MOBISTYLE

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MOtivating end-users Behavioral change by combined ICT based modular Information on energy use, indoor environment, health and lifeSTYLE

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Report: MOBISTYLE Publishable report – intermediate results (M24)

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Executive summary

Within this report are presented first MOBISTYLE achievements of different work packages reached during the **first 24 months of the project duration**. MOBISTYLE is 42-months European H2020 project (www.mobistyle-project.eu) focusing on motivating behavioural change through ICT based solutions.

Nevertheless, as **practice shows energy saving as such is not a sufficient motivation factor for building occupants to change their behaviour**. Therefore, MOBISTYLE recognizes that **personalised feedback on energy use** in combination with information on **generated IEQ**, **health** and **lifestyle** can lead to improved **occupants' awareness**. Hence, this achievement requires a multidisciplinary holistic approach and involvement of various scientific expertise. This expertise are divided in different work packages (WP) its having its own objective contributing to the overarching MOBISTYLE goal.
So far several important milestones have been met:

- WP2 – **Mapped user needs and communication approach for the different user types;**
- WP2 – **Recommendations for ICT developers based on the identified user needs;**
- WP3 – **Multidisciplinary holistic MOBISTYLE methodology involving various scientific expertise resulting in the behavioural action plans per demonstration case;**
- WP4 – **MOBISTYLE ICT architecture integrating outputs from WP2 (user needs and recommendations) and WP3 (behavioural action plans);**
- WP4 – **First MOBISTYLE ICT solutions for identified user groups: Game & Dashboard;**
- WP5 – **Ongoing development on MOBISTYLE Modular Information Services and Open Users Platform as business applications;**
- WP6 – **Close collaboration with the demonstration sites and first interactions with building occupants (start of the engagement campaigns).**

As seen, MOBISTYLE project presents multidisciplinary approach requiring different disciplines:

- **Energy, mechanical engineering and physics** to understand the relation between energy use and occupant behaviour (OB) as well as the relation with indoor environmental quality (IEQ);
- **Health science** to investigate energy, individually based thermo-physiology & health relation;
- **ICT knowledge** for ICT solutions development, development of environment of Internet of Things (IoT) & modifications of monitoring and data acquisition technologies;
- **Anthropology** to understand factors influencing consumer choices and the impact of occupant behaviour on energy use, indoor environment and health.

How is this reflected in MOBISTYLE consortium?

- **Energy in relation to OB***:* Politechnico Torino (POLITO), Aalborg University (AAU), Huygen (HIA)
- **Energy in relation to IEQ***:* Aalborg University (AAU), Huygen (HIA)
- **Health science** for the relation to IEQ: Maastricht University (MU)
- **Anthropology***:* Institute for Innovation and Development of University of Ljubljana (IRI-UL)
- **ICT, IoT***:* Holonix (HOLX), DEMO Consultants (DMO)
- **Gamification***:* Highskillz (HS)
- **End-users***:*
  - TAURON Polska Energia (TAU)
  - Whirlpool (WHR)
  - **Mobistyle Consumers Advisory Board** (MCAB)

MOBISTYLE consortium hopes you will enjoy reading this summary of the work done so far! If you are interested in learning more or see a potential business collaboration do not hesitate to contact us.

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1. The MOBISTYLE challenge and objectives

"Buildings represent 40 % of final energy consumption, offering the highest potential for efficiency improvement and savings on energy bills [1]." This is a commonly used explanation of European Union (EU) when arguing the necessity to increase the number of buildings energy retrofits. Consequently, stricter EU regulations are introducing energy labelling and encouraging the use of smart technologies and advanced control strategies.

Most of today's buildings are equipped with sophisticated building automation systems and sensors measuring large amount of different building performance data types (mostly related to building's energy performance or thermal comfort). This data is commonly used for energy management of large commercial buildings. However, this data is often not available or understandable to the building users, especially residents.

People often find information from their utility bills, smart meters or energy performance certification (EPC) difficult to understand or credible [2]. Oftentimes, users' behaviours do not match the design intentions as users find building technologies difficult to control since these most often do not comply with their needs and their everyday habits [3–5]. A research conducted at Aalborg University analysed 230,000 detached homes building's energy labels and their actual energy consumption revealed that occupants in homes with less efficient energy labels (i.e. G) consumed less energy than predicted by the label [6]. However, occupants in homes with best energy labels (i.e. A) were using more than predicted. As discovered, the users dictate how much energy is consumed, while EU legislation dictates how much this amount should technically be. This result shows there is a need to educate the users on how and why they are consuming energy since often they are not aware their behaviour results in wasteful energy usage.

This leads to development of MOBISTYLE project that attempts to alter a prevailing assumption that buildings use energy to an understanding that in fact, people use energy. Therefore, to successfully accelerate the transition to a low-carbon society and economy more emphasis should be on motivating people and increasing their awareness leading to an energy efficient building use.

Figure 1: The H2020 MOBISTYLE project attempts to change a prevailing assumption that buildings use energy to an understanding that in fact people use energy.

2. The MOBISTYLE vision

The overarching goal of the H2020 MOBISTYLE project is to motivate behavioural change by raising consumer awareness through the provision of attractive personalized information on user's energy use, indoor environment and health, all enabled by an integrated information and communication technology (ICT) service.

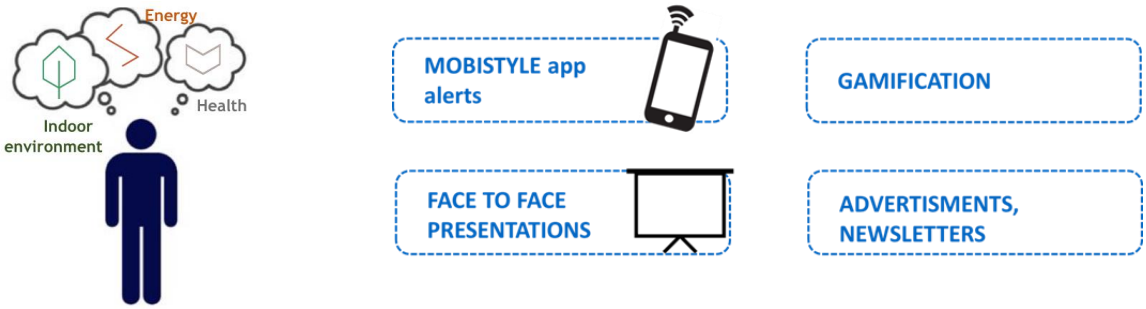

Figure 2: The aim of the MOBISTYLE is to educate building users on how to behave in their buildings by increasing their awareness by combined information on their energy usage, IEQ, health, and lifestyle.

The MOBISTYLE project has the following specific measurable qualitative objectives:

1. To present understandable information and indicators, related to energy use and energy efficiency, in an easy to handle and attractive way for consumers.
2. To provide understandable personalized information for consumers by combining energy monitoring with monitoring of indoor environmental quality, behaviour parameters and daily habits
3. To motivate a prolonged change of consumers' habits and daily practices on energy use by combined modular personalized information on individual energy use, health and lifestyle
4. To foster new business models and applications for future developer engagements
5. To demonstrate a sustainable behavioural change towards significant reduction of energy use in different real environments by deploying and validating the developed solutions and services.

The main quantitative objective of the project is a reduction of energy use for at least 16 %.

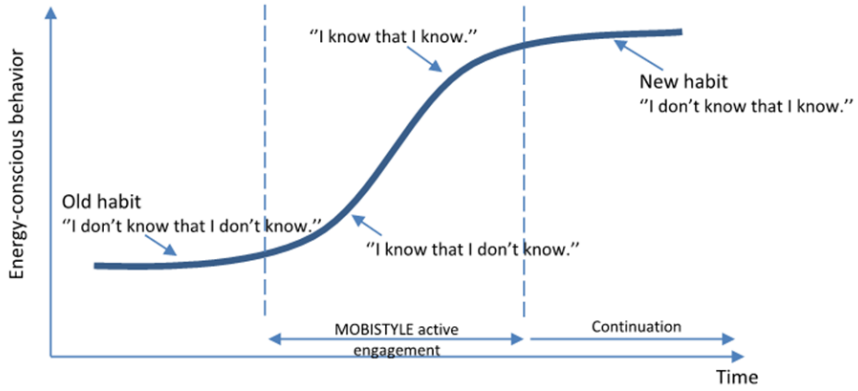

Figure 3: MOBISTYLE awareness process encouraging a change from energy unconscious to energy conscious behaviour due to the engagement with the MOBISTYLE solutions.

As for that, MOBISTYLE demonstration covers five study cases in real life operating conditions in five different geo-clusters:

- **Social housing apartments at Kildenparken, Aalborg, Denmark**

  18 residential apartments in 10 different two-story apartment blocks
  Geocluster: Northern

- **University buildings at the University of Ljubljana, Slovenia**

  8 office rooms in 4 faculty buildings
  Geocluster: Continental Central

- **Apartments at the Hotel Residence L'Orologio, Turin, Italy**

  4 hotel guest rooms/apartments and reception
  Geocluster: Mediterranean

- **2 office building Qeske and Brightlands, Limburg, The Netherlands**

  Open plan offices in two office buildings
  Geocluster: Western Central

- **Residential houses as part of the Smart City Wroclaw, Poland**

  300 residential units (detached & multi-family houses, apartment blocks)
  Geocluster: Eastern

As seen, the MOBISTYLE demonstration covers different building types (residential, non-residential), different scales (building, district) as also distinguish different types of building users.

Interested to get in touch with the MOBISTYLE coordinator?
Then contact the responsible MOBISTYLE partner, Huygen Engineers and Consultants (HIA; website: www.huygen.net/). HIA is independent and leading SME consulting companies in the Netherlands with expertise in: building services, building physics, sustainable building, ventilation, acoustics, energy, environment, indoor air quality, and fire regulations both in consulting in practice and in applied scientific research work.

Key persons involved:

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3. Project inception: mapping of communication and information needs and approach for the different types of energy end-users

To understand people's needs, the first phase of the MOBISTYLE project is focusing on an anthropological observation of building occupants, scrutinizing their level of engagement with building components, technology, energy systems and ICT tools in their everyday life. With this anthropological people-centred approach, users are put at the centre of the ICT tools development process as a necessary and knowledgeable stakeholder.

Figure 4 presents the developed MOBISTYLE anthropological approach; a four-step anthropological approach helping to develop user-friendly ICT tools. Most often, the ICT design of solutions starts with Step 3 where designers and engineers forget for whom they are developing the solutions. In people-centric approach, a fundamental step is Step 1 Identification, where it is observed who are actual users and by looking into their daily behaviour and habits, their needs can be identified.

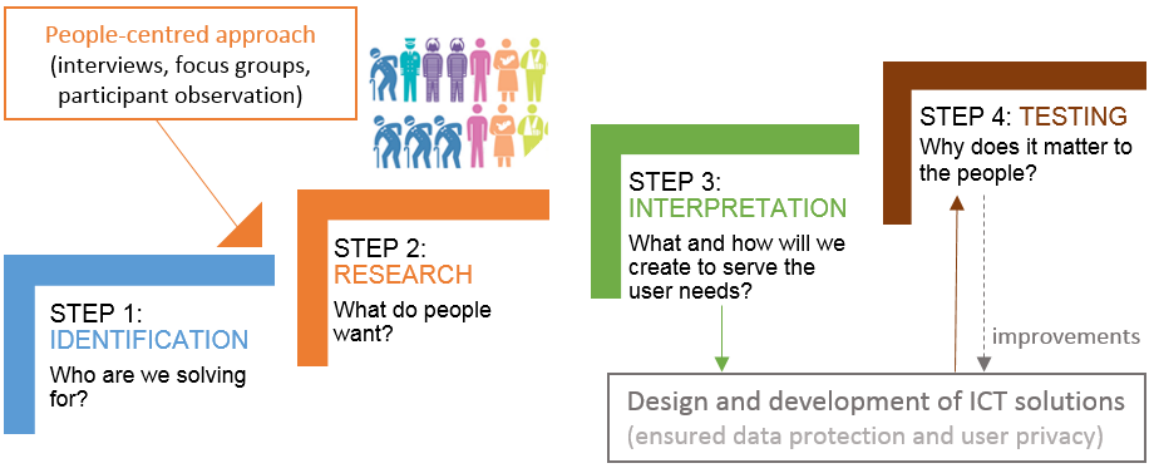

Figure 4: MOBISTYLE approach integrating social science aspects into occupant behavior research.

The anthropological approach enables to access 'thick data', as an in-depth understanding of human behaviour, able to penetrate beyond the quantified behaviour of 'big data' collected via technological solutions. This understanding defines requirements for developing the ICT tools in order to provide user-friendly and attractive services.

Through anthropological observations, it is possible to understand not only how and when people consume energy, but why do they actually do it. This additional layer of personal information opens opportunities to understand and educate users at the individual level, increasing their awareness of how and when their daily habits have an effect on energy consumption. One of the most promising outcomes of this methodology is the shift in perception from passive building occupants to pro-active users, who become co-creators of their surrounding environment.

First findings from the anthropological observations for the 5 demonstration sites showed that:

- Health and well-being more important than energy saving and CO_2 emissions = Consider health upfront;
- People are saturated with technology = Offer non-intrusive, calm technology giving users a choice to decide which services they want, how long and during what time creates a feeling of participation and control where user is pulled instead pushed to use services and is able to decide which data he or she is willing to share;
- Meaningful & relevant information on local (person) as European (society) level = Requirement for information type - Targeting group & individual behaviour in commercial & home environment;
- People do not find information trustworthy = Information coming from a trusted source, supported by scientific studies, users should know who is behind the information. If supported, accepted by people, it is higher possibility they will accept it too (influence of neighbourhood);
- Ensure user privacy and data protection = Explain users clearly how their data will be collected, stored, protected and used. Ethics are a big part of MOBISTYLE as is GDPR compliance;
- Coopetition = cooperation + positive competition = Introducing gamification as a communication strategy integrated in the developed MOBISTYLE services where certain behaviour of individual as of group is encouraged by applying typical elements as when playing a game enhance engagement in a positive way;
- No 'one-size-fits-all' solution = Be aware of differences between and within countries, leading to tailor made information based on segmentation of users (arche-types);

It was confirmed that technologies can influence behaviours and beliefs and help in formation of long-term habits and practices. In addition, it was established that connections to other people matter most in forming and changing daily habits and practices, including the ones connected to energy management, health, and wellbeing. A balance between collaboration and competition seems to be an important factor for the MOBISTYLE project. These results should be used to design a solution which will support making a move from being a passive user of technologies to be an engaged person. The details are available in *D2.2 Inventory of user needs and expectations.*

Focus groups, supplemented by participant observation, have proven to be a useful research technique for studying users' habits, motivations, needs and expectations in the MOBISTYLE project since they allow researchers to study people in a less structured conversation pattern than typically occurs in an ethnographic interview.

For each demo case, one focus group involving 5-8 people users per case, was carried out on:

- ✓ Danish demonstration case: 21 March 2017;
- ✓ Polish demonstration case: 12 April 2017;
- ✓ Slovenian demonstration case: 13 April 2017;
- ✓ Italian demonstration case: 31 May 2017;
- ✓ Dutch demonstration case: 27 June 2017 and 12 October 2018.

Findings from the focus groups, supplemented by one-on-one interviews and participant observation have been instrumental in preparing ten key recommendations which defined the boundary conditions for the further development of the MOBISTYLE ICT tools and awareness campaign, as illustrated in Figure 5.

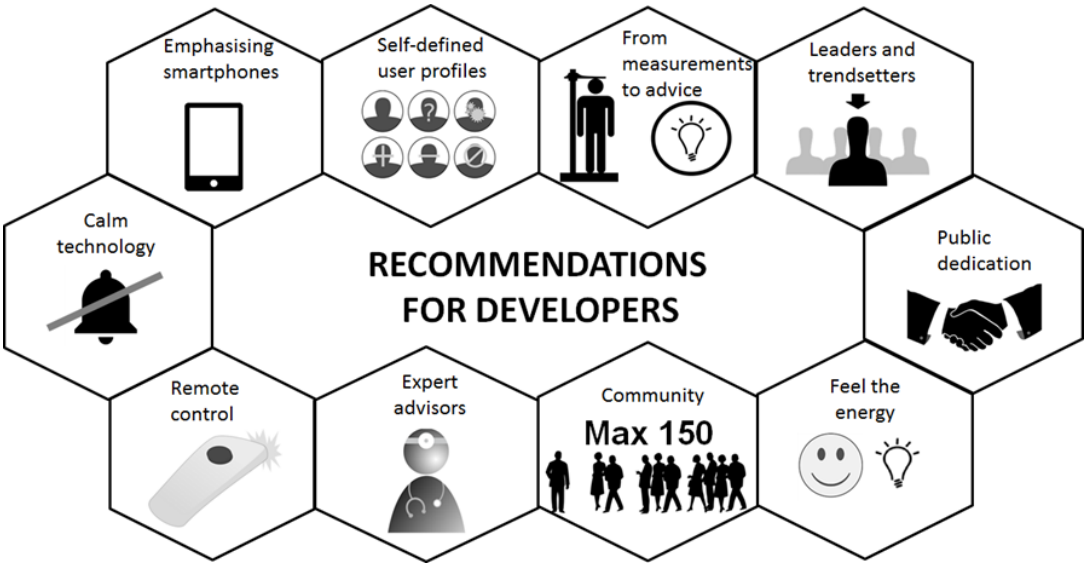

Figure 5: MOBISTYLE recommendations for the ICT developers based on the focus groups findings.

10 people-centred recommendations for the technology development based on focus groups:

1. **Emphasising smartphones**: Smartphones are among the most widespread ICT tools and people in the focus groups preferred the usage of the smartphone as the main platform for communication between the users and the MOBISTYLE service.

2. **Self-defined user profile**: Users should have the possibility to create their own user profiles and to set customized personal pro-environmental goals. This can give them a feeling of active participation in defining settings for influencing their own habits.

3. **Customised and location-based advice**: By combining measurements from sensors with location-based services (e.g. weather data), generic and local-specific advices can be prepared according to the local environmental characteristics.

4. **Calm Technology principles**: ICT tools should not irritate the user with too frequent unnecessary notifications. Instead, the developers should rely on Calm Technology principles[1] which suggest that the most robust and reliable technologies are those that disappear and weave themselves into the fabric of everyday life until they are indistinguishable from it.

5. **Individual controls**: Ideally, the user should be able to adjust various parameters influencing his or her indoor comfort through the same ICT tool providing him or her building performance information.

6. **Expert advisors**: It is recommended to prepare communication material by experts (i.e. researchers) providing advice or explaining tasks which will be encouraged via the ICT tool. Advice should be supported by a trusted reliable source as this can improve people's propensity to behave in a suggested way.

7. **Spreading the concept through leaders and trendsetters**: When implementing the technology, the developers should focus on early adopters trendsetters and influencers who are able

[1] Case, A. Calm Technology: Principles and Patterns for Non-Intrusive Design, 1st ed; O'Reilly Media, USA, 2015.

to motivate others to use the novelty in a community. Furthermore, popular local public figures can help spreading the main message.

8. **"Feel the energy" approach**: The problem related to energy saving is that energy is often impossible to be felt and cognitively processed. The users are unable to perceive the quantity of energy they are using in their everyday practices. Therefore, energy should be visualised in a clear and understandable way, without using standardised units of measuring energy and power.

9. **Public dedication to a goal**: The technology used should enable public commitment to a goal, which has to be meaningful and relevant for an individual and a community. Social media or existing local groups in different cases can be used for this purpose.

10. **Community size**: Buildings with a larger number of inhabitants (> 150) witness problems of social bonds breakdown. In such cases, the developers should support establishing new communities and enable people to create new ties for helping each other and exchanging information through the ICT tool.

The ten general recommendations can be applied in all cases, while the case-specific recommendations take into account requirements of people in different locations and buildings. The description of the case-specific recommendations can be found in *D2.3 Recommendations for improvement and further development of solutions.*

Interested to get in touch with responsible MOBISTYLE partner for anthropological studies?

Then contact the responsible MOBISTYLE partner, Institute for Innovation and Development of University of Ljubljana (IRI-UL; website: www.iri.uni-lj.si). IRI UL is a non-profit research institute, an independent legal body established by the University of Ljubljana and ten technologically advanced Slovenian companies with a mission to initiate the creation, transfer, distribution and application of knowledge by transferring research results into practice.

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4. Multidisciplinary holistic MOBISTYLE methodology involving various scientific expertise resulting in the behavioural action plans per demonstration case

With the fast development of ICT solutions in the recent years, the price of sensors is falling rapidly therefore sensoring of the environment is not an issue. However, the main question is how to efficiently handle all the gathered data in order to provide occupants relevant information. The MOBISTYLE methodology was developed with the objective to make building's energy consumption, indoor environmental quality (IEQ) and health related data understandable for the identified users groups. To provide information on generated indoor environment, health and lifestyle, the MOBISTYLE approach combines four fields of expertise:

- Expertise on **energy and IEQ**;
- Expertise on **health sciences and the human body**;
- Expertise on **ICT tools and solutions**;
- Expertise on **anthropology and human mind**.

Objective is to formulate a methodology to define, gather, elaborate and address energy, indoor environmental quality and health data to users aimed at providing a behavioural change via ICT based tools. This methodology includes:

- Parameters definition;
- Data collection;
- Data analysis;
- KPIs identification;
- Awareness campaign.

During the first year of the project Task 3.1, 3.2 and 3.3 were structured similarly as to collect in the three fields all the needed information for applying the methodology to the demo cases. Objectives were defined for each demonstration case based on the identified needs of the different user groups. For each demonstration case, a **MOBISTYLE Behavioural Action Plan** was developed that includes a full description of:

- Optimization objective(s) of the Behavioural Change Campaign;
- Definition of Action(s) that can be taken (and influences) from the users;
- Definition of the variables that can be monitored, related to:
    - Actual energy usage (using indoor environment monitoring systems and smart meter data);
    - User's motivational drivers, attitudes, subjective norms and perceived behavioural control (using the questionnaire as a foundation of the app system architecture).

Accordingly to these action plans for each demonstration case and based on the information made available from the focus groups (thick data), together with data coming from sensors, wearables and questionnaire responses (big data), scenarios of behavioural change intervention were developed (Figure 6). These is implemented into the MOBISTYLE ICT solutions via which the information is disclosed to end users.

Moreover, different ways how to visualize data for the identified user groups in the dashboard and in the game were identified in terms of KPIs, real-time feedback and alerts. Algorithms and transformation of data for an easy understanding by the users were elaborated.

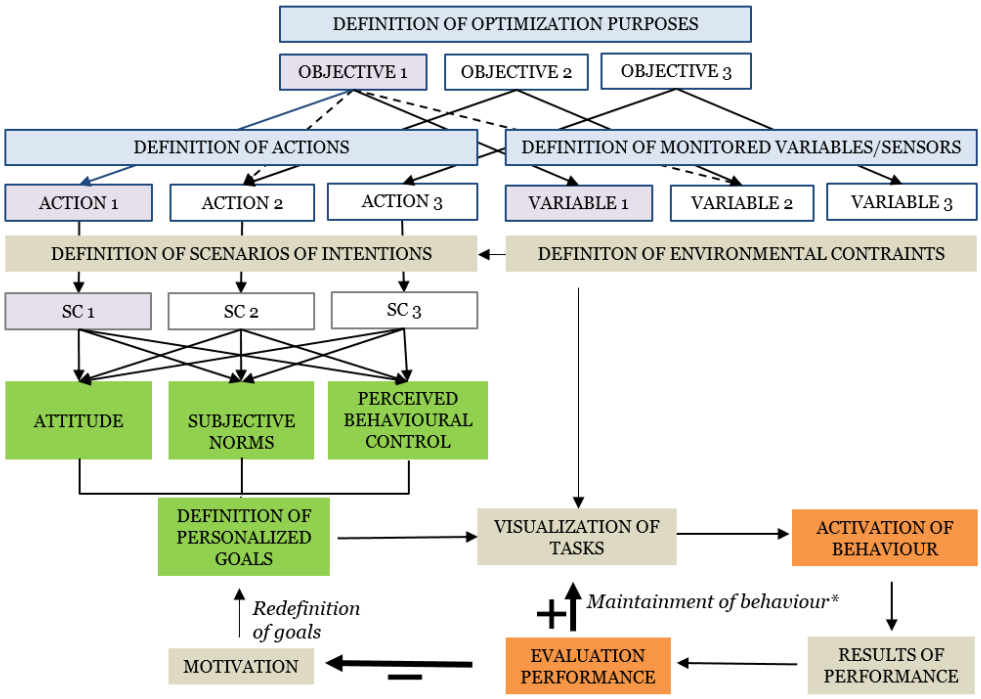

Figure 6: Structure of the Behavioural Change Intervention Action Plan, including optimization objectives, definition of actions and the data gathering from sensor, for the implementation of the scenarios of interventions (serious gaming) and the feedback system architecture into the MOBISTYLE ICT solutions.

The details are available in *D3.1 Detailed monitoring and information campaign parameters (objectives, data requirements, monitoring tools, information services) based on combined feedback about energy, IEQ and health*.

During the first two years also the guidelines to evaluate the application of the project in terms of impact (energy savings) and process (deployed communication environment, tools and apps) were defined. The goal of the evaluation is to figure out the project's effectiveness & project's relevance.

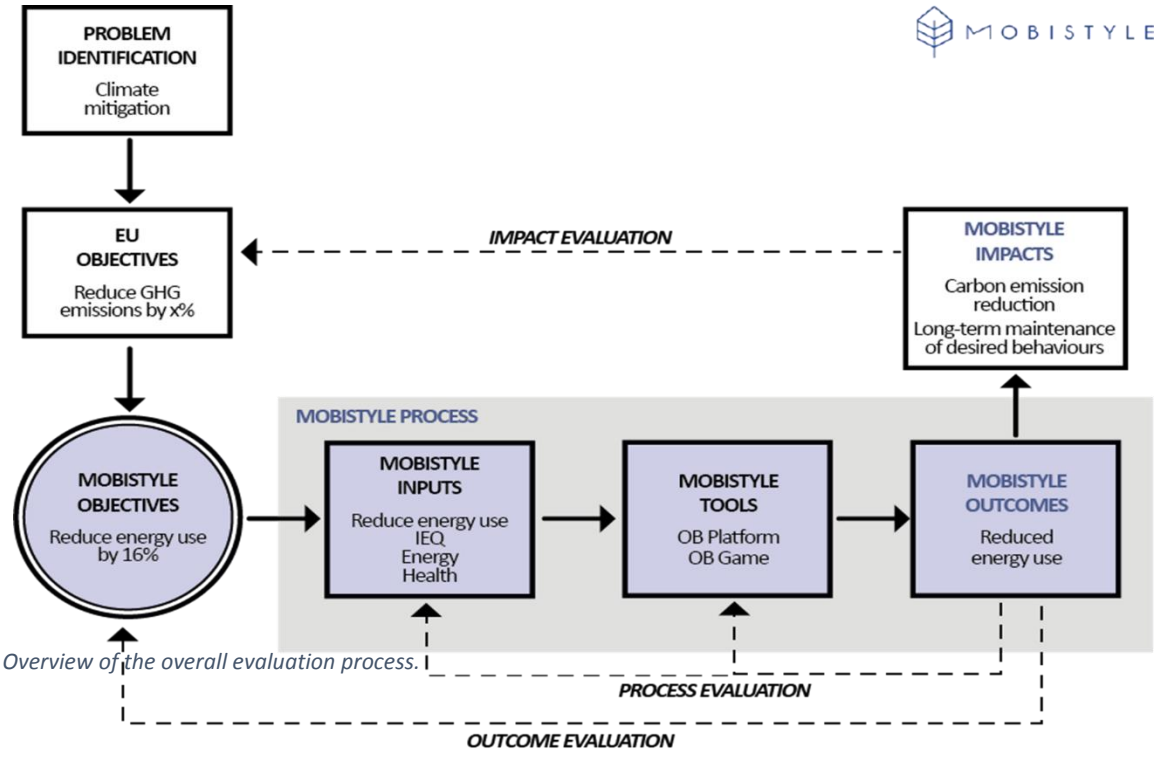

Figure 7: Overview of the overall evaluation process.

By consequence, evaluation strategy consists of different monitoring periods (M0, M1, M2) and evaluation steps (E1, E2, E3) as presented in figure below. In particular, the monitoring periods are the following:

- Initial monitoring (M0) leading to Benchmark definition (E1);
- Feedback provision (M1) leading to Intermediate evaluation (E2);
- Optimized feedback provision (M2) leading to Final evaluation (E3).

Impact evaluation should regard the energy savings and environmental impact at an overall level of the awareness campaign. A comparative analysis of specific KPIs defined in the benchmark (E1) is necessary to evaluate properly the results. Process evaluation includes assessment of possible optimization and improvements of the implemented process. Separate evaluation for each category of provided feedback (for example, advices related to thermostat adjustment or stand by usage of domestic appliances) is performed. Also, in this case, a comparative analysis of specific KPIs defined in the benchmark (E1) is necessary to evaluate properly the results. Questionnaire assessing the usefulness of feedback from the user's point of view should be provided.

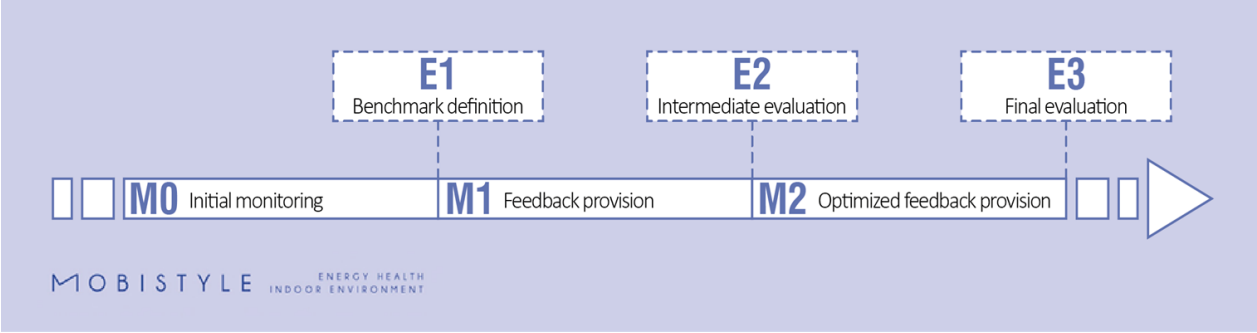

Figure 8: The MOBISTYLE evaluation strategy.

Furthermore **cost-benefit analysis** (CBA) methodology is introduced to show the connection between investment cost in new technologies, energy savings and benefits for society (health, people satisfaction etc.). This is a valuable tool to be used to measure the economic performance of the application of MOBISTYLE solutions in buildings. The details are available in *D3.3 Evaluation method to test the effectiveness of the combined feedback campaigns.*

Interested to get in touch with the responsible MOBISTYLE partner for methodology development? Then contact the responsible MOBISTYLE partner, Politecnico di Torino (POLITO; website: www.polito.it/). Department of Energy is actively involved in developing concepts and technologies for an energy conscious and comfortable built environment. A wide spectrum of research subjects are investigated, as: indoor environmental quality, building energy performance, HVAC and building envelope technologies, lighting and applied acoustics.

Key persons involved:

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5. Development of modular information services

In MOBISTYLE, the goal is to use existing technologies and make them more user-friendly and understandable in its operation. The goal is not so much the access into data but to get insight into data. Hardware components for monitoring energy, IEQ and health are widely available and getting cheaper and cheaper. At the same time the business interest is shifting now from 'selling' hardware to collecting, owning/sharing and managing data, i.e. the core business is not so much selling these hardware components but much more on the development of user-friendly tools, interfaces and augmented reality-based apps and on the management of the collected data. In this sense, the MOBISTYLE Open Users platform offers the possibility for data collection and management and deployment of the developed tools and information services for business development (also by designated third parties).

The design of sensoring network architecture for each of the five demonstration buildings is based on building occupants needs and (existing) requirements of the building. The final decision on what type of sensor network to include is defined by giving the answer to the following question: ''What information do we want to obtain (data types), what existing sensors do we have, how much accuracy we need and how much we are willing to pay?''

The main idea of personalized MOBISTYLE modular information services is to offer so called information/data acquisition bundles where end-users decide which services they want, how long and during what time, and which data they are willing to provide for these services. A modular structure is developed providing tailor-made information giving a possibility to add new modules later, e.g. desire to monitor additional IEQ parameters. Based on the project experiences blue prints will be made how to develop similar campaigns in other projects.

MOBISTYLE Open Users Platform

The MOBISTYLE Open Users Platform will be established having an open architecture for developers' engagements and for further deployment of the developed tools. This platform will focus on the implementation of the end users' behavioural aspects of the solution as well as the algorithms and models defined during elaboration of MOBISTYLE methodology.

To test the attractiveness and ease of use of developed platform and services engaged learning with the end-users at the demonstration sites will be elaborated. Following the people-centred approach, it will be observed how the users interact with new developed services and test whether they can teach the researchers what is their purpose and how they should use them. After the usability testing recommendations will be prepared for improvement and further development of solutions.

In order to come to structural and semantic information services on energy, health and lifestyle, MOBISTYLE creates a database as a tool that continuously add data to enable data analytics and application of grey/black box models. The main objective of the MOBISTYLE Open Users platform is to deliver an IT platform that makes the backend services, in particular the IoT Data repository, accessible to new services that can be developed by developers from outside the consortium, so to ensure the scalability of the platform itself.

This means the platform is to be compatible for integration with existing modular services based on the same data storage and exchange principles (e.g. telecom-routers, smart meter platforms etc.). The

platform will start with at least 10 suppliers offering their products/services (result-commitment), but during the project the effort will be done to increase this number to 25 suppliers.

The most important boundary condition is respecting ethics and privacy (respecting new GDPR). This means that the envisaged business models must building trust by transparency, by putting users fully in control and coping with national and European ethic rules.

The SMEs that have commercial interests in collaboration and continuation are invited to realize their visions by joining the Open Users Platform.

Interested to get in touch with the responsible MOBISTYLE partner for development of the MOBISTYLE Open Users Platform?
Then contact the responsible MOBISTYLE partner, Holonix (HOLX; website: www.holonix.it). HOLONIX was established in 2010 at the Faculty of Engineering Management of the Polytechnic University of Milan, after years of international research conducted by its founders. The goal of Holonix is to aid companies in innovating their products, processes and services, in terms of production, logistics, maintenance, assistance and so on, by implementing an Internet of Things approach that creates added value in product lifecycle knowledge.

Key persons involved:

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Interested to get in touch with the responsible MOBISTYLE partner for exploitation of the MOBISTYLE Open Users Platform?
Then contact the responsible MOBISTYLE partner, DEMO (DMO; website: www.demobv.nl/en/). DEMO is an independent consultancy dealing with strategic management, technical advice and software modelling for the real estate sector. DEMO creates innovative software products offering tools for investment appraisal, portfolio management, strategic decision making and maintenance planning.

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6. Demonstration and validation of the MOBISTYLE approach

The MOBISTYLE perform several demonstration projects in which relevant data about building and occupant performance (e.g. energy, indoor environment quality, health) is collected via sensors and meters and then personalized information presented to the users (the MOBISTYLE Dashboard, Game, Expert tool). The integrated methodology in the ICT tools incorporate behaviour nudging aspects for assessing what has the deepest impact on their behaviour.

The deliverables D2.5 *Composition of specific sets of data acquisition for the five study and demonstration cases* and D4.1 *Applicable hardware and software solutions for sensing technologies* describe the existing and new sensor network, as well as the local data storage infrastructure at each demonstration case.

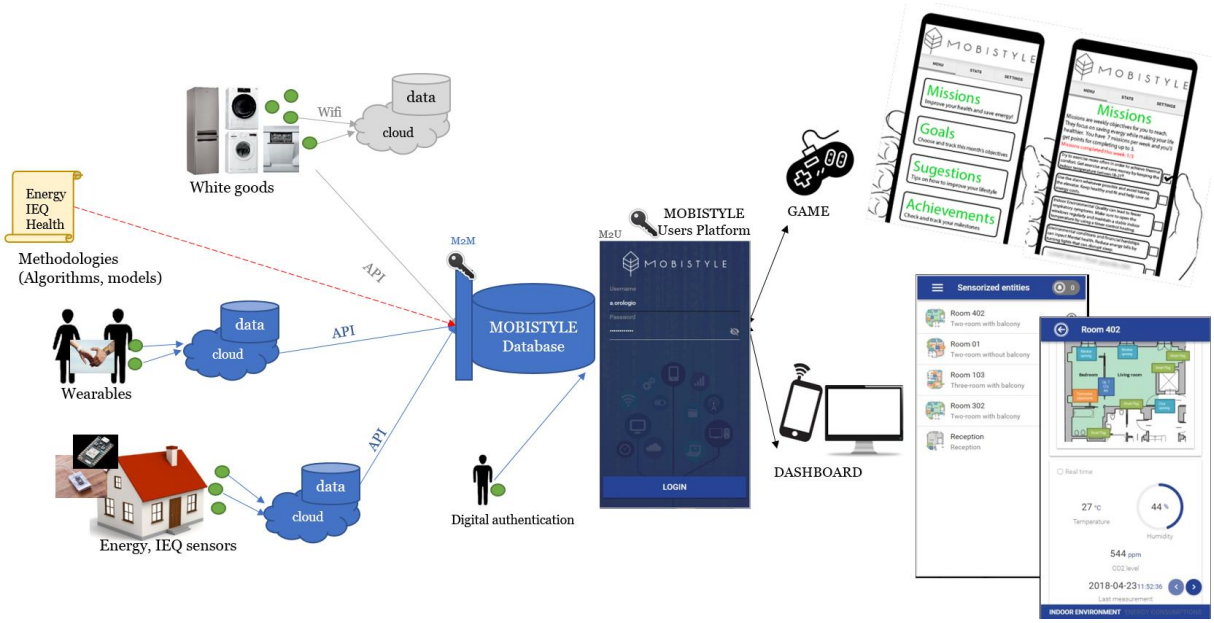

Figure 9: The schematic presentation of the MOBISTYLE data acquisition and information disclosure flow.

In the following paragraph, the MOBISTYLE objectives for the five demonstration cases are listed, describing their unique focus areas and the case specific objectives. One of the immediate challenges revealed itself early in the development process as each case is uniquely different and requires an individual approach.

Another reason for the differences between the specific case objectives are due to the case and user interests and impact areas, where it is attempted to link various parameters that are motivating and relevant for the individual users, as opposed to energy parameters only. Moreover, this tailored information is expected to motivate and increase the user awareness, which helps users behave in a more energy conscious manner long-term. As a consequence, energy efficient behaviour is promoted, but the tailored approach avoids replicating generic feedback programs, which aren't successful long-term.

Table 1 describes the demonstration case unique focus areas and user interaction with technical systems.

Table 1: Demonstration building description, user interaction with technical systems

Case	Type	Target Area	Area/Occupancy	Technical Systems/ User interaction
Case 1 Kildeparken	Residential	18 apartments	Area: 67-130 m2, 1- 5 persons/apartment	Heating (setpoint), DHW use, window opening
Case 2 University of Ljubljana	Office	8 offices	Area: 15 - 60 m2	Solar shading, window opening, lighting, HVAC setpoints
Case 3 Hotel Residence L'Orologio	Hotel	4 hotel apartment, reception area	Area: 36-39 m2, 2-3 rooms/apartment	HVAC (setpoint), window opening, appliances
Case 4 Qeske and Brightlands	Office	Open plan offices	Area: 400 m2	-
Case 5 Smart City Wroclaw	Residential	300 units	Area and persons/residence: Varying	Window opening, lighting, appliances

- **Danish demonstration case: Kildeparken, Aalborg, DK**

The specific case objective is to combine information regarding IEQ (Indoor Environmental Quality) and energy in order to establish how tailoring information according to different user types helps increase awareness and leads to energy efficient behaviour change.

Responsible for the Danish demonstration case: Per Heiselberg (ph@civil.aau.dk) & Sandijs Vasilevskis (sv@civil.aau.dk).

- **Slovenian demonstration case: Faculty buildings of University of Ljubljana, Ljubljana, SI**

The specific case objective is to provide users with information regarding IEQ in order to influence their short-term behaviour and change in long term habits leading towards improved IEQ and energy reduction.

Responsible for the Slovenian demonstration case: Jure Vetršek: (jure.vetrsek@iri.uni-lj.si).

- **Italian demonstration case: Hotel Residence L'Orologio, Turin, IT**

The specific case objective is to monitor IEQ and electricity consumption in order to provide the hotel guests with feedback on energy use and guidance on how to save energy, use smart control of heating and lighting. This could be combined with suggestions regarding healthy daily activities and

encouraging energy efficient usage of whitegoods as additional information to increase user awareness, though these are not directly measured.

Responsible for the Italian demonstration case: Verena M. Barthelmes (verena.barthelmes@polito.it).

- **Polish demonstration case: Smart City Wroclaw, Wroclaw, PL**

The specific case objective is to monitor the electricity consumption of users and motivate their behaviour change towards more energy efficient building usage by giving users attractive information about their daily activity (healthy tips), IEQ and energy (recommendations for actions and measured data). Moreover, the goal is to obtain real household profiles mapping internal needs of customers to understand and communicate potential benefits for both parties – the service providers and building owners. The goal is also to observe daily activities of the residents combining information regarding lifestyle and energy consumption as this is the difference of MOBISTYLE in comparison to the existing projects only concentrating on providing info solely about energy.

Responsible for the Polish demonstration case: Paweł Marciniak: (pawel.marciniak@tauron.pl) & Joanna Herczakowska (joanna.herczakowska@tauron.pl).

- **Dutch demonstration case: Qeske and Brightlands office spaces, Limburg, NL**

Many aspects of human health, physiology and behaviour are dominated by the exposure to surrounding conditions. Therefore, for the Dutch demonstration case it is explored in the MOBISTYLE project how different generated indoor environment situations (requiring a certain energy use) affect users health and well-being. The specific case objective is to establish a correlation between different indoor environment situations (dynamic temperature profile in comparison to traditional constant temperature setting) affect occupant's health (physiological) response and how occupants perceive such conditions (psychological).

This demonstration case is different compared to the rest of the MOBISTYLE cases as it does not start with changing user behaviour from the beginning. First, the aim is to demonstrate that the dynamic temperatures are healthy for people. During first MOBISTYLE demonstration phase at Qeske, the idea is to evaluate physiological acceptance (actual health benefits) when exposed to dynamic temperatures instead of stable. Once this is proved, we can increase the people's acceptance by educating them and raising awareness to reach higher psychological acceptance. This is the next step, where idea is to deploy the tailored MOBISTYLE feedback system to disclose information to the employees at Brightlands.
The goal is also to observe daily activities of the residents combining information regarding lifestyle and energy consumption as this is the difference of MOBISTYLE in comparison to the existing projects only concentrating on providing info solely about energy.

Responsible for the Dutch demonstration case: Loes Visser (l.visser@huygen.net) & Wouter Marken van Lichtenbelt (markenlichtenbelt@maastrichtuniversity.nl).

Demonstration case specific objectives are summarized in the Table 2**.**

Table 2: Demo-case specific objectives related to energy, IEQ, health and user behaviour.

Case	Reduce energy use	Improve IEQ	Improve Health	User practices
Case 1 Kildeparken	Heating, DHW	Reduce overheating, improve IEQ	By improving IAQ (better sleeping quality at night)	Optimize heating setpoint adjustments, window opening strategy, DHW use
Case 2 University of Ljubljana	Indirectly, energy use reduction estimated	Reduce overheating, avoid glare, improve IEQ, lighting quality, view to outside	By providing motivation	Improve user interaction with building systems
Case 3 Orologio Living Apartments	Electricity for HVAC and appliances	Reduce overheating, improve IEQ	By improve the sense of wellbeing in relation to indoor environment	Optimize fan- coil setpoints and window opening strategy, use appliances and electric devices
Case 4 Qeske and Brightlands	Indirectly, energy use reduction estimated as a results of reduced heating setpoints		By exposing occupants to different temperature conditions	Investigate response and perceived acceptability of varying temperatures
Case 5 Smart City Wroclaw	Electricity for appliances and plug loads	Reduce overheating, reduce humidity levels	By improving IAQ (better sleeping quality at night)	Optimize HVAC setpoint adjustments, window opening strategy

Interested to get in touch with the responsible MOBISTYLE partner for demonstration cases?

Then contact the responsible MOBISTYLE partner, Aalborg University (AAU; website: https://www.civil.aau.dk/). AAU was inaugurated in 1974 as the fifth Danish university with more than 20,000 students registered. The Architectural Engineering division of the Department of Civil Engineering is concerned with research and education in the analysis, design, construction, and operation of engineering systems. It focuses on an integrated, multidisciplinary approach to achieve optimal building designs and pays special attention to their impacts on the indoor as well as the surrounding environment.

Key persons involved:

Per Heiselberg (ph@civil.aau.dk)

Sandijs Vasilevskis (sv@civil.aau.dk)

Added value of the MOBISTYLE

Even though there are two demonstration cases with residential households, two cases with office environment and one case with hotel environment, each of the demo-case has its own added value to the MOBISTYLE project.

Looking closer at the residential pilot sites, the Danish case in Kildeparken residential housing area, mainly focuses on improving the heating use and IEQ quality. Meanwhile, in the Polish demonstration case the focus is set more on the electricity use and smart plugs. Furthermore, the use of appliances like Whirlpool smart washing machines is tested only in the Polish demonstration buildings. Also, from upscaling perspective Smart City Wroclaw will have the highest impact potential as it is planned to extend the testbed up to 300 households.

Furthermore, it can be said that Italian demonstration case presents a similar environment to residential buildings but with less or no ownership feeling from the user side, therefore it is a great challenge to make hotel guests more aware of their actions. Also, from all the pilot sites Orologio Living Apartments will be the demo-case with the warmest summer period with actively used mechanical cooling system.

Similarly, users working in office environment are less concerned about their energy use. Therefore, including office buildings adds value to the project. In Slovenian case, University of Ljubljana, buildings have a single-cell room layout, whereas the office buildings in Netherlands have an open plan layout. Furthermore, Qeske and Brightlands office buildings representing the Dutch case present the most unique demonstration case as it will test user perception to the varying indoor temperature profiles, whereas in University of Ljubljana the air temperature is controlled and kept at more constant level according to the traditional constant temperature setting. Additionally, only employees in Qeske building will wear health and activity monitoring equipment like Fitbit wristbands.

Innovation

In the market the existing ICT-based solutions that are used to represent indoor climate and energy use mostly offer visualization of the data without a relevant feedback. MOBISTYLE ICT-solutions (Game and Dashboard) will provide not only feedback on the current conditions, but also information on how to improve the situation. This will be done via notifications in the Dashboard App and various missions in the Game App.

At Brightlands, MOBISTYLE awareness campaigns and information feedback will be provided for employees to further increase people's perception and acceptance with dynamic indoor conditions. To show the employees the benefits of the dynamic conditions created in the offices in a easy to sense way, the virtual reality glasses will be used.

Relevance

While in building industry the implementation of smart building energy meters is already in a process, the same can’t be said about indoor climate metering devices. A partly conclusion is that it could be a barrier to scale-up mainly due to extra cost of installing IEQ monitoring devices. How to solve this? This is a topic to be addressed in future.

Impact potential

Apart from the reduction of energy and improving IEQ and Health, the MOBISTYLE project can increase interest among participating building owners via improved management of the technical systems. Additional information about the user interaction with technical systems and overview of the existing conditions. Thus, the building owners can get more knowledge about how the systems are performing.

Also, offices account for 6% of EU overall building floor area, and we spend in average 5 days a week 8h in them (Building Performance Institute Europe, Europe's buildings under the microscope, October 2011). If MOBISTYLE project will demonstrate that lower temperatures in the office in the morning are acceptable and healthy for the building occupants and at the same time lead to energy saving, this can show that similar approach can be applied to other office spaces.

More about the added value, innovation, relevance and impact potential of each demonstration case is described in the D6.1 *Detailed final monitoring, awareness and information campaigns for the five cases.*

7. User engagement via different MOBISTYLE ICT based solutions

With the MOBISTYLE approach, the goal is to show that improving building technologies and systems is not enough. In order to achieve ambitious goals of European Union regarding energy savings a different approach is needed where users of the buildings are equally important part of the building ecosystem as building technologies. Therefore, the MOBISTYLE exploitable asset is not a single ICT solution but MOBISTYLE approach as a whole. The emphasis should be on educating users on how to behave in their buildings and increasing their awareness by combined information on their energy usage, generated IEQ and lifestyle. For this reason, it was investigated on how to disclose the information to different end-user types at the demonstration locations.

MOBISTYLE has taken an anthropological people-centric approach (focus groups organized at all the demonstration sites, referred to Chapter 3), with the users at the centre of the development process. In the preliminary design workshops with the users from the different cases, we investigated the use of particular technologies and possible scenarios of MOBISTYLE. The use of AR was deemed of significant low value with a strong preference for the gamified App (MOBISTYLE Game for residential building and their occupants) and the dashboard (MOBISTYLE Dashboard for non-residential buildings, users that do not own the buildings they occupy) available as mobile applications.

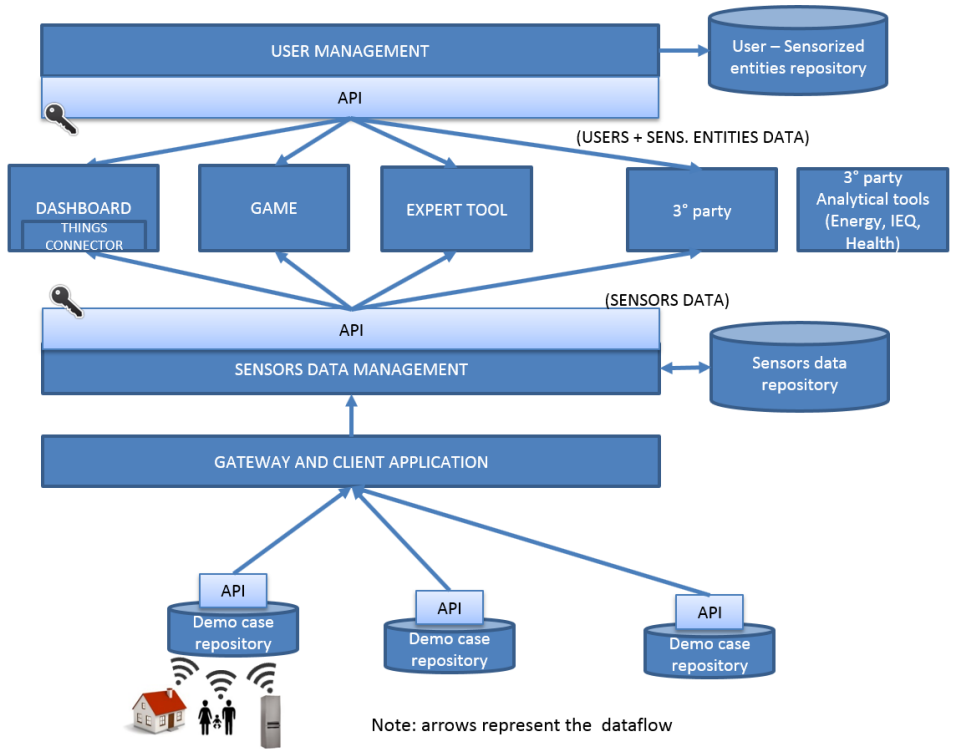

Figure 10: The MOBISTYLE ICT architecture.

The following table introduces the developed MOBISTYLE solutions:

	MOBISTYLE Dashboard	**MOBISTYLE Game**	**MOBISTYLE Expert tool**
What is it?	An application for non-experts that visualizes end-users data on energy use and IEQ (buildings performance) which are based on measured parameters. Visualisation can be customised for different roles (e.g. building occupant or building manager) Through alerts/push messages recommends specific user certain actions that may avoid excessive energy use and/or improve indoor environmental conditions.	A mobile application, that based on defined objectives for preferable user practices, nudges user to change practices in a fun way and is able to track the effect of changed practices on energy use and indoor environment over time. It provides scores to users for recommended practices and desirable changes. It uses "nudges" (based on the sensors data available), complemented by healthy "tips".	It will be available in a desktop version. The expert tool has 3 main purposes. The first one is data management. The expert has access to the data and can validate, check, filter them. The second purpose is to enable the expert to calculate basic KPI and modify parameters and algorithms. The KPIs are related to energy, comfort and health and are made available to the end user through the dashboard. The last purpose of the expert tool is to support data needs of third-party tools.
For which purpose?	Monitoring & Raising awareness	Behavioural change & Raise awareness	Data management, calculation of KPI, support data needs of third party tools.
For whom?	Building manager & Occupants	Residential users (have most control of their environment)	Experts
Where is it tested?	Non-residential buildings	Residential buildings	Not applicable
In which demo cases?	Slovenian case & Italian case	Polish case & Danish case	Not applicable
ICT developer responsible	HOLONIX with a contact person: Manuel Larsen (manuel.larsen@holonix.it)	HighSkillz with a contact person: Joao Costa (joao.costa@highskillz.com)	DEMO with a contact person: Andre van Delft (andre@demobv.nl)

The results and analyses of the demonstrators and feedback from the end-user groups will be used to adjust and fine-tune the methodologies, tools, services and supporting business models.

8. MCAB involvement: Continuous dissemination and exploitation of the developed approach and results as a road to MOBISTYLE future

MOBISTYLE has a combined consumers and market driven approach and is initiated both by industry and SME partners with specific business interests as well as the end-users involved in the 5 demonstration and study cases. The business and exploitation models shall be a key output of MOBISTYLE for ensuring continuation of activities after the project duration.

The five demonstration cases where the MOBISTYLE approach is tested serve as a basis to develop further a strategy and action plan for the exploitation in 5 different climatic regions (geo-clusters) covering different building types (office spaces, university, social housing, smart homes, hotel), different types of end-users and different scales (building, district). The MOBISTYLE project is not a stand-alone development of ICT solutions and services, rather MOBISTYLE project paves the path for a long-term approach where ICT solutions and services are supported by and communicated to users through awareness campaigns at the demonstration sites.

Involving commercial companies interested in MOBISTYLE approach:
In order to ensure adequate exploitation of project results, activities are aimed at defining appropriate measures and methodologies for managing exploitation activities, including management of business models for different target groups, third parties and different countries.

The MOBISTYLE business strategy will be based on a preliminary selection and definition of suitable business model(s) where stakeholders taking part in MOBISTYLE Consumers Advisory Board (MCAB) are invited to take part. Different organizations and commercial companies around Europe have expressed their interest in the MOBISTYLE approach by signing a Letter of Support (LoS).

Interested to take part in MOBISTYLE Consumers Advisory Board and get more insights in this H2020 project?
Then contact our MOBISTYLE Ambassador: Andrei Vladimir Lițiu: litiu@kth.se.

Possible exploitation paths and collaboration opportunities with:

- Building sector organisations: The developed tools could be integrated in a new or existing product, offered as a new service or embedded in existing services or just used as know-how in all stages of a buildings life cycle (concept, design, construction/installation, commissioning, operation);
- EU level decision-making process: Recommendations for the relevant existing EU policy tools covering buildings;
- Building level decision-making process: Could be used as motivator/trigger for building renovations. Could be used as motivator/trigger for changing/upgrading building services or installing new ones (e.g. mechanical ventilation system, opening/closing motors for windows);
- Project partners: The developed tools could be further used in a for-profit business model by one (or several) project partner(s). Different value can be created for different players on the market: manufacturers of home appliances (e.g. WHR), energy providers (e.g. TAU), manufacturers etc.

The business models should be therefore generated and evaluated from the point of view of different stakeholders (building owners, service providers, financing institutions) within the consortium and the MCAB (both groups; demonstration case holders, commercial companies signing LoS).

Foreseen Use Cases for the Platform:

The MOBISTYLE Open User Platform has an architecture that allows Use Cases for diverse building's end-users:

- Support commercial ICT suppliers to offer their products and services to the target group;
- Consumers engagements through a user friendly and attractive application in a 'game-like' environment, including the possibility to provide actions and guidance;
- Case studies demonstrating applications of end-user tools for a number solutions;
- A further and wider deployment of the developed tools and modular information services;
- Access to the developed business and exploitation models to support the modular information services.

Specifically, the MOBISTYLE Open User Platform Use Cases connect to the foreseen business cases (current opportunities and future applications) for the different target groups, as illustrated in the following table.

	Target Group	Business Case	Use Case	ICT Feature Exploitable Assets
Target groups, represented in the MOBISTYLE consortium and/or the consumers advisory board	End-consumers households and users of buildings	Easy access for all end consumers, from building facility managers to households, to information on real energy use by easy accessible media and, as a secondary effect, access to advanced energy services for households to understand their total energy use and energy costs, based on online information on energy use and guidance for measures and change of energy behaviour. Major benefits of the side effects such as better thermal comfort, indoor air quality and health.	• To provide data driven (contexual) behavioral change suggestions and guidance to end-consumers	Gamification Platform, Dashboard
	Manufacturers of monitoring and control equipment, related services	Benefit of a new range of technical services which bring monitoring and user targeted information together. This range of products will be a strong support in the implementation of the EPBD/EED. The positive impact of these products will strengthen the competitiveness of these industries. Guidance to industries for new products in monitoring and control equipment, smart metering and interactive information.	• To offer their products and services to the target group; • To develop interoperable and aspect-oriented CDT solutions; • To free downloads of open standard basic software.	
	Manufacturers of home appliances	Benefit for a new generation of smart home appliances, not only 'communicating' on services and (mal) functioning but also interactive communication with consumers, load prediction, efficient use of appliances. These new services contribute to a better competitiveness of European industries on home appliances.		

	Energy suppliers utilities	Benefit of new tools for real time optimisation of energy demand and supply (smart grid) using intelligent energy management systems for reducing the difference between peak power demand and minimum night time demand, application of future energy storage technologies	• To combine the deployment and implementation of smart meters, control systems and BMS with monitoring real energy use and consumers behavior. • To overcome the limited access to necessary data to understand which factors influence energy use in buildings and behavior and to what extent.	
	ESCOs	Profit by removing one of the major barriers for ESCOs and performance contracts, (the discrepancy between real and predicted energy use). Opportunities for new business in energy services by improved transparent contracts and procurement procedures, implementation of methodologies to control total energy use and savings hence controlling and mitigating the risks in uncertainties of performances. Cost-benefit relations of energy saving measures becomes clearer, increasing the deployment of energy contracting and financing constructions.		
	Social Housing Companies	Possibility to offer affordable energy costs for their tenants in combination with the development of a sustainable housing stock. Controlling real total energy costs is prevents and mitigates fuel poverty.	• To provide case studies demonstrating applications of ICT tools and user-centric methodologies for a number of building types and end-users	

	HVAC and engineering branch	Deployment of the results and application of monitoring and control systems providing information on real energy use and diagnostics of differences, failures and predictive maintenance by comparing with the predicted energy use. The HVAC Branch will engage new market opportunities, for example to the out roll of new energy services based on real energy use. Traditionally, this branch is involved in energy services, yet until now mainly product orientated; this sector can make a transition to advanced energy services based on real performances and energy use and by providing information on performances of HVAC systems.	• To provide e-learning material that can be used for self-instruction and the development of CPD courses	
Target groups, NOT represented in the	Industries on building construction, building fabric, building services (part of the total chain approach)	New opportunities in NZE building and retrofitting market by offering concepts with guaranteed energy performances by better understanding of user behaviour. Possibility to profile themselves by guaranteeing real energy use to their clients rather than only an energy label. Performance contracts with suppliers, contractors/ installers give the certainty of the level of delivered quality and robustness	• To offer their products and services to similar target groups and building types	

	Building constructors Real Estate Developers	Possibility to distinguish themselves by delivering reliable and products with proven performances and taking their responsibility in this chain. Enhancing their image in social engaged and green entrepreneurship. For serious manufacturers and suppliers this gives an extra stimulus for promoting their products and to enhance their competitiveness. Understanding and communicating on real energy use implies that the building and HVAC industry must provide realistic figures on energy performance and energy use in practice. This can be an important marketing tool for serious industries.	• To provide case studies demonstrating applications of ICT tools and user-centric methodologies for a number of building types and end-users	
	Policy makers	Support for standardization and benchmarking of total energy use to set down indicators for energy use in buildings that takes end-user's related factors into consideration, to achieve the better acceptance of energy labelling systems among the public, and to improve the ability to communicate to the public on behaviours that will influence energy use in buildings.	• To overcome the limited access to necessary data to understand which factors influence energy use in buildings and behavior and to what extent.	

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