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PREFACE

This is the first annual progress report of the Brains for Building's Energy Systems (B4B) project, which started on May 1, 2021. In this project, a consortium of 39 partners is working on the ambition to offer (future) solutions for the most important challenges of building management by adding operation intelligence.

After a somewhat slow take-off due to the COVID pandemic, the project activities have come up to speed and partners are very active. We have e.g., been able to set up the living labs, execute the first experiments and started building an international community on smart buildings.

This progress report provides a concise overview of our activities and results in the first year. For more information, you can visit our website or contact us via contact@brains4buildings.org.

Utrecht, May 22, 2022.

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1 INTRODUCTION TO THE B4B PROJECT

1.1 Ambition: offering (future) solutions for the most important challenges of building management

Even in the most modern utility buildings, 10-30% of energy is wasted due to malfunctioning installations and unexpected user behaviour, while in many cases the quality of the indoor environment is insufficient, and the operating costs are high. Smart meters, building management systems and the Internet of Things offer the possibility to collect large amounts of data. The use of this data to reduce energy consumption, increase comfort, respond flexibly to user behaviour and local energy demand and supply, and save on costs for installation maintenance is seen as promising, but is underdeveloped and hardly implemented. 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 really make buildings "smarter", and the implementation is a cumbersome and time-consuming exercise. Given the complexity, a collaboration of parties throughout the value chain and an open-source approach is a must to achieve scalable and integrated solutions and system innovation in the installation sector.

1.2 Objectives

The goal of the B4B project is to add operational intelligence to buildings. Buildings need "brains" for self-diagnosis and self-optimization, to save energy, consider the user and be an active part of the energy system. These brains represent a large market value due to the impact these "brains" have on energy bills, health and comfort of occupants, operations and maintenance costs and ease of use. To this end, the B4B project wants to contribute to the development and market introduction of such smart systems in utility buildings by:

- Developing operating systems equipped with intelligent algorithms that guarantee the comfort, health, and well-being of the users, thereby guaranteeing their privacy and thus improving the adoption of smart systems.
- Developing control systems that reduce energy waste, increase the use of self-produced (renewable) energy and enable adjustable flexibility regarding the heat/cold/electrical 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.

The B4B project has the objective to contribute to the MOOI innovation themes: i) making the (collective) heat and cold supply more sustainable ii) flexibility of/for the energy system (in the built environment) and iii) smart energy use in/between buildings by its users.

1.3 Approach: five integrated work packages

The project is grouped into four work packages, in which work is executed in an integrated manner on the required development of smart building control. Figure 1 provides an overview of the work packages and shows that the activities are organized around open living labs and use & validation cases. Methods, models, and algorithms developed in the work packages are first tested in one or more living labs and then validated in use and validation cases. The fifth work package 'B4B Learning Communities' focuses on knowledge dissemination. Below is a summary of the work packages:

- WP 1 'Self-diagnostic installations for energy efficiency and smart maintenance' focuses on developing smart diagnostic systems to reduce energy losses in buildings by continuously identifying faults in the functioning of the building in an automated manner. These diagnostic systems can also be applied for performance maintenance planning, to energy-flexible buildings and to decentralized control systems where users play a major role. This work package uses results from WP2 and WP3 and provides diagnostic insights to WP3.
- WP 2 'Intelligent control strategies for energy flexibility' focuses on developing smart control models to increase the flexibility of buildings with respect to supplying and consuming heat, cold and electricity from/to the grid outside the building. The control models are multi-objective, which means that it is not only about cost optimization, but also aimed at optimizing CO_2 reduction, comfort, and maximum use of local resources. This work package uses the user scenarios developed in WP3 and provides WP1 with insights into the different control strategies.
- WP 3 'Smart user-oriented interfaces and feedback' focuses on the development of user interfaces (end-users, facility managers and building owners) to ensure an energy-efficient and healthy indoor

environment and to encourage users to energy-efficient and energy flexible behaviour. WP3 provides methods and data to WP1 and WP2 and uses diagnostic insights from WP1.

- WP 4 'Data integration for smart communication' ensures data connectivity between applications, as well as data security, ethical use, and standardization. This WP investigates the use of linked building data (LBD) and building semantic representations to support API-level system integration. Because of the diversity of legacy systems, system-level integration is much more important than data-level integration of individual systems from different manufacturers. That is why the B4B project focuses on integration at the API level.
- WP 5 'B4B Learning Communities' ensures that knowledge and experiences are shared in a learning community, resulting in the development of new collaborations and business models and practical applications in educational programs.

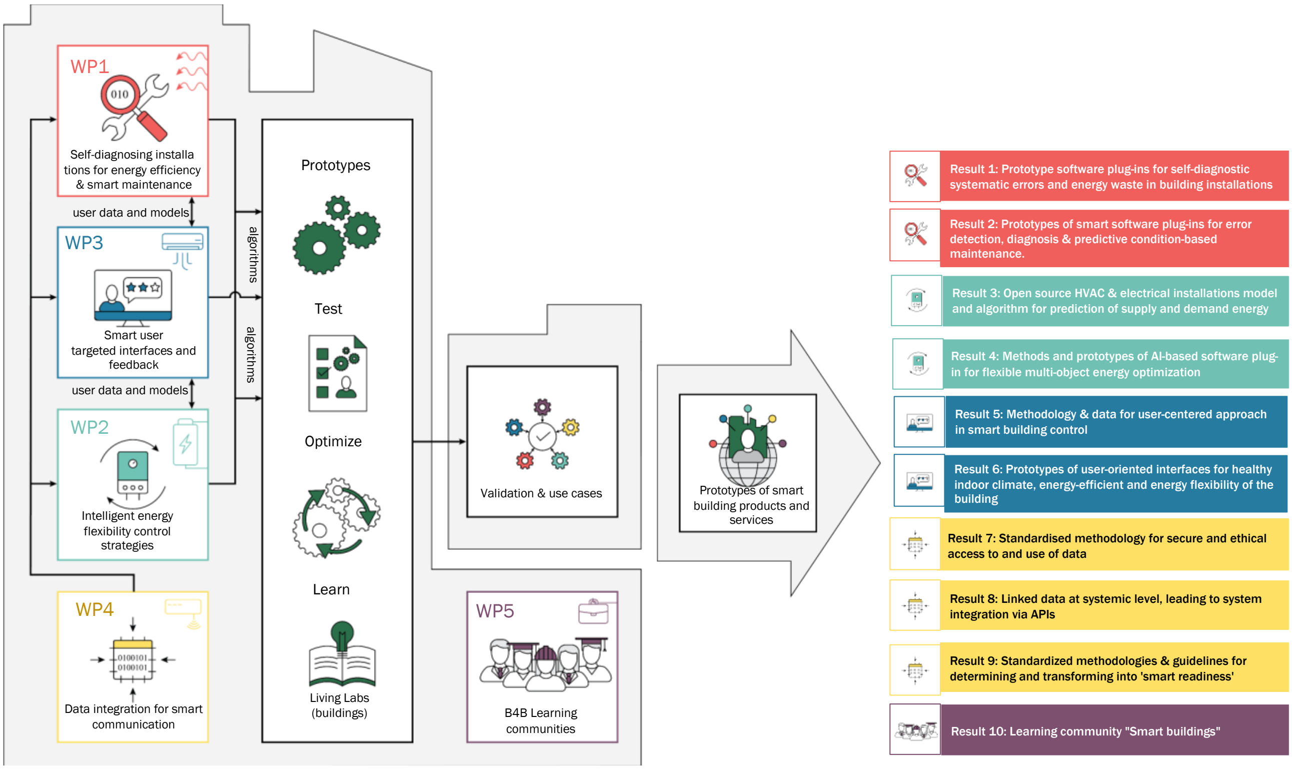


Figure 1: Five work packages organized around livings labs & use cases leading to 10 tangible results

1.4 Open innovation

The B4B activities are executed in an open innovation setting, i.e., methods and algorithms will become publicly available. This will greatly contribute to reducing development costs by companies and thus improve the business case. This is tested within the project by helping the companies develop their own products based on the findings in the living labs. To create these conditions for good open cooperation, the B4B project is set up around living labs (test locations in office and educational buildings that are used as a first validation step to prototype, test and evaluate products and services in a protected environment) (circle 1).

These open-source results are validated by several consortium partners for scale-up and integration possibilities in use and validation cases. This means that results from the first circle are validated by consortium partners in test environments for their potential for scaling up (circle 2).

In addition, we distinguish a circle 3 that includes a broad group of potential users and (market) parties who are interested in the results of the project or who wish to further disseminate these results to their supporters.

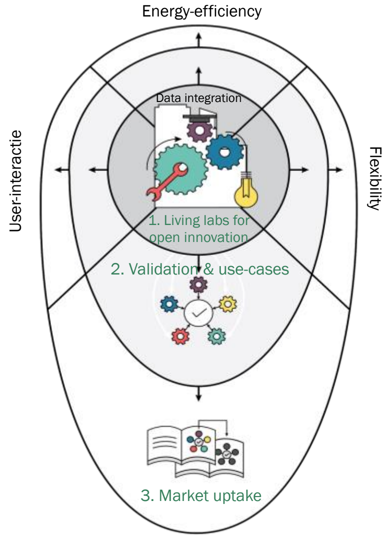


Figure 2: Collaboration around three circles: living labs (circle 1), use & validation cases (circle 2) and potential users & market parties (circle 3).

1.5 Project partners

Figure 3: Overview of project partners

2 ACTIVITIES AND RESULTS FOR YEAR 1

2.1 Livings labs, use and validation cases

TU Delft coordinated the inventory of buildings that will be used as living labs, use cases, and validation cases. A template was prepared that was filled out by facility and building managers from various consortium partners to get a detailed overview of the buildings with respect to the type of energy system in place, type of Building Energy Management (BMS) systems, HVAC descriptions, data availability, sensors in place, availability of principal schemes etc.

Facilities and services for data storage were investigated and for the storage of available historical building data, Surfdrive was selected and for the collection of real-time data of living labs the data platform of The Green Village was chosen.

The following buildings – these buildings are representative of a large group of existing educational and office buildings in the Netherlands - will be available as livings labs:

- HHS: Education building
- TU Delft: Wiskunde & Informatica (building #28)
- TU/e: Atlas Living Lab
- TU Delft: Pulse
- Kropman Breda

The building descriptions of the Living labs have been uploaded to Surfdrive, as well as historical data sets for the HHS living lab and TU Delft livings labs. In the coming period, the number of historical data sets on surf-drive will be further expanded, and we will start with working with the real-time data in the living labs. Real-time data from TU Delft Wiskunde & Informatica (building #28) is available on the data platform, and real time data from Kropman Breda is available through Kropman own platform. Besides a first overview is available of use- and validation cases with various consortium partners.

2.2 WP 1: Self-diagnosing installations for energy efficiency and smart maintenance

Result 1: Prototype software plug-ins for self-diagnostic systematic errors and energy waste in building installations

Result 2: Prototypes of smart software plug-ins for error detection, diagnosis & predictive condition-based maintenance.

Results 1& 2:

TU/e, TU Delft and Kropman made the first steps in the development of the methodology to test the 4S3F[1] method in the Kropman Breda living lab and the HHS livings lab, which form the basis for the development of the AI-based software plug-ins for self-diagnostic systematic errors and energy waste in building installations. The first focus is on the Air Handling Unit (AHU) in the buildings because AHU's are present in almost all buildings and are therefore an important component. Further activities by TU Delf and TU/e included:

- Developing modular and scalar solutions to automate the pre-installation process by applying machine learning approaches.
- Improving the performance of the 4S3F method by using continuous BMS flow data (instead of historical data) to realize structure and diagnosis optimization by applying machine learning approaches.
- Adding and testing additional information layers in the 4S3F methods to improve the fault and diagnostic processes and extend its ability. This includes information from occupants, facility managers, maintenance records etc.

A literature review for fault detection and diagnostics is in progress (important notice is that it might be possible to link this to the activities which are ongoing in the IEA Annex 81 C2 and C1) and first applications are being built in Phyton to be tested in the living labs.

[1] The 4S3F method is derived from a reference architecture based on a network with 3 generic types of faults (component, control, and model faults) and 4 generic types of symptoms (balance, energy performance, operational state and additional symptoms).

TU Delft and HHS performed an analysis of practical issues when applying a previously developed fault detection method (4S3F) on HHS historical data, demonstrating how to build different fault identification networks from the Process & Instrumentation Diagrams. The findings are summarized in a paper that will be presented at the CLIMA2022 congress (14th HVAC World Congress, 22-25 May 2022) (see section 3.3).

A first prototype using a Bayesian network analysing the occurrence of low-dT syndrome in the cooling coil plug-in module at the Kropman Breda living lab was tested and proved to have .90% specificity (these activities build on the results of the TKI project Cx low-dT (Continuous Commissioning of low-dT)).

TNO and Strukton (Spie) started with preparing and analysing the data of the use case TNO Stieltjesweg for implementing the 4S3F diagnosis method on real-time data of the PULSE SPARK data from Strukton (Spie).

TNO furthermore works on virtual sensor analysis for cooling, based on hybrid models and data-driven models.

DWA started research on multi-sensor anomaly detection for indoor Air Quality and automatic calibration of these multiple sensors for diagnostic purposes, and a paper will be presented during the CLIMA 2022 conference (see section 3.3).

An approach for the KPI development as indicators for successful operating of the modules is under development. This enables different approaches (whole building level, sub-system level and component level) as well as the combination of an objective KPI layer and subjective KPI layer. This approach aligns with the development of the smart readiness indicator in WP 4.

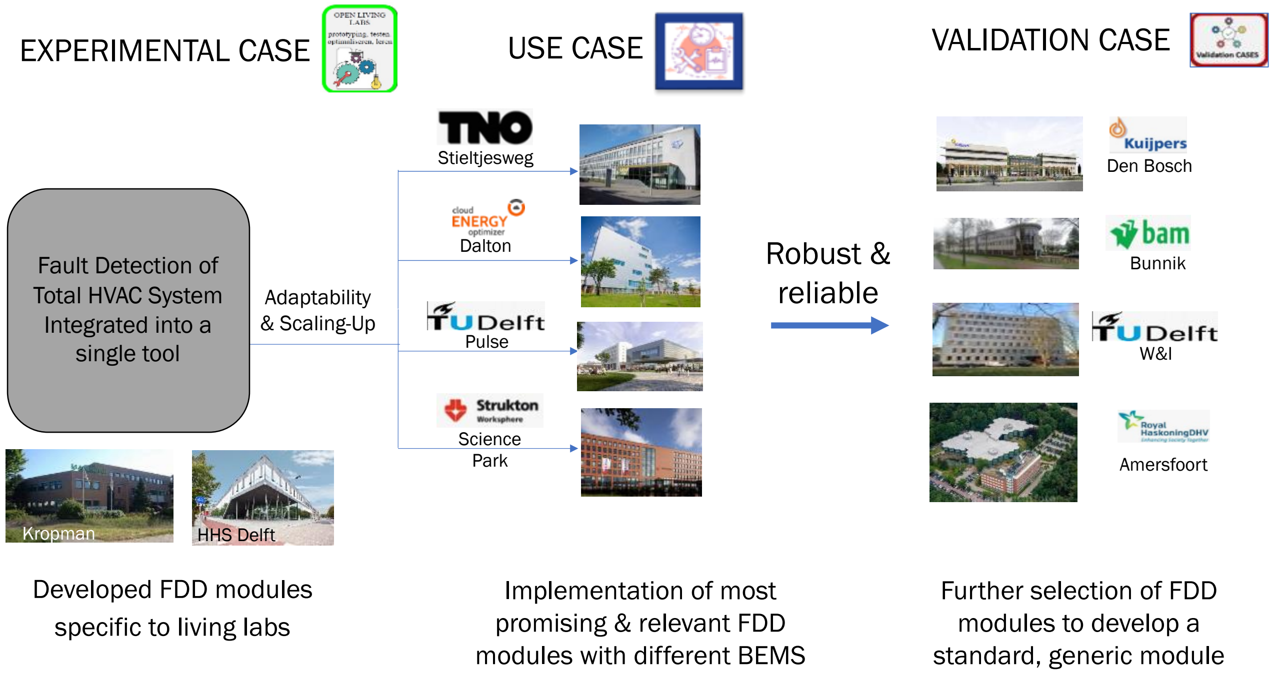
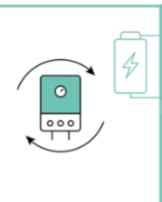


Figure 4: Overview FDD development path in WP 1.

2.3 WP 2: Integrated energy flexibility and control



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

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

Result 3

The HHS carried out a literature review on flexibility measurement methods was carried out in which extended use was made of the work already carried out by IEA EBC Annex 67 Energy Flexible Buildings. The method proposed by Annex 67 was presented and discussed with the participating partners and it was agreed to make use of this method to measure the energy flexibility of buildings.

HSS developed a first energy flexibility assessment method based on building construction and building services characteristics and applied the method to assess the flexibility of two buildings in the portfolio of Rijksvastgoedbedrijf (RVB) and the HHS Building in Delft. Currently, the effectiveness and user-friendliness of the method are being evaluated.

HHS developed a first building model with OpenModelica, making use of the libraries developed within the IBPSA project (The IBPSA creates open-source software that builds the basis of next-generation computing tools for the design and operation of building and district energy and control systems). Currently, a procedure is under development for testing this building model to create building design and control advice to increase building energy flexibility.

Furthermore, HHS has made a comparison of the accuracy of different imputation methods - 3 machine learning methods and a hot deck method - to impute energy Building Management Systems data. The results will be presented at the CLIMA 2022 conference (see section 3.3).

Peutz and Avans Hogeschool have been working on developing and applying machine learning algorithms for robust energy forecasting to balance energy demand and supply of buildings in a flexible way. The first results are now being discussed to evaluate the accuracy of these methods (see publications by Peutz and Avans).

TNO worked on the development of an AHU module written in Python and on the energy prediction model of the building for the use case TNO Stieltjesweg.

Windesheim has been developing and training inverse grey-box models based on the GEKKO Python modelling language for machine learning optimization to learn building model parameters and installation model parameters from residential home data. Furthermore, Windesheim put effort into making the data collection software and hardware (developed earlier in the Twomes project) available to Brains4Buildings project partners under open source licences via Research group Energy Transition at Windesheim (github.com). They furthermore work on the design and implementation of Bluetooth presence detection and CO_2-concentration measurement device suitable for the utility context (battery operated, connectable via Wi-Fi. Low-power battery measurements completed).

Result 4:

The first approach for the research on Model Predictive smart control was prepared and Deerns has been looking into adjusting their model for a Thermal Heating grid to be able to apply a real-time control strategy. Furthermore, TU Delft executed a preliminary literature review regarding energy flexibility assessment, model predictive control (MPC) and the development of control-oriented building thermal dynamics.

2.4 WP 3: Smart user-targeted interfaces and feedback

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

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

Result 5:

TNO, TU Delft and OfficeVitae set up the monitoring platform at the TNO building at the Leeghwaterstraat in Delft and worked on the further development of feedback dashboards displays and filters for building inspectors to view indoor label data according to location and time. These three parties are also working on the strategy and initial implementation of a smart notification system to inform building inspectors when label scores fall below target levels and which is being tested and refined at the TNO living at the Leeghwaterstraat. The approach and first findings were presented at the third B4B webinar by Piet Jacobs and David Keyson. The indoor climate label platform data dashboard was extended with smart notification and data filtering. These new features were demonstrated during several public events, and Binnenklimaat Nederland coordinated monthly sessions with indoor climate experts to get feedback on the dashboard and developed methods. The climate label was further tested in the Strukton building in Son. Activities included building monitoring and applying questionnaires to users. Subsequently Strukton, TNO and Unica started a field study to compare the use of direct feedback using a QR code (currently applied by Unica) with a voting app with voting boxes.

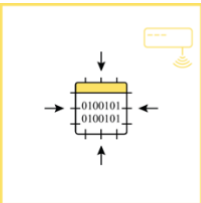
TNO and TU/e together with APTA Tech, Spectral, Strukton, DGBC, Unica, O-Nexus and Cloud Energy Optimizer mapped out interface requirements from a market perspective, which is an important input for the other WPs. Besides, a literature study was carried out by TU/e on the shortcomings and opportunities offered by smart buildings and systems for facilities management, and for building occupants. Results of this review were further enriched with a series of interviews with Spectral, Strukton, Simaxx, Cloud Energy Optimizer, O-Nexus and Unica, and will finally be discussed at a workshop at the international conference Clima 2022 in Rotterdam on the 23rd of May 2023.

TU/e and TNO are carrying out a literature review on occupancy, occupants' behaviour and comfort data utilized in FDD and building control. In the living lab at the TU Delft campus (building 28 wiskunde and informatica) activities are ongoing to determine (1) what causal relationships there are between selected factors related to behaviour and energy use, and how can they be used to form a basis for a Bayesian network similar to 4S3F (WP 1) and (2) how the Bayesian network can be developed and verified through a case study of an office in TU Delft building 28. For these activities, additional sensors were installed, and surveys were carried out. Besides Avans has started two student projects on ML and user interfaces.

Result 6:

Activities not yet started.

2.5 WP 4: Data integration for smart communication



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

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

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

Result 7:

TNO had the lead in conducting a set of interviews with real estate owners and service providers aimed at retrieving the most prevalent regulations, approaches and restrictions around privacy, security, and ethics. Besides, the data ethics and management protocols in relation to the common procedures for data ownership and the EU-wide implemented General Data Protection Regulation (GDPR) were examined. Results are reported in the public deliverable "D4.01 Literature and market study of existing regulations and approaches regarding data privacy, ethics, and security, including GDPR constraints". The results provide important input for the follow-up research to develop a standardised method for verifying the compliance of the data integration solutions and will contribute to emboldening the confidence of the end-users and widening the market acceptance of the project results.

Result 8:

Activities for this result resulted in two deliverables. In "D4.02 Data test set for internal research purposes" includes a set of data as well as an accompanying report that documents how the data from buildings used as living labs can be used and found, and the procedure that needs to be followed to get access to these data.

The second deliverable "D4.03 on Data needs &requirements plan that can be used for data collection and integration", holds the results of a thorough scientific investigation and a review of stakeholders' data needs. This resulted in an explication of different use cases related to smart buildings, as well as the specific data that each of these use cases needs.

The use of data exchange structures like Haystack and Bricks was discussed in a webinar held at TVVL by Pieter Pauwels (TU/e)

Result 9:

Under the lead of Deerns initial work on this task has already started. A procedure was developed for assessing the smart building score of buildings. The B4B Smart Building Assessment or Quick-Scan has been presented on several occasions – among others at the first B4B webinar (see section 3.3) - and is developing well into usable indicators for smart buildings.

2.6 WP 5: Learning community

Result 10: Learning community "Smart buildings"

Result 10:

Within the B4B project various activities have started to gradually build a B4B learning community around the topic of smart buildings:

- We had three consortium meetings (1 online kick-off meeting and 2 in-person meetings) in which consortium partners met (attendance between 60-70 participants) to discuss progress within the project, and various workshops were organized to exchange and further develop ideas and good practices on specific topics.
- We started organizing monthly online Brains4Buildings webinars which are open to all people interested in the topic of smart buildings (inside and outside of the consortium). In these one-hour webinars, we delve deeper into a specific topic. The first three webinars were well attended: between 150 and 75 people subscribed, and several have attended multiple webinars. We have now already compiled a list of 350 people that want to receive invitations for our webinars. Most of the participants come from outside the project, and we already received several requests from other partners to give a lecture. In this way, we are gradually building a broader (international) learning community and an online repository of “smart building” topics. The full list of webinar slides and recordings can be found on our website.
- Together with the Dutch Green Building Council (DGBC) – which is the developer and manager of the BREEAM certification in the Netherlands - an online refresher training was developed for BREEAM experts to train them on the topic of smart buildings.
- The TVVL organized a series of 4 webinars on “The Big data potential” for turning buildings into smart buildings. Several consortium partners were actively involved in the organization and execution of these webinars. Announcements and recordings of these webinars are actively shared within the B4B community.

TU Delft started the development of a refresher course, for which we pooled resources with the ongoing activities within the NWO funded Transact project. Within this project, an online refresher Course Smart Buildings (Upskilling and reskilling on smart, energy-efficient utility buildings) is being developed which fully aligns with the B4B objectives of the refresher course. It was therefore decided to join forces which enables us to dedicate more resources to the content development, resulting in a much more comprehensive course. The course will become available on the TU Delft open course (OpenEdX) platform and will be ready to start in September.

Furthermore, we are working on embedding the B4B project in the broader learning community network Energy Switch which was signed on Sept 20th, 2021, as part of the Human Capital Agreement initiated by the Province of South Holland and the Economic Board of South Holland. The Energy Switch consortium consists of educational institutions, knowledge institutes, and companies that aim to organize learning, working and innovation close to each other. The B4B consortium is an important thematic learning community on Smart Buildings and will be an important building block for the Energy Switch consortium.

3 OTHER ISSUES

3.1 Contribution to objectives of the MOOI scheme

The B4B project contributes to the realization of the objectives of the MOOI theme 'built environment' by developing smart integrated user-friendly prototypes of affordable, modular and scalable software plug-ins for utility buildings. These software plug-ins will be ready for further upscaling to the market in 2025 and will lead to:

(1) Less energy is wasted in the heating and cooling supply of building installations and the related CO_2 emissions. According to ECN (2016) the average energy consumption in office buildings is

- 17m ^{3} gas/m^2 and 60 kWh electricity/m^2.
- 1 m^3 of gas produces 1.89 kg of CO_2 emissions, 1 kWh of generated electricity produces 0.649 kg of CO_2
- Assuming 25% energy savings through smart controls and plug-ins, this results in a saving of 4.25 m^3 of gas and 15 kWh of electricity per m^2.
- This sums up to a total CO_2 reduction of 1.89x4.25+15x0.649=18 kg CO2/m^2

With 24 million square meters of offices equipped with a BMS system (offices of more than 5000 m^2), the potential for CO_2 reduction 0.4 Mton per year, equalling 5.7% of the total reduction required for the built environment. This does not yet consider that part of the 23 million square meters of smaller offices will also need to switch to a BMS. In addition, there is also great potential in educational buildings, hospitals, shops, etc. The Netherlands has a total of 460 million non-residential buildings (Climate Agreement, 2018). If these buildings have the same energy consumption per m^2 and 52% of these buildings are equipped with a smart plug-in, then 4 Mton CO_2 is saved in one go. That is more than half of the government targets for the built environment. This highlights the enormous importance of BMS data-based energy diagnostic methods and plug-ins. This CO_2 reduction is obtained with very low investments per square meter (4EUR/m^2)

(2) Increase in end-user comfort, indoor air quality and user-friendliness of decentralized control systems. Ultimately, every technical solution stands or falls with its acceptance and correct use by the end-user. Until now, it has almost never been included in research into fault diagnosis and control strategy, so the connection with user experience and acceptance by users is completely missing. Including it 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 the transformation of the built environment by 20-40%. By smart management of the storage capacity, the use of local sustainable energy production can be increased by 40-50% (and the use of fossil sources is reduced proportionally). An increase of 90-95% is also mentioned, but the costs are still very high. This applies equally to photovoltaic cells and to storage in the ground in combination with geothermal energy. Assuming a modest OEM (Onsite Energy Matching) value of 40%, building self-consumption of approximately 15% is now increased to 40%. This means 25% less use of the grid by utilizing the adjustable energy flexibility, high investments in grid reinforcement can be prevented or postponed.

3.2 Spin-off inside and outside the sector

We envision the following spin-off for the various stakeholders:

Building end-users:

- *Improved user interfaces (WP3)* will give building managers, tenants, and end-users a better understanding of how their building systems work, thereby increasing acceptance and confidence in the use of innovative solutions such as smart building control. The user interfaces provide improved decentralized control options to the end-user, without sacrificing energy efficiency in the building.
- *Smart Diagnostic Systems (WP1)* will have a major role to play in ensuring comfort and indoor air quality. Indoor air quality is not visible, and the link with user-oriented interfaces will help to make this visible, thus improving the acceptance of the underlying controls, thus guaranteeing a healthier environment.

Building managers/building owners

- In general, what is of value to the end user is also of value to administrators and owners, if only because the number of complaints is greatly reduced. In the daily practice of building managers, a lot of time is spent on solving indoor climate complaints, and this costs money. On the road to energy efficiency, building managers and owners will need to make investments in building management systems (BMS). This will be mandatory for almost all buildings of more than 5000 m^2 (power greater than 290 kW). By default, a BMS is usually not equipped with energy functionality. With the smart software plug-ins that are developed in

B4B, a lot of energy can be saved on an annual basis. However, this is only a small part of the story because the building owner/manager also has other interests in increasing the value of the smart plug-in (he has long known that his energy bill is negligible compared to other expenses such as salaries, maintenance, insurance, cleaning, etc.), because this will also:

- Reduce indoor environmental and comfort complaints, handling these costs the administrator and facility manager a lot of time
- Reduce failure costs by getting a timely warning if a component is about to break or the energy control is not optimal
- Reduce lost time by figuring out the origin of a problem in the installations or in the indoor climate
- Enable to plan maintenance activities and manage the energy bill on time
- Enable to monitor sustainability goals: many owners and managers would like to achieve sustainability goals and can use the plug-in to aim for CO_2 reduction.
- Optimize building use and flexibility: by providing insight into the occupancy per room, for example, the thermostat and ventilation settings can be adjusted accordingly, resulting in energy savings.
- Providing better insight into the operational aspects of complex installations is often also a wish of building managers.

Maintenance companies

- Maintenance companies that do remote management will also want to purchase the B4B products and use them in their new and current maintenance contracts. It gives them the opportunity to better monitor performance contracts and to schedule maintenance work better and well ahead of time, thus generating a profit.
- The active participation of many of these stakeholders in all B4B meetings in the different work packages, and the many ideas that are exchanged give us good faith that such spin-off will be realized during the B4B project.

3.3 Publications and dissemination activities

Project deliverables

No	Title
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

Publications

Date	Title	Publisher
Taal A., Itard L (2022)	Automatic Energy performance Diagnostic of HVAC Systems by the4S3F method	CLIMA2022, TU Delft Open, Proceedings will be released soon
Wang Z., Meijer A., Itard L (2022)	4S3F Diagnostic Bayesian Network method: discussion about application and technical design	CLIMA2022, TU Delft Open, Proceedings will be released soon
Hajee, Bram; Wisse, Kees; Mohajerin Esfahani, Peyman (2022)	Health monitoring: a machine learning approach for anomaly detection in multi-sensor networks	CLIMA2022, TU Delft Open, Proceedings will be released soon
Chamari, Lasitha; Pauwels, Pieter; Petrova, Ekaterina (2022)	A web-based approach to BMS, BIM and IoT integration: a case study	CLIMA2022, TU Delft Open, Proceedings will be released soon
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, TU Delft Open, Proceedings will be released soon

Date	Title	Publisher
Pieter Pauwels, Gabe Fierro (2022)	A Reference Architecture for Data-Driven Smart Buildings Using Brick and LBD Ontologies	CLIMA2022, TU Delft Open, Proceedings will be released soon
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, TU Delft Open, Proceedings will be released soon

Media

Date	Title	Title of journal, website etc.
2022/04/30	Smart buildings: Trends & Ontwikkelingen	"Topic" (Rexel)
2022/03/11	Gebouwen als dynamische energiecomponent in het energienet (Robert Jan Dikken)	Peutz
2021/12/01	Brains4Buildings	Home of innovation
2021/11/10	News Brains 4 Buildings project	BTIC Newsletter
2021/08/01	De vinger aan de pols voor beter presenterende gebouwen	TU Delft stories
2021/07/18	Binnenkort verkrijgbaar: een brein voor jouw gebouw	OG Wijzer

Presentations

Date	Title (Presentor)	Event
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
2022/04/20	B4B Webinar #3: Indoor climate label: user centric assessment methods of comfort and health (Piet Jacobs |TNO), David Keyson |TUD/Office Vitae)	B4B webinar series
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
2022/03/17	B4B Webinar #2: Fault Detection and Diagnosis the 4S3F method (Arie Taal | HHS)	B4B webinar series
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
2022/02/17	B4B Webinar #1: Smart Building Assessment (Christina Papachristou, | Deerns)	B4B webinar series
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
2022/01/13	Brains for Building Energy Systems: Models & ML for an Efficient Approach of Operation (Laure Itard | TU Delft)	Urban Energy Insitutie lecture
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
2021/11/09	The Green Village: Smart Buildings co-creation centre (Joep van der Weijden | TU Delft)	Bit, Bricks & Behaviour

Date	Title (Presentor)	Event
	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)	
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
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