms for MPC
4) Test algorithms in a simulation environment
5) Implementation MPC algorithms in living labs/use cases

Result 3 covers point 1, while Result 4 covers points 2 to 5. Main highlights of WP 2 are:

- The analysis of the performances of different schemes and Demand Requests for continuous flexibility in buildings (maximum use of building mass).
- A clear definition of downward and upward flexibility for on-off systems in buildings (like heat pumps) and related constraints.
- A set of MPC-optimisation algorithms that can cope with inherent uncertainties in State Prediction, so-called Robust Optimisation, and a related thesis.
- MPC–test successfully conducted in two living labs (Kropman Building for flexibility with heat pumps and TNO Building for flexibility in Air Handling Units) and one use-case (O-nexus building).
- Increased knowledge on practical constraints and limitations in the real-world implementation of MPC for energy flexibility.

3.1 Result 3: Open-source HVAC & electrical installations model and algorithm for the prediction of supply and demand energy.

Core focus

Developing and validating open-source models and algorithms for HVAC systems, electrical installations and buildings, enabling prediction of energy demand, comfort-related variables and local energy supply as a foundation for energy flexibility and control applications, like Model Predictive Control.

Key activities

- Development of open-source building and installation models using white-box, grey-box and data-driven approaches.
- Implementation of HVAC and electrical system models using Modelica, EnergyPlus, Python and hybrid modelling frameworks.
- Development and testing of energy demand and local energy supply prediction algorithms, including PV production and solar radiation forecasting.
- Comparison of forecasting and data-imputation methods using real BMS data.
- Integration of occupancy, ventilation and comfort-related variables into prediction models where data allowed.

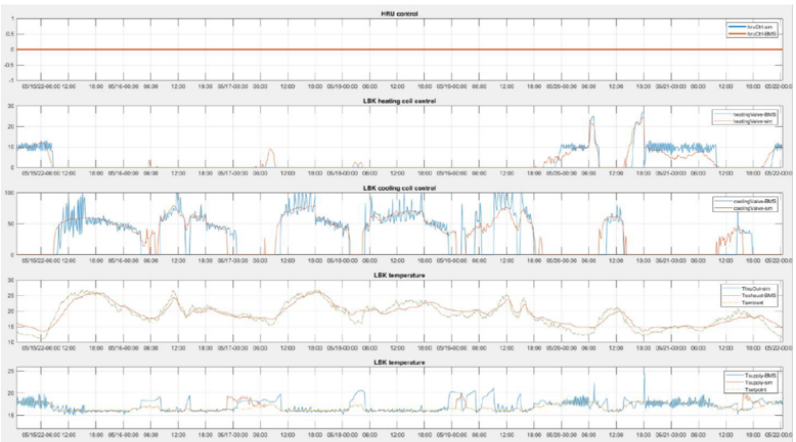

Figure 5: Simulated and measured results Sunday, May 15, up until May 21, 2022.

Key results

– Open-source HVAC and electrical installation models based on physical, grey-box and data-driven approaches.
– Building energy demand and local energy supply prediction algorithms, suitable for short-term forecasting using operational data.
– Hybrid modelling frameworks combining physical system knowledge with data-driven methods.
– Comparative analyses of forecasting and data-imputation methods, including quantified accuracy and robustness indicators.
– Validated model implementations tested with real building data under varying data-quality conditions.
– Reusable modelling components and scripts shared within the consortium for further application and development.
– Documented applicability boundaries, including dependencies on sensor availability, data quality and building-specific characteristics.
– All results are reported in one deliverable aggregating D 2.01, 2.02, 2.03.

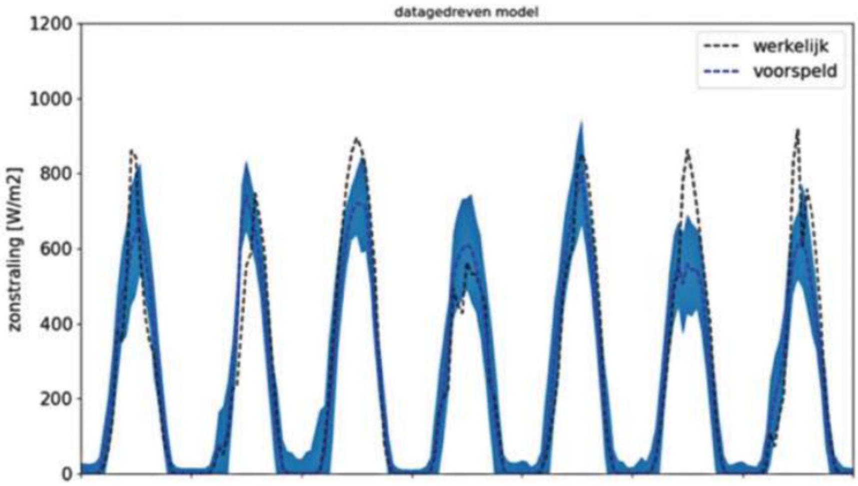

Figure 6: Prediction of solar radiation

Contributing partners

TNO, TU Delft, TU Eindhoven, Haagse Hogeschool (HHS), Windesheim University of Applied Sciences, Avans Hogeschool, Peutz, DWA, O-Nexus, Avans, Almende, Unica

Deliverables

– D 2.01, 2.02, 2.03: Building and building systems energy prediction models to enhance energy flexibility control.
– Datasets and Software code on prediction models.

3.2 Result 4: Methods and prototypes of AI-based software plug-in for flexible multi-object energy optimization

Core focus

Developing and testing methods and prototype software plug-ins for flexible, multi-objective energy optimisation in non-residential buildings, using the operational flexibility of HVAC systems and building thermal mass while respecting comfort constraints.

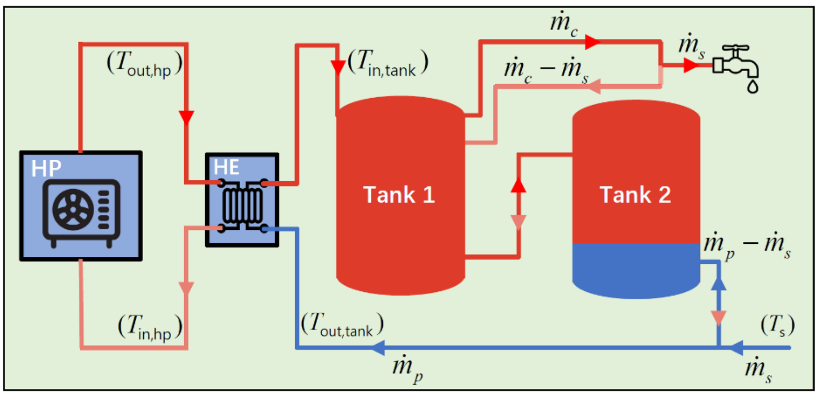

Figure 7: Schematic overview of the domestic hot water supply system in Kropman's use-case office building

Key activities

– Development of control-oriented building and system models suitable for optimisation and real-time control.

- Design of multi-objective optimisation strategies, balancing energy cost, CO_2 emissions, grid constraints and indoor comfort.
- Development of Model Predictive Control (MPC) and optimisation algorithms that exploit building thermal inertia and installation flexibility.
- Integration of prediction outputs (from Result 3) into control and optimisation workflows.
- Implementation of prototype flexibility management plug-ins.
- Testing and validation of control strategies through simulation studies and living lab experiments.
- Iterative refinement of control approaches based on practical constraints observed in operational buildings., including new Robust Optimization algorithms

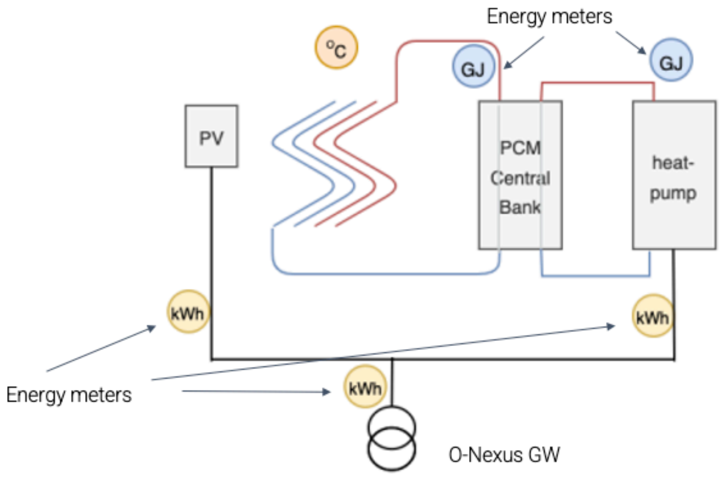

Figure 8: Test set-up of O-Nexus at The Green Village

Key results

- Multi-objective optimisation methods addressing energy use, flexibility, emissions and comfort (D2.04, D2.05, D2.06).
- Model Predictive Control (MPC) strategies for exploiting building thermal inertia and installation flexibility (D2.04, D2.05, D2.06).
- Prototype software plug-ins for flexibility management and energy optimisation (D2.06, D2.07, D2.08).
- High-frequency energy balance and control workflows supporting predictive optimisation (D2.04, D2.05).
- Simulation and field-test results quantifying achievable load shifting and peak reduction under defined conditions (D2.06, D2.07).
- Implementation insights and validation outcomes describing requirements for data quality, system access and control stability (D2.06, D2.07, D2.08).
- Prototype-level optimisation concepts and software components, forming a basis for further development rather than deployable products (D2.04, D2.05, D2.06, D2.07, D2.08).

Contributing partners

TU Delft, TNO, Avans Hogeschool, DWA, Deerns, O-Nexus, Kropman

Deliverables

- D 2.04 | D.2.05 Open high-frequency energy balance model & Flexibility management control system.
- D 20.6/D 2.07 D 2.06: Implementation of flexibility management & control & Proof-of-principle of selected functions of flexibility management.
- D 2.08: Open balance software implementation by industrial partners.
- Software code: Tamas & Yun Li

Next to the listed deliverables, two companies involved in WP2 drafted separate reports detailing the results they achieved and their progress on the project. These include reports from:

- Almende: Crownstone IPS for smart offices
- Peutz: Research on sensor data interpretation through a hybrid inverse modelling approach and fictitious sensors

4 WP 3: SMART USER-TARGETED INTERFACES AND FEEDBACK

The goals of WP3 were to:

1) Develop & test methods to collect and assess real-time comfort feelings by occupants
2) Understand which feedback occupants need to accept flexibility solutions
3) Develop methods for using occupant data in models and Fault Diagnosis
4) Develop visualisations that can help occupants and designers to understand technology/occupants
5) Design and evaluate occupant/technology interfaces

Goals 1 to 3 are handled in Result 5, while goals 4 and 5 are addressed in Result 6. The highlights in WP3 are:

- Measurement protocol for user-reported comfort and coupling with sensor data, tested in 2 living labs: HAN building and HHS building.
- 4 instruments to collect user-reported comfort and health data: QR-codes, Vote boxes, Comfort apps and Smart Watches.
- Structured data sets linking user perception, indoor climate indicators and system behaviour.
- Evaluation of user behaviour models for potential integration in hybrid modelling and control approaches
- interface concepts, design methods and prototype designs, dashboards and feedback mechanisms (including filtering, notifications, and feedback prompts).
- Interface redesign studies in 2 use-cases: Philips Campus and HINES Building from Spectral.

4.1 Result 5: Methodology & data for user-centered approach in smart building control

Core focus

Developing a methodological and data-driven foundation for incorporating user comfort, health, behaviour and perception into smart building monitoring, commissioning and control, in a way that is compatible with technical optimisation approaches.

Key activities

- Development of methods to assess comfort, health and user perception, combining indoor environmental measurements with user input.
- Design and execution of user studies, including questionnaires, interviews and workshops, in office and educational buildings.
- Collection of user-related data and indoor climate data in living labs, following privacy and ethical guidelines.
- Development of data sets and indicators linking user perception, indoor climate quality and system behaviour.
- Exploration of how user-related data can support fault detection, diagnostics, commissioning and control in interaction with Results 1–4.

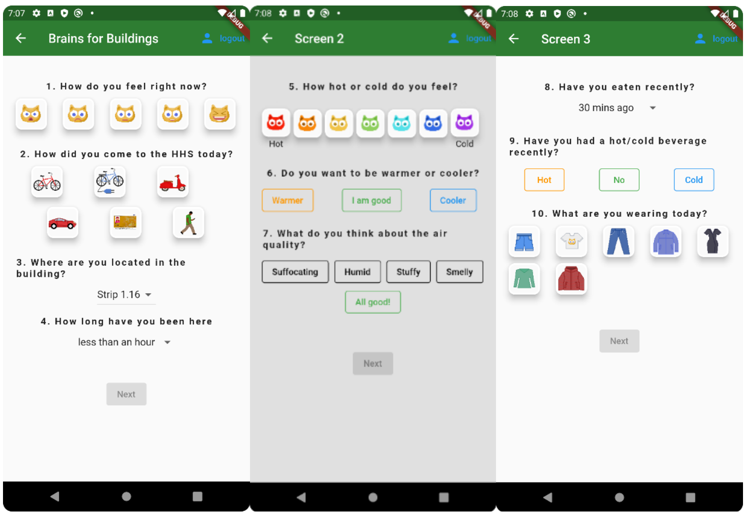

Figure 9: Screenshots of the mobile comfort App

- Review and evaluation of user behaviour models for potential integration in hybrid modelling and control approaches.
- Testing and refinement of methods in operational building contexts.

Key results

– A documented methodology for systematically assessing user comfort, health, and perceptions of building operations was delivered, suitable for application in non-residential buildings (D3.01).
– Measurement protocols and instruments were developed and tested for collecting user-reported comfort and health data alongside indoor environmental measurements (D3.01, D3.05).
– Structured data sets were produced that link user perception, indoor climate indicators and system behaviour, enabling joint analysis of technical and user-related performance (D3.05).
– Indicators and metrics were defined that translate user feedback into information usable for diagnostics, commissioning and evaluation of building operation (D3.04, D3.05).
– Validated approaches were established for combining subjective user input with objective sensor data under real-world constraints, including privacy and participation limitations (D3.05, D3.07).
– Design and data requirements were documented to support subsequent development of user-oriented interfaces and feedback mechanisms (Result 6) (D3.03, D3.06).
– The result provides practical methods, data structures and insights that support user-centred building operation, rather than automated user-adaptive control solutions (D3.07, D3.08).

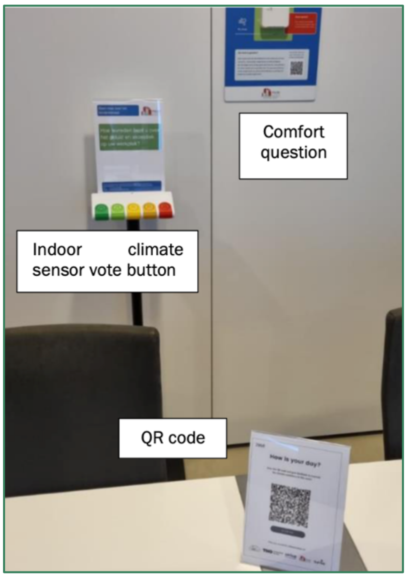

Figure 10: Set-up of the experiment at the office of Spie

Contributing partners

TNO, TUD, TU/e, BinnenklimaatNederland, Avans, RVB, Unica, O-Nexus, Spie, Spectral, APTA Technologies RVB, DGBC, Unica, O-Nexus, Qien (Cloud Energy Optimizer), HAN, Almende

Deliverables

– D3.01 – User-oriented determination method for comfort and health.
– D3.03 / D3.06 – Interface and data requirements based on interviews, surveys and international workshop input.
– D3.04 – Method to determine relevant feedback to help office users understand climate system control strategies.
– D3.05 – Comfort and occupant behaviour data for fault detection, diagnostics and building control/management.
– D3.07 – Determination of behavioural changes and relevant feedback to improve flexibility management and user acceptance.
– D 3.08 – Review and evaluation of user behaviour models for use in hybrid modelling and control approaches.
– Software code: self-reporting app.
– Software code: interpretable machine learning for FM

4.2 Result 6: Prototypes of user-oriented interfaces for healthy indoor climate, energy-efficient and energy flexibility of the building.

Core focus

Developing and validating prototype user-oriented interfaces (for occupants, facility managers and building professionals) that translate indoor climate and system information into actionable feedback, supporting healthier indoor climate, energy efficiency and (where relevant) energy-flexible operation.

Key activities

- Translating user requirements and personas into interface concepts and prototype designs.
- Developing and iterating dashboards and feedback mechanisms (including filtering, notifications, and feedback prompts).
- (Re)designing interfaces based on design dimensions and design guidelines derived from WP3 methods.
- Implementing prototypes in practice contexts (including a beta application trajectory) and preparing usability testing.
- Testing and validating interface concepts via focus groups and field activities in selected buildings and living labs

Key results

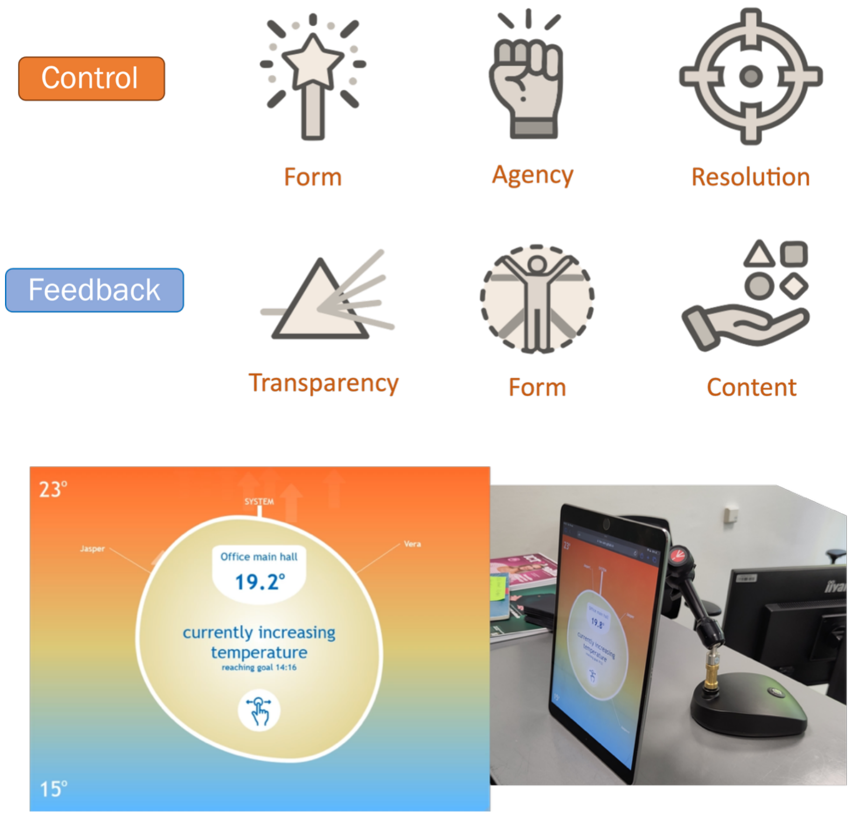

Figure 11: Research through design: design dimensions

- Prototype user-oriented interfaces for indoor climate quality, energy performance and system status, tailored to different user groups (D3.09, D3.10, D3.12).
- A set of dashboard components and visualisations translating monitoring and diagnostic data into user-readable information (D3.10, D3.12).
- Feedback and interaction mechanisms enabling user input on comfort and perception in relation to building operation (D3.09, D3.10).
- Validated interface concepts based on testing in operational environments under realistic data conditions (D3.11, D3.12).
- Design guidelines and implementation insights for integrating user-oriented interfaces with existing building management and analytics platforms (D3.10).
- Documented limitations and boundary conditions related to data availability, integration effort and user onboarding (D3.11, D3.12).
- A collection of tested interface prototypes and design artefacts forming a basis for further development rather than finished products (D3.10, D3.11, D3.12).

Contributing partners

HAN, Spectral, O-Nexus, Unica, OfficeVitae, TNO, TU/e, TUD, Avans

Deliverables

- D3.09 – Interface requirements/programme of requirements for different stakeholder groups (personas, requirements as input for redesign).
- D3.10 – Results of applying WP3 methods to the (re)design of interfaces; synthesis into design insights and guidelines.
- D3.11 – Testing and validation approach and results for interfaces based on the design guidelines
- D3.12 – User-centric approach for the design and evaluation of smart buildings.

5 WP 4: DATA INTEGRATION FOR SMART COMMUNICATION

The aims of WP4 were to:

1) Develop a Privacy, Ethics and Security framework
2) Determine how to integrate different types and formats of data in a building to facilitate their use
3) Inventory Market and Standardisation Opportunities
4) Deliver data sets for the living labs
5) Develop methods for the Smart Readiness Indicator

Goal 1 is handled in Result 7, goals 2 to 4 in Result 8 and goal 5 in Result 9. The highlights are as follows:

– A reference architecture for system-level data integration in smart buildings, based on API-level connectivity
– A Privacy, Ethics and Security framework, with practical guidance
– A practical road map for data-related asset management
– A main step in standardisation: Actualization ISSO 115 publications (Building Automation and Energy Monitoring in non-residential buildings) based on Reference Data Architecture and Privacy, Ethics and Security Framework
– Reference architecture successfully implemented for data integration in 2 living labs: Atlas Building TU/e, TU Delft Building 33.
– Public historical and/or live data in living labs TU Delft, TU/e and HHS
– Two market tools to assess Smart Readiness: Deerns SRI-tool, tested in use cases Philips Campus and Heijmans; and the VIKTOR platform from W/E.

5.1 Result 7: Standardised methodology for secure and ethical access to and use of data

Core focus

Ensuring that data-driven smart building solutions can be developed and applied in a way that is privacy-aware, secure and ethically responsible, while remaining practically applicable for asset owners and service providers.

Key activities

– Analysis of relevant regulations, standards and practices related to data privacy, security and ethics, with specific attention to GDPR.
– Interviews with asset owners, service providers and other stakeholders to understand how regulatory requirements are interpreted and applied in practice.
– Examination of data ownership, data governance and responsibility distribution in smart building contexts.
– Development of an integrated perspective on privacy, security and ethics, including attention to cyber-physical risks associated with connected buildings.

Key results

– A consolidated overview of regulations, standards and practices for privacy, security and ethical use of building data, including GDPR-related constraints (D4.01).
– A standardised assessment framework for privacy, security and ethics in data integration and analytics solutions for smart buildings (D4.05).
– Clarified role definitions and responsibility structures for data ownership, access and use within building ecosystems (D4.05).
– A set of assessment criteria and checklists supporting structured evaluation of data-driven applications.
– Identified cybersecurity risk categories relevant to connected building systems and incorporated them into the assessment framework (D4.01, D4.05).

- Practical guidance materials supporting responsible adoption of smart building data applications, without formal certification or enforcement (D4.05).

Contributing partners

TU/e, TNO, TUD, WE, NEN, DGBC, RVB, Philips RE, Simaxx, Kropman, Deerns, Qien, Philips RE, Simaxx.

Deliverables

- D 4.01 Literature and market study of existing regulations and approaches regarding data privacy, ethics, and security, including GDPR constraints
- D 4.05 Privacy, ethics, and security framework with a view to increasing market acceptance and innovation.

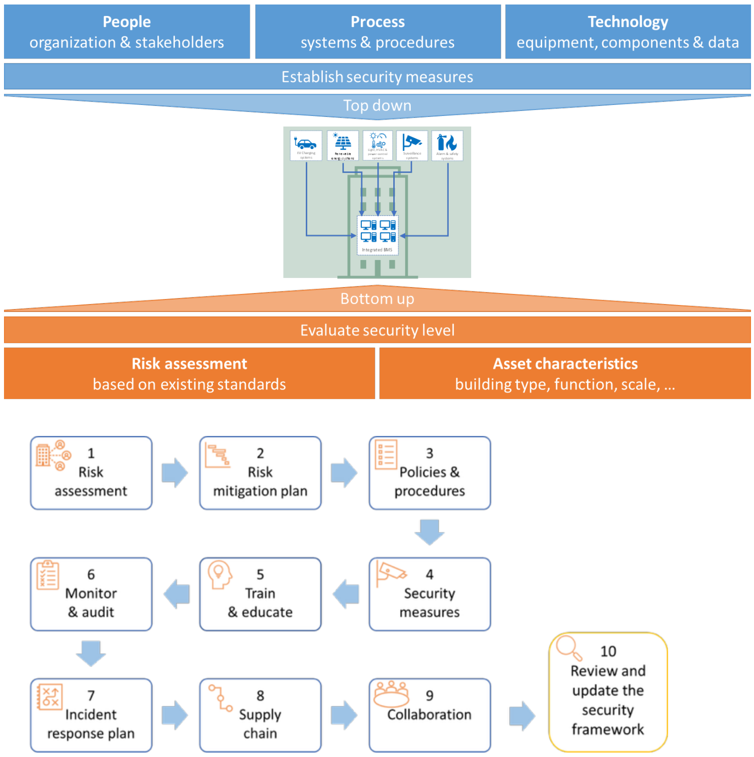

Figure 12: Standardised assessment framework for privacy, security and ethics

5.2 Result 8: Linked data at the systemic level, leading to system integration via APIs

Core focus

Improving system-level interoperability in smart buildings by enabling data exchange across heterogeneous systems through API-based integration and semantic structuring, rather than through full data standardisation.

Key activities

- Identification and documentation of data needs and requirements for a range of smart building use cases.
- Development of example data sets and access procedures based on living lab buildings.
- Design of a reference system architecture for smart buildings, focused on API-level integration.
- Implementation and testing of the architecture at TUe, TUD and Kropman, including experiments on:
- Semantic metadata generation (#GenerateMyDataMetaSchema)
- Real-time data access (#RealTimeDataAccess)

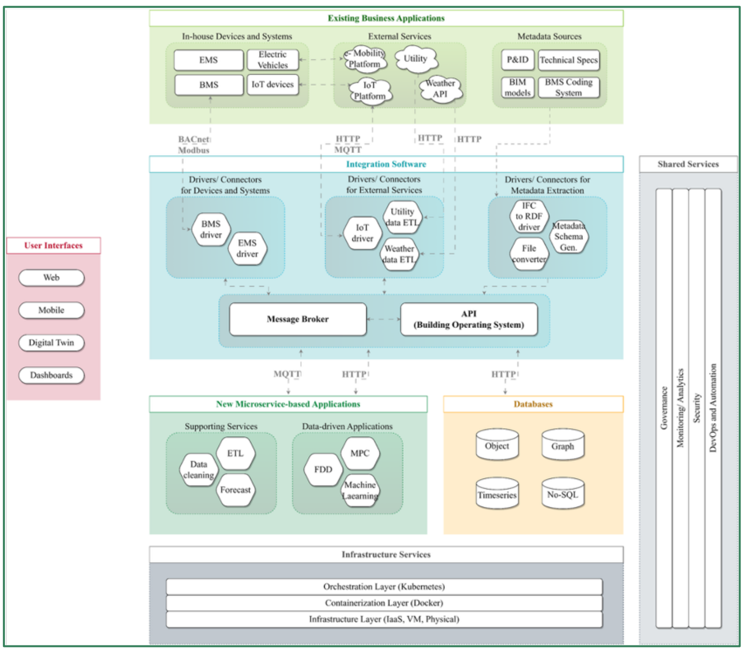

Figure 13: Reference architecture for smart buildings.

- Inventory and analysis of relevant standards for data management and integration, covering national and international frameworks (NEN, CEN, ISO, CENELEC).
- Development of a practice-oriented roadmap to support asset owners in leveraging existing data and gradually moving towards more advanced, data-driven building operations.

Key results

- A reference architecture for system-level data integration in smart buildings, based on API-level connectivity (D.4.06).
- Documented data needs and requirements for data exchange between building systems and applications (D4.03).
- Semantic data structures and metadata approaches supporting interpretability and reuse of building data (D4.02, D4.03, D4.06).
- A validated proof-of-concept for real-time data access and system integration in operational building contexts (D4.02, D4.06).
- A consolidated overview of relevant standards for data management and integration (NEN, CEN, ISO), supporting navigation of the standards landscape (D4.08).
- A Roadmap for Leveraging Smart Buildings, translating technical insights into stepwise guidance for asset owners (D4.07).

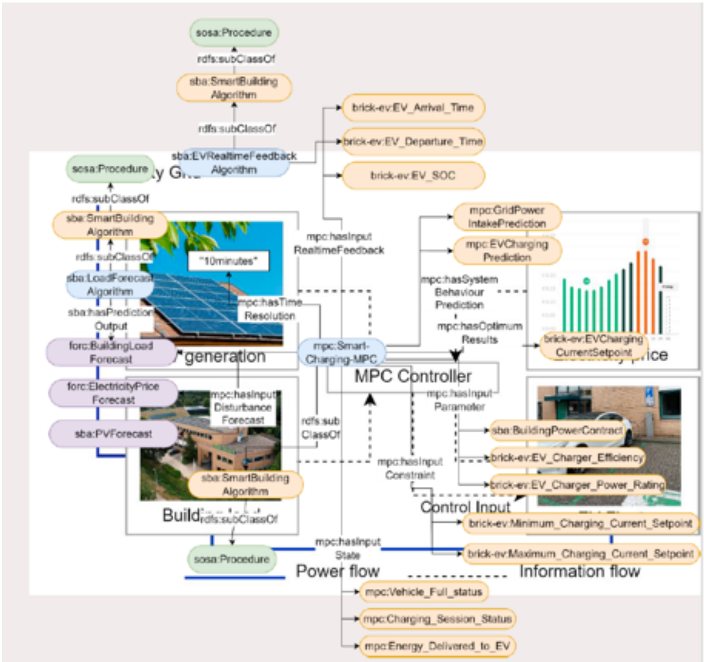

Figure 14: Experiment with #RealTimeDataAccess testing MPC targeted at energy flexibility

- Identified scalability limitations and boundary conditions related to heterogeneity of building systems and organisational constraints (D4.09, D4.03).
- ISSO publication: Update of ISSO 115 “Ontwerpeisen voor gebouwbeheerssystemen.

Contributing partners

TUe, TNO, TUD, WE, NEN, DGBC, RVB, Philips RE, Simaxx, Kropman, Heijmans, Royal Haskoning DHV

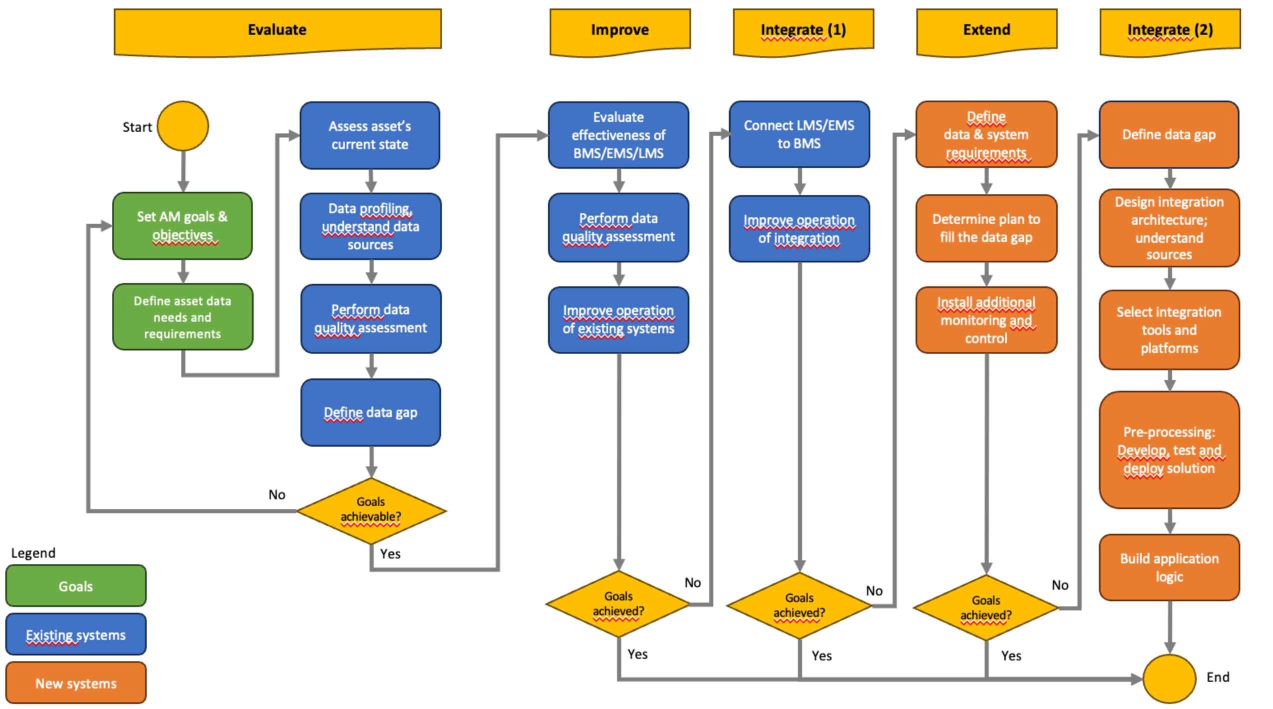

Figure 15: Roadmap for leveraging Smart Buildings: A practical roadmap for achieving asset management goals through data-driven building solutions

Linked deliverables

- D 4.03 Data needs & requirements plan that can be used for data collection and integration
- D4.08 Report standardisation of data management and integration results (NEN, CEN, ISO)
- D 4.07 Roadmap for leveraging Smart Buildings
- D 4.09: Evaluation of business opportunities for the market adoption of technical solutions in smart buildings
- D 4.02 Data set for internal research purposes
- D 4.06 Reference system architecture for data integration in smart buildings
- Software code: Live data access 4 control: Johnson control BMS data extraction
- Software code: Generate #metadatascheme

5.3 Result 9: Standardised methodologies & guidelines for determining and transforming into 'smart readiness'

Core focus

Providing a practical and structured method to assess the current level of smartness of buildings and to support informed decisions on how buildings can be incrementally improved.

Key activities

- velopment of a Smart Building Quick Scan covering multiple dimensions, including HVAC, energy performance, monitoring and control, connectivity, data and user interaction.
- Testing and internal application of the methodology on real buildings.
- Analysis of the relationship between the developed approach and the European Smart Readiness Indicator (SRI).
- Translation of assessment outcomes into guidelines and improvement pathways that are understandable for both technical and non-technical stakeholders.

Key results

- A Smart Building Quick Scan methodology for assessing smart readiness across multiple technical and organisational domains (D4.04).
- Assessment criteria and scoring structures supporting structured evaluation of building smartness (D4.04).
- Guidelines for prioritising improvement measures based on smart readiness outcomes (D4.04).
- Benchmarking and validation insights derived from the application of the methodology across multiple buildings (D4.10).
- Decision-support materials that enable dialogue among asset owners, advisors, and technical stakeholders (D4.04).
- A practice-oriented assessment framework positioned as guidance rather than a regulatory or certification instrument (D4.04, D 4.10).

Contributing partners

WE, TUe, TNO, TUD, Deerns, NEN, RVB, DGBC, Philips RE, Kropman

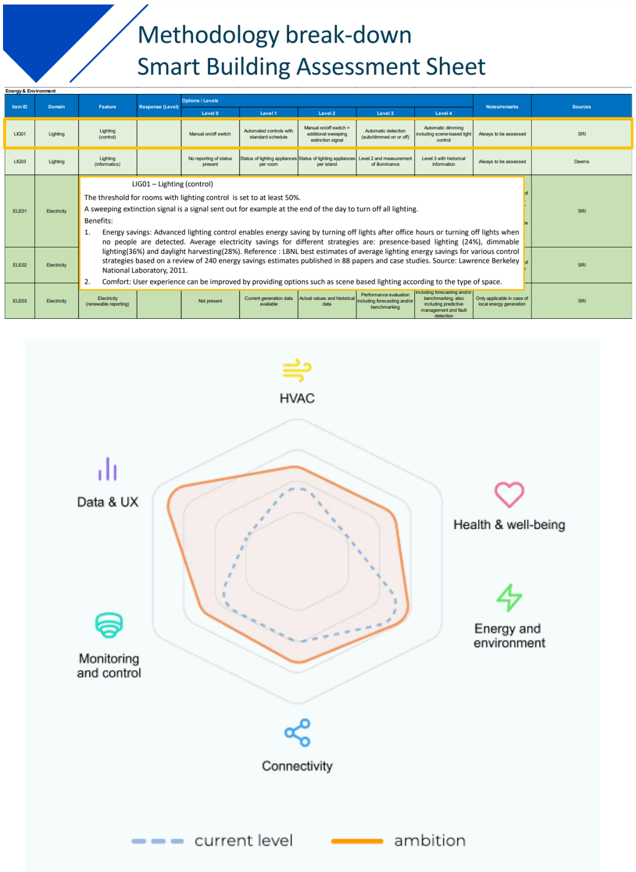

Figure 16: Smart Readiness Assessment tooling

Deliverables

- D 4.04 Smart Building Assessment + SRI tool
- SRI tool
- D 4.10 Benchmark analysis and validation of smart readiness indicator

6 WP 5: LEARNING COMMUNITY

The main goals of WP5 were to:

1) Set up a learning community "smart buildings"
2) Set up a knowledge platform
3) Develop a "refresher course" Smart building essentials"

Main achievements are:

– 24 public webinars and a lively community consistently meeting twice a year.
– A MOOC-like platform about HVAC for data scientists and data science for HVAC engineers Brains4Building open knowledge platform)
– A refresher course "Smart building essentials"
– MOOC, Course, and all other deliverables sustainably hosted on Dutch Green Building Council platform, DGBC kenniscentrum.

6.1 Result 10: Learning community "Smart buildings"

Core focus

Creating a sustainable learning community around smart buildings that supports knowledge exchange, reflection and capacity building among researchers, industry partners and building professionals, and contributes to broader dissemination of project insights.

Key activities

– Setting up the organisation of the learning community:
– Definition of the scope, objectives and target groups of the learning community
– Establishment of an organisational structure, including roles, coordination and communication arrangements, and
– Organisation of learning community meetings and sessions focused on smart building themes addressed in the project.
– Building a knowledge platform:
– Collection and structuring of project knowledge, insights and lessons learned from living labs and work packages
– Development of a shared knowledge base to support access to presentations, summaries and reflection documents, and use of the platform to support exchange between research and practice, rather than as a public dissemination portal.
– Development of refresher course 'Smart Building Essentials':
  - Design of a refresher course concept based on the knowledge and experiences developed within the project.
  - Translation of project insights into educational content suitable for professionals seeking an overview of smart building principles and
  - Preparation of course materials and learning objectives to support capacity building beyond the project duration.

Key results

– A gradually formed learning community within the consortium, emerging through recurring consortium meetings focused on shared reflection, exchange of experiences and joint interpretation of project results (D 6.01).
– A functioning knowledge and learning platform serving as the central repository for project knowledge, including structured insights, presentations, summaries and reflection materials (D 6.02, D 6.03).
– An integrated refresher course, 'Smart Building Essentials', is embedded within the DGBC platform and consists of modular learning content and supporting materials derived from project outcomes (D 6.03).

- A series of webinars used as a structured means for knowledge transfer and exchange, enabling the dissemination of project insights and interaction with a broader professional audience beyond the consortium (see Annex 3) (D 6.01, D 6.03).
- A curated and shared knowledge base covering technical, organisational and user-related aspects of smart buildings, developed incrementally during the project (D 6.02, D 6.03).
- A common reference framework and vocabulary for smart buildings, supporting alignment between consortium partners and external stakeholders (D 6.02, D 6.03).
- A sustainable foundation for continued learning and professional development, with the platform, webinars and course materials enabling reuse of project knowledge beyond the project duration (D 6.01, D 6.02, D 6.03).

Figure 17: Brains4Buildings Webinar series

Figure 18: DGBC Knowledge centre on smart building essentials

Contributing partners

TUD, DGBC, FHI and all other project partners

Deliverables

- D 6.01 – Setup and organisation of the learning community smart buildings
- 🔗 D 6.02 – Knowledge platform and documentation of learning community activities and lessons learned
- 🔗 D 6.03 – Refresher course *Smart Building Essentials*, including course structure and learning materials

7 PERSPECTIVE: SPIN-OFF INSIDE AND OUTSIDE THE SECTOR & FOLLOW-UP PROJECTS

7.1 Introduction: spin-off per application area

– The Brains for Buildings (B4B) project was explicitly designed not only to generate scientific insights but to accelerate market-ready solutions for smart buildings. Over the project duration, B4B has demonstrably acted as an innovation accelerator, enabling participating companies to translate research outcomes into new products, platforms, methods, and services.
– This chapter provides an overview of spin-offs within and beyond the traditional building sector, structured by the application areas for smart buildings defined in Deliverable 4.09. For each application area, we clarify:
  - Which concrete products and methods have emerged
  - Who already benefits today
  - Who is expected to benefit next

Figure 19: Overview of the B4B solutions per application area.

The focus is deliberately on tangible outcomes rather than concepts or future ideas.

Application Area – Fault Detection, Diagnosis analysis in HVAC Systems

Products and Methods Resulting from the Project

– Automated Fault Detection and Diagnosis (FDD) approaches
– Structured methodologies for identifying systematic errors
– Data-driven analysis tools to detect inefficiencies in HVAC systems
– Plug-in concepts for integration in Building Management Systems (BMS)
– Monitoring and performance analysis methods

Who Already Benefits

– Building owners and facility managers participating in pilots benefit from improved insight into system performance.
– Maintenance companies gain better tools to identify faults and optimise service activities.
– Engineering firms can apply structured diagnostics in their advisory services.

Who Will Benefit

– Asset owners seeking to reduce operational expenditure.
– Service providers offering performance-based contracts.
– Building operators aiming to reduce energy consumption and CO_2 emissions.

Outside the building sector, the structured diagnostic methodologies may also be relevant for other technical asset management domains.

Application Area – Energy flexibility and Demand Side Management (DSM)

Products and Methods Resulting from the Project

- Methods for assessing building energy flexibility
- Control strategies for flexible multi-objective optimisation
- Forecasting models for energy demand and supply
- Optimisation algorithms for peak reduction and demand shifting
- Integration approaches linking building systems with grid-related signals

Who Already Benefits

- Pilot buildings implementing flexibility strategies.
- Engineering and advisory firms developing grid-aware building concepts.
- Stakeholders facing grid congestion challenges.

Who Will Benefit

- Grid operators that require peak load reduction.
- Real estate portfolios transitioning toward electrification.
- Energy service providers offering flexibility services.

Outside the building sector, predictive control and optimisation approaches may be transferable to broader energy system applications, including district heating

Application Area – Occupant and occupant behaviour prediction

Products and Methods Resulting from the Project

- User-oriented interface concepts
- Methodologies for incorporating occupant feedback
- Structured approaches to translate subjective input into performance indicators
- Behaviour-informed control strategies
- Design dimensions supporting user-centric interface development

Who Already Benefits

- Occupants in pilot environments are experiencing improved transparency and control.
- Facility managers in the pilots receive more structured feedback on comfort issues.
- Interface developers applying user-centric design approaches.

Who Will Benefit

- Asset managers aiming to improve user satisfaction and to build value.
- Employers seeking healthier and more comfortable workplaces.
- Developers of smart building applications integrating behavioural aspects.

Beyond the building sector, structured user feedback integration may support broader development of the human-technology interface.

Application Area – Asset Management and Monitoring building performance

Products and Methods Resulting from the Project

- A reference architecture for data exchange and structure in smart buildings
- Methods for integrating heterogeneous data sources
- Semantic modelling approaches
- Procedures for metadata generation
- Guidelines for secure and ethical data use
- A roadmap for leveraging smart buildings

Who Already Benefits

- Advisory firms integrating smart readiness assessment approaches.

– Technology providers applying structured data integration methods.
– Participating Organisations are improving digital building infrastructures like NEN, ISSO and DGBC.

Who Will Benefit

– Public and private building owners aiming to scale smart building deployment.
– Digital twin solution providers.
– Stakeholders involved in Smart Readiness implementation.

Outside the building sector, semantic data integration and interoperability principles support cross-domain digital transformation initiatives.

Cross-Sector Spin-offs and Knowledge Infrastructure

Beyond individual products, B4B has generated cross-sectoral spin-offs:

– Open and semi-open method libraries (DBN models, AFDD building blocks)
– Learning communities, summer schools, and professional tracks

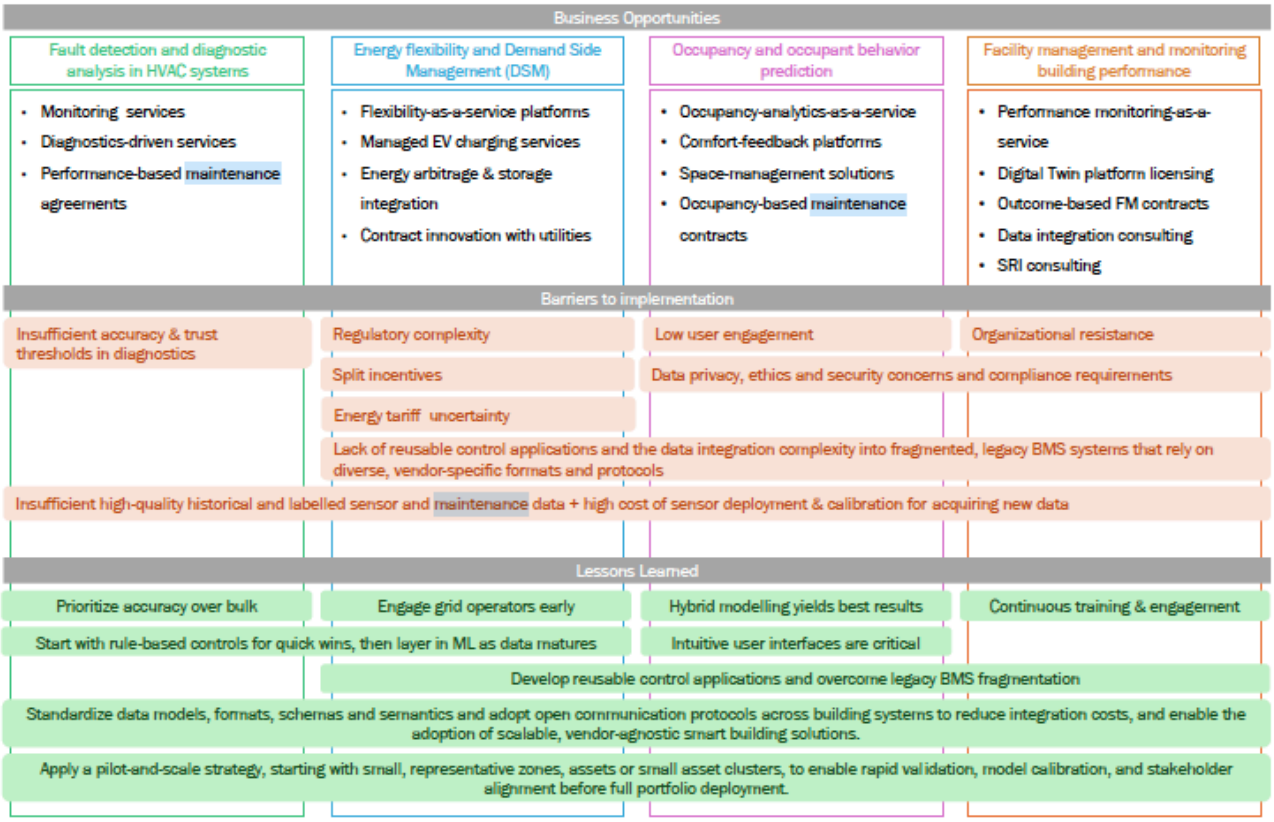

Figure 20: Overview across the four application areas of the common and unique business opportunities (top layer), the barriers to implementation (middle layer) and the lessons learned (bottom layer).

7.2 Follow-up projects

The Brains for Buildings project has resulted in multiple funded follow-up projects that are currently operational. These include publicly funded research and innovation projects, partner-funded pilot deployments, internally financed platform continuations, and commercially funded client projects. All identified follow-ups demonstrably build on methods, software, sensor concepts, or frameworks developed within B4B. Together, they confirm that B4B outcomes have successfully transitioned from research into sustained application and further development.

8 CONTRIBUTION TO THE OBJECTIVES OF THE MOOI SCHEME

The B4B project contributed to the realisation of the MOOI theme 'built environment' by developing smart, integrated, user-friendly prototypes of affordable, modular, and scalable software plug-ins for utility buildings.

(1) Less energy is wasted in installations' heating and cooling supply and the related CO_2 emissions.

The B4B project focused on buildings equipped with Building Automation and Control Systems (BACS) Since 1 January 2026, all buildings with a combined heating and/or cooling capacity of 290 kW or more must have a BACS in place. As of 1 January 2030, this requirement will also apply to buildings with a capacity above 70 kW. This means that a large share of non-residential buildings must have a BACS installed, enabling them to actively monitor energy consumption, detect energy waste, and take action to eliminate it.

It is difficult to determine how many non-residential buildings will exceed the 70 kW threshold, as this depends on insulation levels, the efficiency of building installations, and the building's use. As a rule of thumb, we assume that all non-residential buildings with a floor space above 1000 m^2 will need to comply with the BACS obligation. According to RVO (2026), this corresponds to about 9% of the total non-residential floor area.. Of this, about half of the floor space is occupied by industry and health care buildings. We assume that these buildings are exempt from the BACS obligation. This leaves about 50.000 m^2 of buildings (4% of the total non-residential floor area) that already have or still need to install a BACS. If we assume that most building owners have not yet invested in continuous monitoring of energy performance, a conservative estimate is that about 15%-30% savings can be achieved, which equals an emission reduction of 0.3-0.5 Mton of CO_2[1]. This is very substantial compared with the national aim of reducing 3.4 MT of CO2 in the Built Environment by 2030.

In addition, in work package 1 of B4B, a simulation-based method for estimating energy waste from malfunctioning air handling units was developed, showing, for instance, that failure of the heat recovery wheel results in 32% energy waste (for the total HVAC system). However, this fault does not occur very often, and, statistically speaking, on many AHUs (more than 11,000 were studied), it would result in only 10% waste. This is the first time such statistically valid insights have been generated.

(2) Increase in end-user comfort, indoor air quality and user-friendliness of decentralised control systems.

Ultimately, every technical solution stands or falls with its acceptance and correct use by the end user. Until now, it has rarely been included in research on fault diagnosis and control strategies. End-user comfort and indoor quality are generally accounted for by setting boundaries for acceptable temperatures and indoor CO2 Emissions. This, however, is a very static approach with no possibility for interaction. In B4B project, a complete work package was devoted to methods to continuously measure user experience and acceptance, and to test it in diverse use-cases. Including it in the design of controls and interfaces will, in addition to additional energy savings, lead to wider acceptance of smart control systems.

(3) Greater controllable energy flexibility that increases the use of self-produced renewable energy for heating and cooling and reduces system costs for transforming the built environment by 20-40%.

By smart storage capacity management, local sustainable energy production can be increased by 40-50%, and fossil sources are reduced proportionally (TopSector Energie; Onderzoek Navigant 2019). A 90-95% increase is also mentioned, but the costs are still very high. Assuming a modest Onsite Energy Matching value of 40%, building self-consumption of approximately 15% can be increased to 40%. Regarding net congestion, the most important thing is reducing the peak load by shifting demand. In the B4B project, we investigated how to realise this in practice by using Model Predictive Control methods that can cope with uncertainties arising in real-world situations, such as weather uncertainties and building mass affecting the shifting potential of heat pumps and associated buffer tanks.

[1] For these calculations energy numbers were taken from (WE, 2025) MEPS and ZEB Utiliteit. Bijlage 1 tabel 8. Assuming: Average use use per building fuctions equals use for building period 1978-1995, and for office buildings average use is energy label C.

9 DISSEMINATION OF PROJECT RESULTS

Dissemination and communication have been a core component of the Brains for Buildings (B4B) project, aimed at ensuring that project results were shared effectively with scientific, professional and societal stakeholders. The dissemination strategy combined internal knowledge exchange, scientific dissemination, professional outreach and broader communication activities, thereby supporting uptake of results beyond the consortium.

An important internal dissemination mechanism was the periodic consortium meetings, which served as structured opportunities for knowledge exchange among work packages and partners. These meetings enabled alignment of methodologies, discussion of intermediate results, and cross-fertilisation between academic and industrial perspectives. The meetings were, on average, attended by 60-70 participants from the consortium partners, and almost all partners kept actively engaged throughout the whole project period. The final consortium meeting served as a synthesis event, focusing on integrated results, lessons learned and the identification of concrete follow-up activities.

External dissemination to professional and policy audiences was organised through a final conference, where the project's main outcomes were presented and discussed with an audience of over 200 participants from industry, government and knowledge institutes. This event highlighted validated methods, tools and use cases, and facilitated interaction with stakeholders outside the consortium.

In addition, B4B actively disseminated results through webinars, which proved an effective format for reaching a broad and diverse (international) audience. The webinars focused on key project themes, including smart sensing, fault detection and diagnosis, data-driven building operations, and practical implementation challenges. They enabled interactive engagement with professionals who could not attend physical events and supported wider knowledge transfer (see Annex 3). The attendance ranged from over 100 participants for webinars organised during the COVID pandemic to approximately 20-40 participants in the following years. The webinars were also viewed extensively after the live sessions via recordings on our website.

Scientific dissemination formed a central pillar of the dissemination strategy. Project partners contributed to peer-reviewed scientific publications addressing topics such as fault detection and diagnosis, data-driven control strategies and smart sensing in buildings. In parallel, B4B results were disseminated through REHVA publications and special issues. In total 50 papers were published ensuring direct outreach to the HVAC and building services community (see Annex 2).

Beyond formal publications, project results were shared through numerous presentations at national and international conferences, workshops and sector events. These presentations targeted researchers, engineers, facility managers and policymakers, and played an important role in translating research outcomes into actionable insights (see Annex 4)

The project achieved broader visibility through media presence, including online articles, professional newsletters, project websites and sector platforms. This media outreach contributed to raising awareness of the B4B project, its results and their relevance for the energy transition in the built environment (see Annex 5).

Finally, positioning the learning platform, the course "Smart Buildings Essentials" and all deliverables of the project on the DGBC platform ensures a high visibility.

Together, these dissemination and communication activities ensured that B4B results were systematically shared with relevant audiences, supporting knowledge transfer, professional uptake and long-term impact beyond the project duration.

ANNEX 1: B4B DELIVERABLES

Del number	Title
D1.01	Real time Implementation of part of the 4S3F in 2 living labs
D1.02a	Publication about use-cases data processing for pre- and post-processing (Basic preprocessing)
D1.02b	Publication about use-cases data processing for pre- and post-processing (Advanced preprocessing and sampling)
D1.03a	Open library of standardized DBN models for the most common components & sensors / models / control in installations
D1.03b	Open library of standardized DBN models for the most common components & sensors / models / control in installations (Final): Fault detection and diagnosis for heat recovery ventilation using 4S3F
D1.04a	Impact of prior and conditionals probabilities in DBN (ready under embargo until publication)
D1.04b	Expansion of the method: additional data from building management in DBN/expert knowledge
D1.05a	Extension of the 4S3F HVAC B28 framework to account for end-user and indoor climate quality
D1.05b	Extension of the 4S3F AHU framework for identifying undefined end-user use and poor indoor climate quality analyzing subject live data
D1.05c	Extension of the 4S3F framework for identifying suboptimal controls in energy-flexible buildings
D1.06	Tools for Continuous Commissioning with a) Pareto LEAN energy analysis and b) data trends of continuous monitoring for detection and GBS plug-ins (to be further developed by industry partners)
D1.07	Evaluation Machine Learning algorithms, applying new sensors & possibilities dynamic air conditioning
D1.08a	Interim overview Machine learning software module (beta version) for FAULT DIAGNOSIS
D1.08b	D1.08b1 Final overview Machine learning and other techniques for FAULT DIAGNOSIS D1.08b2: State of the art DBN for Building energy systems
D1.10	Overview of existing knowledge and inventory of existing products with potential for application / First software modules for application condition dependent maintenance at sub-system level
D2.01 |D2.02| D2.03	Report on modular energy model of the HVAC and electrical system, open-source energy demand and energy supply forecasting methods and algorithms including accuracy of predictions
D2.04 | D 2.05	Open high-frequency energy balance model & Flexibility management control system
D2.06 | 2.07	Implementation of flexibility management control | Proof-of-principle of selected functions of flexibility management
D2.08	Open balance software implementation by industrial partners
D3.01	Method for monitoring and collecting real-time subjective comfort data

Del number	Title
D3.02	Method to assess occupants' comfort and health
D3.03 |D3.06	End-user requirements for fault detection and diagnosis control systems and interfaces + End-user requirements for energy flexibility control systems and interfaces
D3.04	Insight of what feedback to the user will help user acceptance, reduce complaints and increase energy saving
D3.05	Comfort and occupancy data for Fault Detection and Diagnosis
D3.07	Data-driven method to visualise building's systems, energy use, perceived health and impacts of behaviour, according to requirements of different end-users developed with ML algorithms
D3.08	Occupant models for use in hybrid building models
D3.09	Requirements for the re-design of interfaces for O-nexus, Unica and Spectral
D3.10	Interface guidelines for occupant-centered smart climate systems
D3.11	Practical use cases of design dimensions for interface selection and design in Smart Buildings
D3.12	User-centric approach for the design and evaluation on interfaces
D4.01	Literature and market overview of existing regulations and approaches on privacy, security and ethics
D4.02	Data test set for internal research purposes
D4.03	Data needs &requirements plan that can be used for data collection and integration
D4.04	Guidelines to make every building "smart", incl. specification of the Smart Readiness Indicator
D4.05	Privacy, ethics and security framework with a view to increasing market acceptance and innovation
D4.06	Reference system architecture for data integration in smart buildings
D4.07	Roadmap for leveraging smart buildings
D 4.08	Report standardization of data management and integration results (NEN, CEN, ISO)
D4.09	Evaluation of business opportunities for the market adoption of technical solutions in smart buildings.
D4.10	Benchmark analysis and validation of smart readiness indicator
D5.01	A structural partnership between participating educational institutions, knowledge institutes, companies to organize learning, working and innovation close to each other.
D5.02	Open knowledge platform where existing knowledge is collected and merged and clearly arranged (DGBC kenniscentrum and Brains4Building open knowledge platform)
D5.03	Learning track Smart Buildings (DGBC kenniscentrum and and Brains4Building open knowledge platform)

ANNEX 2: PUBLICATIONS

Date	Title	Publisher
2022 06	Dikken, Robbert Jan (2022) Gebouwen als dynamische component in het energienet	Peutz website (11-6-2022)
2022 07	Taal A., Itard L (2022) Automatic Energy performance Diagnostic of HVAC Systems by the4S3F method	CLIMA2022
2022 07	Wang Z., Meijer A., Itard L (2022) 4S3F Diagnostic Bayesian Network method: discussion about application and technical design	CLIMA2022
2022 07	Hajee, Bram; Wisse, Kees; Mohajerin Esfahani, Peyman (2022) Health monitoring: a machine learning approach for anomaly detection in multi-sensor networks	CLIMA2022
2022 07	Chamari, Lasitha; Pauwels, Pieter; Petrova, Ekaterina (2022) A web-based approach to BMS, BIM and IoT integration: a case study	CLIMA2022
2022 07	Mohammad Samir Ahmed, Joep Van der Velden, Paula Van den Brom, Ali Soleymani, Maaike Konings, Laure Itard, Marcus Specht, Ellen Sjoer, Wim Zeiler (2022) Learning and Knowledge Transfer of Professionals within the Building Services Sector	CLIMA2022
2022 07	Pieter Pauwels, Gabe Fierro (2022) A Reference Architecture for Data-Driven Smart Buildings Using Brick and LBD Ontologies	CLIMA2022
2022 07	Adrien Lucbert, Juliën van der Niet, Albert Corson, Michael Weij, Ramon Isaac van der Elst, Jesús Mª Martínez de Juan, Tadeo Baldiri Salcedo Rahol (2022) Time Series Building Energy Systems Data Imputation	CLIMA2022
2022 07	Chitkara, S., van den Brink, A. H. T. M., Walker, S. S. W. & Zeiler, W., (2022) An early prototype for fault detection and diagnosis of Air-Handling Units	CLIMA2022
2022 09	Zeiler, W. (2022) Energieflexibiliteit opschalen metdata-gestuurde slimme gebouwen: Internationaal project IEA Annex 81.	September 2022, 30-34, VVplus
2022 11	Zeiler, W. (2022) Brains for Buildings to achieve Net Zero. In A. Sayigh (editor), Achieving Building Comfort by Natural Means	Achieving Building Comfort by Natural Means redactie, Vol. Innovative Renewable Energy, blz. 1-2. Springer Nature.
2022 12	Wisse, K. (2022) Evaluatie klimaatklasse A in de praktijk	TVVL magazine Nr 6 December 2022

Date	Title	Publisher
2022 01	Vera Lange (2022) Creatieve onderzoeksmethoden verhelderen gebruikersperspectief	Website HAN
2022 01	Chorius, Misscha (2022) Energiezuinig gedrag bevorderen in kantoorgebouwen	Website HAN
2023 02	Xiang Xie, Jorge Merino, Nicola Moretti, Pieter Pauwel, Janet Yoon Chang, Ajith Parlikad (2023) Digital twin enabled fault detection and diagnosis process for building HVAC systems	Automation in Construction Volume 146, February 2023, 104695
2023 02	Wisse, K. (2023) Comfort apps: hoe vaak gebruiken we ze?	TVVL magazine Nr 1 February 2023
2023 03	Chamari, L., Petrova, E., Pauwels, P., van der Weijden, J., Boonstra, L. & Hoekstra, S., 30 Mar 2023. Metadata Schema Generation for Data-driven Smart Buildings	Proceedings of the 11th Linked Data in Architecture and Construction Workshop .
2023 03	Chamari, L., Petrova, E. & Pauwels, P., (20 Mar 2023) Extensible real-time data acquisition and management for IoT enabled smart buildings.	Proceedings of the 2023 European Conference on Computing in Construction.
2023 06	Srinivasan Gopalan, Hailin Zheng, Shalika S.W. Walker, Rick P. Kramer, Wim Zeiler (2023) Evaluation of the performance of low-cost monitors for their use in fault detection and diagnosis	Proceedings of Healthy Buildings 2023 Europe
2023 06	Karzan Mohammed, Vinayak Krishnan, Hailin Zheng, Shalika Walker, Rick Kramer, Wim Zeiler (2023) Low cost-effective measurements for schools	Proceedings of Healthy Buildings 2023 Europe
2023 06	Piet Jacobs, Coen Hoogervorst, Agata Rijs, Sander van der Harst, David Keyson (2023) User centric assessment of comfort and health in offices – an explorative field study	Healthy Buildings Europe 2023: Beyond Disciplinary BoundariesVolume: 2Pages: 713 - 720
2023 06	Boogaard, Stefan, Cheung, Dave and Salcedo-Rahola, Tadeo-Baldiri (2023) "Building Energy Flexibility Assessment with Static Data."	2023 International Conference on Future Energy Solutions (FES), IEEE, 2023, pp. 1–4,
2023 06	Dols, Isa, and Salcedo-Rahola, Tadeo-Baldiri (2023) "From Energy Flexibility to Design Choice."	2023 International Conference on Future Energy Solutions (FES), IEEE, 2023, pp. 1–6
2023 06	Spiekman, Marleen; te Duits, Noa; Lange, Vera; Jeurens, Jasper; Sluis-Thiescheffer, Wouter (2023) Methodology to develop interfaces to help office users better understand control strategies of climate systems	Healthy Building Conference 2023
2023 07	Yun Li, N Yorke-Smith, Tams Keviczky (2023) Robust Optimal Control with Inexact State Measurements and Adjustable Uncertainty Sets. IFAC-Papers Online	IFAC world congress 2023 (9-14 July 2023)

Date	Title	Publisher
2023 09	Hicham Johra, Han Li, Flavia de Andrade Pereira, Kingsley Nweye, Lasitha Chamari, Zoltan Nagy (2023) IEA EBC Annex 81 – Data-driven smart buildings: Building-to-grid applications	IEA EBC Annex 81 – Data-driven smart buildings: Building-to-grid applications. 4-6 September Shanghai
2023 10	Lasitha Chamari; Ekaterina Petrova; Pieter Pauwels (2023). An End-to-End Implementation of a Service-Oriented Architecture for Data-Driven Smart Buildings	IEEE Access, Volume 11
2023 12	Yun Li, Neil Yorke-Smith, and Tamas Keviczky (2023) Unlocking Energy Flexibility from Thermal Inertia of Buildings: A Robust Optimization Approach. IEEE Conference on Decision and Control 2023.	IEEE Conference on Decision and Control 2023
2023 12	Yun Li, N Yorke-Smith, Tams Keviczky (2023) Unlocking Energy Flexibility From Thermal Inertia of Buildings: A Robust Optimization Approach	62nd IEEE Conference on Decision and Control (CDC 2023), Singapore, December 13-15, 2023, pp. 2555-2562.
2023 03	Stephen White et al. (2023) International Energy Agency: A Data Sharing Guideline for Buildings and HVAC Systems	IEA Annex 81
2024 02	Robbert Jan Dikken (Peutz) Lokale zonvoorspelling met hybrid AI op basis van beperkte weerdata	TVVL Magazine
2024 04	A.C. Taal (2024) Foutdetectie en diagnose met behulp van de 4S3F-architectuur	TVVL Magazine
2024 06	Y. Li, N. Yorke-Smith and T. Keviczky (2024) “Robust Optimal Control With Binary Adjustable Uncertainties,”	Proceedings of the 22nd European Control Conference (ECC 2024) p 3721-3727),
2024 08	W. Tang, Y. Li, S. Walker and T. Keviczky (2024) “Model Predictive Control Design for Unlocking the Energy Flexibility of Heat Pump and Thermal Energy Storage Systems”	8th IEEE Conference on Control Technology and Applications (CCTA) to be held in Newcastle upon Tyne, UK, August 21-23, 2024 (p 433-439)
2024 09	Srinivasan Gopalan, Agata Rijs, Shobhit Chitkara, Anand Thamban, Rick Kramer (2024) “Fault prioritisation for Air Handling Units using fault modelling and actual fault occurrence data”	Energy and Buildings Sept 2024
2024 09	Pieter Pauwels, Lu Wan, Lasitha Chamari Rathnayaka Mudiyanselage, Juan David Barbosa Ramirez, Ekaterina Petrova, Gabe Fierro, Francesco Goia (2024) Metadata for Smart Control in Smart Buildings	ASHRAE Journal, Vol. 66, no. 9, September 2024
2024 10	Nitant Upasani a, Olivia Guerra-Santin a, Masi Mohammadi (2024) Developing Building-Specific, Occupant-Centric Thermal Comfort Models: A Methodological Approach	Journal of Building Engineering Volume 94, Oct 2024

Date	Title	Publisher
2024 10	Pieter Pauwels, Juan David Barbosa Ramirez, Lasitha Chamari Rathnayaka Mudiyanselage, Ekaterina Petrova, Lu Wan, Gabe Fierro, Francesco Goia (2024) The Meta of Data in Smart Buildings: What's In It For You?	ASHRAE Journal, Vol. 66, no. 10, October 2024
2024 12	Chujie Lu, Ziao Wij, Martin Mosteiro-Romero, Laure Itard (2024) Introducing Causality to Symptom Baseline Estimation: A Critical Case Study in Fault Detection of Building Energy Systems	Proceedings of ASim Conference 2024: 5th Asia Conference of IBPSA
2024 12	Martín Mosteiro-Romero*, Z. Wang, C.J. Lu, L.C.M. Itard (2024) Whole-Building HVAC Fault Detection and Diagnosis with the 4S3F Method: Towards Integrating Systems and Occupant Feedback	Proceedings of ASim Conference 2024: 5th Asia Conference of IBPSA
2024 12	Z. Wang, C.J. Lu, Martín Mosteiro-Romero, L.C.M. Itard (2024) Simultaneous presents faults detection by using Diagnostic Bayesian Network in Air Handling Units	Proceedings of ASim Conference 2024: 5th Asia Conference of IBPSA
2024 12	Li, Y., Yorke-Smith, N., & Keviczky, T. (2024). Machine learning enabled uncertainty set for data-driven robust optimization.	Journal of Process Control, 144, 103339.
2025 03	Karthik Mallikarjun Gunderi, Stefanie Doljé (2025) Bridging the Smart Readiness gap: A holistic approach to smart buildings	BUILD UP March 2024
2025 04	Marleen Spiekman, Vera Lange, Jasper Jeurens, Olivia Guerra Santin (2025) TVVL 2025	TVVL Magazine April 2025
2025 07	Chujie Lu and Laure Itard (2025) Leveraging LLM for P&ID-based Automated Code Generation in HVAC Fault Detection and Diagnosis	Proceedings CLIMA 2025, Milan, Italy, Jun 2025.
2025 08	Chujie Lu, Ziao Wang, Martín Mosteiro-Romero, Laure Itard (2025) Diagnostic Bayesian network in building energy systems: Current insights, practical challenges, and future trends	Energy and Buildings Volume 341, 15 August 2025, 115845
2025 10	Lars van Koetsveld van Ankeren, Chujie Lu, Laure Itard (2025) Implementing Diagnostic Bayesian Networks for Heat Recovery Ventilation in Real-world Scenarios: A Dutch Case Study	Journal of Building Engineering Volume 111, 1 October 2025, 113527
2025 11	Karzan Mohammed , Wei Luo , Shalika Walker , Rick Kramer (2025) Developing key performance indicators for occupant-centric buildings using occupant feedback: A scoping review and methodological framework	Energy and Buildings Volume 347, Part A, 15 November 2025, 116228
2025 07	Tang, W., Li, Y., Walker, S., & Keviczky, T. (2025) Model Predictive Control for Unlocking Energy Flexibility of Heat	Preprint

Date	Title	Publisher
	Pump and Thermal Energy Storage Systems: Experimental Results.	
2026 02	Li, Y., Yorke-Smith, N., & Keviczky, T. (2025) On Data-Driven Robust Optimization With Multiple Uncertainty Subsets: Unified Uncertainty Set Representation and Mitigating Conservatism.	Journal of Process Control
202511	Li, Y., Shi, J., Jones, C. N., Yorke-Smith, N., & Keviczky, T. (2025) Model predictive building climate control for mitigating heat pump noise pollution.	European Journal of Control
2025 08	Nitant Upasani, Olivia Guerra-Santin, Masi Mohammadi, Mazyar Seraj & Frans Joosstens (2025) Understanding thermal comfort using self-reporting and interpretable machine learning	Energy Efficiency (2025) 18:74
2025 12	The Rehva European HVAC Journal – Better climate control through better interfaces (Marleen Spiekman, Vera Lange, Jasper Jeurens & Olivia Guerra Santin) – Integrating Privacy, Security, and Ethics in Smart Buildings: A Practical Framework for Digital Resilience (Elena Chochanova & Tousif Rahman) – Towards Open-Structure BMS: AI for Forecasting and Predictive Control (Jan-Willem Dubbeldam, Petros Zimianitis, Shalika Walker & Joep van der Velden) – Brains4Buildings – Open Knowledge Platform: Practical Insights from Data (Martín Mosteiro Romero & Laure Itard) – Smart Building Reference Architecture with Linked Data (Lasitha Chamari, Jan-Willem Dubbeldam, Niels de Jong, Ekaterina Petrova & Pieter Pauwels) – Human-informed Building Automation: Enhanced Whole-Building System FDD (Martín Mosteiro Romero & Laure Itard) – The Home Battery in a Changing Energy Market (Patrick van Tol, Catharina Clasina Nollet & Tadeo Baldiri Salcedo Rahola)	
2026 01	Ziao Wang, Chujie Lu, Arjen Meijer, Shalika Walker, Laure Itard (2026) Fault detection and diagnosis for heat recovery ventilation using 4S3F method: impact of diverse sensor configurations	Energy and Buildings (January 2026)
2026	Martín Mosteiro-Romero, Ziao Wang, Arie Taal, Chujie Lu, Laure Itard (2025) Diagnostic Bayesian Networks for Whole-Building Fault Detection and Diagnosis: Development, Experimental Evaluation and Testing during operation.	Under review

Date	Title	Publisher
2026	Ziao Wang, Chujie Lu, Martín Mosteiro-Romero Arjen Meijer, Laure Itard AHU FDD under divergent expert judgments using fuzzy set theory, knowledge fusion and LLM-assisted Bayesian Networks	Under review

ANNEX 3: WEBINARS

All webinars are available here https://brains4buildings.org/learning-community/

Date	Title & presentor(s)
2022/02/17	B4B Webinar #1: Smart Building Assessment (Christina Papachristou, | Deerns)
2022/03/17	B4B Webinar #2: Fault Detection and Diagnosis the 4S3F method (Arie Taal | HHS)
2022/04/20	B4B Webinar #3: Indoor climate label: user centric assessment methods of comfort and health (Piet Jacobs |TNO), David Keyson |TUD/Office Vitae)
2022/05/19	B4B Webinar #4: Energy transition requires adaptive buildings (Niels de Jong | Cloud Energy Optimizer)
2022/06/16	B4B Webinar #5: Monitoring Heat Pump performances (Dave Baas | Renor)
2022/09/15	B4B Webinar #6: FDD of the low Δ T syndrome (Anand Thamban | TU/e)
2022/10/13	B4B Webinar #7: Setting up a living lab (Jan Willem Dubbeldam | Kropman)
2022/11/13	B4B Webinar #8: Prescriptive, predictive and preventive maintenance of rotating assets (Eric van Genuchten | Sensing 360)
2023/01/12	B4B Webinar #9: Comfort apps in smart buildings, do we use them and what's their effectiveness (Kees Wisse | DWA)
2023/02/16	B4B Webinar #10: Security. Privacy and Ethics in Smart Buildings (Elena Chochanova, Tousif Rahman | TNO)
2023/03/16	B4B Webinar #11: Experiences with user feedback in a living lab environment (Sander van der Harst | Unica & Frans Joosstens | HHS)
2023/04/06	B4B Webinar #12: Securing Operational Technology (OT): New Kid on the Block or Familiar Risk? A wake-up call for one of the biggest threats for the future (Johan de Wit | Siemens)
2023/06/14	B4B Webinar #13: Optimizing energy consumption and increasing energy flexibility of a nearly transparent building using MPC (Naveen Rajappa | TU Delft)
2023/10/19	B4B Webinar #14: Reference Architecture (Lasitha Chamari | TU/e)
2024/01/18	B4B Webinar #15: Fault experiments to generate data from living laboratory (Karzan Mohammed & Srinivasan Gopalan | TU/e)
2024/01/25	B4B Webinar #16: Harnessing UDMI Methodology to making buildings smarter (Ged Tyrell, Susan Gibson, Thomas Hynes | Tyrrell Building Technology)
2024/02/28	IEA Annex 81 | B4B online webinar "Scaling Adoption of Operational Intelligence to Energy Productivity in Smart Buildings"
2024/05/23	B4B Webinar #17: Modelling and understanding thermal comfort using self-reporting and interpretable machine learning (Nitant Upsani | TUe)
2024/06/20	B4B Webinar #18: Fault Detection and Diagnosis in Buildings (Chujie Lu | TUD)
2025/10/17	B4B Webinar #19: Optimizing Asset Management: A Roadmap for Leveraging Smart Buildings (Joep van der Weijden | TUD and Joppe Stello | Heijmans)
2024/10/31	B4B Webinar #20: Real-time monitoring of Building Energy Systems (Lars van Koetsveld van Ankeren | TUD)
2025/02/20	B4B Webinar #21: Open Knowledge Platform: Practical Insights into Data in the Built Environment (Martis Mosteiro Romero | TUD)

Date	Title & presentor(s)
2025/03/20	B4B Webinar #22: It takes two to tango: Balancing smart climate systems and occupant needs (Vera Lange | Han)
2025/03/15	B4B Webinar #23: FD(D) on Large Scale – Implementation in the PULSE Core Living Lab (Coen Hoogervorst | Spie and Olav Vijlbrief | TNO)

ANNEX 4: PRESENTATIONS

Date	Title (Presentor)	Event
2021/04/13	Brains for buildings: where to find all the relevant smart building data? (Pieter Pauwels | TUe)	AIVC Workshop: Webinar- big data, IAQ and ventilation
2021/11/09	The Green Village: Smart Buildings co-creation centre (Joep van der Weijden | TU Delft) Integrating human needs in building automation by Artificial Intelligence (Dr.ir. Shalika Walker, Dr.ir. Rick Kramer, Prof.ir. Wim Zeiler (TU Eindhoven) Behaviour-Aware and Data-Driven: Building Control Strategies (Dr Neil Yorke-Smith | TU Delft) Data integration for smart communication (Dr Pieter Pauwels | TUe)	Bit, Bricks & Behaviour
2021/11/12	TVVL webinar series #2 Fout Detectie & Diagnose (o.a. Wim Zeiler | TUe) & Dave Baas | Renor)	TVVL webinar series THE (Big) Data potential
2022/01/13	Brains for Building Energy Systems: Models & ML for an Efficient Approach of Operation (Laure Itard | TU Delft)	Urban Energy Insitutie lecture
2022/02/14	TVVL webinar series #3 Data management and storage Haystack versus Brick (Pieter Pauwels | TUe)	TVVL webinar series THE (Big) Data potential
2022/02/17	Hoe versnelt leren de uitvoering in de energietransitie? (Pauline van der Vorm | TGV)	Topsector Energy conferentie
2022/03/14	TVVL webinar series #4 Predictive and condition-based maintenance (Wim Zeiler |TUe, Rick Kramer | TUe), Mike van der Heijden | Strukton)	TVVL webinar series THE (Big) Data potential
2022/03/29	Presentation label by Piet Jacobs (TNO) at event hosted by Binnenklimaat Nederland& Office Vitae in an exhibition stand about the label.	Workplace Experience
2022/04/21	How smart buildings work: some easily forgotten issues (Kees Wisse, DWA)	Powerweb Institute lecture
2022/04/21	Brains for buildings, data, meet- en regeltechniek, voorspellingen (Joep van der Velden | Kropman)	The Future of Energy | Avans Hogeschool
2022/11/08	Niels de Jong Cloud Energy Optimiser | Slim samen besparen	FHI Digitaal Gebouw
2022/11/12	TVVL webinar series #1 Energy flexibiliteit van gebouwen (o.a. Dennis van Goch | BAM & Dave Baas | Renor , Shalika Walker | TU/e)	TVVL webinar series THE (Big) Data potential

Date	Title (Presentor)	Event
2022/11/29	Mirjam Harmelink | Brains 4 Building's Energy Systems	Paris Proof congres (DGBC) | | Rotterdam
2023/02/06	Mirjam Harmelink | Brains 4 Building's Energy Systems	TKI Urban Energy Consortium podium | Utrecht
2023/03/27	Rick Kramer (| De energiesystemen van gebouwen worden te complex)	ABB relatiesdag | Leusden
2023/09/19	Presentation by Shalika Walker	TVVL dag
2023/10/05	Huiskamer sessies B4B Smart Buildings with presentation by – Je GBS uit handen geven aan AI? Geen haar op mijn hoofd die daaraan denkt! (Stefan Hoeksta | The Green Village) – Gebruiker en gebouw als gelijkwaardige partners? Vera Lange / Wouter Sluis-Thiescheffer (HAN) – Fault Detection and Diagnosis (#FDD): wanneer is dit zinvol en waar is de business case? Laure Itard (TUD)	Smart Buildings Event (Building G 100)
2023/11/15	"Brains for buildings Energy Systems" Joep van de Weijden en Stefan Hoekstra (The Green Village)	FHI Digitaal Gebouw van de Toekomst
2024/03/08	"From connected to Automated Buildings" Pieter Pauwels (TUe)	REHVA Expert Talks at Lighting Buildings
2024/06/10	Presentaties door Joep van der Weijden over de onderzoeksmogelijkheden die The Green Village	Webinar van de Smart Energy Community: Built together!
2024/06/10	Presentie door Roel Derks (Qien) over de mogelijkheid om (bestaande) klimaatinstallaties adaptief te maken en hoe gebouwen daarmee ook klaar zijn voor aankomende GACS- en EBS-regelgeving.	Webinar van de Smart Energy Community: Built together!
2024/06/10	Presentatie door Jan Kadijk van DGBC over de Europese ontwikkelingen en Karthik Gunderi van DEERNS over de de Smart Building Assessment Tool, waarmee vastgoedeigenaren, gebouwbeheerders en -gebruikers zelf aan de slag kunnen gaan met slimme gebouwen	Webinar van de Smart Energy Community: Built together!
2024/06/25	Pieter Pauwels (TUe) "1+1=3 – Doorgedreven opsplitsing van kennis en systemen voor beter informatiebeheer en efficiëntere beslissingen – Toch?"	WOI Symposium: Datagedreven slimme gebouwde omgeving: hoe kunnen wetenschap en praktijk elkaar versterken?
2024/06/25	Rick Kramer (TUe) "Data-gedreven aanpak combineren met expertkennis voor efficiënte én effectieve installaties: Onderzoek en maatschappelijke impact.	WOI Symposium: Datagedreven slimme gebouwde omgeving: hoe kunnen

Date	Title (Presentor)	Event
		wetenschap en praktijk elkaar versterken?
2024/06/25	Martin Mosteiro Romero (TU Delft): Knowledge platform and handbook developed with the Brains4Building project.	WOI Symposium: Dat-agedreven slimme gebouwde omgeving: hoe kunnen wetenschap en praktijk elkaar versterken?
2025/10/02	Elena Chochanova & Stan van Wersch: Brains4Buildings: Van Onderzoek naar Praktijk	Smart Building conference Nieuwegein

ANNEX 5: MEDIA

Date	Title	Title of journal, website etc.
2021/07/18	Binnenkort verkrijgbaar: een brein voor jouw gebouw	OG Wijzer
2021/08/01	De vinger aan de pols voor beter presenterende gebouwen	TU Delft stories
2021/11/10	News Brains 4 Buildings project	BTIC Newsletter
2021/12/01	Brains4Buildings	Home of innovation
2022/03/11	Gebouwen als dynamische energiecomponent in het energienet (Robert Jan Dikken)	Peutz
2022/04/30	Smart buildings: Trends & Ontwikkelingen	“Topic” (Rexel)
2023/02/01	Brains4Buildings: Slimme, data-gedreven gebouwen (Martijn Kruijsse | HHS)	TVVL Magazine
2023/03/05	Thema Smart Building: Overspoeld door data (interview met Laure Itard | TUD)	Property NL
2023/03/27	The B4B Project aims to develop scalable and modular solutions that save 20-30% of energy (interview met Mirjam Harmelink | TUD)	Build Up
2023/09/26	Brains4Buildings: Unlocking Flexibility with Near Real-time Buildings Models (Wouter Borsboom | TNO)	Flexcon 2023, Brussels
2023/10/1	Data security en privacy in smart buildings: “Mensen zijn de zwakste schakel” (Interview met Elena Chochanova en Tousif Rahman van TNO)	FHI Nieuwsbrief
2023/10/5	Want to make buildings more sustainable? Give them a brain!	Innovation Origins
2023/10/24	Slimme gebouwen helpen ons betere beslissingen te nemen (Interview met Karthik Gunderi | Deerns)	FHI Website
2023/11/8	Hoe met AI stappen maken in de Energiestransitie (Interview met Stefan Hoekstra en Joep van der Weijden van The Green Village)	FHI website
2025/04/01	“Met Brains4Buildings werken we samen om nieuwe kennis te ontwikkelen” (Interview met Laure Itard en Mirjam Harmelink)	Unica Jaarverslag (link)

ANNEX 6: DATA AND SOFTWARE CODE

Code and data files available through the Brains4Building GitHub page.