MOBISTYLE

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

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Executive Summary

This report is an outcome of *T4.3: Software applications and apps in combination with serious gaming*. The objective of T4.3 according Description of Action (DoA) was to develop mobile software modules and applications to engage users and foster change of behaviour. Augmented Reality (AR) and 3D models were initially planned to be used in order to support the user engagement and foster their change of behaviour. However, MOBISTYLE has taken an anthropological approach, with the users at the centre of the development process. In the preliminary design workshops with the users from the different cases, the use of particular technologies and possible scenarios of MOBISTYLE was investigated. As result, the use of Augmented Reality was deemed of not enough added value. Gamified Apps and friendly User Interfaces (UI) to access and understand energy, health, and comfort data, on the other hand, did.

For this reason, the decision was to develop the MOBISTYLE Game, the MOBISTYLE Dashboard and the MOBISTYLE Office App to support user engagement towards a more energy efficient behaviour.

The final version of D4.3 (Month 42 of the project) shows the final results of the main ICT tools developed within the MOBISTYLE project, with respect to the feedback given by the potential end users of the tools during the user testing workshops performed in the different demonstration cases. In this context, this report also presents the approaches, methodologies and results of the user testing activities performed by WP2 (Task 2.5), in collaboration with WP6 in the different demonstration cases.

The COVID-19 outbreak throughout Europe during the last months of the project (February-May 2020) and its impact on MOBISTYLE research resulted in the suspension of final demonstration activities (e.g. final focus groups). In particular, for this report, the final usability testing for the MOBISTYLE Office App and the MOBISTYLE Game were not entirely performed, thus, no outcomes related to the end-user testing were registered or recorded in this document.

In this context, the ICT tools presented in this report: **the MOBISTYLE Dashboard**, developed by the consortium partner Holonix, **the MOBISTYLE Game**, developed by the consortium partner HighSkillz and **the MOBISTYLE Office App** developed by partner Huygen are described in detail, together with the user testing activities performed before the suspension of the activities for certain demo cases.

Each partner was responsible to identify and present the main features of their tools, the challenges and decisions taken during the implementation of the solutions, and next steps based on the recommendations to be taken for further development and testing of the Dashboard, the Game and the Office App.

Note: The fourth MOBISTYLE tool is the Expert tool, developed by the consortium partner Demo. This tool is however presented in D4.4 Systematic data exchange approach due to the objectives and the functionalities of this tool.

Introduction

The goal of MOBISTYLE is to raise consumer awareness and motivate behavioural change by providing attractive personalized combined knowledge services on energy use, indoor environment, health, and lifestyle, by Information and Communication Technologies (ICT) tools. Providing more understandable information on energy, health and lifestyle will motivate end-users to change their behaviour towards optimized energy use and provide confidence in choosing the right thing. It will offer consumers more and lasting incentives that only information on energy use.

In WP4 Practical ICT tools are developed, including:

- robust and cost-effective sensing technologies that can be deployed with a minimal setup in small and large-scale installation spaces;
- an integration platform with modular configuration for data and software interoperability, inter-connecting sensor networks that aim to improve the range and type of energy-efficient behaviours;
- a set of software applications for mobile devices and wearable, to enable energy-efficient behaviours of the end-users.

The main aspects of ICT tool development that are covered by MOBISTYLE are:

- embedding strategies of emotional, corporeal seduction for stimulating of end-users, without significantly increasing cognitive load in the tools;
- including mobile technologies, grounded in conceptual narrative frameworks, to encourage end-users to feel an emerging need to delve further and become curious about energy, health and the resulting lifestyle;
- integrating narrative techniques from choreography, music, and serious gaming.

The first deliverable of WP4, D4.2, aimed to describe the overall MOBISTYLE architecture for providing feedback and raising awareness to the end user, starting from the data collection – coming from sensors – about energy use, indoor environmental quality and health.

The second deliverable of WP4, D4.1, was about the applicable hardware and software solutions for sensing technologies used in MOBISTYLE. This deliverable presents also the decision taken for the development of the MOBISTYLE platform in reference to the connection between the demonstration cases and the MOBISTYLE database for data collection, to the setup of the database itself and to how sensors data are then shared with the end user applications.

The current report, D4.3, is the third deliverable of WP4 and shows the final results of the main ICT tools developed within the MOBISTYLE project, with respect to the feedback given by the potential end users of the tools during the user testing workshops performed in the different demonstration cases. For this reason, in this deliverable are presented not only the status of the development of the ICT tools but also the approached, methodologies and results of the user testing activities performed by WP2 in collaboration with WP6 in the different demonstration cases.

Chapter 1 describes the methodology provided from WP2 to perform user testing of the ICT solutions, namely the Dashboard, the Game and the Office App, in the different demonstration cases. User

experiences were gathered to form recommendations for the further development and improvements which are highlighted in this chapter.

Chapter 2 briefly explains the positioning of the ICT tools into the MOBISTYLE architecture.

Chapter 3 shows the state of the development of the MOBISTYLE Dashboard, developed by the consortium partner HOLX. Main functionalities, based on the recommendations of the users, are presented. Next steps according to the responsible partner HOLX have been presented.

Chapter 4 shows the state of the art of the MOBISTYLE Game, developed by the consortium partner HS. Main functionalities, based on the recommendations of the users, are presented. Next steps according to the responsible partner HS have been presented.

Chapter 5 shows the state of the art of the MOBISTYLE Office App, developed by the consortium partner HIA. Main functionalities, based on the recommendations of the users, are presented. Next steps according to the responsible partner HIA have been presented.

Chapter 6 describes conclusions for this part of the research. The final conclusions and recommendations are being presented in this final version of the deliverable at M42.

1. User testing approach and methodology

1.1. Introduction

User testing related activities covered the initial testing in Slovenian (SI) case that helped for methodology development resulted in the user testing protocol that was implemented in other demo sites.

In the initial phase of the MOBISTYLE project the users were identified, recruited and grouped, as described in D2.2: Inventory of user needs and expectations. With their involvement, following the iterative people centred design approach, the recommendations for developing a new solution with potential to influence habits based on needs and expectations of people, living and working in MOBISTYLE demonstration cases, i.e. in the Netherlands, Slovenia, Poland, Italy, and Denmark were prepared, as described in D2.3: Recommendations for improvement and further development of solutions. This deliverable serves as orientation for developing solutions influencing user behaviour and supporting a long-term shift towards healthier lifestyle and sustainable habits at home and work. Several ethnographic and qualitative research methods were used; questionnaires, participant observations, interviews and focus groups (FG).

The first versions of solutions were tested on the same users previously participating in the research following the people-centred development approach with iterations. It was carried out in focus groups (one per country) tailored to specifics of each demo case. An extensive report was prepared for each demo case as part of T2.5; in this document, only a summary is presented. The activities of T2.5 have now at M42 been completed, but work related to the improvement of the solutions is being performed within WP6. For this reason, the full report of the user testing activities in each demonstration case is available as annex of this D4.3.

1.2. Preliminary usability testing

In the Slovenian demo case, focus groups were organized in spring 2018 as preliminary usability testing, as described in T2.5 (e.g. Focus group user testing protocol). The goal of usability testing is recommendations for improvement and further development of solutions operationalized by other work packages. The testing for the Slovenian case was a foundation for development of the protocol. Suggested designs of ICT solutions and formulation of messages in the nexus of health-energy-indoor climate were tested.
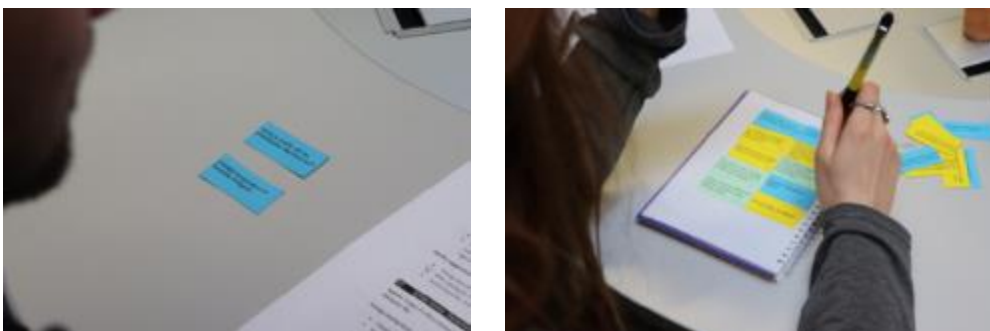

Figure 1: Slovenian focus groups were organized as preliminary usability testing in spring 2018

The Protocol for MOBISTYLE solutions testing

The Protocol for MOBISTYLE solutions testing (See Annex 1) using focus groups was prepared for project partners, so they were able to individually carry out the focus group in their circumstances. The protocol comprises of chapters briefly presented below. General recommendations provide guidance regarding the testing and report preparation time-frame, facilitator and participant selections. In the preparation chapter all necessary activities prior to the testing are described in details. References on support documents, e.g. Instructions for recruitments of participations in the ethnographic study are mentioned to ease the work. The whole process described covers the introduction of the event. The use and implementation of Standard Usability Scale is described, together with data evaluation. The questions prepared cover intuitiveness and simplicity of Graphical User Interface (GUI), possible channels for distributions and relevance of advices. The final ones, developed in T3.4, were tested in order to get feedback from the people. Finally, guidelines for documentation and follow up with an example of a report were provided to make the work easier.

1.3. Focus groups in partner countries

Using the prepared protocol, focus groups for solution testing were carried out. Afterwards, reports for each focus group were prepared as part of T2.5.

Table 1: List of activities in each demonstration case

WHEN	WHERE	WHAT
09.03.2018 3.10.2019	Slovenian case (SI)	Focus group & Testing of solution design Testing of the final Dashboard & App
10.08.2018 10.03.2020	Polish case (PL)	Testing of the Game mock-up Intermediate evaluation
27.09.2018	Italian case (IT)	Focus group & Usability testing of the Dashboard
12.10.2018, 24.6.2019. 28.10.2019	Dutch case – Qeske & Brightlands (NL)	Focus group to discuss what could be the relevant features (12.10.2018, Qeske), Focus group on first version of the solution (24.6.2019, Brightlands) & Intermediate Usability testing of the Office App (28.10.2019, Brightlands)
12.12.2018 11.03.2020	Danish case (DK)	Focus group & Usability testing of the Game Intermediate evaluation

The Dashboard was tested in the SI and IT cases, the Game in DK and PL case and the Office App for the NL case.

In the SI case testing was performed on the design solution of the Dashboard. Then the App version of Dashboard was developed and tested in the IT case.

In the DK and PL case usability testing was performed on a prototype of the Game. This was useful to give input for the further development of the App version of the Game itself. The DK and PL intermediate evaluations of the game were done in 2020 just before the restriction measures were put in place all around Europe due to the COVID-19 situation.

Due to change of a building in the Dutch demo case (Qeske and Brightlands), new focus groups were organized. At Brightlands, MOBISTYLE awareness campaigns and information feedback is provided for employees to further increase people's perception and acceptance with dynamic indoor conditions. The first focus groups were organized to discuss the first version (prototype) of the solution and see

how to improve the solution. The evaluation questionnaire and another focus group was done to see the intermediate evaluation.

Quantitative measurement by System Usability Scale

In general, after the focus group (FG) participants were familiarised with the MOBISTYLE solution and initial interaction was established, the testing was carried out by presenting to the participants the System Usability Scale (SUS) test. The SUS testing has been done for Slovenian (SI), Italian (IT), Danish (DK) and Polish (PL) case. Due to the different readiness level, for the SI and IT case the SUS was used during the first evaluation period (E0) as the first version of the dashboard was mature enough for SUS testing. For PL and DK case, SUS testing was used during the intermediate evaluation (E1). Due to the changes in the Dutch case, the timeline of the Office App development was postponed compared to original Gantt Chart and this lead also to a postponement of the testing periods. The SUS evaluation (SUS testing) was planned for 23 Mar where the COVID-19 restriction measures in the Netherlands became active as of 15 Mar. Therefore, no physical SUS testing was possible.

The table below is used to assess the result of the SUS questionnaire.

SUS Score	Grade	Adjective Ranking
> 80.3	A	Excellent
68-80.3	B	Good
68	C	Okay
51-68	D	Poor
< 51	F	Awful

Bangor, Kortum, & Miller, 2008

1) **Results and examples of SUS results for the IT case are summarized below (also Annex 2).**
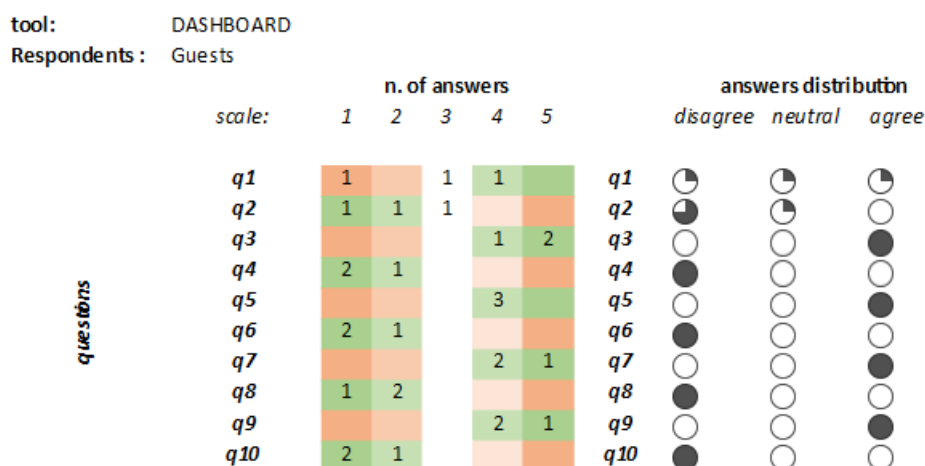
Figure 2: Result of SUS testing for the dashboard in the Italian case done by guests.

Most of the people do not think that the tool is unnecessary complex (q2), while all of them have almost the same opinion about the other issues that the survey intended to investigate. In particular, they do not think that the tool requires a technical support (q4) or more knowledge (q10) to be used. Furthermore, they do not agree that the tool have internal inconsistency (q6) or that it is cumbersome

to use (q8). Conversely, they agree that the tool is easy to use (q3) and that it has well integrated functions (q5). They felt confident using the dashboard (q9) and then they think that most people would be able to learn quickly how to use it (q7).

The same procedure was carried out for the receptionist and hotel manager. In addition, the App version of the Dashboard was tested with all 3 user group and SUS was filled.

2) **Results and examples of SUS results for the SI case are summarized below (also Annex 3).**

Table 2: Results of SUS testing in the SI case dashboard

SUS Calculation

Participant	SUS Score
p1	82,5
p2	72,5
p3	55,0
p4	30,0
p5	90,0

This was done in the Focus Group taking place in October 2019.

3) **The summary of the SUS implemented in DK case is presented below in the table (also Annex 4).**

Table 3: Results of SUS testing in the DK case for the prototype Game

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	1	5	2	5	2	5	1	5	2	**92.5**
p2	5	2	3	1	3	3	4	2	3	2	**70.0**
p3	4	4	4	1	3	3	4	1	3	3	**65.0**
p4	5	1	4	1	5	1	4	1	5	1	**95.0**
p5	5	1	5	2	5	3	5	1	5	1	**92.5**
p6	5	5	5	1	4	3	5	1	5	1	**82.5**
p7	5	5	5	1	5	1	5	1	4	4	**80.0**
p8	5	1	5	1	5	1	5	1	5	1	**100.0**
p9	5	1	4	2	4	3	5	1	5	1	**87.5**
p10	4	5	4	2	5	2	5	2	4	2	**72.5**
p11	5	1	5	1	4	1	5	1	5	3	**92.5**
p12	5	1	5	1	5	1	5	1	5	1	**100.0**
p13	3	2	5	3	4	2	4	2	4	3	**70.0**
Average SUS score											**84.6**

* 1 – Strongly disagree; 5 - Strongly agree

** Most of the scale answers marked as 1 and 2 means that users mostly disagree with the statement, 3 – which they have neutral position, 4 and 5 – that they agree with the statement

The overall Average SUS Score was 84.6% which corresponds to a result of **Excellent**.

Table 3: Results of SUS testing in the DK case for the Game after 2-3 months of application

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	4	3	4	1	4	1	4	1	3	2	**77.5**
p2	3	2	4	1	3	2	4	1	2	1	**72.5**

p3	5	2	4	5	4	1	4	2	4	3	**70**
p4	1	3	3	1	3	3	5	3	4	1	**62.5**
p5	1	5	1	5	1	3	1	5	5	3	**20**
Average SUS score											**60.5**

The overall Average SUS Score was 60.5% which corresponds to a result of Poor.

With the significant impact of data quality, sensor install issues and delay in data availability (30m-60m), it is not possible to distinguish the usability driven issues from the issues caused by data not being available. For users, this distinction was not visible.

For the DK case, 3 extra questions in addition to SUS were requested on the prototype from the consortium partner HighSkillz (HS) regarding the game:
1. Do you find the comparison to your community motivating for you?
2. Do you find the award system motivating for you?
3. Do you find the missions and the associated actions clear enough for you?

For the DK case, 3 extra questions in addition to SUS were requested from the consortium partner HighSkillz (HS) regarding the game:
4. Do you find the comparison to your community motivating for you?
5. Do you find the award system motivating for you?
6. Do you find the missions and the associated actions clear enough for you?
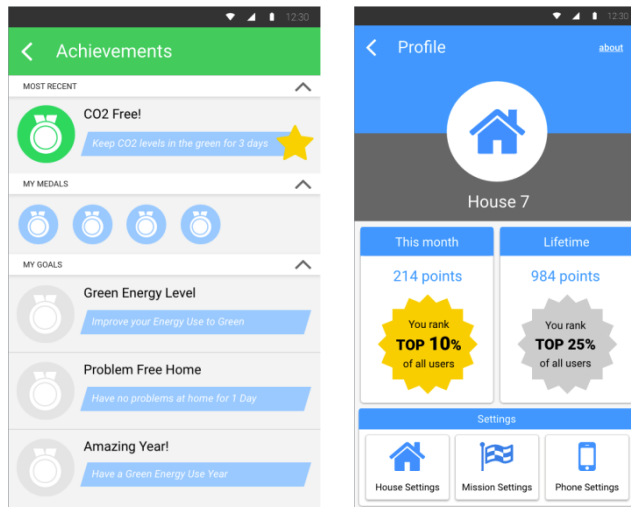
Figure 3: Tested mock-ups of the game screen in the DK case

Table 4: Results of the HS questions in the testing.

HS questions:	No of answers:					Answer distribution**:
Scale*:	1	2	3	4	5	
11. Do you find the comparison to your community motivating for you? (Profile section)	1	1	5	3	3	Neutral/Agree
12. Do you find the award system motivating for you? (Achievements section)		3	3	4	4	Agree
13. Do you find the missions and the associated actions clear enough for you? (Missions section)			2	4	7	Agree

* 1 – Strongly disagree; 5 - Strongly agree

** Most of the scale answers marked as 1 and 2 means that users mostly disagree with the statement, 3 – that they have neutral position, 4 and 5 – that they agree with the statement

It must be noted that participant did not spend much time with Game App in DK testing. Therefore, it is suggested to repeat the same questions again when one-on-one interviews with the residents will be carried out.

4) **Results of SUS results for the PL case are summarized below. More information is available in Annex 5.**

	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	3	1	5	1	4	1	5	1	5	1	**92.5**
p2	4	3	2	2	3	5	4	4	3	3	**47.5**
p3	4	4	4	2	4	4	4	4	4	2	**60.0**
p4	5	1	5	2	2	3	5	2	4	1	**80.0**
p5	5	4	5	2	3	4	4	1	3	2	**67.5**
p6	4	2	4	1	3	3	4	1	4	1	**77.5**
p7	5	1	5	4	4	3	4	1	4	1	**80.0**
Average SUS score											**72.1**

Table: Results of SUS testing in the PL case for the Game

The overall Average SUS Score was 72.1% which corresponds to a result of **Good**.

For more information refer to Presentation on [T6.4: Definition of 'impact assessment', means of verification & impact evaluation](#) (page 20).

Detailed results for SUS SI, IT, DK and PL testing are available in Annexes.

1.4. Questions addressed in the testing

The following questions were developed as part of the Protocol for MOBISTYLE solutions testing described in chapter 1.2.

Q1: Intuitiveness and simplicity of the graphical user interface (GUI): How do you find the design of the solution? Can you recognise the main features? What do you think of the symbols used on the screen?

Summarized feedback from testing:
SI case: the acronym **RH is not understandable** to everyone. It should be more clearly stated how e.g. air humidity is presented. All people do not understand the units, e.g. what kWh means. "Euro" is a widely understandable variable and symbol. A suggested symbol for intuitive understanding of **comfort** should be a **smiley** ☺ (smiling face). The heart with pulse is overall understood as a symbol of health (only a heart would represent love). For more information refer to document: [Focus group in Slovenia demo case (UL FKKT FRI) – testing the solution design.](#)

Figure 4: Focus group in the SI case.

IT case: Most of hotel guests do not think that the **dashboard** is unnecessary complex. In general, also for the staff, the dashboard is **consistent and not cumbersome**. They believe that its usage does not require technical support or particular skills. However, they are **not sure that most people could learn to use the dashboard very quickly**. **None** of the receptionists has a strong position in affirming that they **would be willing to use it**.

The usage of the smartphone application, carried out in the second phase, resulted in producing more agreement among the guests on some issues. With respect to what they affirmed for the dashboard, guests are surer that they would be willing to use the app. They agree that the app is not unnecessarily complex and that most people would learn to use it very quickly.

Figure 5: Focus group in the IT case.

DK case: Access to the Game mock-up version was provided to the participants one week prior to the meeting. However, **none of the users did try to access** the App. The questions relating intuitiveness of GUI and its simplicity for use were done in the frame of SUS. Overall, SUS evaluation was very good.

Figure 6: Focus group in the DK case.

NL case: In this example, the questions were different due to the nature of the demo case. The first focus groups organized at Qeske offices revealed that people associate more with the control over building systems and perceived indoor environment. Here are some examples: "*It is never really known what the set points of the different units (AHU) are.*" "*Not everyone knows how the remote control of the units works*". Furthermore, temperature remains the most influential parameter of how they are perceiving their indoor office environment. People would like to go out more often if the area was nicer. It is an industrial area. "*If there was a small park, I would sit there for at least an hour. Now I stay inside most of the time.*"

Figure 7: Focus group in the NL case.

Q2: Possible channels of content distribution, e.g. public screens and other IT devices in the building that could be used for motivating them to change the existing practices: Where would you like to use the MOBISTYLE solution? Do you know any good place in the building where it could be shown to others?

Summarized feedback from testing:

SI case: Maximum two messages (push notifications on smartphone) should be sent per day. Each advice should be used in a specific context; in addition, an optimal information channel should be used (e.g. an advice to use of stairs instead of elevators makes most sense near an elevator).

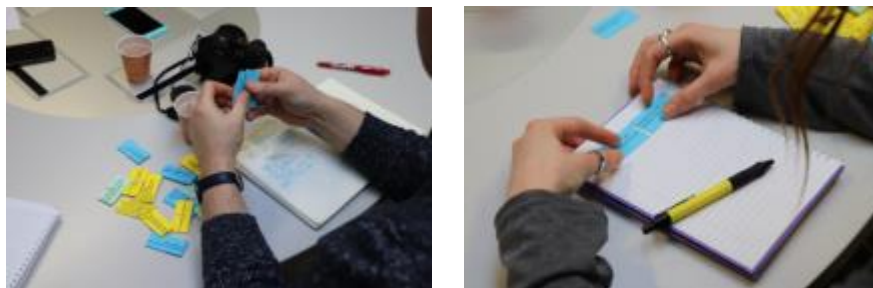**Figure 8: Focus group in the SI case.**

IT case: The guests stated they prefer the App version of the Dashboard, while receptionists liked more the desktop version, since they are used to work with laptops. Receptionists also believe there is no space to install a public dashboard in the common rooms of the hotel; however, in new rooms it could be interesting to have someone to test the solution.

Figure 9: Focus group in the IT case.

DK case: The comparison with neighbour apartments is questionable for this user group. For example, tip which states **comparison** (*"Yesterday your neighbours used by 10 % less heating energy than you."*), was voted one of **the worst advices** (6 votes). People asked if and when the Game App will be available in Danish language. Some **would not like** to see the messages and problems that were accumulated during the day, in situations when they arrive late at home. It was suggested to turn off notifications if the users not in the house.

NL case: The employees expressed that the disclosure of information on **the wall** when entering the meeting room would be the best, to understand the quality inside each room immediately (). Furthermore, they would like to be able to **express their opinion** over the conditions (*''if it is too cold, I want someone to know that and perhaps they will do sth about it''* and *''just clicking the buttons like at the airport''*). They would like to hear some other **tips** too via the same app (*''remind me that is possible to put the table high so I can work standing''*).

Figure 10: Focus group in the NL case.

Q3: Relevance of advices, recommendations and tips: Which advices do you like the most? Which are the least relevant for you? Why?

Feedback from testing

SI case: "It's **sunny** outside, do you really need the **light on**?" was selected as the best advice. The question is motivating, but not too "bossy". "The outdoor conditions are excellent for letting some fresh air in!" was also well accepted by participants of the focus group.
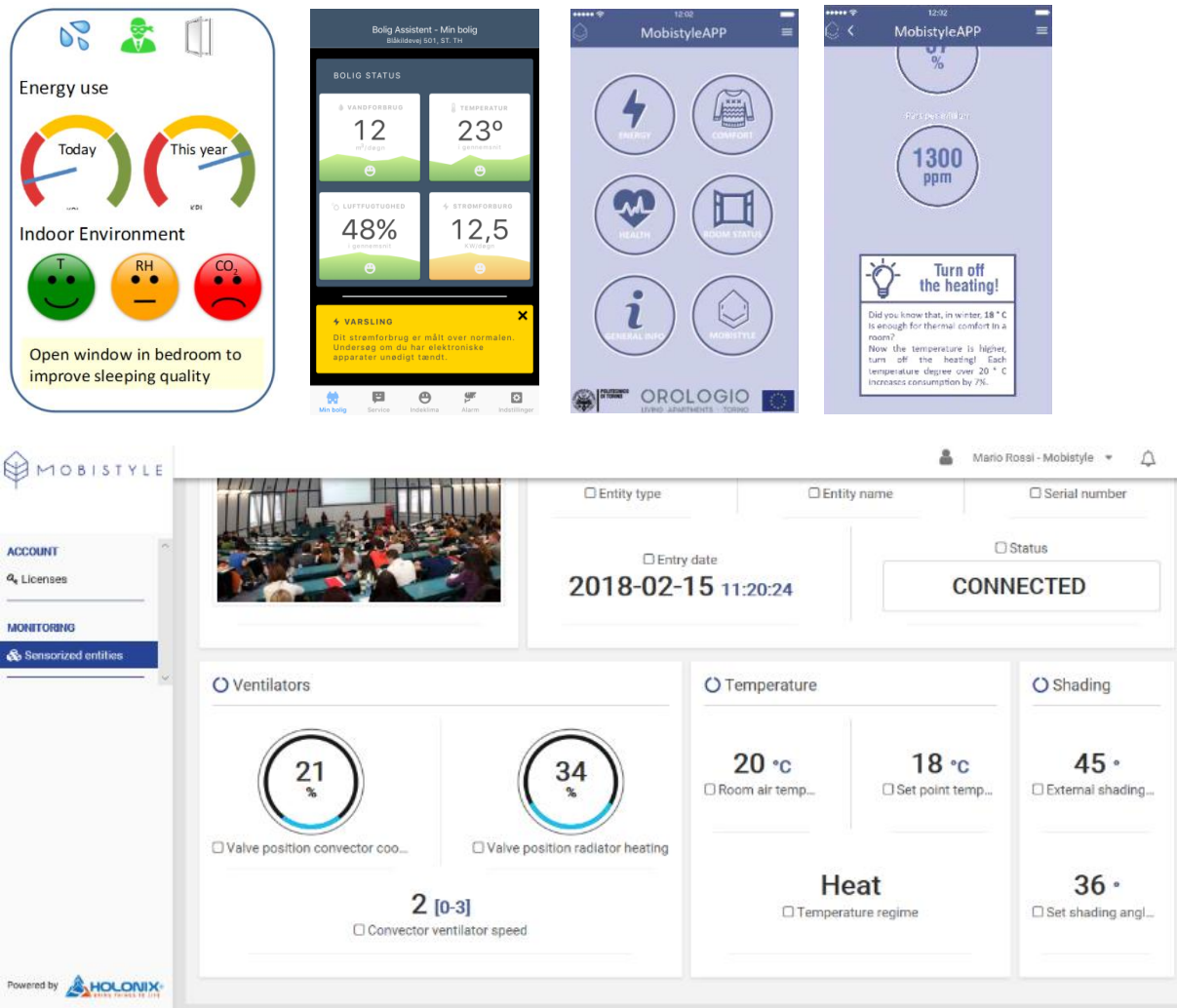
Figure 11: Visualization examples that have been evaluated for the Slovenian case.

IT case: The communication **should be kind** and should not leverage on touchy and personal issue (e.g. all the guests choose the advice related to weight as one of the worst).

No numerical thresholds should be presented because they are difficult to understand.

Feedbacks related to health are valued, but some of them are perceived as exaggerated. Some guests and the manager put their attention on specifics of the hotel guests: the **guests are paying for service**; therefore, tips, suggestions, comparisons and judgments could be perceived as annoying. Communication should push the people to remain interested in the tools.

Dutch case: To visualize the **dynamic climate**, the temperature, color temperature and light intensity must be displayed separately from each other. They found the satisfaction questionnaire with the scale (-3,0,3) too complicated and would prefer giving **feedback** in different way: ''*like what you have at the airport, these simple press buttons*''. They indicated that a value did not mean much to them without reference (e.g. colouring what is good and bad), even at temperature. They found the following visualization very clear.
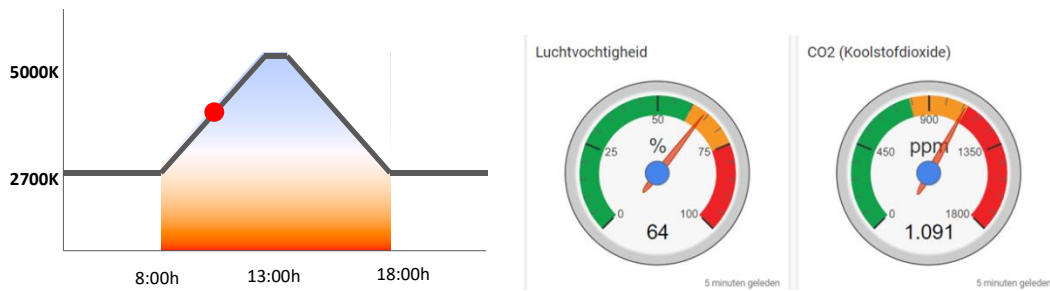
Figure 12: Visualization examples that have been evaluated as understandable for the Dutch case.

DK case: Generally **HEALTH related tips scored good** voting results, **except** the advice **about losing weight via increased metabolism and low temperature**. Improve the **sleeping quality** related tips scored high. In addition, the tip "Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"" - is among the top 3.

From the **ENERGY CONSUMPTION** related tips, the advice ''Always turn off your radiator when you vent the room by opening the windows.'' and ''Your monthly hot water consumption is higher than it used to be. You will save money by reducing your consumption!" were mostly well received.

Advices that suggest building residents **to adjust their clothing level**, was **poorly accepted**.''

1.5. General recommendations & closing remarks

General recommendations coming out of the testing, which can be used to improve the MOBISTYLE solution in local case? The recommendations can include your personal impression about the positive and negative aspects of the MOBISTYLE solution and about possibilities for improvement.

Summarized feedback from testing

SI case: It was specified that an advice or recommendation **should be carefully selected and checked**. Each advice should be used in a **specific context**; in addition, an optimal information channel should be used (e.g. an advice to use of stairs instead of elevators makes most sense near an elevator). Participants **don't like receiving text messages**; if anything, push notifications should be used max. twice per day. There should be a simple option available for disabling the push notifications.

IT case: The communication should be kind and should not leverage on touchy and **personal issues** (e.g. all the guests chose the advice related to weight as one of the worst). Use of numerical thresholds in the advices text is not effective because they are difficult to understand. **Feedback related to health is appreciated**, but some of them are perceived as being exaggerated (e.g. "Expose yourself to a variable internal temperature (feel cold occasionally) reduces the risk of cardiovascular diseases, diabetes and obesity. Test it!"). Feedback on health related issues with **immediate effects** is preferred to the one with long term results. Peer comparison between guests is valued by some of the participants of the focus groups, since it leverages the sense of competition and gaming. However, some guests and the manager pay their attention on the peculiarity of the hotel final use: **guests are paying for their service**. For this reason, internal comparison and kind communication are important prerequisites.

During all the survey session, many participants ask for clarification about what they were seeing.

PL case: The users had overall healthy homes (IEQ parameters within the recommended ranges) so it did not make much sense to them to be checking the application after a while as everything was fine. The application affected the overall knowledge and awareness of home occupants but after a while

they already knew that it is good, so no new, appealing information came to them. A need for a more sophisticated system emerged which would attract users to use the application on a longer term.

DK case: The users didn't spend so much time with Game App; therefore, AAU will conduct a round of **one-on-one interviews** with the residents after a fully functional Game App is available to users. HighSkillz could prepare additional questions and include them in interviews. It should be noted that **comparison with neighbour** apartments is questionable for this user group.

NL case: The temperature is perceived good where they **are aware of having control** over the air-conditioning unit according to their preferences with the remote control. Furthermore, to have a long-term engagement the feedback button feature should be available on the front page (home/default) so they can vote directly. They would also like to know what **others** have "voted" over a period, for example that hour or day. They explained that when seeing red, they could not accurately estimate what exactly they have to do to improve it. They agreed **tips** would be very useful to see what they can do in their power to improve it.

In this document, only a part of the testing results obtained with focus groups are presented. The developers should look at the overall reports from specific cases and tailor the solutions in the iterative process in close cooperation with demo case holders.

2. Positioning of the ICT tools into the MOBISTYLE architecture
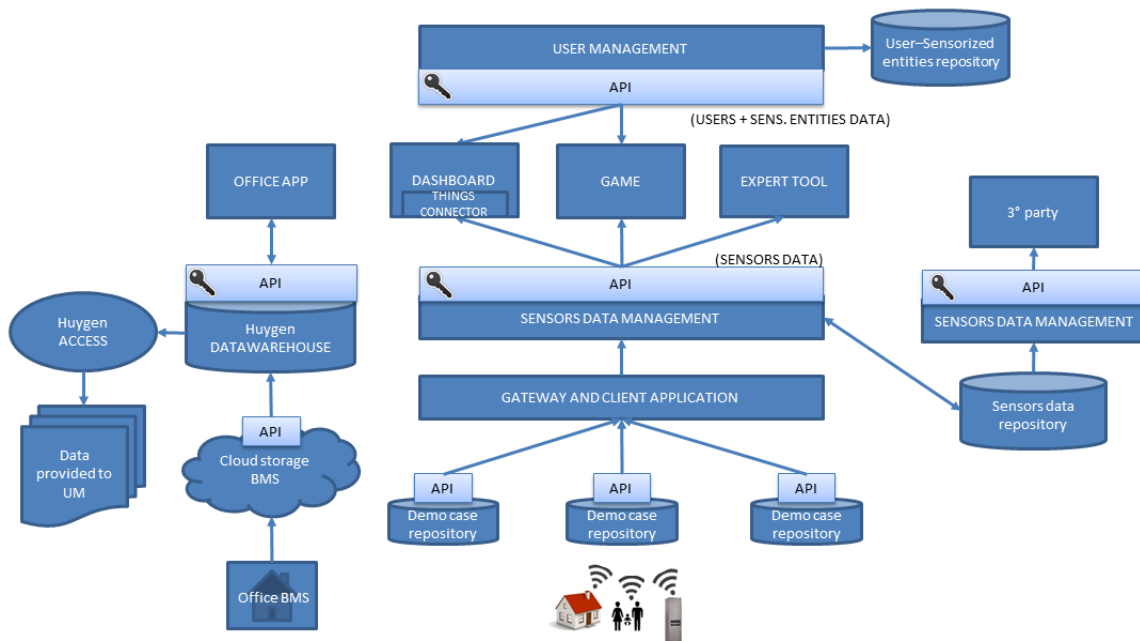

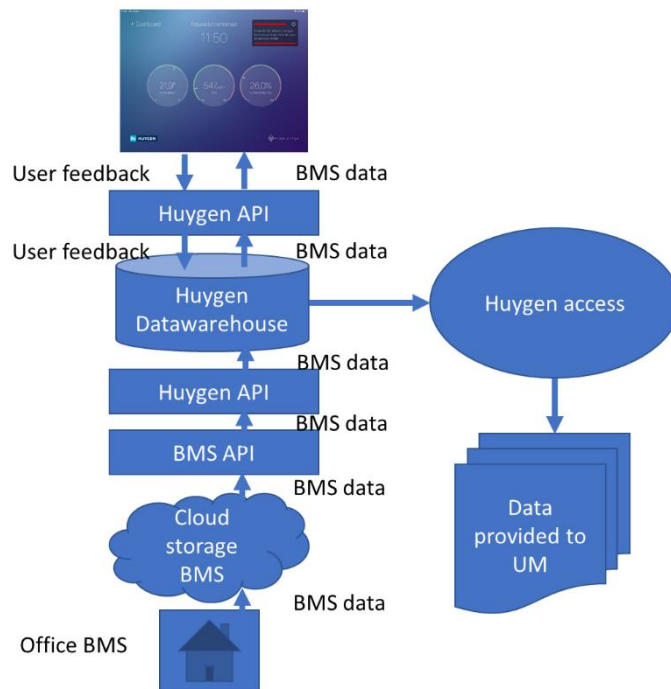Figure 13: MOBISTYLE Architecture in month 42 (M42)

Figure 14: ICT architecture of the MOBISTYLE Office app

Figure 13 shows the positioning of the ICT tools into the MOBISTYLE architecture. The MOBISTYLE architecture has been continuously updated based on the design decision taken when developing all the components. This is the actual status of the MOBISTYLE architecture at M42.

As already explained in D4.1, the Dashboard, the Game, and the Expert Tool were the 3 main software tools within MOBISTYLE. Nevertheless, once the Dutch demonstration case has finally been confirmed, the need arose for an additional tool that allows education of the occupants on the advantages of the dynamic conditions and the actual indoor climate situation. Thus, in figure 14 the ICT architecture of the MOBISTYLE Office App is being visualised.

All the tools make use of sensors data collected from the demonstration cases. Sensors data are related to energy data (both from commercial buildings, apartments and appliances) and Indoor Environmental Quality (IEQ) data. These data are then interpreted in different ways in the 4 tools and made available to the end users. In particular:

- The Dashboard is developed for non-residential buildings and has as target groups managers of the buildings or users of the sensorized spaces.
- The Game is developed for residential buildings and has as target groups the different households.
- The Office App is developed for office spaces introducing the dynamic indoor temperatures.
- The Expert Tool is not related to the demonstration cases. The end users are the experts within the MOBISTYLE consortium who will need access to the data to perform analysis and evaluation of the users' behaviour with respect to energy, comfort and health. Due to the objectives and the functionalities of the Expert tool, this tool is presented in D4.4 Systematic data exchange approach.

The Dashboard, the Game and the Office App make use also of users' data and comply with the GDPR requirements as indicated in D5.2.

Moreover, following the MOBISTYLE approach, in the preliminary design phase, mock-ups of the Dashboard, the Game have been tested by test groups of users to give input and feedback on their usability, as described in chapter 1 of the present deliverable.

The Dashboard, the Game and the Office App are currently being distributed in the different demonstration case to validate the MOBISTYLE approach.

3. MOBISTYLE Dashboard

The Dashboard is a tool that allows different kind of users to receive information about the buildings they interact with, through specific authentication. Different kinds of parameters are received by the building through sensors, and they are shown into the tool. A preliminary description and mock-up of the Dashboard was presented in D4.1 (M24).

A second version had been presented in previous versions of this D4.3. A project-related final version is ready and presented in the actual version of D4.3. Further developments are expected after the project ends, according to the Expert Usability Analysis actually on-going and to be presented in T6.5 and according to the exploitation timeline defined with partners.

The aim of this chapter is to let the reader understand the reasoning behind the development of the dashboard and the solution identified together with experts (POLITO, IRI-UL as first) and users (IT, SL, externals).

The demo version of the dashboard is available at: http://MOBISTYLE.demo.holonix.biz/

The Dashboard App is currently available for download from Google Play as "MOBISTYLE".

Accesses should be requested to administrators of connected buildings.

3.1. Methodological Approach: Agile Development Loops

The design of the solution followed the project's people centric approach (see D2.3). The Dashboard addresses the two not residential demonstration cases (IT and SL) hence there was a close collaboration with the demonstration case holders and support from the energy experts (POLITO, IRI-UL).

During the entire project the solution evolved, with a stable version released in March 2019. Afterwards only minor improvements had been applied.

- A first version was ready in February 2017 with the Things Connector, D5.1. This had been tested and used as mock-ups in first focus groups.

- Improvements had been applied, and then the solution had been focused on non-residential buildings, and opened to other kind of sensors data connected.

- A second version with dummy data had been released and presented on April 2017 during the Ljubljana GA meeting. It had been used for a second feedback loop.

- A third version with real data had been officially presented on April 2018 during the Milano GA meeting, although it was available for demo case holders feedbacks and focus groups even before. This version, with minor improvements, had been presented at the Review meeting in Brussels during June 2018.

- Additional improvements till July 2019 had been related to the development of the Mobile APP solution, working on the same group of data and information. Preliminary live testing activities for desktop and mobile versions had been made in the IT and SI cases till July 2019, while official testing started in the demo cases later on.

From July 2019 on, comments and feedbacks are collected and minor improvements had been added as continuous improvements, while more relevant modifications will be reported in D6.4 as improvements expected for a commercial future release.

Developments, modifications and improvements had been always validated by the consortium thanks to the participation of domain experts from WP2 and WP3, and demo case holders of the TI and SI cases.

3.2. MOBISTYLE Dashboard development History

3.2.1.   Inputs from WP2 and WP3: general recommendation and samples

In WP2, partners have defined 10 general recommendations for the development of the MOBISTYLE IT tools as described in D2.3. Holonix has integrated them, focusing on 6 in particular, as shown in Figure 13.

Other information collected in WP2 and used for the dashboard development are the list of expected users of the demo cases. The skeleton of the users' structure had been developed as described further on.
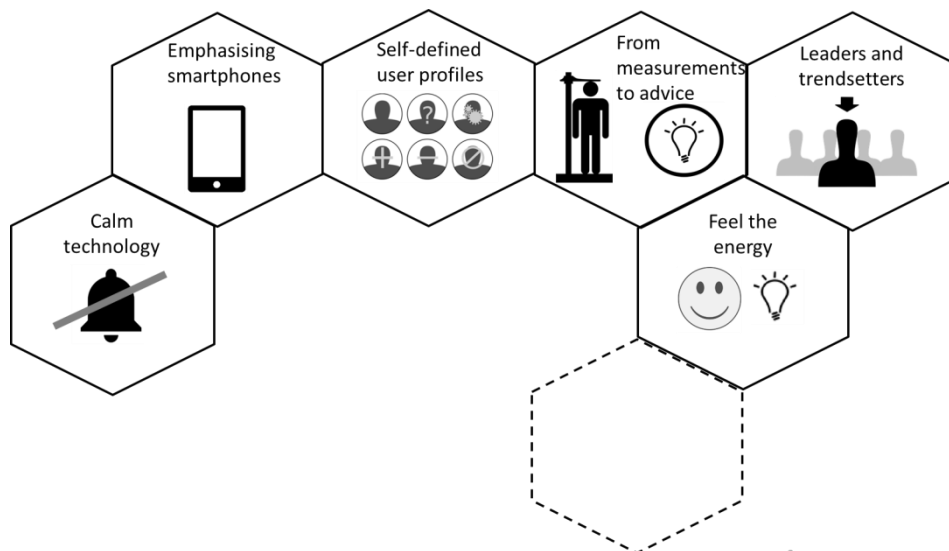
Figure 15: Recommendations used to define dashboard specifications.

In WP3, partners have created examples of charts representing the trends to be shown into the dashboard. An extraction of the examples is shown in Figure 16.

Figure 16: Examples about how to show the trends (input from WP3)

3.2.2. Inputs from WP5: MOBISTYLE Things Connector

In D5.1 HOLONIX developed the Things Connector together with Whirlpool. This tool was the preliminary version of the dashboard, where three fridges had been connected to the dashboard and real time data where shown. An example of the Things connects is in Figure 17 and Figure 18.

Figure 18: Thing connector - fridge general info

Figure 17: Things connector - fridge dashboard

The Things connector had been shown as first mock-up of the dashboard to partners through Focus Groups, and a list of suggestions coming from potential users had been produced. As described in chapter 1 of this report, the Dashboard was tested both in the Italian and Slovenian demonstration case. In general, the main suggestion for improvements was related to the fact that numbers were not user friendly, so widgets had been proposed. In general, something more visual was of interest. Additionally, trends about data changes during time had to be added.

3.2.3.   Inputs from WP6: Monitoring Action Plan

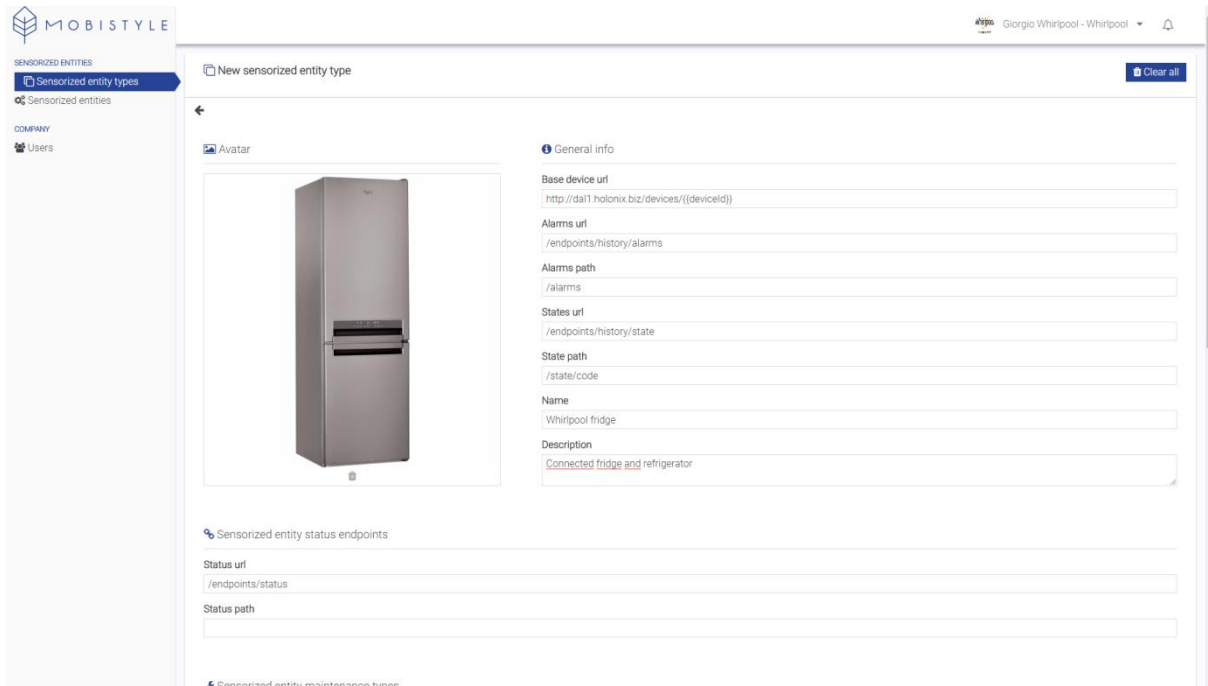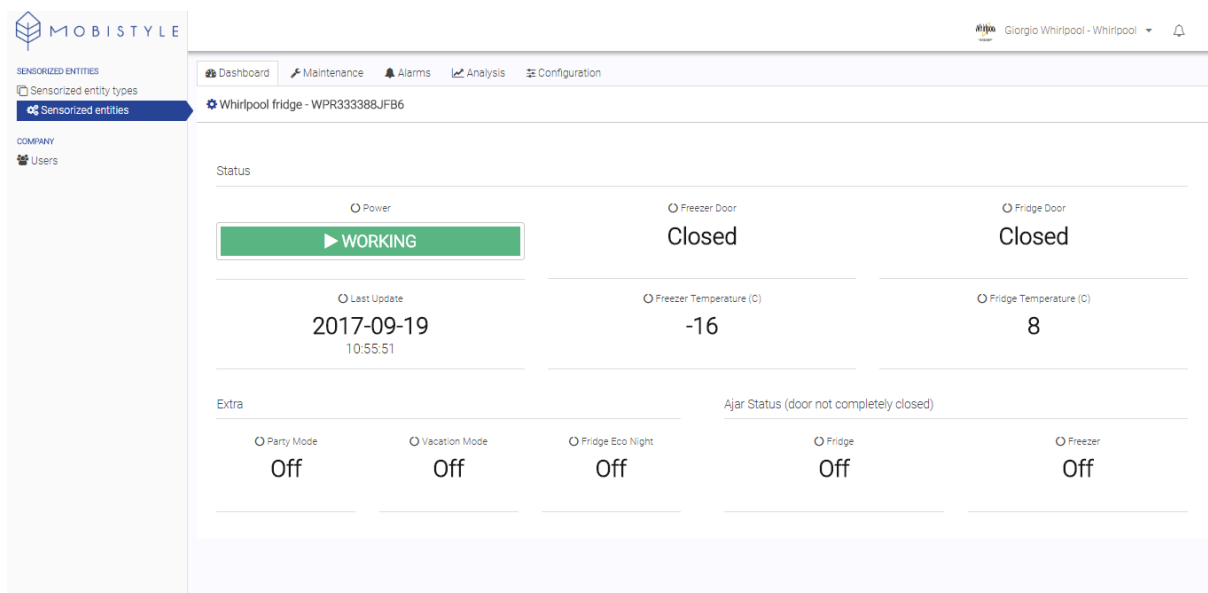The results and the suggestions are explained into the Monitoring Action Plan (T6.1, WP6). Here, in Figure 19, follows an extraction to show ideas that came from users, for example to define ranges, to show trends, to give immediate and easy to understand tips through images, etc.

Label	Set-point temp. (winter day) ºC	Set-point temp. (winter night) ºC	Set-point temp. (summer day) ºC	Set-point temp. (summer night) ºC	CO_2 (ppm)	RH (%)
RED	> 23	> 18	<23	<24	> 1000	>70 or <30
ORANGE	22-23	16-18	23-25	24-26	$800 - 1000$	50-70
GREEN	< 22	< 16	>25	OFF	< 800	30-50
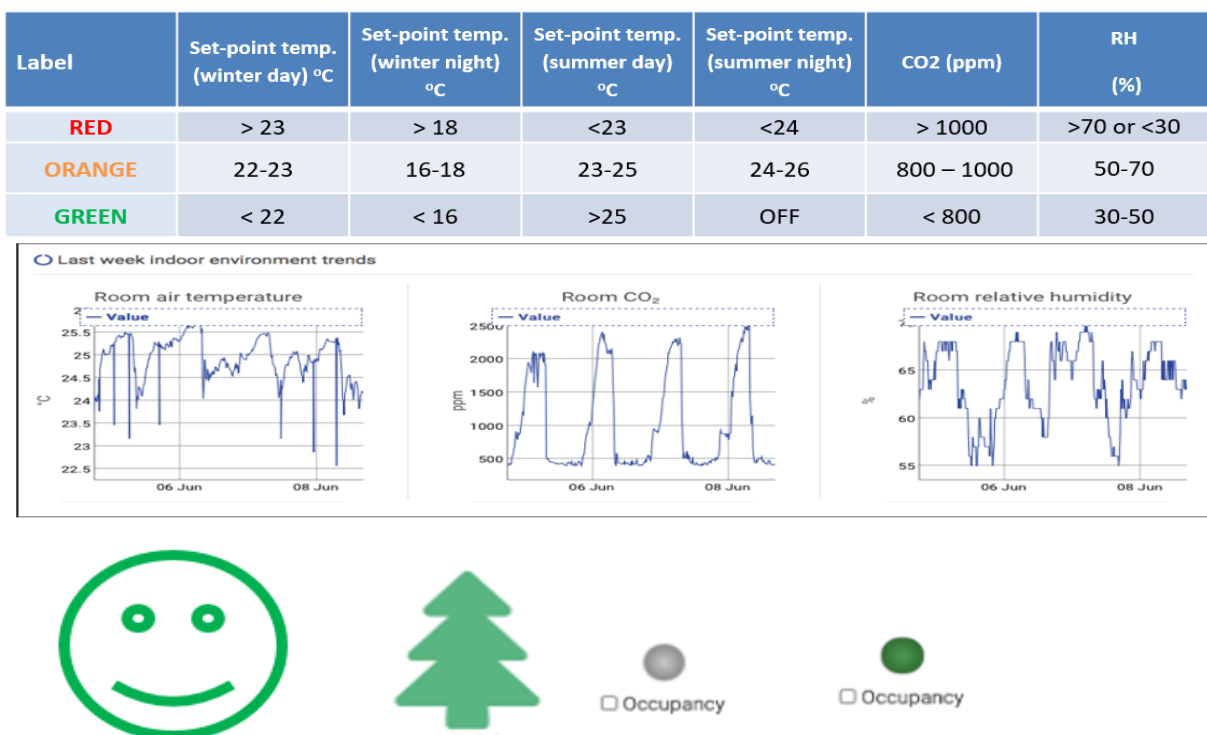
Figure 19: Widget proposals from MAPs

3.3. MOBISTYLE Dashboard Features and Structure

The dashboard is available in two versions, one for desktop access from a computer and one as mobile phone APP. The information shown, the structure and the widgets are the same in both. As they address the same scope, the possibility to use different devices increases the usability experience.

In the following pages, the desktop dashboard is shown, while some screenshots of the APP are proposed at the end of the chapter.

3.3.1.   Purpose of the MOBISTYLE Dashboard

According to MOBISTYLE and to the inputs received from other WPs, the purposes of the dashboard are:

1. Actively involve users
2. Raise awareness in users
3. Motivate behaviour change
4. Stimulate energy usage reduction and IEQ improvement
5. Give as much information as possible
6. Create a feedback loop that improves knowledge and awareness into users

3.3.2. Features of the Dashboard

The development of the MOBISTYLE dashboard has defined following features, which will be explained further on:

A. Customizable sensorized entity structure
B. Articulated users/actors structure
C. Customizable suggestions management

The sensors have been grouped based on the location and provided information in "sensorized entities" (e.g. a hotel room, a classroom, etc.), from which can be retrieved the current status of the entities and their history. The sensorized entities belong to the demonstration case holder (owner/manager), which have the possibility to decide which information to show to the users and how. Data provided are about: energy usage, appliances consumption, data about Indoor Environment Quality and health related parameters.

Information can be given through simple data monitoring, historical trend analysis, specific widgets, and ad hoc suggestions. For each building, different actors interact with the dashboard based on the identified user type (user profile, e.g. building manager, employee).

A. Customizable sensorized entity structure

Sensorized entities can be rooms, apartments, buildings, single smart appliances, personal wearable devices, and so on. It refers to any entity which can be sensorized.

The sensorized entities structure is made of: *Sensorized entity type*, which defines the structure and behaviour of a group of similar entities, and a single instance of the sensorized entity.

For each sensorized entity type it is possible to define:

1. The list of type of sensors available;
2. The list of type of data to be shown to users;
3. The structures of all the dashboards, which can even be more than one, i.e. one per kind of user.

For each sensorized entity, as for example a single room of a hotel which has 3 identical rooms for 3 different guests, it is possible to define:

1. The entity type it refers to;
2. The sensors instantiation available in the specific entity (i.e. in the specific room);
3. The users connected able to visualize information in the dashboard;
4. The eventual hangout that lock the access to users after a defined period of time.

B. Articulated Users/Actors Structure

There are different types of users and different types of dashboard to visualize based on the role of the user and their associated entities. Users can be classified in three categories:

- **Admins:** specific for case holders, it is a SuperUser in charge of the overall management of the entities and creation of the dashboard to be shown to the users. The admins are in charge of the account management and they have permissions to create or remove users linked to their organization. They can create new entity types and connect them to the sensor interface. Simple IT skills are required for the role of Admin.
- **Managers:** specific for case holders, it has most of the privileges of the admin, but not the creation of new entity types. Roles:
  - Their first role is to create single sensorized entities, starting from the sensorized entity types created by the company admin.
  - Then they are able to create and modify specific dashboards (i.e. one for the admin/manager, one for the MOBISTYLE user).
  - They can allocate users to sensorized entities and relative dashboards and allow and remove access permissions, as the Admin.
  - They can even create new suggestions types for each sensorized entity type.
- **Users:** consumers of the sensor data and receivers of the suggestions. They can access MOBISTYLE user's dashboard and visualize all the sensorized entities data they are connected to, for the time they are allowed to. They cannot change the dashboard structure. They receive the suggestions and notifications for the sensorized entity they are connected to.

MOBISTYLE has two different kinds of users:

- **MOBISTYLE users:** people, connected to MOBISTYLE solution, able to download the MOBISTYLE tools; they can have access to different buildings if they are connected to them, as for example their home, their office and the hotel room during a holiday.
- **Buildings users:** employees of a MOBISTYLE "customer" (i.e. hotel / apartments management service, university managers, offices managers, etc.); they are able to see the same dashboard which is shown to all MOBISTYLE users connected to their company.

Admin and Managers, being the owners of the sensorized entities, are capable of seeing on the dashboard all the sensorized entities they own. A specific dashboard is available for the managers and admins, and can be seen exclusively by them. Admins and managers belonging to different organization (i.e. case holders) cannot see each other sensorized entities.
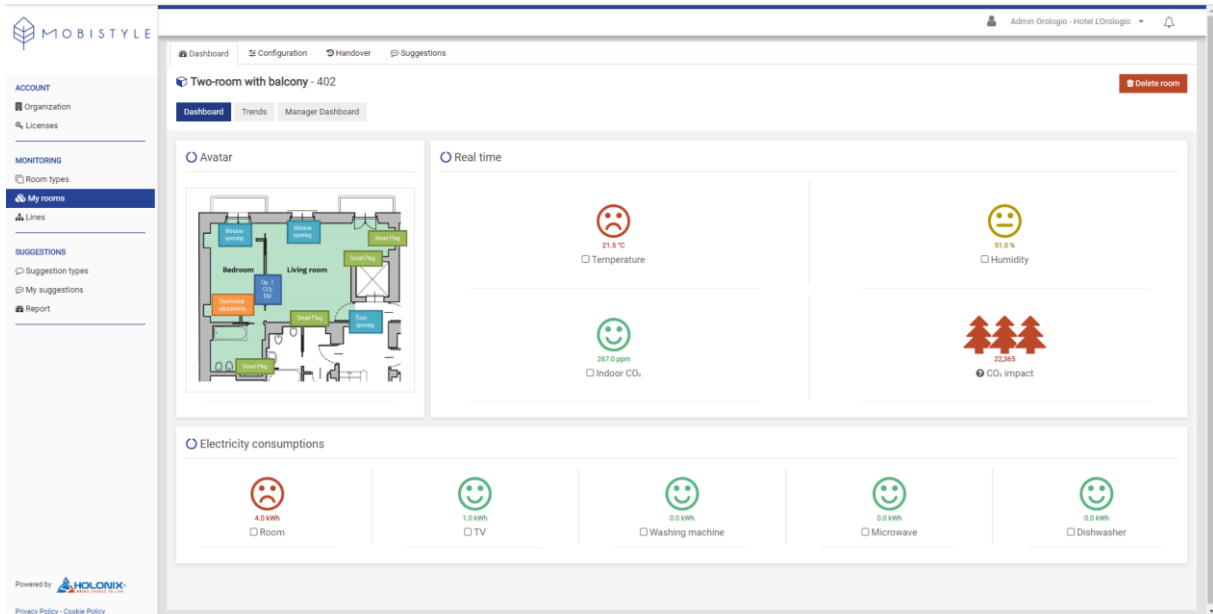
Figure 20: Example of User dashboard - IT case

Figure 21: Example of trends for user's dashboard - IT case
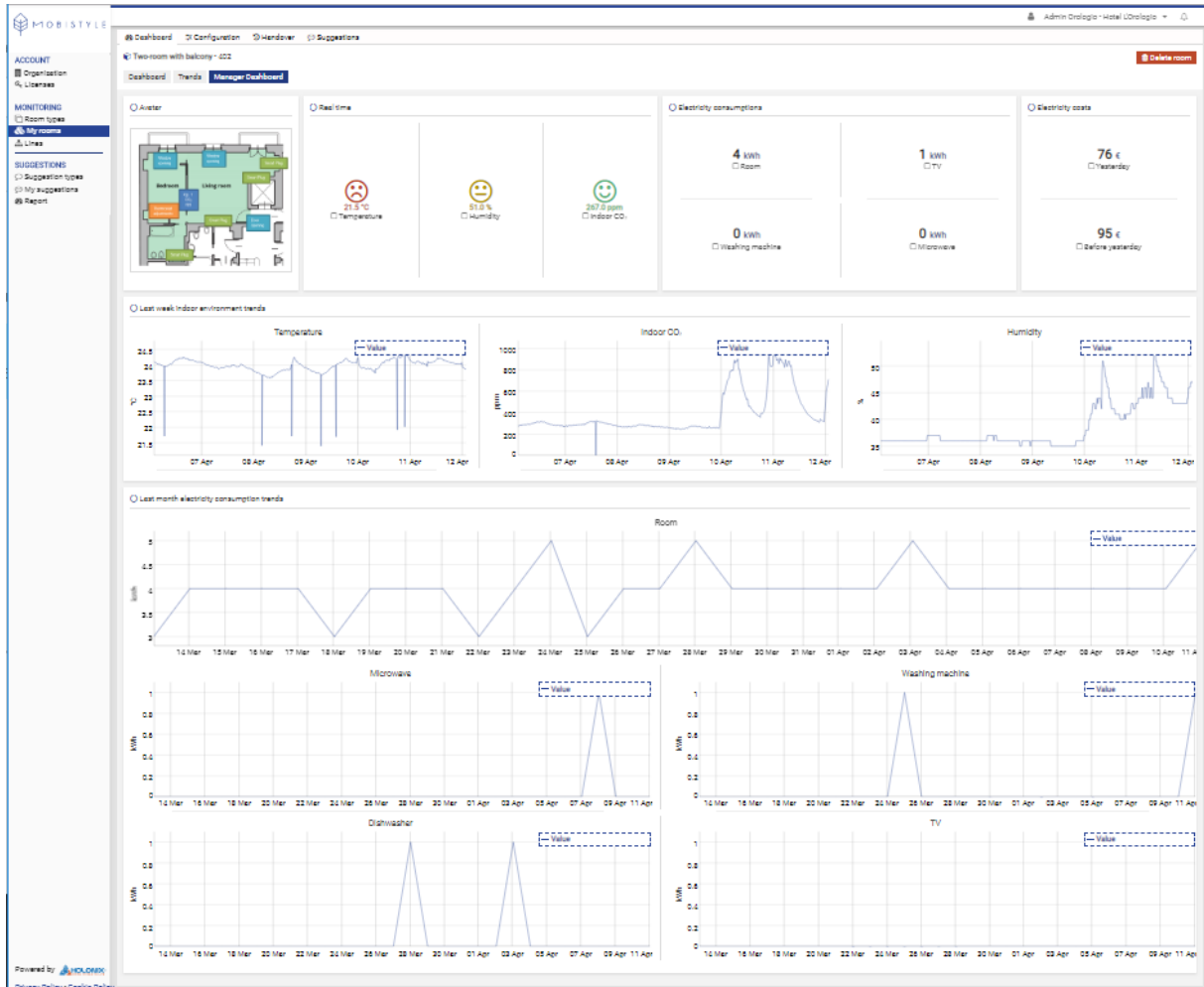
Figure 22a: Example of manager dashboard – IT case

Admins and managers have the possibility to grant access to a specific user dashboard to users of the platform. Permission can be granted only to users, it cannot be granted to any manager or admin belonging to other organization.

Users can receive permission to consume sensor data by multiple admins or managers, meaning that a single user can see data coming from sensorized entities belonging to different organizations (e.g. a hotel room and a classroom). The users can see a user dashboard for each sensorized entity assigned.
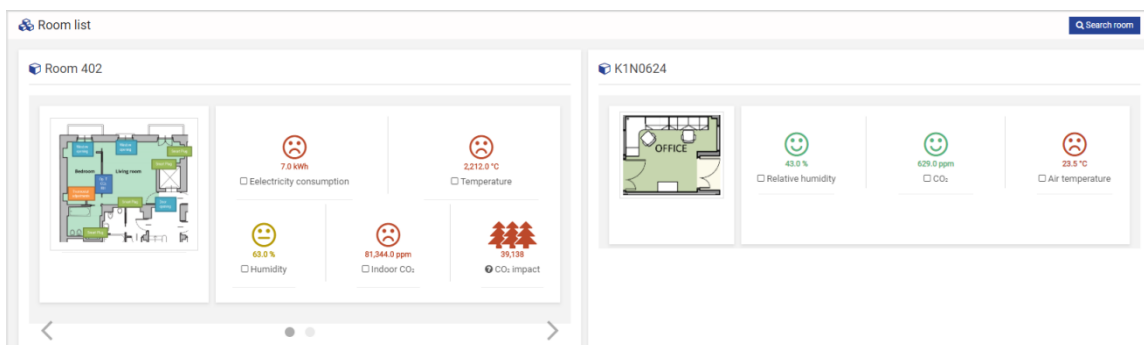
Figure 22b: Example of list of sensorized entities for the user. Here the user can see a hotel room (Room 402) and a classroom (K1N0624).

C. Customizable suggestions management

The suggestions had been created according to WP3 indications and following the MOBISTYLE dashboard structure. For each sensorized entity type, the admin and the moderator are able to create different suggestions type.

The suggestions type is the group of rules that enables the creation and deactivation of suggestions. Each suggestion type is related to a single parameter, as shown in Figure 23. They are described by:

- A symbol + colour code
- A message title
- A message content
- Starting rules (parameter + operator + value)
- Ending rules (parameter + operator + value)
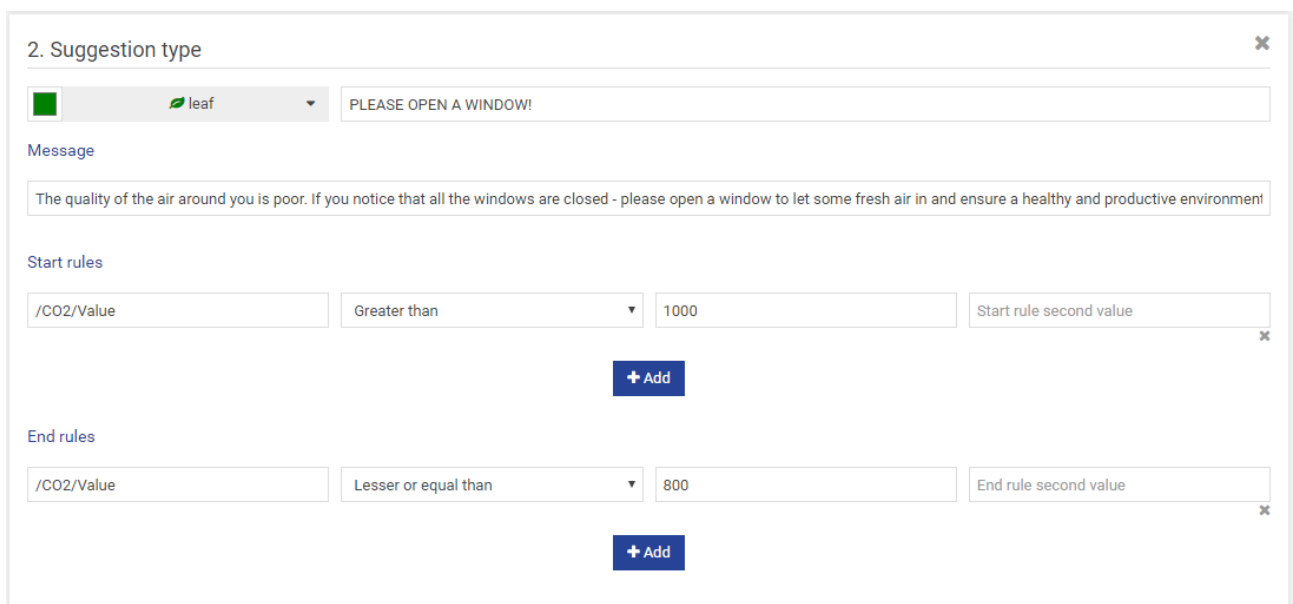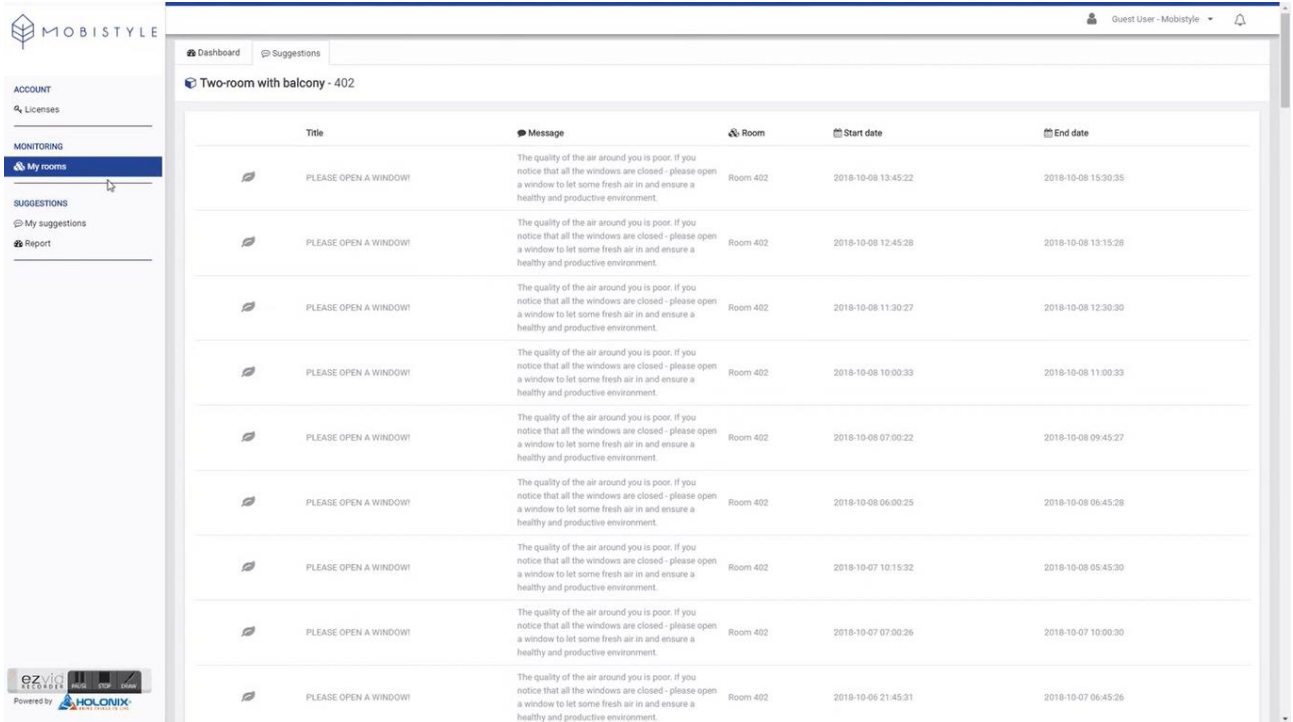
Figure 23: Suggestions type example

The single instantiation of the suggestion is created according to the rules, and for each single sensorized entity. It is visible to all the users that have access to the sensorized entity, only for the period of time in which they are allowed to access.

In Figure 254 there is an example of historical suggestions received by a MOBISTYLE user in a room. In tab "My suggestion" it is possible to visualize suggestions active, and in report it is possible to see the suggestions occurred in the timeline, as shown in Figure 245.

Figure 24: List of historical suggestions for a room
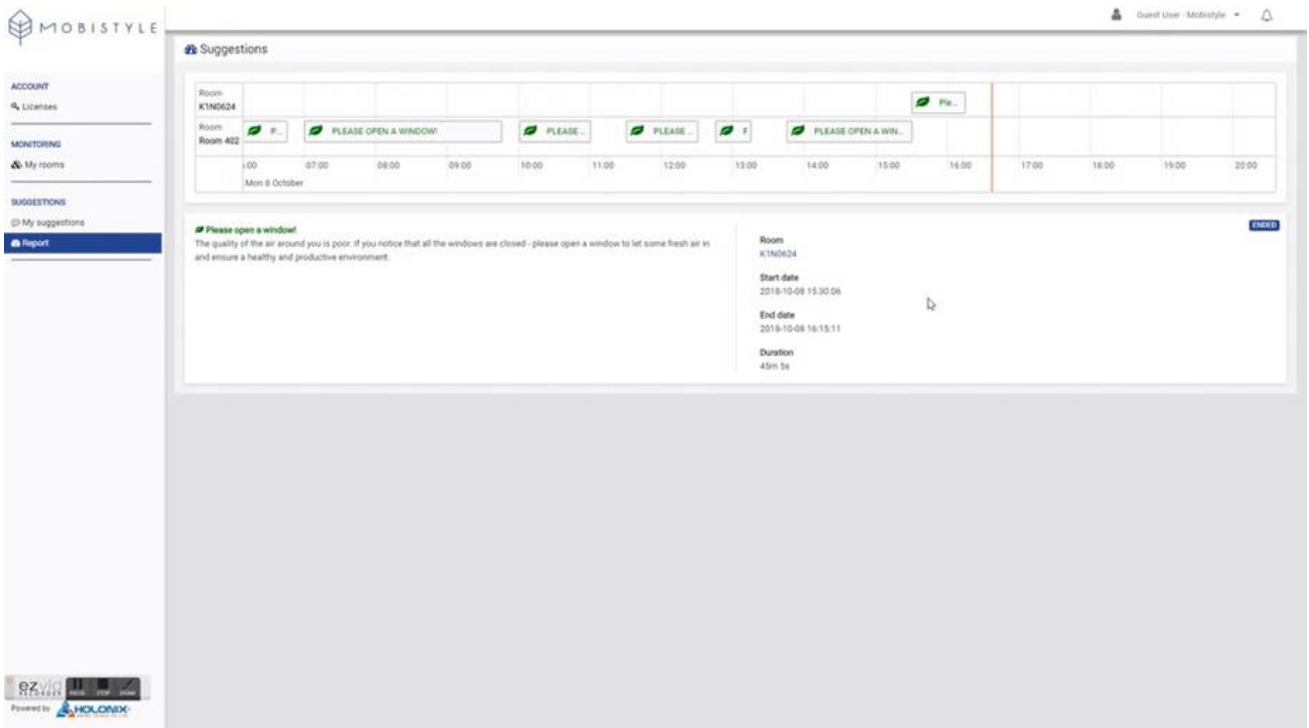
Figure 25: Suggestions report

3.3.3. MOBISTYLE Dashboard mobile APP

In the following images are shown some screenshots from the MOBISTYLE Dashboard APP. As stated, the features are exactly the same of the desktop version. Data and information shown in the Dashboard APP are the same provided in the desktop version.

The creation of new rooms, the customization of dashboards for the users, the creation and customization of suggestions are not available on the Dashboard APP version as management and moderating features will remain available only for admins and moderators through the Desktop version.

Here follows some screenshots reporting MOBISTYLE Dashboard APP:

1. Home page

2. User rooms list

3. Room detail visualization

4. Suggestion list

5. Suggestion detail

The MOBISTYLE Dashboard APP is available in Google Store under the name: "MOBISTYLE".

Figure 26: MOBISTYLE dashboard APP login
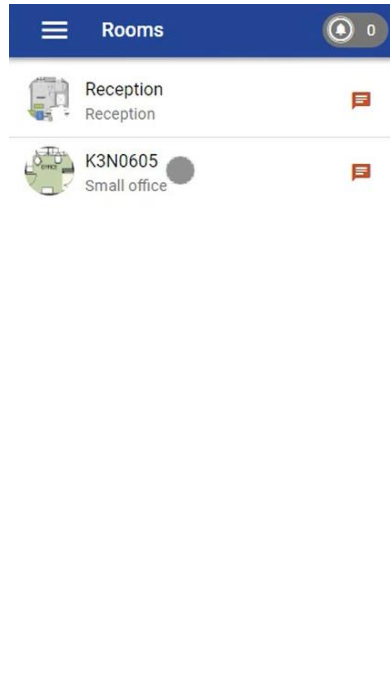
Figure 27: MOBISTYLE dashboard APP user rooms list

Figure 28: MOBISTYLE dashboard APP room visualization
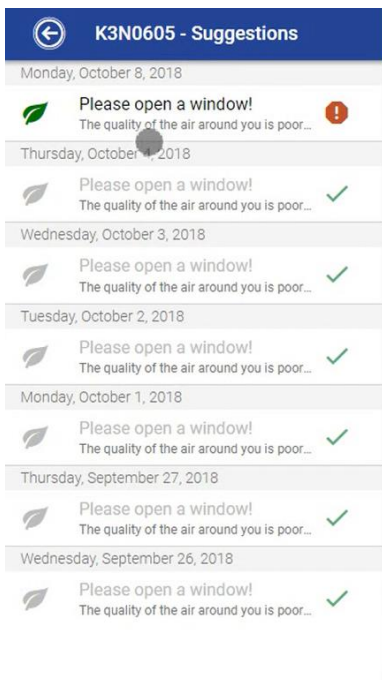
Figure 29: MOBISTYLE Dashboard APP suggestions list & details
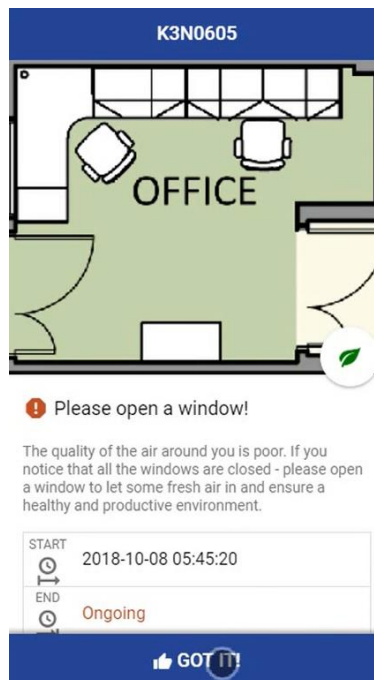
The MOBISTYLE Dashboard APP is available in Google Store under the name: "MOBISTYLE".

3.4. Further development of the Dashboard after usability testing (M31-M42)

The tool is working and had been tested and validated by external users and in the IT and SL cases. Improvements had been integrated in the MOBISTYLE Dashboard both Desktop and APP versions.

Additionally, in WP6, task 6.5, an expert had carried on an iteration of Expert Usability Testing.
In WP5 a deep analysis of the future exploitation had been carried on also with external experts support. The outcomes have guided the definition of needed developments during the project and further developments to be addressed for a real commercial exploitation.

Feedbacks collected through the final Users Testing in IT and SI cases and Expert Testing will be reported in WP6 Tasks 6.4 and 6.5. They will be used to define improvements in the developments and next steps up to the commercial exploitation.

4. MOBISTYLE Game

The MOBISTYLE Game App is a gamified app for behavioural change regarding energy use and also for awareness creation on associated health benefits. In deliverable D4.1, a preliminary version of the solution was described, and a mock-up available at the time was presented in detail. The aim of this chapter is the description of the work that led to the current version of the solution, as well as the introduction to the final user interface. Finally, the next steps in user testing and features integration will be introduced.

The Game App is currently available for download from Google Play as a beta version to all consortium partners and initial set of users.

4.1. Anthropological Approach: Development Feedback Loops

The design of the solution followed the project's people centric approach (see D2.3). The Game App addresses the two residential demonstration cases (PL and DK) hence there was a close collaboration with the demonstration case holders and support from the energy experts (AAU, POLITO).

During the last six months of the project the development of the solution evolved, and several feedback loops informed the decisions made:

- 1st feedback loop, September 2018. An interactive mock-up of the solution was released (as described in D4.1). The mock-up was used to collect feedback on the user experience from the Polish and Danish demo case holders.
- 2nd feedback loop, November 2018. The interactive mock-up of the solution was tested in a structured focus group session with end-users from the Danish demo case (as described in chapter 1 of this deliverable).
- 3rd feedback loop, March 2019. A first online working version of the MOBISTYLE Game was shared with the consortium members for feedback and testing of the implemented features and functionalities.

Following this approach all the Game App mechanics and objectives were validated by the consortium domain experts from WP2 and WP3.

4.2. Development Approach

A set of goals with associated missions on energy efficiency have been defined in collaboration with energy experts from the consortium. Each goal is linked to related energy missions aiming at the achievement of the goal. In order to trigger the digital "nudges" that would encourage the user to take action, each one of the missions was linked to a set of rules. In addition to the goals and missions related to energy efficiency, a list of health tips is being defined to encourage healthier lifestyles on association to energy efficient behaviours.

The adopted gamification approach for the Game App was defined as focused on home-centric sensorized gamification, aiming to influence the user behaviour on energy efficiency, indoor environmental quality and health.

In addition to focusing on behaviours that could be triggered and detected via sensorized data (i.e., not self-reported), there was also a strong focus on providing notifications and actions recommendations that were relevant to the user.

We believe that the combination of these 2 design decisions (sensorized gamification combined with focus on relevance) reduce the likelihood of users abandoning the use of the app, especially in a residential scenario where there is a continued use, and where indiscriminate alerts can disturb the users and lead to the app being ignored or even uninstalled.

The Game App is also able to deal with different data sources. In MOBISTYLE, it makes use of existing sensors in both residential cases via the MOBISTYLE Database, as well as from external sensors available through public weather APIs.

4.2.1. Goals and behaviours

An analysis of the MOBISTYLE User Awareness Action Plan (detailed in T3.4) led to the definition of an initial set of goals for all four demonstration cases. Taking into account only the demo cases related to the Game App (Danish and Polish cases) the total number of goals was 7 (see Table 5: Initial set of Goals).

Table 5: Initial set of Goals

ID	Area	Goal Description	PL	DK
G1	E	Save heating Energy by reducing use of window opening	X	X
G8	H	Create a comfortable environment by Opening/Closing Windows (T, RH, CO2)	X	X
G2	E	Energy Saving through adjusting the Set point temperature on Heating devices		X
G3	E	Energy Saving through managing Equipment usage	X	
G6	E	Energy Saving through switching off Standby devices	X	
G4	E	Energy Saving through reduced use of artificial lightning	X	
G5	E	Energy Saving thought reduced use of Hot Water		X

Some of the goals found application in both the residential demo cases (PL and DK case), others just to one of them. Each one of the goals was labelled according to the area it addressed, either as energy or a health goal. The great majority of the goals were energy related, except one which addressed health. The result was five goals being assigned to the PL demo case and four goals for the DK demo case.

Following the identification and sorting of the goals, each of them was associated to a certain behaviour of the user that would lead to the achievement of the goal (see Table 6).

Table 6: Initial set of Behaviours

ID	Goal Description	Behavior Description
G1	Save heating Energy by reducing use of window opening	Try using natural ventilation to regulate room temperature (opening windows) before using the air-conditioner
G8	Create a comfortable environment by Opening/Closing Windows (T, RH, CO_2)	Increase Indoors Air Quality (RH, CO_2) by using natural ventilation and letting the air flow
G2	Energy Saving through adjusting the Set point temperature on Heating devices	Adjust the set point temperature on the A/C or radiator valve to Save Energy

ID	Goal Description	Behavior Description
G3	Energy Saving through managing Equipment usage	Manage equipment not in use to reduce electricity consumption
G6	Energy Saving through switching off Standby devices	Turn off standby devices instead of leaving them on standby
G4	Energy Saving through reduced use of artificial lightning	Use natural light during the day and save energy
G5	Energy Saving thought reduced use of Hot Water	Use less water (less hot water) to save energy

Finally, taking into account the available sensors and data for each demo case, as well as the sensor-based gamification approach, the Game App centred its focused on behaviours related to a comfortable healthy indoor environment while reducing energy usage.

4.2.2.   Rules and Missions

In order to implement the desired behaviours into the game and turn them into actionable missions, specific rules and conditions needed to be defined for each one of them. During this process a set of detailed tables was created in order to describe all the rules and conditions (the tables below are indicative examples, see Table 7 and Table 8).

Table 7: Example of working document on mission conditions

G1: Save heating Energy by reducing use of window opening in heating season			
Scenario/conditions		**Action OK**	**Action BAD**
Hot-season / HOT_INSIDE	T.Inside >> comfort AND T.Outside < T.Inside	Open Window (w/ AC Off)	AC On with closed Window
		Disconnect AC and Open Window	AC On with opened Window
Cold-season / Heating on	T, CO2 or RH Inside >> comfort	Open Window	Keep windows closed
	T, CO2 and RH Inside << comfort	Keep windows closed	Open Window
Condition	**Incentivize/Demote**	**Metrics and/or event detection**	
Hot-season / HOT_INSIDE	(+) try to AC->OFF and Open Windows and see T. Inside is still comfortable	• % periods of HOT_INSIDE where "good" behaviors were detected 　o Immediate action (broken down by effectiveness assessment) 　o T.Inside did not reduce and AC was turned on afterwards • # events (or # days) where AC was turned OFF and Windows opened • # hours AC was turned on (total, or T.Inside << comfort, or during HOT_INSIDE) • % periods of HOT_INSIDE where "bad" behaviors were detected	
	(+) before AC-ON, try Win-Open and if see T. Inside decreases		
	(-) Try AC-ON before Win-Open (unless (+) was tried before)		
	(-) Both AC-ON and Win-Open		
?	how to reward those who keep temp in acceptable range w/o AC and never trigger an alarm/nudge? How to distinguish these from the ones who are lucky that the conditions outside never cause these threshold to happen?	•	
Kind		**Outcome examples**	

REVIEW	(+)	Congrats! This mth/wk you (achieved G1 / completed M1) by trying natural ventilation to regulate temperature! This relates to G8
	(-)	Oops… This wk/mth you failed to achieve G1 because you didn't try natural ventilation before A/C… Let's try this next time!
NUDGE	n/a	Are you feeling the heat??? Try opening the windows to let some cooler air inside
	(-)	Did you know that you have a choice to open the windows and let cool air inside?
Sensors					
Temp.Inside(ri)	Temp.Outside, or Weather station, or Weather report	Wind.Outside, or Weather station, or Weather report	Window(ri).IsOpen		Motion(InHome), or Motion(ri)

Table 8: Example of working document on mission conditions

G1. Save heating Energy by reducing use of window opening
Generic

		Condition			Action Recommended	Effectiveness Check	Post	
	T.In>TComf.Up	T.Out<T.In	Window	AC				
1	x	OK	closed	off	Open Window	15m	A is OK	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Try another
2	x	OK	open	off	Close Window; Start AC	15m	A is OK	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Give Up
3	x	OK	closed	on	Open Window; Stop AC	15m	A fixed	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Try another
4	x	OK	open	on	Stop AC	15m	A fixed	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Try another
5	x	x	closed	off	Start AC	15m	A fixed	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Give Up
6	x	x	open	off	Close Window and Start AC	15m	A fixed	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Give Up
7	x	x	closed	on	(No possible Action)	-		
8	x	x	open	on	Close Window	15m; A	A is OK	OK
							ΔT.Inside < 0C	Wait 15m
							ΔT.Inside >= 0C	Give Up
9	OK	OK	-	-	-	-		
10	OK	x	-	-	-	-		

4.2.3. Mapping of rules and missions to available data

When doing so, some restrictions were identified, which caused a reduction on the number of rules and missions that could be implemented:

- Data freshness and sampling period: the data path from the sensors to the Game App services introduced a delay ranging from 15m to 35m between measured data and data being available for processing, due to a combination of polling cycles in the upstream provider (15m), in fetching that

data to the MOBISTYLE database (15m), and in fetching the data into the Game App data repository and streaming system (5m). This led to a redesign of the missions and the app itself to reduce the expectation of immediate reaction of the Game App to an action in the real world.

- No external Temp and RH were available initially; this lead to the implementation of an additional data source where these data points were obtained from a 3rd-party weather-data provider for both PL and DK cases.

- The Window sensors in the DK case lack the ability to trigger an event with the exact time when a the Window was opened/closed, providing instead the state at the sampling point in time, plus a counter of number of opening/closing; This means the ability to correlate the user action with the notification is further reduced and less accurate, but it was deemed as still possible to use the data by implementing a monitoring mechanism and a synthetic event trigger. An additional restriction is that more refined mechanisms taking in to account how long a window was opened have a much lower resolution.

4.2.4. Selection of technological platform

After identifying the effective set of rules that would need to be implemented, it was necessary to identify which technologies could be used to implement the gamification behaviours.

Some of the characteristics of the data and of the domain were considered:

- Ungrouped data: the data provided by the MOBISTYLE DB is provided in a value-per-measurement approach, which while having some benefits in terms of implementation simplicity, makes it more difficult to access all data from a sensor in the same reading, as they may arrive out of order, and for processing data in micro-batches (which would allow some kind of look-ahead on the incoming behaviours).

- Incremental and efficient download of new data: since the data is being fetched by interlinked polling loops, where each sensor or home has an independent and potentially unrelated frequency, querying the MOBISTYLE DB separately for each sensor sand/or measure would not scale for the target number of homes (1000 in the case of PL); for this reason a more efficient method to download new data in the MOBISTYLE DB was proposed and implemented, where the requests would be made by time fetched, and across all sensors / measures of a use-case location.

- Even with a reduced number of rules and missions, implementing the rules as part of batch cycles on the Game App repository would introduce additional delays in reaction, especially when considering the scalability goals of 1000 homes in PL. As an indicator on dimension, 1000 homes correspond to approx. 5.000 rooms, which correspond to at least 15.000 rule/mission instances.

- Delays in receiving data from the sensors raised some interesting questions on what actions to carry out with "old" data. The decision was mainly to process the data as long as it arrived in a time-increasing manner, ignoring data arriving out of order. This processing would allow continuation of accounting for the gamification mechanisms even in the face of a delay or outage. In the future more elaborate mechanisms maybe implemented to deal with this class of problems, such a preventing notifications from being sent when triggered data is older than a threshold.

In order to be able to process the data efficiently, it was decided to deploy the following architectural components:

- **Database** (PostgreSQL): This server holds the data received from the different data sources, as well as data generated by the Game App services (missions, actions, scores, intermediate calculations, app parameters and access data) while operating the Game App. Meta-data is imported from MOBISTYLE DB manually, and converted to an independent meta-data layer designed to provide more effective support to the Game App, and allow implementation of automated change detection in the future (for meta-data). Data samples are stored in Timescale DB hyper tables that allow effective scale up support even when using cost-controlled commodity servers.
- **Data Ingest** (Apache Nifi): this server is responsible for data ingestion, clean-up, ensuring schema compliance, mapping between the source and the target meta-data layers, enrichment of original data, storing in the database, and forwarding to the stream processing servers.
- **Azure EventHub** (Kafka): all received data is also converted into messages that are written to a Kafka Bus, in addition to being written in the database. This allows the downstream services the ability to process data with little latency, and in a relatively decoupled manner.
- **Game App Pattern Detection** (Apache Flink): this stream-processing component is responsible for the primary processing of weather and sensor data, extracting higher-level patterns required for the implementation of rules/missions of the Game App. The result of this process is then passed to Akka via Kafka bus.
- **Game App State Machines** (Akka): this component is responsible for managing the state of all rules/missions instances, coordinating the combination, of different conditions and states, interacting with Flink, the DB and the FWNS to communicate with the Game App.
- **Batch jobs**: this component is hosted as a Kubernetes Cron Job and is responsible for triggering various calculation components that are required for the Game App, including non-real time missions and reports' calculations;
- **Game App API**: this component is a REST based server which is responsible for interacting directly with the Game App devices, with functions including device authentication, invite-code processing, and providing data to the devices. It is also responsible for recording data that can be used to generate usage statistics for the project.
- **Google Firewire Notification Services**: this service is required to trigger notification to the mobile devices, which in the case, are only Android.
- **Google Play store**: this service is required to allow the end users to download the app to their mobiles. Builds are automatically uploaded to the store via the Automated Build System.
- **Automated Build System** (Gitlab CI): this service is responsible for automatically the compilation of the application, as well as its introduction to the Google Play store platform.
- **Monitoring** (Grafana and Sentry): these components provide the ability to monitor and facilitate troubleshooting of the remaining components of the Game App and services.
- **Ionic**: this technology was selected to allow the development of the Game App for mobile devices using technologies commonly used on web development. In addition, this technology eases a future migration of the Game App (which is currently available as an Android App) to iOS.

4.2.5. Introduction of sensor-based gamification related features

After the start of the development process, it was identified that there were other opportunities to introduce features that could be useful to help the users assess and modify their behaviour, even

though they were not aligned with the original design decisions of sensorized gamification. Currently examples include Tips and Reports.

4.3. Features and Structure

The approach followed for the development of the features of the Game App was centred on home-specific conditions and actions, based on the concept of maintaining a "healthy" home. This means that all users who use the game associated with a specific home will share the same state and progression.

The current beta version of the MOBISTYLE Game App already includes the most relevant and critical features planned for the app. This is a semi-final version shared with the consortium members and a selected group of end-users only, with the aim to gradually test the whole set of features, before releasing the app to the end-users.

The following features are implemented in the Game App:

- **Missions:** Detection of undesirable conditions (**problems**) and specific measures the user needs to take in order to correct them (**actions**), usually in the short/immediate term;
- **Points and Ranking:** A simple metric on how close the home is to being "healthy";
- **Achievements:** Longer-term sequences of actions a user needs to take;
- **Home Data:** Allows the user to access data from the sensors installed in their home;
- **Reports:** User access to chart-based information on their home performance, tied to recommendations whenever such information is available;
- **Tips:** Short ideas or comments conveying facts on health, energy use or indoor air quality.

The Game App also supports localization and will be translated to Danish and Polish.

4.3.1.   The Game App Features

The Game App Missions are actions encouraging user behaviors in different areas.

Both real-time and differed missions and actions are implemented.

Real-time missions, where adverse conditions are detected (problems) and available actions are recommended (missions). When no recommended action is available, an explanation of the reason is provided. In most cases it has to do with the required sensors not being available or the recommended action already being taken.

- Indoor temperature is above threshold and outdoor temperature is lower than inside;
- Indoor relative humidity is above threshold and outdoor relative humidity is lower than inside;
- Indoor CO_2 level is above threshold;

Besides detecting the conditions that trigger a mission and, possibly, a notification, the Game App tries to detect when the recommended action is carried out, and whether it was performed before or after the notification was sent.

The different conditions are then recorded in the database and can be used for generating new gamification mechanics in the future.

While not providing a hard proof that the action was carried out in response to the notification, the fact that actions are detected via input from the sensors provides a stronger correlation than self-reporting. In addition to that, being a home-centric multi-user application, it is more relevant that the action is taken to allow the conditions in the home improve, than trying to detect who exactly is the user performing the action.

Deferred-missions are missions where a period is analysed in order to provide recommendations for the next similar period. In the current version, the "Comfy Room" includes missions that detect when thresholds for Temp, RH or CO_2 in room exceed the predefined threshold during an evening period. For the initial implementation, a common period was defined in all homes of both PL and DK cases.

On the first night that conditions in the room exceed the threshold, a specific problem is created, and a specific mission is displayed in the Game App. However, since the goal is to nudge the user(s) to open a window before going to sleep, the notification is only sent on the following evening, closer to when the action needs to be carried out.

On the second night that conditions in the room exceed the thresholds, a different message is shown to the user, with a bit more emphasis on the importance of correcting the situation.

For the use of **Points**, there were extensive discussions on how to combine scoring of different criteria on a single number and on how to balance the rewarding of fire fighting behaviour (i.e. users who are fast in correcting a behaviour) vs. preventive behaviour (i.e. users whose homes are not even getting into undesirable situations). Additional questions were related on whether it would be fair to compare a home that, due to its orientation, tented to have more problems than another in the same block, or whether a home with more rooms should have a bigger number of absolute points than a smaller home. The currently implemented score is based on "**MobiPoints**" which are tentative to represent the concept of "Good Home", i.e. a metric of what is the weighted percentage of day where there were no active problems in the home, regardless of the actions taken. A top level in MobiPoints means that no mission or problems were detected in any of the rooms.

In addition, user provided feedback on the 2nd loop seemed to indicate that users were more interested in information that could help them with their consumption and behaviours than with competition with other neighbours. For this reason, and due to the difficulty of having a consistent way to identify homes while complying with privacy requirements, no leader board was implemented, and instead the **Ranking** of the home's MobiPoints in their region case is shown.

Other possible score possibilities were discussed and may be implemented in the future if the feedback from the partners and/or users deems them more interesting, such as measuring time to react in performing an action (needing considerations on how to assign points in the cases where no action is possible, or is taken before the notification is sent).

Regarding the use of **Achievements**, they were designed as independent series of related, related to consistently achieving some goals over a period of time (streak):

- "**Fresh Air**" medals: Healthy CO_2 air levels inside the home;
- "**Cool Home**" medals: Healthy temperature values inside the home;
- "**Dry Home**" medals: Healthy relative humidity levels inside the home;

4.3.2. The Game App Structure

The Main Screen

The Main Screen of the App displays an array of information on the status of the house (see Figure 30):

- The collected "MobiPoints" in the last day and last week;
- The ranking of the house on the last day and last week;
- Historical view of the MobiPoints achieved in the last 7 days;
- Heat Use report (in the case of DK);
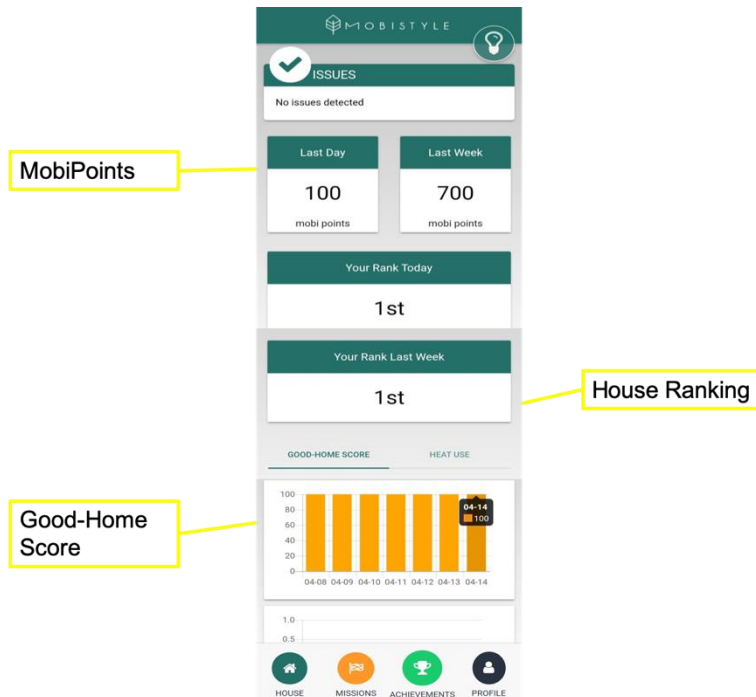
Figure 30: Main Screen: Features

The Main Screen is also where the notifications regarding possible issues are displayed (see Figure 30). The user receives a brief message with information on the room where the issue is detected and a short description of the issue itself. By clicking on the notification, the user is redirected to that particular Room Screen (e.g. Bedroom).

Another feature of the Main Screen is the display of tips for the user (see Figure 31 and Figure 312Figure 31).

People who use stairs have 15% more chances to live to the old age.
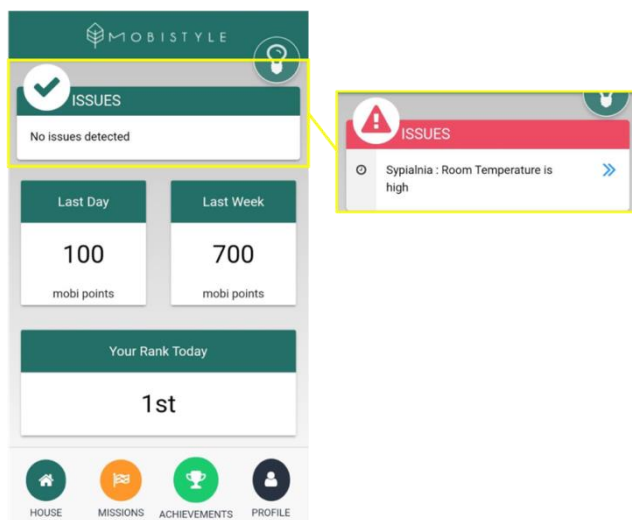
Figure 31: Home Screen: Notifications   **Figure 32: Main Screen: Tips**
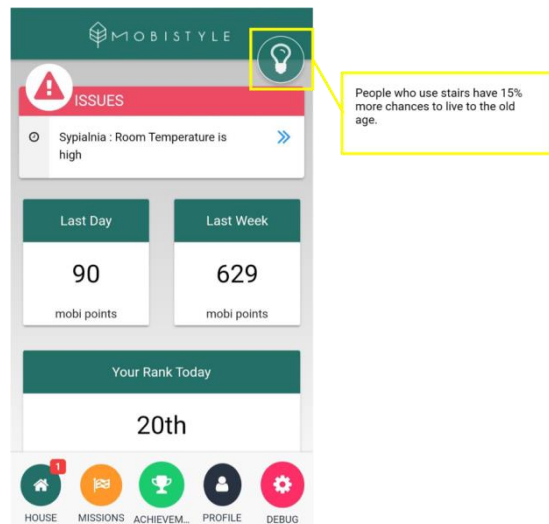
Home Data Screens

There is a detailed screen for every room of the house with different information according to the available sensors that can be accessed from the 'House' button on the bottom menu (see Figure 33). Examples of displayed information are:

- Temperature;
- Relative humidity;
- Total energy produced;
- Electrical power;
- Electrical consumption;
- Window state;
- Power switch state;
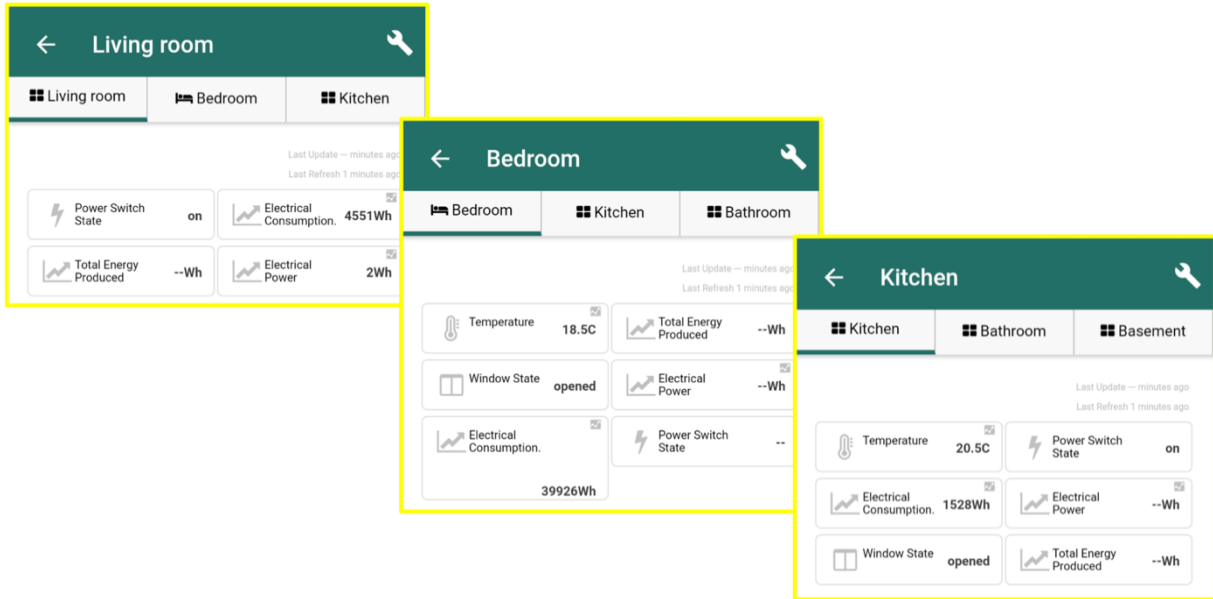
Figure 33: Home Data Screens: Rooms Screens

Graphical charts are available for the user when clicking on the displayed values (see Figure 34 and Figure 35).
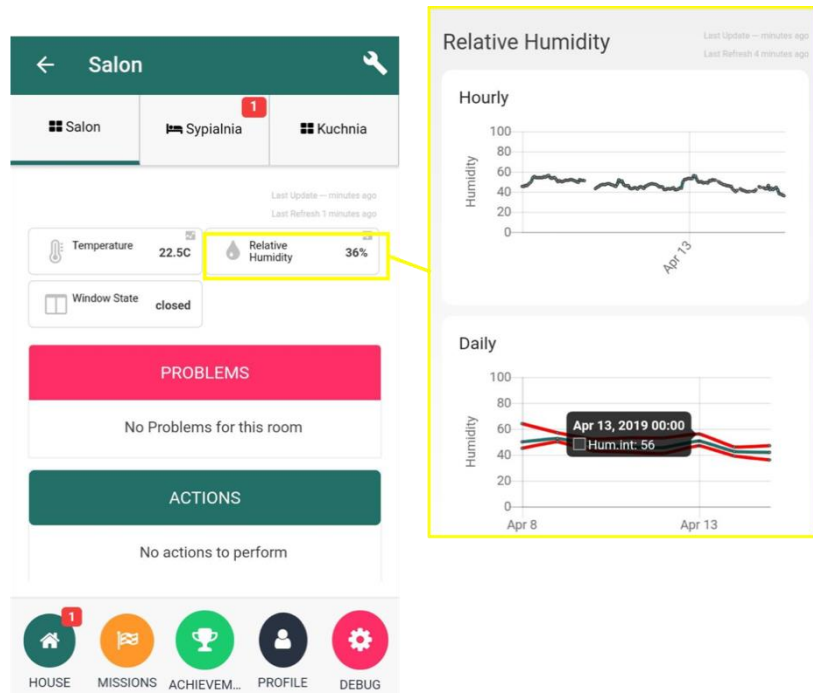
Figure 34: Home Data Screens: Humidity Chart
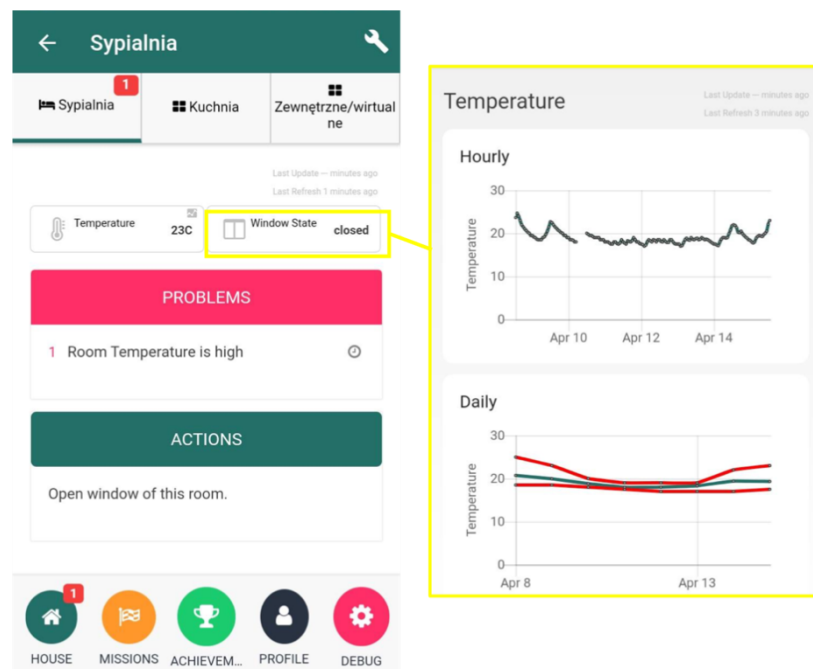
Figure 35: Home Data Screens: Temperature Chart

Missions Screens

If an issue is identified in any room, it will be described in the 'Problems' section (see Figure 36). The user can check for problems in the rooms either by choosing the room from the Home Data Screens or directly from the notifications in the Main Screen.
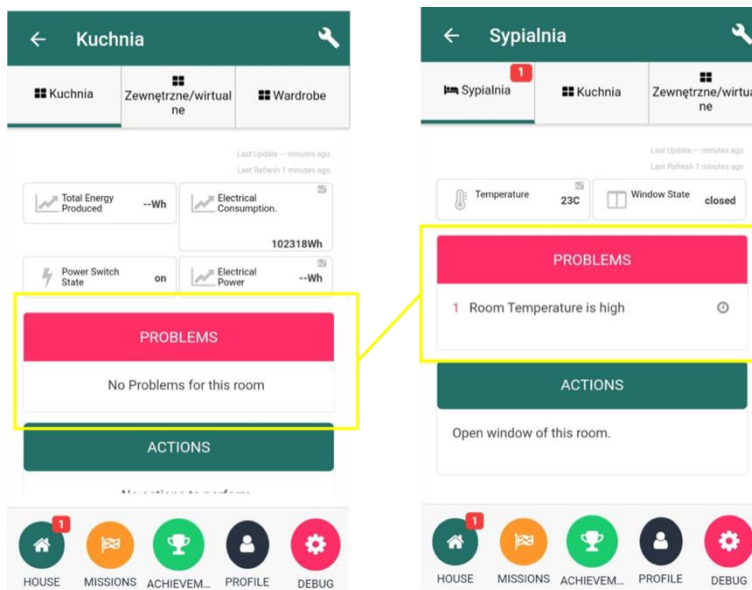
Figure 36: Mission Screens: Problem Identification

For every identified problem there is a recommended action for the user to take, or an explanation of why an action is not available. As shown in the example (see Figure 36), high temperature values were identified in the bedroom and an associated message describing the problem was displayed. The user can readily see the available actions that would solve the problems. In this example, the suggestion provided by the Game App was to open the window in the bedroom. Once the window is opened, and once data arrives to the Game App Servers, the action is identified as taken, which marks the mission as completed. Once the temperature values drop back to normal, the situation is corrected, and the problem is no longer displayed.

Achievements Screen

In this section, the user may access the currently active goals (medals that are active to be won) and the list of the medals already earned in the past (see Figure 37).
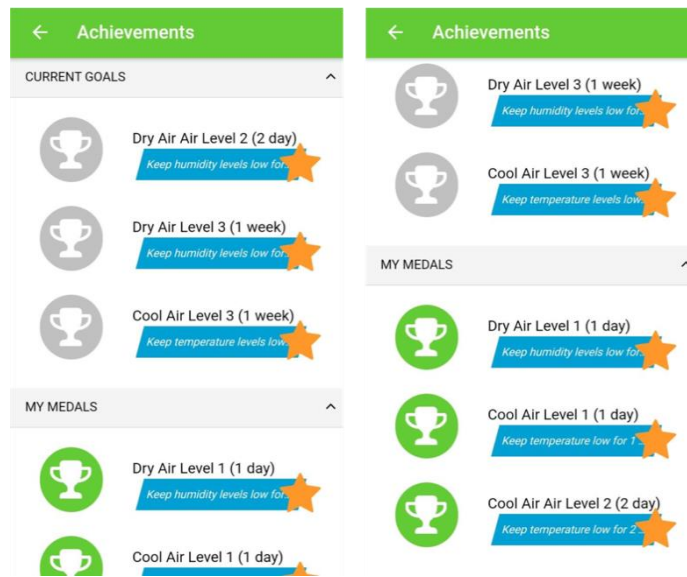
Figure 37: Achievements Screen: Medals

Profile Screen

Being a home centric application, the Profile Screen of the Game App allows the user to configure parameters of the app, which currently are limited to renaming the rooms of the house to something more meaningful for them (see Figure 38).
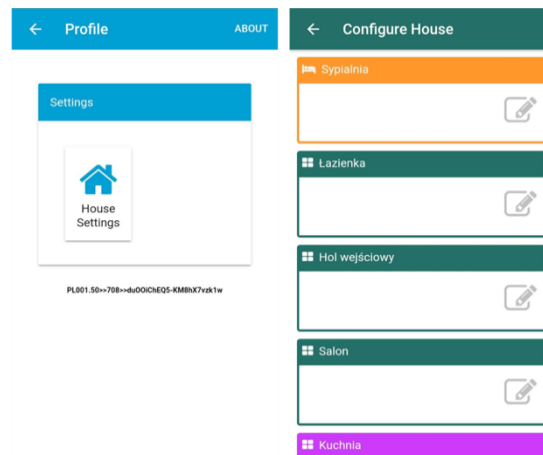
Figure 38: Profile Screen

Future versions will enable the user to enable/snooze or disable alerts and missions for the whole home or just specific rooms.

4.4. Steps integrated during the M30-M39 period

The improvement steps for the development of the MOBISTYLE Game App and services included the following:

- Completion and optimization of the features currently implemented or in final stages of completion (as of 2019-04-15)
  - Report for Heat Use;
- Additional features
  - Deferred missions: Night-time missions for Temp, Rheum and CO2;
  - Report for DCW;
  - Report for DHW;
  - Addition of EULA and GDPR compliant Privacy Policy document;
  - Mechanism to convert the data from DK door sensor (sampling based) to a pseudo-event based sensor, to allow its use in the existing Real time missions;
  - Distribution of new tips over time without requiring application updates;
  - Ability to control notifications on the Game App;
- Fine tuning of the thresholds used in the missions, including assessment on minimum periods of occurrence to trigger both occurrence and resolution;
- Improvements to the copywriting of the messages across all the application; This includes more granular recommendations for actions, and compilation of additional tips;
- Deployment of the application to Google Play Store in non-restricted environment;
- UI/UX revision and identification of graphic and usability improvement opportunities;
- Setup and support the localization of the interface to PL and DK, and its deployment to the Game App and Services;
- Preparation of metadata update procedures to support the addition of new houses to the PL use case during the scale-up phase;
- Various improvements related to monitoring and troubleshooting procedures;
- Preparation of access codes to be provided to both PL and DK use cases, so they can distribute them to the end users and allow the association their mobile devices to one of the homes;
- Continued support for the assessment period by the end-users.

The following features may be added in the future, but are still pending confirmation:

- Reports for *Washing Machine Efficient Program*;
- Reports for *Electrical consumption*;
- Addition of new sensors for indoors VOC and PM in the PL case;
- Addition of a new channel to obtain outdoors PM values in the PL case.

Recommendations to enable additional recommendations and scenarios:

- Add A/C sensors to enable more elaborate actions to be available to correct temperature (Temp) and relative humidity (RH) deviations.
- Consider installing individual heat/thermostat sensors in each room to allow more fine grained missions on heat consumption to be implemented;

- Consider implementing user-reported survey of home geometry to allow more elaborate natural-ventilation rules (for example, by proposing to open opposing windows in different rooms).

4.5. Next Steps

In terms of the MOBISTYLE Game design and UX, the following actions could help address the usability and adoption concerns that were identified:

- The navigation system of the application could be simplified and made more intuitive;
- The presentation of data should indicate more clearly if data is stale and create different visualizations for those situations; For instance, if data is more than 15 min old, it could either be hidden or marked with an unequivocal label;
- The Good Home score concept and the achievements should have additional information to allow the user to map them to the underlying compounding factors;
- Provide onboarding videos explaining the concept of missions, and how it is different from alerts based on thresholds; This could also be a good vehicle to explain the usefulness of correct sensor installation and classification.

However, for the reasons explained in D6.4, we believe the single most impactful improvement in terms of improving user engagement is the reduction of data flow latency, from the current 15 to 30 minutes to below 30 sec to 1 min, in order to allow the user to receive immediate feedback from their actions, and in ensuring a consistent and stable data flow of installed sensors. When a user takes 30m to see an app taking 15m to show the effect of closing a window, or fails to see updates in data on the app, it will be reported as app not responding, and usefulness will be rated low.

5. MOBISTYLE Office App

The MOBISTYLE Office App is a dashboard application aiming to educate, inspire and mobilize building occupants to accept the dynamic conditions indoors. As many commercial buildings are preheated even before any occupant enters the building in the morning, this shows what a vast potential for saving there is in case where buildings would be heated to a lower setpoint. Hence, to accept this, occupants need to be satisfied when entering the building in the morning with lower conditions while knowing it will get warmer through the day.

The application is therefore used for behavioural change achievement where it is educating building occupants (employees) about the benefits of dynamic conditions, specifically over dynamic temperatures. Hence, the application's aim is not the energy efficiency education but educating building occupants about the indoor air quality (based on the measured data) and benefits of dynamic conditions. The aim of this chapter is the description of the work that led to final version of the solution. Finally, the possibilities for further upgrade of the solutions (new features) are proposed in the last phase in case there would be an exploitation opportunity with new commercial buildings.

The MOBISTYLE Office App is currently available as a private version (not downloadable through the app store) to the employees at the office at Brightlands, the Netherlands (part of the Dutch demonstration case).

5.1. Results from the focus groups (anthropological inquiries) shaping the MOBISTYLE Office App development

The design of the solution followed the project's people centric approach (see D2.3). The MOBISTYLE Office App addressed the office environment of the Dutch pilot case (NL) where the demonstration and deployment of the application was done for the building Brightlands. While following carefully the 10 anthropological recommendations, certain adjustments needed to be made as this demonstration case is specific while adopting the dynamic conditions.

During the last six months of the project the development of the solution evolved, and several feedback loops informed the decisions made:

- **1st feedback loop, October 2018**. Once confirmed the new demonstration buildings and agreed there is possible to do dynamic conditions testing in real life environment (office buildings), a need arose for a simple ICT tools that will educate users about the dynamic indoor profiles instead just imposing these with no awareness raising.
- **2nd feedback loop, June 2019**. First interactive mock-up of the solution was tested in a structured focus group session with building occupants at the Brightlands office (as described in chapter 1 of this deliverable).
- **3rd feedback loop, October 2019**. A second version of the solution has been deployed together with the testing of the dynamic conditions at Brightlands.

The MOBISTYLE Office App functionalities were validated by the consortium domain experts from WP2 (IRI-UL).

5.1.1 Intermediate evaluation and ICT solution improvements

After the first usability testings, the solution was improved where the following improvements based on the 2nd focus groups (June 2019) several recommendations were given to the ICT designers:

- Increase the width of the green/red/yellow marker in the circles
- Round the numbers: temperature in 0,5 degrees, CO_2 in 50 ppm, relative humidity in 5%, lux in 50.

Tab 'Patroondynamisch binnenklimaat' (dynamic profile):

- Replace 2700K by 'warm wit', 3200K bij 'helder wit', 5000K by koel wit etc
- Replace 200 lux by gedempt, 1000lux by helder etc.

Tab Feedback:

- Show smileys for feedback in green-orange-red colors.
- Replace 'algehele binnenklimaat' (overall indoor climate) by sensastion: 'koel' (cold), 'neutraal' (neutral), 'warm' (warm). Combined with the result of the other indicators (Binnentemperatuur, kleurtemperatuur licht en licht intensiteit) tips developed manually (connected to Excel database) or by machine learning.

Tab Overall Satisfaction tab:

- Add a title to the graph on the feedback page: "Feedback responses overall indoor climate";
- Add labels to graph axes on the feedback page. Y-axis: "Number of responses", x-axis: "Time"

The first version of the app looked as shown below:
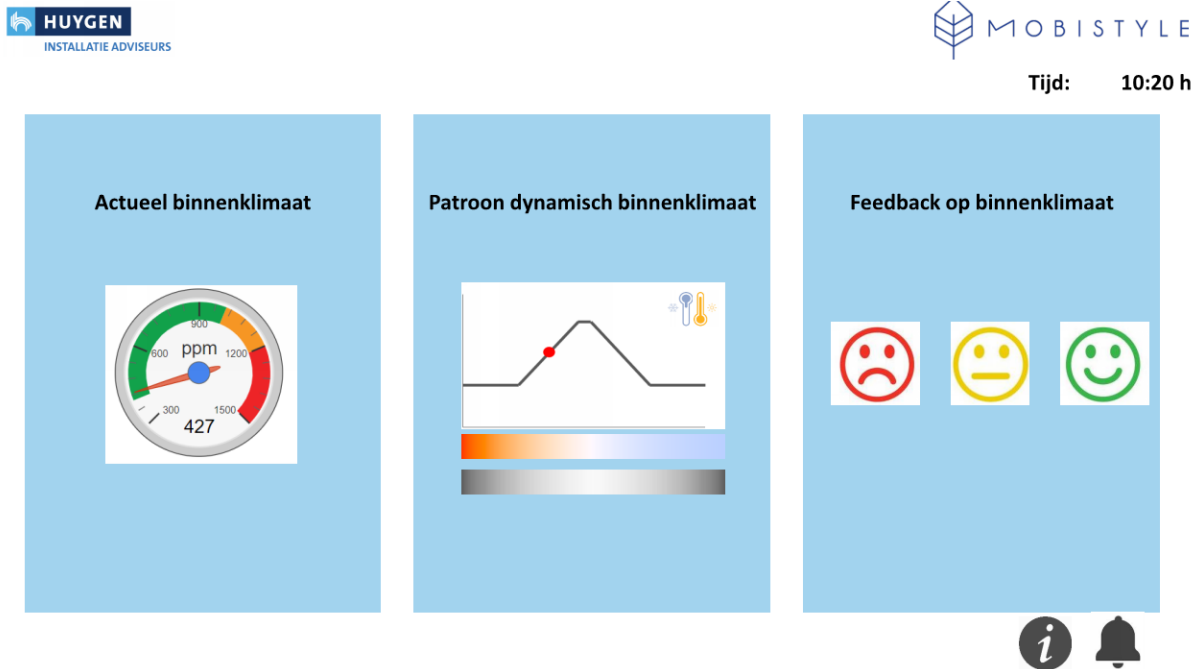
Patroon dynamisch binnenklimaat

Tijd: 10:20 h

Patroon dynamisch binnenklimaat

Tijd: 10:20 h

Bij een constante binnentemperatuur hoeft het lichaam minder hard te werken om de kerntemperatuur op peil te houden. Wij ervaren dit dan als comfortabel, maar dit is niet perse gezond. Door je lichaam bloot te stellen aan een dynamisch temperatuurprofiel, train je je vasculaire systeem en blijf je weerbaar voor weersextremen.
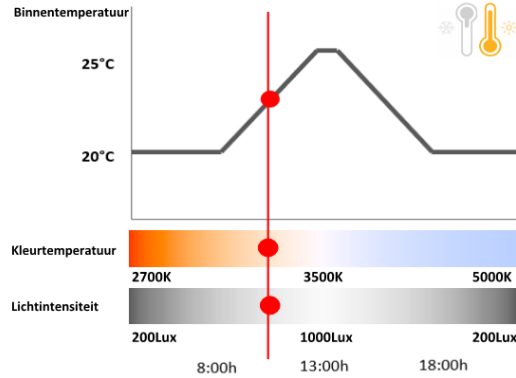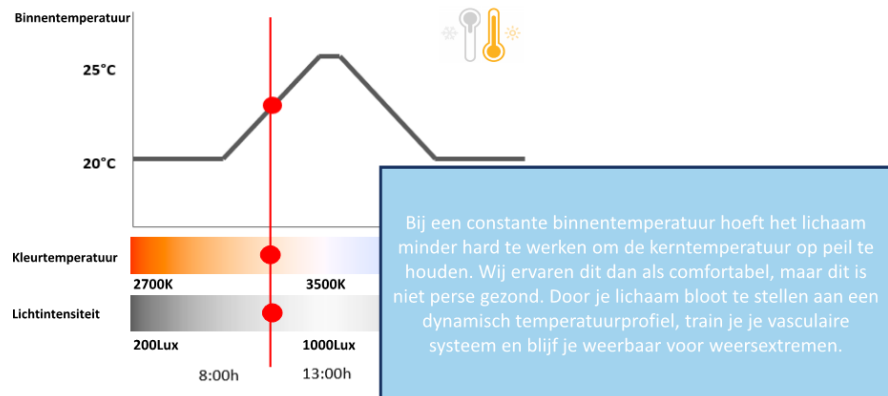
Feedback op binnenklimaat
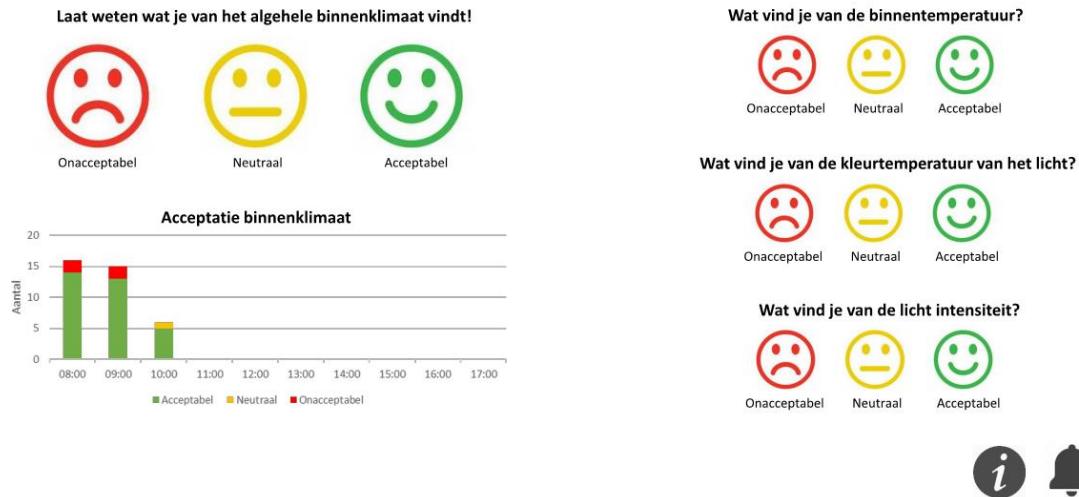
5.2. Features and Structure

The approach followed for the development of the features of the Office App was centred around the objective to give users simple user-friendly ICT dashboard accessed via a tablet to increase the acceptance with such conditions. Based on the anthropological investigations, it has been agreed that the following functionalities are to be integrated:

- **Informing the office occupants about their surrounding indoor environmental conditions in them understandable graphics** (based on measured parameters: Operative temperature, Relative Humidity, CO_2 concentrations),
- **Including building occupant's satisfaction evaluation through a feedback loop** (thermal and visual -sensation, -acceptance, and -comfort),
- **Providing tailored suggestions on dynamic profiles of temperature and its positive effects to increase their acceptance.** Furthermore, general tips are given that encourage users to a healthier, more sustainable and energy efficient behaviour and actions (e.g. **Tips:** Short ideas or comments conveying facts on health, energy use or indoor air quality.

The following features are implemented in the Game App:

- **Selection of the room that the person is in:** left on top of the main screen the room name is mentioned, by clicking it a dropdown menu is shown to select a different room
- **Feedback on indoor climate:** on the main screen people can leave feedback on the indoor climate by clicking the green, orange or red smiley. After clicking this smiley, there vote will be shown in the graph below the smileys. In this way all users can see the entries of other users of the building. After clicking the smiley a few more questions are asked about specific topics like temperature (comfortable or not, cold or warm) and light (comfortable or not, cool or bright)
- **Information about the current indoor climate:** this screen shows three 'clock graphs', where the data from the BMS is shown of the selected room. With colours in the circle feedback is

giving if the measured value is green (within good bandwidth), orange (climate condition could be improved) or red (climate condition could cause health problems on long term)

- **Information about the current temperature and lighting profile:** on the profile page the current temperature and lighting profile is shown, as well as the current values for the setpoints by means of the red line that corresponds with the current time.
- **Tips:** Short ideas or comments conveying facts on health, energy use or indoor air quality.

The Office App is at the moment in Dutch as the office employees are Dutch native. Nevertheless, the application allows localization, customization and easy translation in another language if needed.

5.2.1. The Office App Features

Below the different screens of the app are shown with the features described in 5.2.
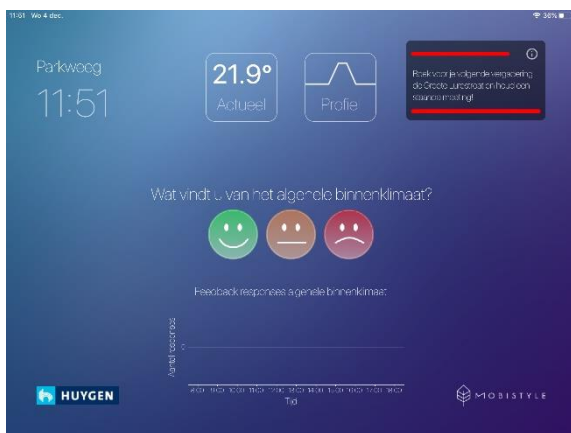
Figure 39: Main screen with room selection, feedback buttons and graph
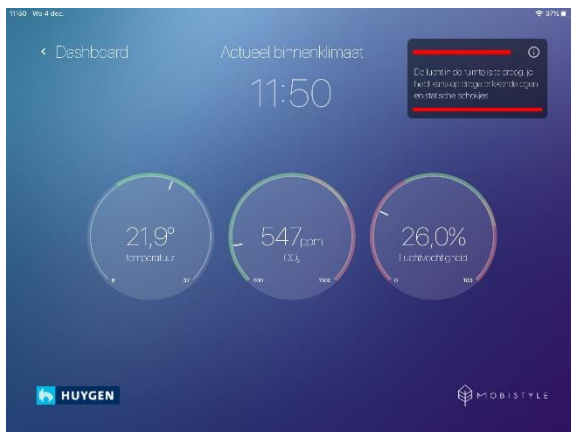
Figure 40: Information on current indoor climate screen, with in the corner a tip
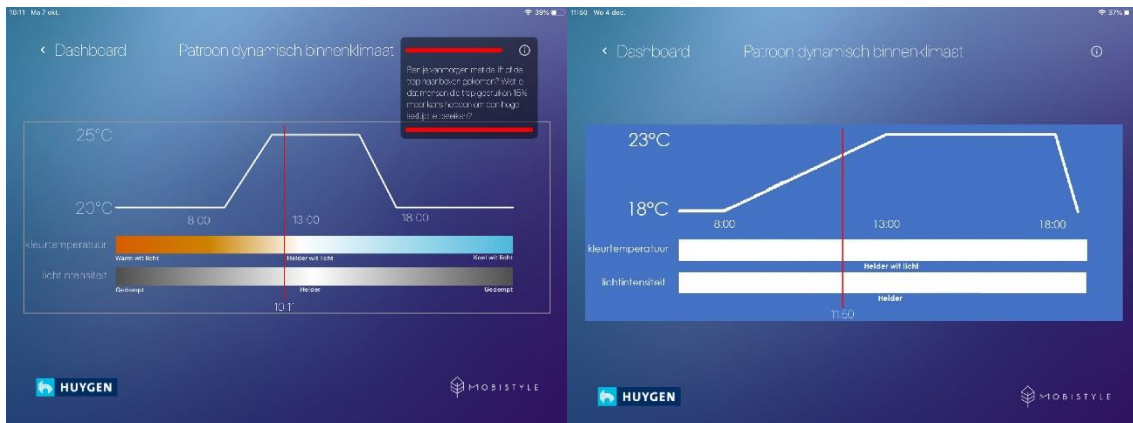
Figure 41: Two different versions of the temperature and lighting profile screen. The red line indicated the current situation of the different set points.

5.2.2. The Office App Structure

The Main Screen

The Main Screen of the Office App displays:

- Room location and time
- Indoor temperature value where if you click on it you get access to detailed indoor climate overview (evaluation of T, RH, CO_2).
- One general tip which you can click to obtain more information;
- Feedback question and overview of people's satisfaction that day.
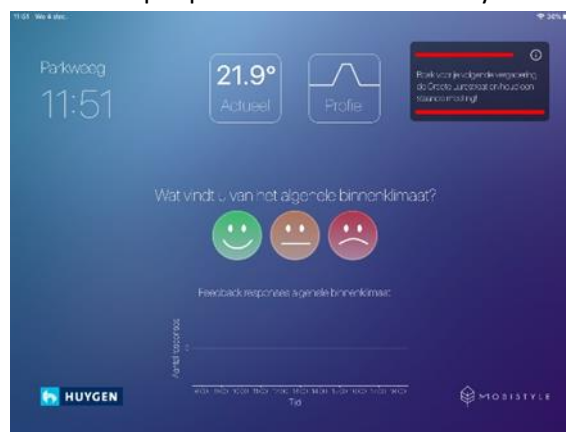
Figure 42: MOBISTYLE Office App Home screen features

Clicking on MOBISTYLE Logo on the Home Display also the EU funding recognition is showed.

Figure 43: MOBISTYLE funding recognition and EU logo display

Actual indoor temperature screen

For every office room IEQ information based on the available sensorised data is displayed. As shown before, this can be accessed from the 'House' button if clicking tab with Temperature value. Examples of displayed information are:

- Temperature, green: 19-23 °C;
- CO_2 concentration, green: 400-1000 ppm, orange: 1000-1200 ppm, red: >1200 ppm;
- Relative humidity, red: <40 %, green: 40-70 %, orange: 70-80 %, red: > 80%.

Figure 44: Actual indoor climate display

Feedback loop screen

Building occupant's satisfaction evaluation is done through a feedback loop tab where thermal and visual -sensation, -acceptance, and -comfort are evaluated. These possibilities are chosen directly from the Main Screen. The data is stored per entry time, so the answers to the follow-up questions are all linked to each other so evaluation of the feedback is possible. Below the different questions are shown.
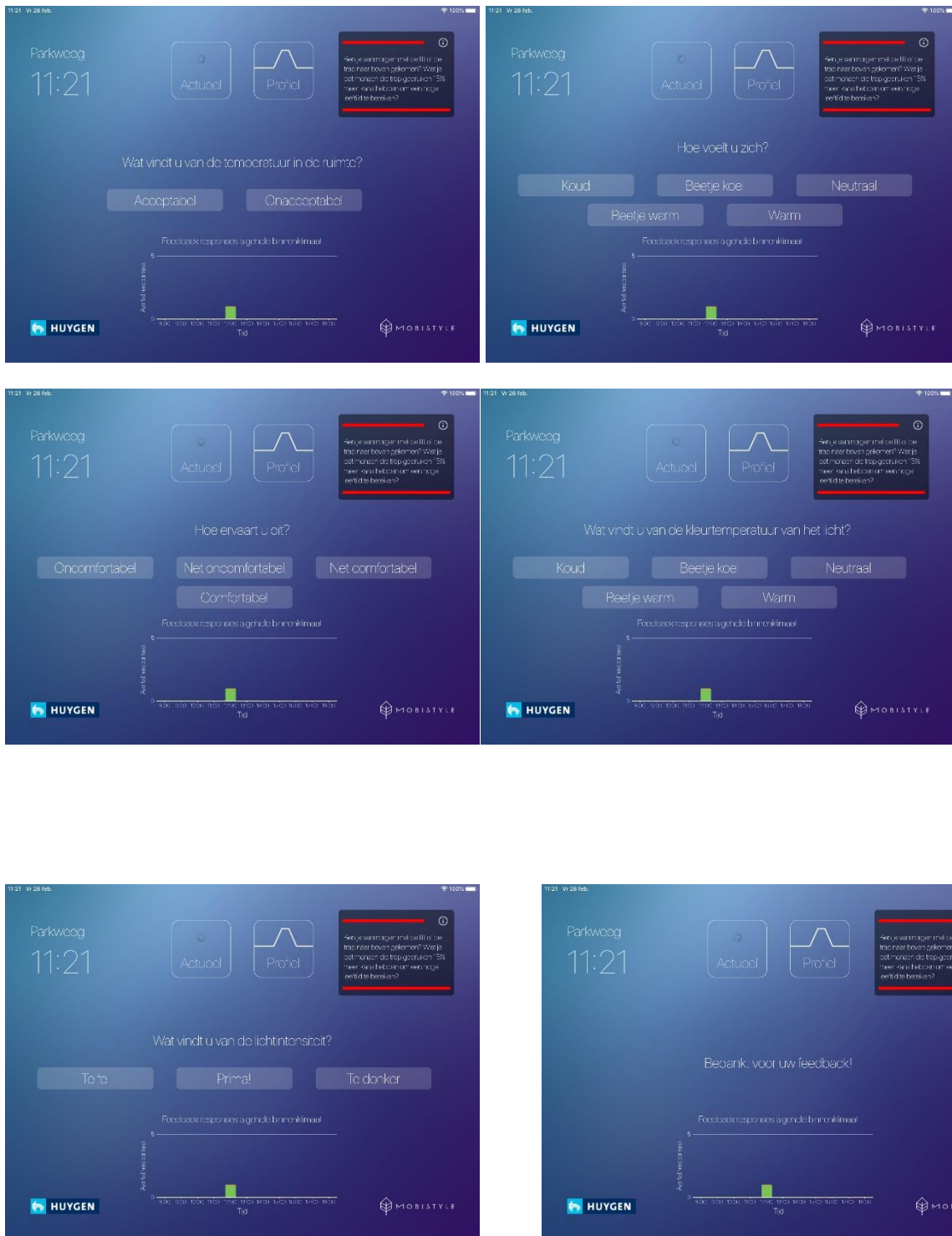
Figure 45: Feedback evaluation screens

Overall satisfaction screen

In this section, the user may access the currently active goals (medals that are active to be won) and the list of the medals already earned in the past (see Figure 37 46).

Figure 46: Overall satisfaction screen

Dynamic profile screen

The screen where the dynamic temperature and light profile is shown two different 'graphs' are included. First a white line is shown with the temperature profile of that day. Below an example is shown. Here the setpoint temperature is set at 20°C in the morning until 9h, after that the temperature is increased to 25°C at 12h to be kept stable until 14h. Finally, the setpoint is slowly lowered to 20°C at 18h. The second and third part of the graph is about the lighting settings of the profile, color temperature and light intensity. Color temperature is shown in a range from red (2700K)-white (3000K)-blue (4000K). Light intensity is shown in dark grey (300 Lux) – white (1000 Lux) colors. The red line indicates the current time and shows hereby the current settings.
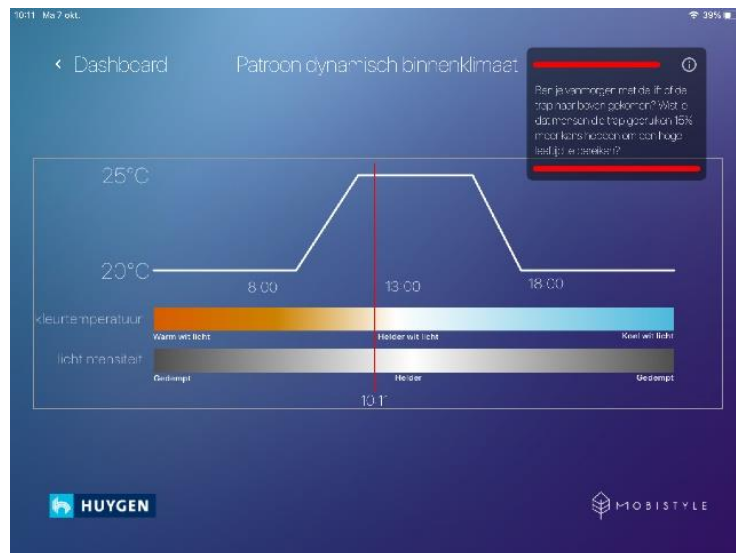
Figure 47: Dynamic profile screen

5.3. Next Steps

The following features could be added in the future to upgrade the current version of the Office App.

- Integration of the Daily weather forecast;

- Integration of the agenda and room occupation (this can be further connected with the BMS system so there is no or minimum heating/cooling/ventilation when room is not anymore booked for a day);
- Integration of self-assessment productivity tests (e.g. if employer wants to see the correlation between employee's productivity and surrounding office environment);
- Addition of more sensors to obtain for example outdoor air quality, occupancy sensors;
- Addition of monthly reports to see how was the satisfaction and indoor quality over a month.

It was not possible to perform full SUS testing and give the employees the final evaluation questionnaire as Huygen requested work from home as of 15 Mar 2020. The final focus groups and SUS testing was scheduled for 24th Apr, however, due to the COVID-19 situation this has been suspended.

6. Conclusions

This document is a final report showing the progress in the development of the MOISTYLE ICT solutions based on the user centric approach.

In MOBISTYLE, users play a fundamental role in providing recommendation for developing the ICT solutions with potential to influence habits based on needs and expectations of people living and working in MOBISTYLE demonstration cases. In the initial phase of the project, the users were identified, recruited, and grouped (D2.2). With them (organized in focus groups), usability testing was performed for the MOBISTYLE Dashboard, Game and Office App in the different demonstration cases. It should be noted that the building for the Dutch case has been changed along the project therefore the Office App was developed later than the Dashboard and the Game (after focus groups in the new building have been realized). The experts within the MOBISTYLE consortium supported each demonstration case preparing a Protocol for MOBISTYLE solutions testing, containing the main guidelines, questions and activities to be performed. The user testing gave as result a list of recommendations for the further development of the ICT solutions. For example, notifications and messages should not be intrusive but used maximum twice a day. The messages have to be informative but not negative nor related to personal issues.

Following the recommendations, the Dashboard, the Game and the Office App have been developed.

The Dashboard is developed for non-residential buildings and has as target groups managers of the buildings and users of the sensorized spaces. The Dashboard is a tool that allows different kind of users to receive information about the buildings they interact with, through specific authentication. The dashboard is available in two versions, one for desktop access from a computer and one as mobile phone APP. The information shown, the structure and the widgets, is the same in both. As they address the same scope, the possibility to use different devices increases the usability experience. The development of the MOBISTYLE dashboard has defined following features: 1) Customizable sensorized entity structure; 2) Articolated users/actors structure; 3) Customizable suggestions management. The tool is actually working and ready to be tested and validated by external users. It will be tested in the IT and SI cases. Additionally, according to WP6, task 6.5, an expert will carry on a Usability Testing.

The Game is developed for residential buildings and has as target group the households. The MOBISTYLE Game App is a gamified app for behavioral change regarding energy use and also for awareness creation on associated health benefits. The approach followed for the development of the features of the Game App was a home-centric, based on the concept of maintaining a "healthy" home. This means that all users who use the game associated with a specific home will share the same state and progression. The current beta version of the MOBISTYLE Game App already includes the most relevant and critical features planned for the app. The following features are implemented in the Game App: 1) Missions: Detection of undesirable conditions and specific measures the user needs to take in order to correct them; 2) Points and Ranking: A simple metric on how close the home is to being "healthy"; 3) Achievements: Longer-term sequences of actions a user needs to take; 4) Home Data: Allows the user to access data from the sensors installed in their home; 5) Reports: User access to chart-based information on their home performance, tied to recommendations whenever such information is available; 6) Tips: Short ideas or comments conveying facts on health, energy use or indoor air quality.

The Office App is developed for office buildings to introduce the dynamic conditions by giving users information about their indoor environment. The aim is to increase occupant's acceptance as such conditions can lead not only to lower energy bills but also to more productive and healthier employees. The Office App provides tips and information on how such conditions affect people's well-being, productivity and also building's IEQ and energy use. The Office App is tested in an open-plan offices at Brightlands innovation campus in the Netherlands.

Feedbacks collected through the final Users Testing and Expert Testing will be reported in WP6 Tasks 6.4 and 6.5. They will be used to define solutions improvements and recommendations for the next steps up towards commercial exploitation.

Annex 1: Protocol for MOBISTYLE solutions testing

General recommendations

Please keep in mind that the whole process, including preparations and analysis, should not take you more than one workday (8 hours) of one person. Note that the meeting with participants should not take more than hour and a half. It is important to select a right person to conduct the testing and facilitate the debate. Most importantly, the person in charge of facilitating the testing should be communicative and ready to accept different perspectives of participants.

Preparation

This is a general guideline for conducting the testing and making all necessary preparation activities. If necessary, adapt the preparations to your local situation.

- Invite 5-7 people to the testing. If possible, establish a contact with the people who are already familiar with the project or use specific guidelines[1] when recruiting new participants.
- Prepare a quiet and comfortable room with available PCs or laptops (at least one per group, ideally one per person) where you will be able to show the products and their functionalities.
- Try out in advance if the solution actually works on the location. Check the internet availability if you need it. Have a backup.
    - Dashboard is available via http://MOBISTYLE.demo.holonix.biz. Use the right location an user specific login credentials (manager and user).
    - Mock-up of the game is available via https://share.axure.com/[2].
- Print out enough paper copies of the System Usability Scale (SUS) test (see point 3.2. in this document). Before printing them out, translate the 10 questions and 2 remarks above the scales ("Strongly disagree" and "Strongly agree") to your local language.
- Prepare printed versions of MOBISTYLE advices and recommendations. Print out each advice on a small piece of paper (or simply print all of them on one piece of paper and cut them out). Prepare the same list of 10-15 advices for each participant (see point 3.4. in this document).
- The testing should be carried out in your local language. IRI UL expert will provide you support via video call, if necessary.
- Audio record the full conversation (for example with you smartphone or any other appropriate audio recording device) after obtaining the permission of the participants. Most probably, the participants have already signed the informed consent for MOBISTYLE study, but please check. Have few printed copies prepared. Make photos of the process.

Process

Introduction

- Each participant of the testing event introduces him/herself. Ideally, make a quick round of introductions, especially if participant do not know each other. The leader of the event should start.

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[1] Recruitment of participants in the ethnographic study, Instructions for the MOBISTYLE project partners. Available upon request.
[2] The consortium partner HS needs to allocate you permissions.

- Briefly present the objectives of the MOBISTYLE project.
- Present the purpose of the testing, i.e. collecting user feedback on the current stage of the solution; keeping users involved in the design and development process.
- Tell them about the timeframe of the meeting (not more than 1.5 hours).

Quantitative measurement by System Usability Scale

After the users are presented the solution and interact with it for few minutes, start the testing by presenting to the participants the System Usability Scale (SUS) test. The questions should be provided on paper for all participants. Take approx. 5 minutes to finish the test.

System Usability Scale

© Digital Equipment Corporation, 1986[3]

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently					
	1	2	3	4	5

2. I found the system unnecessarily complex					
	1	2	3	4	5

3. I thought the system was easy to use					
	1	2	3	4	5

4. I think that I would need the support of a technical person to be able to use this system					
	1	2	3	4	5

5. I found the various functions in this system were well integrated					
	1	2	3	4	5

6. I thought there was too much inconsistency in this system					
	1	2	3	4	5

7. I would imagine that most people would learn to use this system very quickly					
	1	2	3	4	5

8. I found the system very cumbersome to use					
	1	2	3	4	5

9. I felt very confident using the system					
	1	2	3	4	5

10. I needed to learn a lot of things before I could get going with this system					
	1	2	3	4	5

Questions addressed

After the SUS test, continue with the debate. While showing the participants the MOBISTYLE solution, focus on the following topics and adapt your questions accordingly:

1. **Intuitiveness and simplicity** of the graphical user interface (GUI): How do you find the design of the solution? Can you recognise the main features? What do you think of the symbols used on the screen?

2. Possible **channels of content distribution**, e.g. public screens and other IT devices in the building that could be used for motivating them to change their existing practices: Where would you like to use

---

[3] Accessed 25.7.2018 https://hell.meiert.org/core/pdf/sus.pdf H2020 MOBISTYLE_723032_WP2_Task 2.5

the MOBISTYLE solution? Do you know any good place in the building where it could be shown to others?

3. Relevance of **advices, recommendations and tips**: Which advices do you like the most? Which are the least relevant for you? Why?

Testing advices and recommendations
After the last question, put some additional attention to MOBISTYLE health, energy and wellbeing related tips and recommendations. Arising from activities in T3.4, the recent list of possible statement can be found on Sharepoint here. Select the most appropriate and relevant tips for you demo case and print them out on small pieces of paper. Keep in mind that their purpose of the tips is to influence behaviour of people and to establish new habits.

- Provide a deck of 10-15 advices per participant. They should all get the same deck.
- Let them have a look of the questions (1-2 min).
- Ask them about the wording used. Let them comment and suggest better or even new tips, which would work best for them.
- Ask them to choose the 3 best tips (the ones they like most or find most useful in their own case) and 3 worst tips.
- After they pick 3 tips, ask them to explain their selection (1-2 min per participant).

Example texts used in SI demo case:
- *It seems you have left the window open for X hours, and outdoor conditions are not favourable.*
- *Open the window, it is warmer/colder outside.*
- *Reduce the temperature and boost your brain!*
- *Want to lose some weight due to increased metabolism? Reduce the heating in your office!*
- *If you feel cold, put on some clothes!*
- *Ventilate the room! CO_2 has been above X ppm for X minutes, you might get a headache and your productivity might decline.*
- *The outdoor conditions are excellent for letting some fresh air in!*
- *Ventilate the room! There is a risk of mould growth that can be hazardous to your health.*
- *Why waiting for the elevator? Use the stairs, save time, get fit and live longer.*
- *Turn off your computer and monitor.*
- *Its sunny outside, do you really need the light on?*
- *Turn off the light and equipment if there is no one in the room.*
- *Do you really need hot water for washing your hands?*
- *If you feel cool, put on some clothes!*
- *If you feel hot, you should cool yourself and/or move to another room.*
- *If you do X sit-ups, you will feel warmer and more focused.*

Figure 48: images from testing the tips in Slovenian case.

Conclusion

Finally, thank the participants for their time and contribution and inform them that the MOBISTYLE team will keep them posted about the outcomes of the project.

Follow up

After you conclude the testing, analyse it and prepare a short report. First, analyse received SUS by using standard model to get numerical score for each participant. A table is provided here.

Use the audio recording to prepare a report of the qualitative part of the testing. First, include the metadata of the focus group (Title, Date, Type, Recorder/Facilitator, Duration, Location, Prepared by) and include your short comment at the beginning, explaining if there were any special circumstances or issues which affected the procedure. After that, prepare a list of participants' names and their initials, which are used in the report. Prepare a list of keywords, i.e. the main topics of the discussion. Describe each topic (add a subtitle above the paragraph(s) with a new topic) and explain what do people think about the user interface, how do they perceive the used symbols, how do they find the MOBISTYLE tips and advices (which are the most and least relevant for them), etc.

Finally, prepare some general recommendations coming out of the testing, which can be used to improve the MOBISTYLE solution and tailor it to your own local case. The recommendations can include your personal impression about the positive and negative aspects of the MOBISTYLE solution and about possibilities for improvement. Example of a report is available here[4].

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[4] Focus group in Slovenia demo case (UL FKKT FRI) – testing the solution design.

Annex 2: FG report for the IT case

Title: Focus group in the Italian demo case (Hotel Orologio Living Apartments) – Usability testing of ICT solutions

Date: 27/09/2018 12:30h
Type: Focus group
Recorder/Facilitator: Verena M. Barthelmes, Cristina Becchio, Giulia Vergerio
Duration: 2 hours
Location: Hotel Orologio Living Apartments, Turin, Italy
Prepared by: Verena M. Barthelmes, Cristina Becchio, Giulia Vergerio

Comments:

Representatives of hotel manager (HM), employs (HR) and guests (G) were chosen from the identified user groups. The focus group was carried out in Italian language. 3 researchers (energetics) were present at the FS. The questionnaire "System Usability Scale" was compiled twice by each participant: once for the dashboard and once for the mobile application.

Three main limitations to the test occurred:

1. Guests were not available for the focus group, since its organization was not compatible with the scheduled meeting for which they travelled. Actors substituted them;

2. The GUI for the manager did not work. PT members asked her to have a look at the interfaces of both the guests and of the staff, explaining her that manager interface will include all the information that the guests and the receptionists can see, apart for the feedback;

3. Due to some problems in the database, some of the Key Performance Indicator values were out of scale. PT members asked to the participants to focus their attention on usability, design and symbol/indicator choice effectiveness instead of on contents.

Participants:

Polito Team = PT (VB: Verena Barthelmes, CB: Cristina Becchio, GV: Giulia Vergerio)
Hotel Manager = HM
Receptionist 1 = R1
Receptionist 2 = R2
Guest 1= G1
Guest 2= G2
Guest 3= G3

Figure 49: Participant at the FG for the IT case

Faces are covered to protect privacy according to GDPR.

Keywords:

"Graphical user interface", "Intuitiveness", "Dashboard usability", "Mobile application usability", "Visualization", "Communication", "Advices for users", "User feedback".

Introduction

CB from PoliTo team (PT) made an introduction about the MOBISTYLE project. She briefly presented the aim of MOBISTYLE project and its activities. VB (from PT) introduced the MOBISTYLE tools developed for the Italian demo case (dashboard and app) and, with GV (from PT), the main goals of the Focus Group (FG).

Intuitiveness and general impression about the Graphical User Interface (GUI):

Various GUIs were presented to the FG, one by one: the Dashboard and the App.

Firstly, the dashboard was presented in two of the three available versions: the one for the guests and the one for the staff. Since the account for the manager did not work, PT members asked to the HM to have a look at both the interfaces, explaining her that HM interface will include all the information that the guests and the receptionists can see, apart for the feedback.

After the presentation of the tool, participants interacted with it for a while. Then, PT asked to users to fill the questionnaires (which was translated in Italian) related to the usability scale of the dashboard. The answers are reported in the following.

tool: DASHBOARD
Respondents: Guests

questions	n. of answers					answers distribution		
scale:	1	2	3	4	5	disagree	neutral	agree
q1	1		1	1				
q2	1	1	1					
q3				1	2			
q4	2	1						
q5				3				
q6	2	1						
q7				2	1			
q8	1	2						
q9				2	1			
q10	2	1						
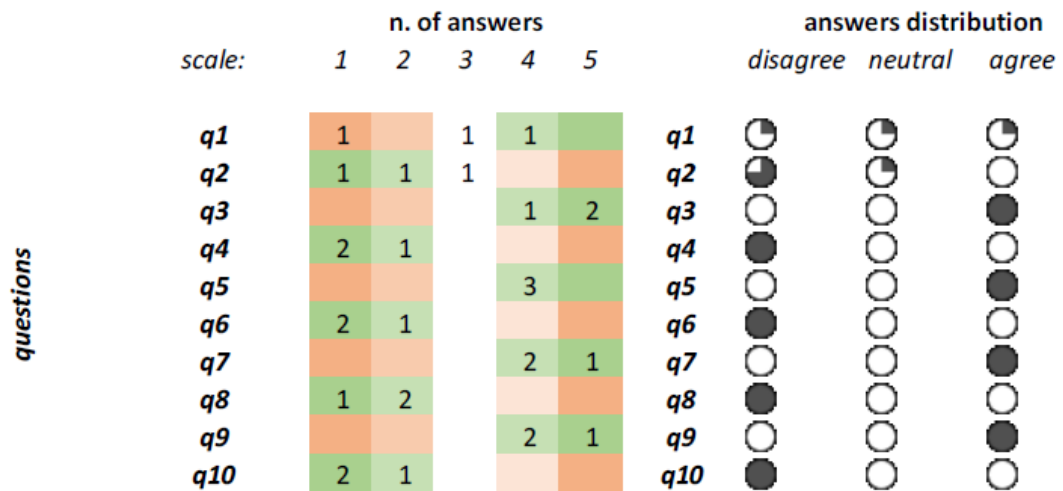
Figure 50: Guests answers about usability of the Dashboard[5]

G1, G2 and G3 have different opinions about the frequency with which they would be willing to use the tool (question 1). Most of them do not think that the tool is unnecessary complex (question 2), while all of them have almost the same opinion about the other issues that the survey intended to investigate. In particular, they do not think that the tool requires a technical support (question 4) or more knowledge (question 10) to be used. Furthermore, they do not agree that the tool have internal inconsistency (question 6) or that it is cumbersome to use (question 8). Conversely, they agree that the tool is easy to use (question 3) and that it has well integrated functions (question 5). They felt confident using the dashboard (question 9) and then they think that most people would be able to learn quickly how to use it (question 7).

---

[5] Scale from 1 (strongly disagree) to 5 (strongly agree) are coloured in a different way to highlight when agreeing implies a positive opinion about the tool (from red to green) and when disagreeing implies a positive opinion about the tool (from green to red) because the question is negative.

tool: DASHBOARD
Respondents : Receptionists

	n. of answers							answers distribution		
scale:	1	2	3	4	5			disagree	neutral	agree
q1			1	1			q1			
q2	1	1					q2			
q3					2		q3			
q4	2						q4			
q5			1	1			q5			
q6	2						q6			
q7			2				q7			
q8	1	1					q8			
q9				2			q9			
q10		2					q10			
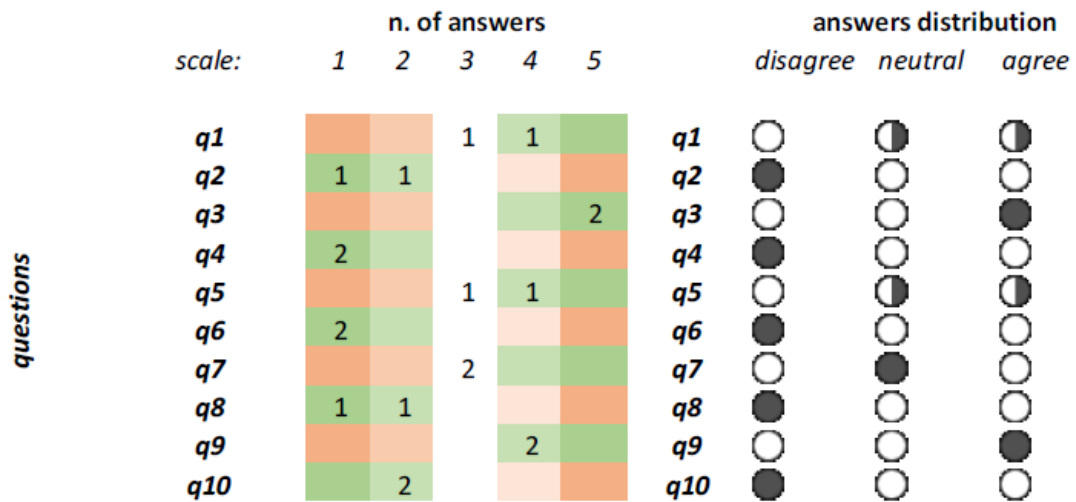
Figure 51: Receptionists answers about usability of the Dashboard[5]

R1 and R2 have a similar opinion to the guests' one on questions 4, 6, 8 and 10. It means that in general also for the staff the dashboard resulted consistent and not cumbersome and that its usage do not require technical support or particular skills. With respect to the guests, R1 and R2 are surer in affirming that the tool is not unnecessarily complex (question 2). But R1 and R2 do not totally agree about the integration of the different functions (question 5) and they are not sure that most people could learn to use the dashboard very quickly (question 7). By their side, they felt confident using the tool (question 9). Indeed, they think it is easy to use, but none of them has a strong position in affirming that she would be willing to use it (question 1).

tool: DASHBOARD
Respondents : Hotel Manager

	n. of answers							answers distribution		
scale:	1	2	3	4	5			disagree	neutral	agree
q1				1			q1			
q2	1						q2			
q3			1				q3			
q4				1			q4			
q5					1		q5			
q6	1						q6			
q7			1				q7			
q8		1					q8			
q9			1				q9			
q10		1					q10			
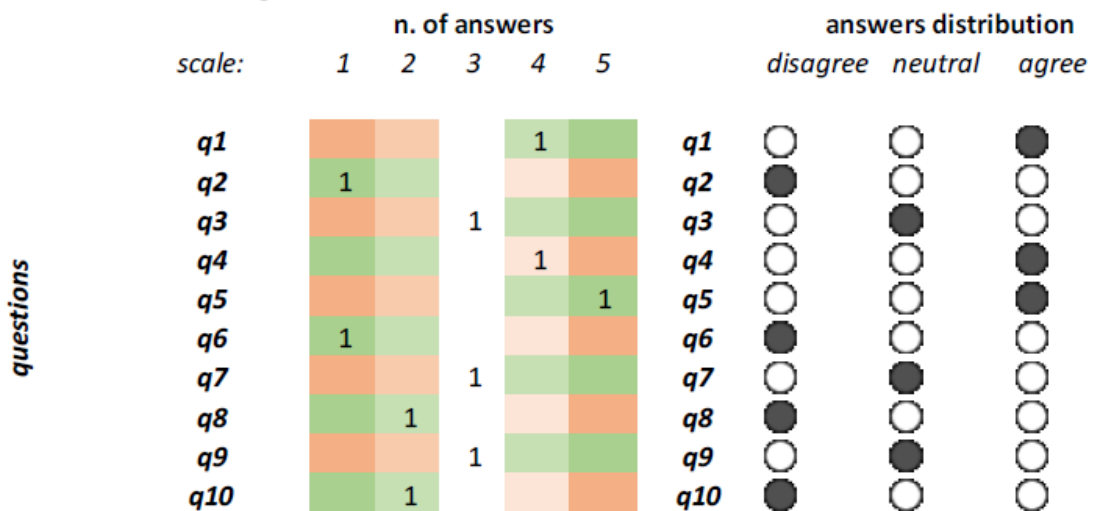
Figure 52: Hotel manager answers about usability of the Dashboard[5]

By her side, the HM thinks that the dashboard is not unnecessarily complex (question 2), it is quite easy to use (question 3), it has well integrated functions (question 5), it is internally consistent (question 6), it is not so cumbersome to use (question 8), although she is not sure about the confidence

she had in using the dashboard (question 9). Indeed, she has not a strong position in affirming that she would be willing to use the dashboard (question 1), since she feels to need a technical support in its usage (question 4). Beyond her personal feeling, she is not sure that most people would learn to use the dashboard very quickly (question 7).

After the presentation of the dashboard, the smartphone application was presented in two of the three available versions: the one for the guests and the one for the staff. Since the account for the manager did not work, PT members asked to the HM to have a look at both the interfaces, explaining her that HM interface will include all the information that the guests and the receptionists can see, apart for the feedback.

After the presentation of the tool, participants interacted with it for a while. Then, PT asked to users to fill the questionnaires (which was translated in Italian) related to the usability scale of the application. The answers are reported in the following.
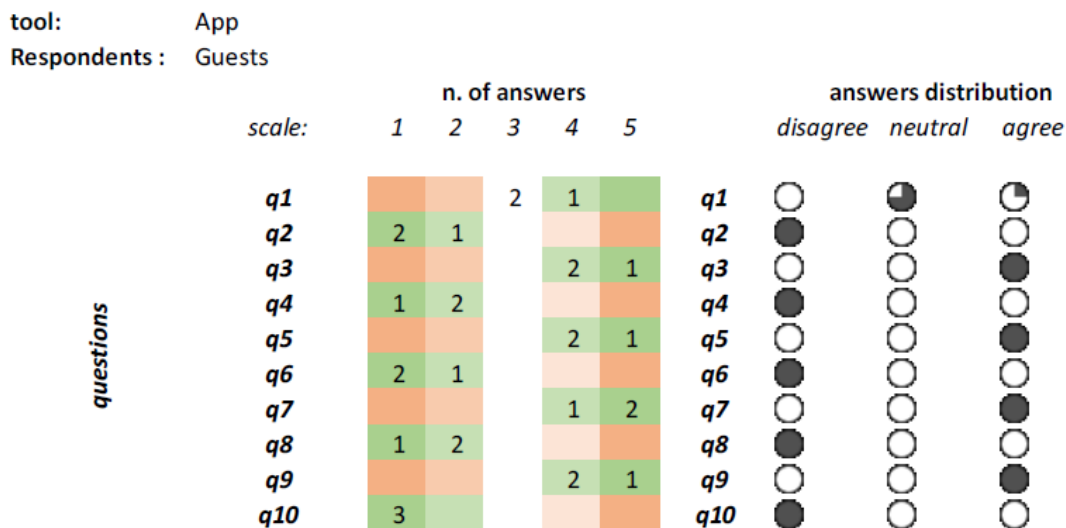
Figure 53: Guests answers about usability of the Mobile Application[5]

The usage of the smartphone application resulted in producing more agreement among the guests on some issues. With respect to what they affirmed for the dashboard, G1, G2 and G3 are surer that they would be willing to use the app (question 1); they agree that the app is not unnecessarily complex (question 2), that the functions are well integrated (question 5) and that most people would learn to use it very quickly (question 7), since they strongly disagree about the necessity for specific knowledge in using the app.

tool: App
Respondents: Receptionists
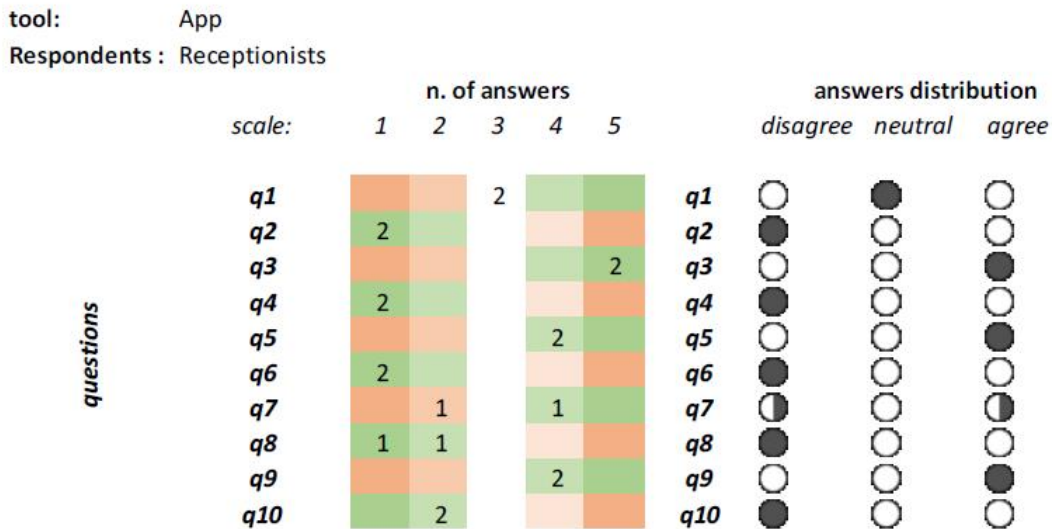
Figure 54: Receptionists answers about usability of the Mobile Application[5]

With respect to what they affirmed for the dashboard, the receptionists are less sure that they would be willing to use the app (question 1). Their answers of disagreement about the app complexity (question 2) and of agreement about a good integration in the different functions (question 5) are stronger that the ones given for the dashboard. They still are not sure about the capability of people to learn to use the tool very quickly (question 7).

tool: App
Respondents: Hotel Manager
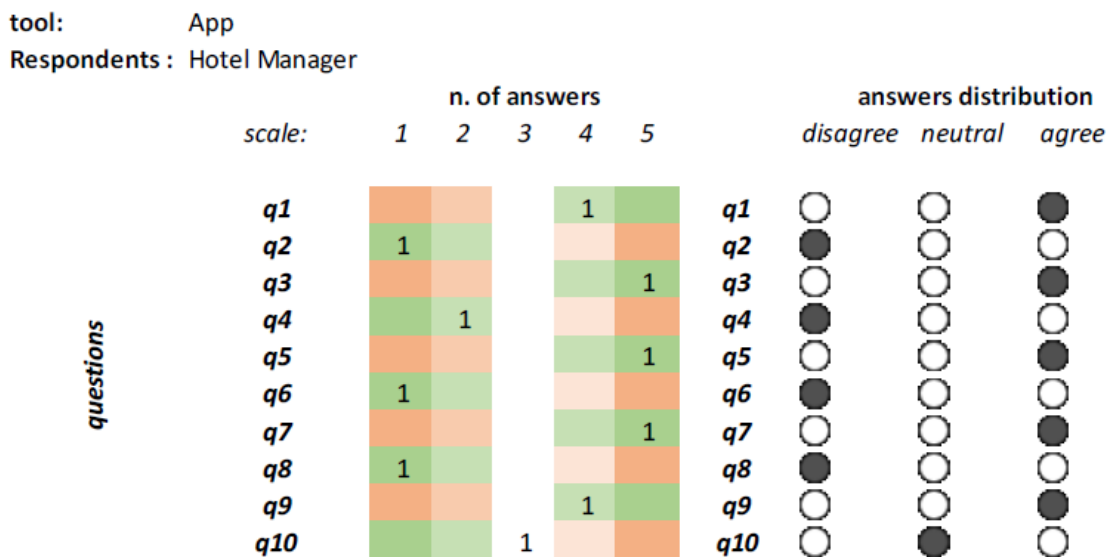
Figure 55: Hotel manager answers about usability of the Mobile Application[5]

The HM thinks that the app is easier (question 3) and less cumbersome to use (question 8) than the dashboard. While she affirmed to need a support in using the dashboard, she disagrees about the necessity for technical help in using the app (question 4). Thanks to the answers it is possible to read how she feels more confident with the app then with the dashboard. She also has a more optimistic

position about the capability of people to learn to use the app with respect to the one declared in the survey related to the dashboard (question 7).

During all the survey session, many participants ask for clarification about what they were seeing, while no feedbacks were given by the PT members during the questionnaires filling. Despite the opinions revealed through the surveys are not negative, the users stated some criticalities.
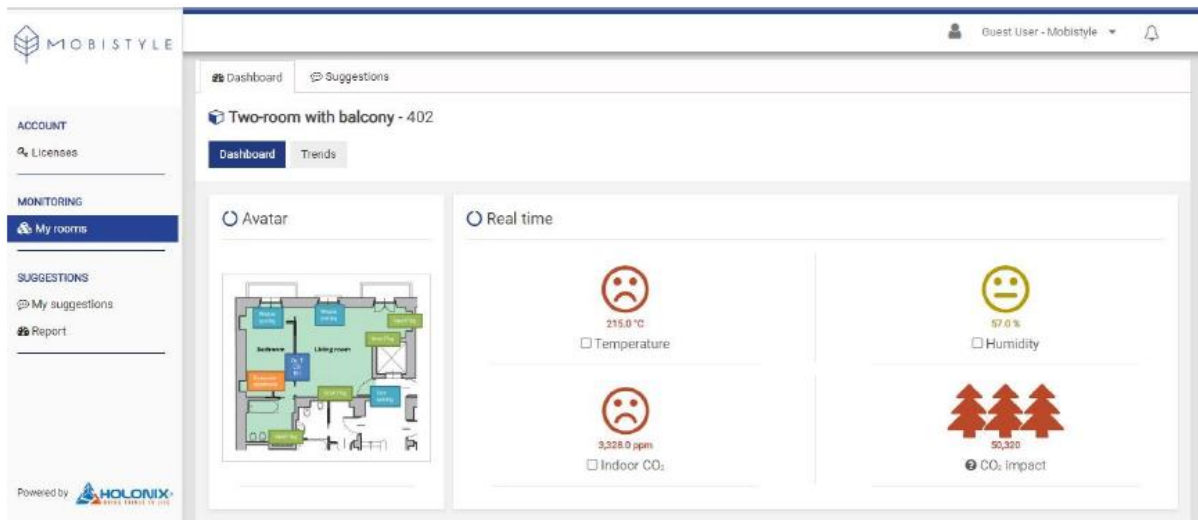
Figure 56: Dashboard interface
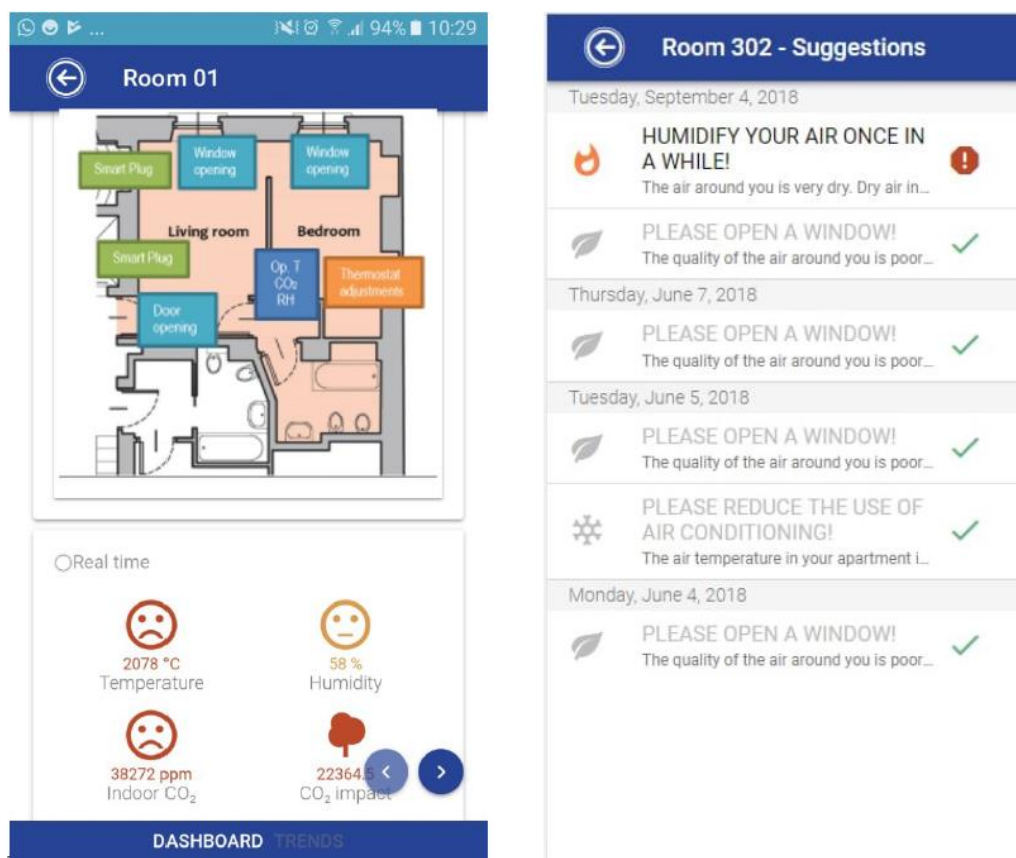
Figure 57: Mobile application interface

For this reason, after the surveys session, the PT members activated a discussion, asking to the users to give comments about the two tools they used. All of the participants to the FG find the tools intuitive, but R2 is not sure that all the potential users will be able to use the tools. Everybody agree that the symbols and the colours are quite effective and that the indicators are interesting. HM, R1 and R2 appreciate the possibility to see historical trends of the KPIs. However, G3 and HM comment that someone of them are not easy to be understand. G3 suggest to use equivalent pollutants and indicators, more intuitive that the CO_2, while HM affirm that the indicators should be explained in a more explicit way (e.g. "carbon dioxide in the internal environment" instead of "indoor CO_2"), also though interactive windows, in order to keep the main interface synthetic. Indeed, HM thinks that be direct and explicit in the communication is a prerequisite to attempt the users to use the tools, otherwise, if they do not understand, they are not going to use the tools. To G1, for example, it was not clear that there are some thresholds that make the tools dynamic according to the real time conditions. With respect to the design, G1 find some misunderstood elements, like the squares next to the symbols, which seem to be made to be clicked. Both G1 and G2 would like to zoom the screen, since we are used to do it daily with our smartphones. The guests (G1, G2, G3) state their preference for the app, while the receptionists (R1 and R2) for the dashboard, because they are used to work with the laptop all the day. R1 and R2 thinks that there is not space to install a public dashboard in the common spaces of the hotel, but maybe in the new rooms it could be interesting to have someone to test.

Feedback on tested advices

After the discussion on the usability of the tools, 15 advices chosen by the PT members and printed on small pieces of colour paper were distributed among the FG participants, one by one. They were ask to choose the 3 best advices and the 3 worst ones. Then, PT members activated a discussion asking to the participants to motivate their choices.

Tested advices

The 15 feedback chosen by PT members were:

5 related to the energy field:

1. *"Your electric energy consumption seems to be high. Do you really need all that devices on? Turn off the devices you are not using and do not leave anything in stand-by (e.g. TV or laptop)!"*
2. "Your electric energy consumption is the …% higher than the average one of the other guests!"
3. "Your electric energy consumption is the …% higher than it used to be. You can do better!"
4. "You used the dishwasher many times this week! Use it only when it is full"
5. "The most convenient energy tariff is between the hour … and the hour …! Do you have other commitments?"

5 related to IEQ and environment:

6. *"Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"*
7. *"Open the window! The CO_2 level has exceeded the limit of … mg / m$_3$ for 30 minutes and could cause headaches and reduce your concentration!"*

8. *(in winter) "If you feel could, before putting the temperature on the thermostat, put some more garments!"*
9. *(in summer) "The temperature in your apartment is excessively low. Please increase the set temperature on your thermostat!"*
10. *"Your apartment yesterday was responsible for ... kg of CO_2 emissions into the environment. Save energy and protect the environment!"*

5 related to health:

11. *"Expose yourself to a variable internal temperature (feel cold occasionally) reduces the risk of cardiovascular diseases, diabetes and obesity. Test it!"*
12. *"Avoid too much moisture to reduce possible symptoms of asthma and allergies!"*
13. *"Open the window! There is a risk that molds can grow dangerous to your health."*
14. *"Do you want to lose some weight the easy way? Lower the temperature and accelerate your metabolism"*
15. *"People who use the stairs (and not the elevator) have 15% more chance of living longer. Why wait for the elevator?"*

General recommendations on advices

- Some advices are too imperative. A friendly communication would be better;
- The communication should be kind and do not leverage on touchy and personal issues (e.g. all the guests choose the advice related to weight as one of the worst);
- The use of numerical thresholds in the advices text is not effective because they are difficult to understand (e.g. advice number 7);
- Feedback related to health are valued, but some of them are perceived as too exaggerated (e.g. advices number 11 and 13, which were never chosen among the best ones);
- Feedback on health related to immediate effects are preferred to the ones with cause-effect relationship distant in time (e.g. advice number 11);
- Peer comparison between guests is valued by some of the participants to the FG because it leverages the sense of competition and gaming. But some guests and the manager put the attention on the peculiarity of the hotel final use: guests are paying for a service, then comparison and judgment can be perceived as annoying (for example, the HM does not appreciate leverage behaviour through cost-related advices), discouraging the use of the tools and resulting in no effects on behaviour. For this reason, internal comparison and kind communication are important prerequisites;
- The communication should push the users to keep interested in the tools.

Pictures of the FG
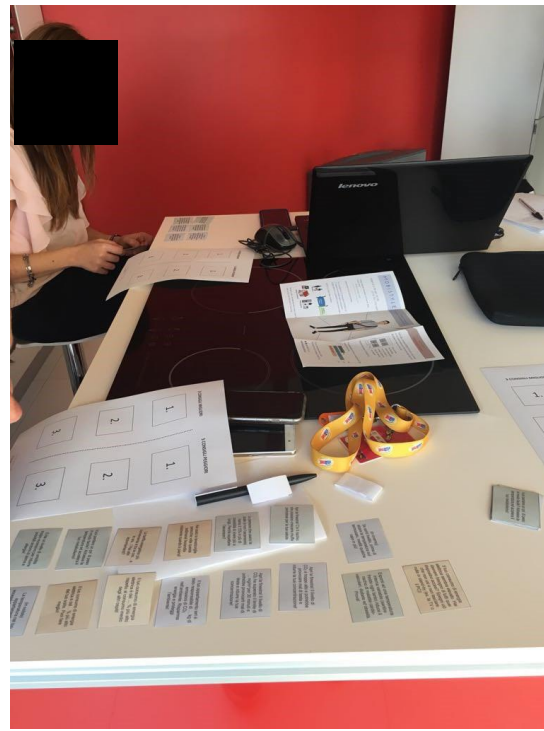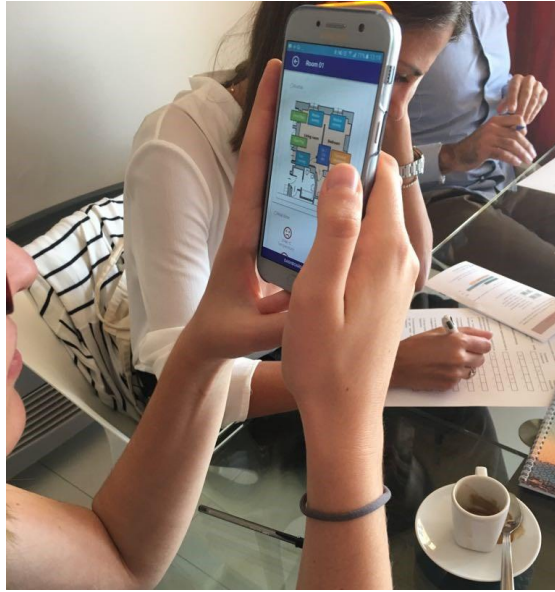
Annex A: advices chosen by the participants

In **yellow** the advices related to energy; in **green** the ones related to environment and IEQ and in **light blue** the ones related to health.

- The **energy-related** advices were chosen 6 times among the best ones and 8 times among the worst ones.

- The **environment-related** advices were chosen 8 times among the best ones and 4 times among the worst ones.

- The **health-related** advices were chosen 4 times among the best ones and 6 times among the worst ones.

G1:

3 best advices:

1. "Your electric energy consumption seems to be high. Do you really need all that devices on? Turn off the devices you are not using and do not leave anything in stand-by (e.g. TV or laptop)!"

6. "Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"

9. (in summer) "The temperature in your apartment is excessively low. Please increase the set temperature on your thermostat!"

3 worst advices:

5. "The most convenient energy tariff is between the hour … and the hour …! Do you have other commitments?"

11. "Expose yourself to a variable internal temperature (feel cold occasionally) reduces the risk of cardiovascular diseases, diabetes and obesity. Test it!"

14. "Do you want to lose some weight the easy way? Lower the temperature and accelerate your metabolism"

G2:

3 best advices:

1. "Your electric energy consumption seems to be high. Do you really need all that devices on? Turn off the devices you are not using and do not leave anything in stand-by (e.g. TV or laptop)!"

6. "Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"

15. "People who use the stairs (and not the elevator) have 15% more chance of living longer. Why wait for the elevator?"

3 worst advices:

*5. "The most convenient energy tariff is between the hour … and the hour …! Do you have other commitments?"*

11. "Expose yourself to a variable internal temperature (feel cold occasionally) reduces the risk of cardiovascular diseases, diabetes and obesity. Test it!"

14. "Do you want to lose some weight the easy way? Lower the temperature and accelerate your metabolism"

G3:
3 best advices:
2. "Your electric energy consumption is the …% higher than the average one of the other guests!"

6. "Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"
12. "Avoid too much moisture to reduce possible symptoms of asthma and allergies!"

3 worst advices:
5. "The most convenient energy tariff is between the hour … and the hour …! Do you have other commitments?"
7. "Open the window! The CO_2 level has exceeded the limit of … mg / m_3 for 30 minutes and could cause headaches and reduce your concentration!"
14. "Do you want to lose some weight the easy way? Lower the temperature and accelerate your metabolism"

R1:
3 best advices:
2. "Your electric energy consumption is the …% higher than the average one of the other guests!"

6. "Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"

15. *"People who use the stairs (and not the elevator) have 15% more chance of living longer. Why wait for the elevator?"*
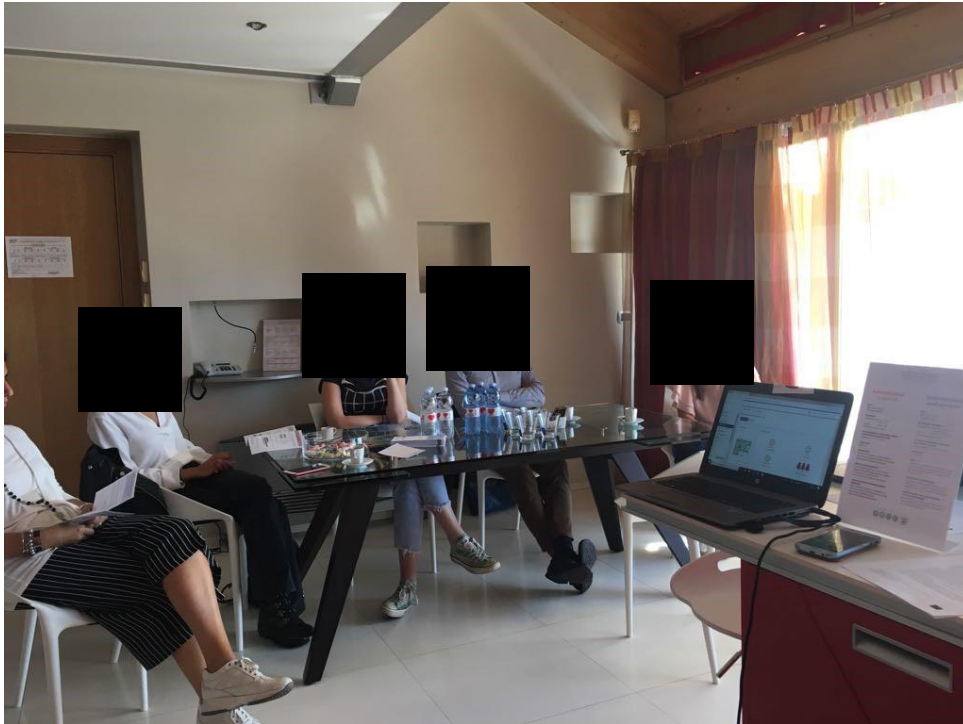
3 worst advices:
1. "Your electric energy consumption seems to be high. Do you really need all that devices on? Turn off the devices you are not using and do not leave anything in stand-by (e.g. TV or laptop)!"
4. "You used the dishwasher many times this week! Use it only when it is full"
8. (in winter) "If you feel could, before putting the temperature on the thermostat, put some more garments!"
R2:
3 best advices:

1. "Your electric energy consumption seems to be high. Do you really need all that devices on? Turn off the devices you are not using and do not leave anything in stand-by (e.g. TV or laptop)!"

7. "Open the window! The CO_2 level has exceeded the limit of ... mg / m_3 for 30 minutes and could cause headaches and reduce your concentration!"

8. (in winter) "If you feel could, before putting the temperature on the thermostat, put some more garments!"

3 worst advices:

3. "Your electric energy consumption is the …% higher than it used to be. You can do better!"

5. "The most convenient energy tariff is between the hour … and the hour …! Do you have other commitments?"

10. "Your apartment yesterday was responsible for … kg of CO_2 emissions into the environment. Save energy and protect the environment!"

HM:

3 best advices:

5. "The most convenient energy tariff is between the hour … and the hour …! Do you have other commitments?"

10. "Your apartment yesterday was responsible for … kg of CO_2 emissions into the environment. Save energy and protect the environment!"

14. *"Do you want to lose some weight the easy way? Lower the temperature and accelerate your metabolism"*

3 worst advices:

2. "Your electric energy consumption is the …% higher than the average one of the other guests!"

6. "Open the window! The CO_2 level is too high and it could cause headaches and reduce your concentration!"

13. *"Open the window! There is a risk that molds can grow dangerous to your health."*

Annex 3: FG report for the SI case

Supporting document: LINK

1st Focus groups in 2018

Date: 9/3/2018 9 h
Type: Focus group
Recorder/Facilitator: Dan Podjed, Jure Vetršek
Duration: 1.5 hour
Location: UL FKKT, Ljubljana, Slovenia
Prepared by: Jure Vetršek
Comments: Representatives of FRI and FKKT were chosen from the identified user groups. The focus group was carried out in Slovenian language. 4 researchers (anthropologists) were present at the FS. Recording stored in file *FS fkkt 18-3-9.mp3*

Participants:

Dan Podjed = DP

Ajda = A, PhD student FRI

Simon = S, responsible for maintenance and safety systems in the building

Andrej Šeruga = AS, caretaker (FRI)

Matej = M, student (FRI)

Urška = U, Professor at FKKT

Jure Vetršek = JV

Observers: Sara, Gregor, Hana Uma (HU), Manca (M)

Keywords: "Intuitiveness", "Graphical user interface", "Advices for users", "User feedback"

Introduction

DP and JV made an introduction about the MOBISTYLE project. They presented past activities in the project and defined a plan and main goals of the focus group.

Intuitiveness and general impression about the graphical user interface (GUI)

Various GUIs were presented to the FG, one by one.

- T and CO_2 is immediately understandable.
- CO_2 is understandable; however, the numeric values are not straightforward and clear.
- RH is not understandable to everyone. Should be stated, e.g., air humidity.
- Colour changing based on parameters (from green, meaning OK) to red (not OK). To them, this is an analogy with traffic light and is widely understood.
- The direction of the pointer should increase from left to right (as car speed), and not the other way round.
- There should be a reaction based on provided information.
- Max. two messages (push notifications) per day. In addition, there should be an option to limit the number of notifications per day.

- People do not know what 12,5 kWh means.
- T is understandable.
- According to the FG members, everybody is an expert on financial issues – euro is a widely understandable variable.

A: "It (irrational use of energy, our explanation) is not good for environment; Earth not the people."

- The lightning for electricity is an understandable, straightforward symbol.
- The pullover is not an understandable symbol. If one wishes to show cold, a snowflake could be used.
- When choosing a symbol for comfort, there should be a difference for heating and cooling period – a pullover in summer is not very appealing.
- A suggested symbol for intuitive understanding of comfort could be a smiley ☺ (smiling face).
- The hearth with pulse is overall understandable as a symbol of health (only a hearth would represent love).
- The icons should be unified.
- It could be useful even if they are not immediately understandable, since once the user clicks it, he or she gets the information what an icon actually means.
- There should be a possibility to turn off notifications (messages). They should not be enforced. (cf. calm technology principle)
- The circular representation was not clear and straightforward. It looks nice, but the values are not equally represented, e.g. the washing machine's graph is longer than the microwave's.
- The advice presented in this form was recognized as good. Additional info should be available by clicking on it.
- References or links to relevant articles were seen as desirable and important.
- A beautiful, clear interface – a general opinion.
- Intended for facility management.

Feedback on tested advices

Advices were printed on small pieces of colour paper. They were distributed among the FG participants, one by one, and evaluated.

- "*Its sunny outside, do you really need the light on?*" was selected as the best one. The question is motivating, but not too "bossy".

- "*The outdoor conditions are excellent for letting some fresh air in!*" was also well accepted by participants of the FG.

General recommendations

- It was specified that an advice or recommendation SHOULD not be wrong – it should be carefully selected and checked.
- Each advice should be used in a specific context; in addition, an optimal information channel should be used (e.g. an advice to use of stairs instead of elevators makes most sense near an elevator).
- Participants don't like receiving text messages; if anything, push notifications should be used (max. 2 per day).
- There should be a simple option available for disabling the push notifications.

Questions for the focus group

1. Intuitiveness and simplicity the graphical user interphase (GUI)
2. Possible channels for contents distributions and attitudes (e.g. public screens and other IT devices in the building that could be used for motivating them to change behaviour…)
3. Relevance of advices, recommendations and tips.

Tested advices

- It seems you have left the window open for X hours, and outdoor conditions are not favourable.
- Open the window, it is warmer/colder outside.
- Reduce the temperature and boost your brain!
- Want to lose some weight due to increased metabolism? Reduce the heating in your office!
- If you feel cold, put on some clothes!
- Ventilate the room! CO_2 has been above X ppm for X minutes, you might get a headache and your productivity might decline.
- The outdoor conditions are excellent for letting some fresh air in!
- Ventilate the room! There is a risk of mould growth that can be hazardous to your health.
- Why waiting for the elevator? Use the stairs, save time, get fit and live longer.
- Turn off your computer and monitor.
- Its sunny outside, do you really need the light on?
- Turn off the light and equipment if there is no one in the room.
- Do you really need hot water for washing your hands?
- If you feel cool, put on some clothes!
- If you feel hot, you should cool yourself and/or move to another room.
- If you do X sit-ups, you will feel warmer and more focused.

2nd Focus groups in 2019 (UL FKKT FRI) – feedback from the users

Date and time: 3/10/2019, 10:00-11:15

Type: Focus group

Recorder/Facilitator: Dan Podjed, Jure Vetršek

Duration: *1 hour*

Location: UL FKKT, 3rd floor, section B, Ljubljana, Slovenia

Prepared by: Jure Vetršek

Comments:

Representatives of the Faculty of Computer and Information Science (FRI) and Faculty of Chemistry and Chemical technology (FKKT) of the University of Ljubljana were identified among the users of MOBISTYLE solutions on the site. The focus group (FG) was carried out in Slovenian language. In addition to discussions, questionnaires were handed out to all participant. There were some people not present there all the time: arrived late, left earlier or just came by for a short time and provided impressions and feedbacks regarding the MOBISTYLE solutions. 14 people were invited via email 10 days before the event, with reminder a day before the meeting. 7 showed up. 4 were the same that participated in MOBISTYLE from the beginning and this was their 3rd FG. 2 researchers were present at the FG following the proposed protocol "MOBISTYLE solutions testing, users understanding and feedback" as part of T6.4 was used. Recording stored in file *Fg fkkt sep19.mp3*

Participants:

Dan Podjed = DP
Simon = S, maintenance and safety systems in the building
Dominika = D, occupational safety specialist
Matej = M, technical staff (FRI)
Marko = MT, assistant (FRI)
Urška = U, Professor at FKKT
Lev = L, assistant (FKKT)
Jure Vetršek = JV

Keywords:

"Analogue solutions", "habits and practices", "LED light", "window opening", "chemicals"

Introduction

JV made an introduction about the MOBISTYLE project and approach combining energy, health and IEQ and summarized the main functionalities of solutions deployed. The main goal of the FG: receiving opinion of the participant regarding the MOBISTYLE solution implemented in Slovenian demo case buildings and receiving feedback about the potential long-term impact of the solution to support new habits and practices.

Opinions regarding the MOBISTYLE solutions

The solutions in focus were: dashboard use on phone (as an app) and desktop PC via web page, offline (analog) campaign combining energy, health, IEQ and productivity in the buildings and a device with LED lamp showing air quality in demo rooms (see images below).

Faculty of Chemistry and Chemical Technology, Faculty of Computer and Information Science

There was interest for outcomes of the campaign on other buildings. An example was given by JV regarding the decreased (~25%) elevator use at Faculty of Economics (EF) (4:30). MT was familiar with the campaign there as well and mentioned this one on the right. DP: At Faculty of Arts the Dean publicly declared that he will use stair to reach the 5th floor where his office was (5:35).

MT noticed the stairs use related campaign at EF but not at the FRI where he spends his days (6:05). "No one is looking at big screens" at the site, he emphasised (6:46). U: "I've seen some in the building, this style" – black frames (7:01). Locations are critical for noticing the signposts (MT: 7:25) and were well chosen at EF. U said: "I never use the elevator" (8:40). However, she has the office on top floor. The reason is that when she arrives to the building, the staircase is the first option to choose from; it is closer to the entrance than the elevator. This could be an important remark regarding the design of buildings, so they stimulate or "nudge" people, e.g. to exercise by the use of stairs.

Changed habits based on information from MOBISTYLE project:

After asked about possible new habits due to MOBISTYLE project, D replied: "opening windows" (10:01). D: "In the times without heating and cooling I have window opened all the time with the tilt turn. In summer and winter in the way Jure taught me, I open the window and the door for short time" (10:15). She changed habits at home as well.

Sensor with LED:

D: "I come early in the morning when the cleaning lady wipes the floor and I can see there is red light on" (10:40). Reason are chemicals because sensor monitors volatile organic compounds (VOC). D: "This irritates me" (10:53). M: "I think it is ok, since at home, when you could choose cleaning chemicals, you could do something about it. It is the way to see that also in cleaning chemical there are several things in them." (11:05). U: "I find this light ok, I see when it goes toward red" (11:13). She notices when it starts to become red. U: "It is visible enough" (11:28). Was the reply to JV explaining the possibility to enable beep (sound or blinking of the LED on sensor. After being asked if she does something when the light turns red, U says: "I do it, I open the window"(11:40). This is a new behaviour supported by the LED light.

Office users are not fully aware that they do not have ventilation (12:14). The celling cooling convector with ventilator is perceived as ventilation device. The functioning of cooling, air movement in the room and sensor properties were discussed in details. JV explains that a "cooling convector is a mixer" (13:25) meaning without fresh air supply it causes only air movement and cooling. All demo rooms with sensors are not mechanically ventilated. DP: "Air quality is dependent on you" (13:40).

U says, by referring colleagues who also have a sensor installed in their offices, "it is often red and it is meaningless for them" (14:20). After long debate the participants realised that lab robes used in organic chemistry lab are hung next to a sensor (D: 30:30). There is a high probability that the VOC originating from robes are detected. MT and DP (15:40) shared experience with testing similar sensor (provided by

IRI UL). Examples were given how the sensors react to cooking, nail painting, use of cleaning agents, etc. DP shared how he changed habits (16:05) of letting fresh air in during cooking, based on sensors. L: "It reacts to certain things definitely" (16:45). After asked if it reacts to chemicals, he said that actually it reacts to food (16:55). L: "Oranges make it completely red" (16:58). L: "Response is often unusual… My feeling is that the air quality is not poor" (17:22). U: "I was looking at the light all the time "(18:05). D: "I noticed it makes a difference when there are more people in the room" (18:14). D: "For me, my nose is still the main sensor" (19:24). M: "But it (nose) does not work when you are constantly in the room". Poor air quality is senses only when changing the room. DP: "I need this light if I'm in the room"(19:40). U: "LED is ok" (26:20). It bothers MT that the light intensity of LED is to strong sometimes.

Dashboard (ICT tools) use

L did not use the app very much (17:40). L: "I used to check it in the beginning, later not anymore" (18:03). After directly asked, they did acknowledge being familiar with the app/dashboard. They all at least saw it, however, they were in fact checking only the LED lamp on the wall. U said: "I don't need any of this" (19:50), referring to the app, but is keen to keep the device on the wall.

Question regarding ICT tools use was raised again by JV (23:40) only to find out there is quite poor interest. After suggesting to provide help (she mentioned problems with login), D replied "Not at this time" (24:00). MT: "There was a problem with log in, it was difficult to find things. I managed to login, then one forgets the URL and password… and I gave up" (24:03). M: "App is made in a way to get certain information but it takes a lot of effort to get a single piece of information" (24:40). M: "I think I'd monitor this daily if there would be a table computer next to a sensor." MT: "Parameters are roughly constant, daily trends are the same, once you see them."(24:55). DP: "It is interesting to see the parameters when in the room, if I get notification to ventilate the office and I'm at home, it makes no sense, I just feel guilty". (25:10). It is irritating (U). DP: "I got too many push notifications, that was the reason that I turned it off" (25:50).

Improved building use

MT (20:10): Explain how they "misused" the room. They have it in the room with 8 people, and had a lot of problems with air quality. MT: "When someone came to the room at 1 pm, it smelled really bad, but if you were in it, you did not notice" (20:25). It that specific room they don't like to ventilate the room in the winter. There was a person sitting close to the window that felt cold fast and there was a problem when window was opened and as a consequence they did not ventilate. MT: "Light is one excuse to… open the window" (20:46). They know before that they have to ventilate, but now they have objective information. For someone it might be worse to feel cold than to have stuff air. DP: "It is healthy if you feel a bit cold" (21:40). JV explained the temperature training and its benefits.

DP (23:00) explained the change of room temperature perception. It used to be 16-18°C 100 or 200 years ago, and since that time the temperature has increased significantly. S did not change habits base on sensor and app he used (33:56). He does notice the red light always, usually when leaving the room. Later he acknowledged that noticing the light has an impact (34:15). D sated, that S, with whom she shares the office, is very tolerant and when asked if she should open the window, he is ok with whatever. They concluded that they also have the lab robes and shoes close to the sensor (35:15).

Understandable of information

MT: "I did not like it because I did not know what the sensor is showing" (28:05). He did not believe; trust that the light corresponds with the scale. L: "I think the issue is I did not make the conception from the light, air quality and inpact on me" (29:05). This results in ignoring it and it just blends in the bakground. L stated he did not open windows more than before based on light. JV explain that measurments take time, and the change is not imidiate when window is opened. It takes at least 15 minutes.

Future use of solutions

They (MT and U) asked if we are going to take senzors away. U: "Leave it to me, it works fine" (31:37). JV asked if someone would like the dashboard, needs new user names. DP does not care about the

app, it mostly bothers him. U aggred (32:05). MT would prefere numbers instead of colours. They would prefer to see the paramaters on the sensor, not on the app. Should not be a wifi conection, the issue was explanine based on Awair testing. D, S and U mentioned, that everyone who enters the room notices the sensor and they explain what it is. Colour use approach seem to be ok; everyone is trigerd by the red light (38:55).

JV asked abou possible use of the app with only SCADA data (no air quality) showing heating, cooling, setppoint etc.(41:35) in relation with temperature training. The reaction poor, no iterest shown.

DP sugeted to show the people when the temperature trainign is taking place and they need to have possiblity to opt out. Emploees do not know what are monthly energy costs at the faculty (D 43:40).

General recommendations

- It seems that ICT tools represent too much of a burden to the room users. They look at them in the beginning and later they tend to lose interest.
- Information needs to be presented in the context; one should be aware of poor air quality when he or she is in the room and not somewhere else.
- Communicating IAQ via wall mounted LED changing colour seems to be well accepted.
- Sensors should be regularly checked and calibrated in order to make trustworthy measurements, since equipment can always fail.
- Appropriate decision making in rooms with more people should be facilitated, so that the room conditions are not based on individuals mood; instead, they can be collectively decided.
- Push notifications should not be sent too often – only when urgent or necessary.
- IAQ parameters are mostly constant, thus not so interesting.
- Parameters, such as temperature, humidity and CO_2/VOC concentrations could be shown on the sensor itself.
- Micro-location of campaign boards in the building and sensor in the room is essential, so they are taken in to account. .
- Identifying the right reason for poor air quality is critical so that the measures are effective (robes, shoes, cleaning chemicals, …).
- Colours from green to red are suitable.

Questions for the focus group

These topics were addressed during the FG, following the "Protocol for the evaluation focus groups"

- Understandable information related to energy use.
- GUI usable and attractive.
- Understandable and useful personalized information for users by combining energy monitoring with monitoring of IEQ, behaviour parameters and daily habits.
- Prolonged behaviour change due to combined modular information on energy, IEQ and health.
- Solution attractive and willingness to use the services in future.
- Self-reported behavioural change and reduction of energy use in different real environments by deploying and validating for the demo cases.

- Involved end users show structural behavioural changes and embed the tools in daily routines.

Annex 4: FG report for the DK case

Date: 12/12/2018 18:00h
Type: T2.5 Usability testing WP2, meeting with building users
Facilitator: Per Heiselberg, Aalborg University (AAU)
Recorder: Sandijs Vasilevskis, Pernille Viktoria K. Andersen, AAU
Duration: 2 hours
Location: Meeting center Sundheds/Kvartershuset, Fyrkildevej 7, 9220 Aalborg East, Denmark
Meeting place, catering organized by: Sven Buch and Rasmus Hjorth, Himmerland Social Housing Company
Report prepared by: Sandijs Vasilevskis, AAU

Participants:
Thirteen people from apartments that are involved in the MOBISTYLE project attended the meeting, together with two representatives from Himmerland Social Housing Company and three from Aalborg University.

Comments:
AAU presented the current MOBISTYLE prototype version of the Game (interactive desktop –mock-up) with detailed explanations about each section of the app (Missions, Achievements, Profile). The current Game version was welcomed with great curiosity – questioning the capabilities and functionality of the App. Generally, a positive feedback was received from the building residents for the further development. Meeting was held in a friendly atmosphere, furthermore catering from Himmerland Social Housing Company was provided to make building residents feel more involved.

Additional notes:
- Access to the Game mock-up version was provided to the participants one week prior to the meeting. However, none of the users did try to access the App.
- Additional questionnaire regarding user perception of their energy use, indoor climate and behavior was given to the participants (see Annex B: Evaluation Questionnaire – Benchmark definition E1), based on the template in D3.3 Annex B. This is done in order to evaluate the change of user perception as described in Objective 3 of the MOBISTYLE project.
- 3 extra questions from HighSkillz (HSz) added in the end of System Usability Scale SUS
- Pernille Viktoria K. Andersen (AAU), communication specialist, will perform additional interviews with building users after the Game will be fully deployed.

Keywords:
"Graphical user interface", "Intuitiveness", "Game usability", "Mobile application usability", "Communication", "Advices for users", "User feedback".

Meeting Agenda:
1. MOBISTYLE project status and objectives, Game App release, AAU presents
2. Questionnaire (User perception), participants fill-in (see Annex B: Evaluation Questionnaire – Benchmark definition E1)
3. Game App content and structure, AAU presents
4. System Usability Scale (SUS), users fill-in
5. Dinner break
6. Selection of the 3 best and 3 worst advices, users select

7. Discussion and round-off of the meeting

Pictures from the meeting
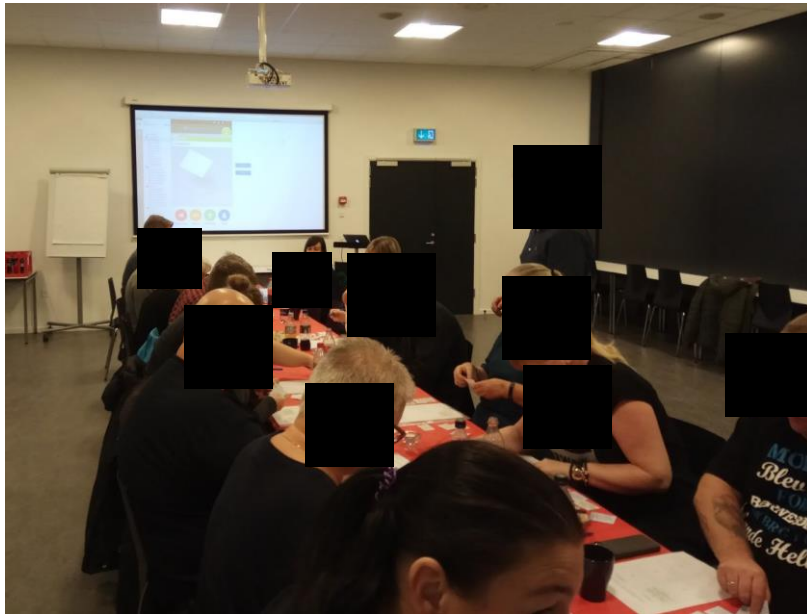
Figure 58: Presentation of the Game mock-up

Figure 59: Selection of the best and worst advices/tips

System Usability Scale (SUS)

Results – answers to SUS

SUS score is calculated and presented in Annex A: SUS Score calculation.

The overall Average SUS Score was 84.6%. which corresponds to a result of Excellent.
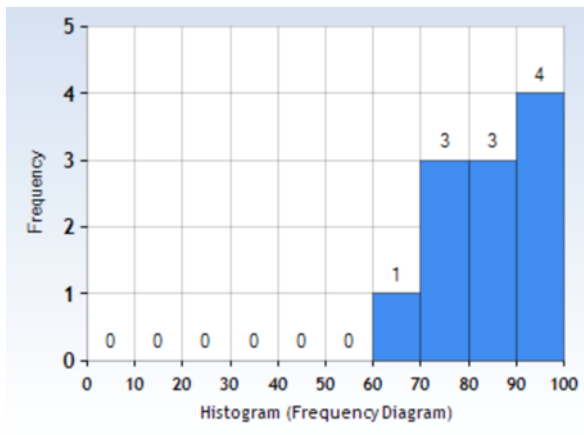
SUS statements:	Scale*:	No of answers:					Answer distribution**:
		1	2	3	4	5	
1. I think that I would like to use this system frequently				1	2	10	Agree
2. I found the system unnecessarily complex		7	2		1	3	Disagree
3. I thought the system was easy to use				1	4	8	Agree
4. I think that I would need the support of a technical person to be able to use this system		8	4	1			Disagree
5. I found the various functions in this system were well integrated				2	4	7	Agree
6. I thought there was too much inconsistency in this system		5	3	5			Disagree
7. I would imagine that most people would learn to use this system very quickly					4	9	Agree
8. I found the system very cumbersome to use		10	3				Disagree
9. I felt very confident using the system				2	3	8	Agree
10. I needed to learn a lot of things before I could get going with this system		6	3	3	1		Disagree

* 1 – Strongly disagree; 5 - Strongly agree

** Most of the scale answers marked as 1 and 2 means that users mostly disagree with the statement, 3 – that they have neutral position, 4 and 5 – that they agree with the statement

SUS score is calculated and presented in Annex A: SUS Score calculation. Results show 4 participants with 70%, 2 -80%, 5 – 90% and 2 100% SUS Score (see Figure 3: SUS Score interpretation), so overall - a very good evaluation.

Additional questions from HighSkillz (HSz):

Three extra questions (11. -13.) were requested from HSz. They were added to the Usability testing questionnaire. They were presented as an additional page to the standard SUS, see the following page (Usability – MOBISTYLE GAME App).

The results from these questions won't be included in the SUS calculation; however the answers from users will be presented separately in the following section.

Usability – MOBISTYLE GAME App
© HighSkillz

	Strongly disagree				Strongly agree
11. Do you find the comparison to your community motivating for you? (Profile section) Any comments?	1	2	3	4	5

| 12. Do you find the award system motivating for you? (Achievements section) Any comments? | 1 | 2 | 3 | 4 | 5 |

13. Do you find the missions and the associated actions clear enough for you? (Missions section) Any comments?	1	2	3	4	5
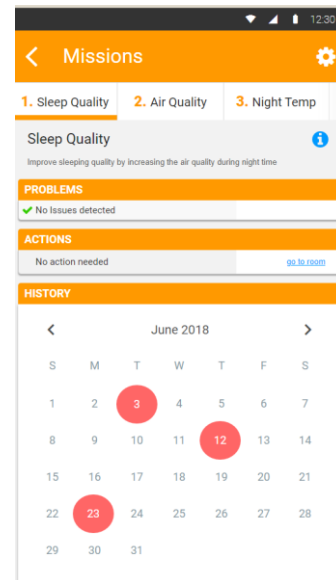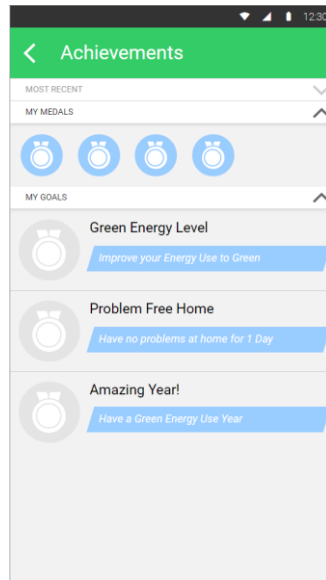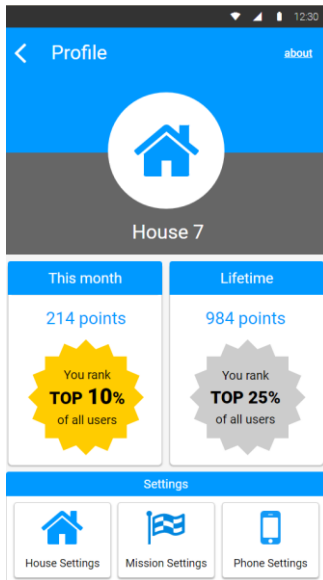
Answers to additional questions from HSz:

HSz questions:		No of answers:					Answer distribution**
	Scale*:	1	2	3	4	5	
11. Do you find the comparison to your community motivating for you? (Profile section)	1	1	5	3	3		Neutral/Agree
12. Do you find the award system motivating for you? (Achievements section)		3	3	4	4		Agree
13. Do you find the missions and the associated actions clear enough for you? (Missions section)			2	4	7		Agree

* 1 – Strongly disagree; 5 - Strongly agree

** Most of the scale answers marked as 1 and 2 means that users mostly agree with the statement, 3 – that they have neutral position, 4 and 5 – disagree with the statement

User Comments to additional questions from HSz:

11: ''It is my own consumption that interests me, we are not paying for others' consumption.''

''No, not really. I don't know of course who is in another families and how their consumption is relatable to my family and my consumption.''

12: ''I don't think I will use it but I would also not deny that it could be motivating.''

N.B.: As mentioned in the beginning of the report (Additional notes:) the users haven't spent so much time with Game App, therefore AAU suggest to ask the same questions again when Pernille (AAU) will conduct one-on-one interviews with the residents.

Evaluation of the tips

15 tips were chosen by AAU (5 related to the energy field, 5 related to IEQ and environment and 5 related to health). Each advice / tip has an ID No attached to it and users were writing down the numbers. All the tips are presented in the table below:

ENERGY CONSUMPTION	HEALTH	INDOOR CLIMATE/ENVIRONMENT
1. "Yesterday your neighbours used by 10 % less heating energy than you."	**6.** "Open the window! The CO2 level is too high and it could cause headaches and reduce your concentration!"	**11.** "Being exposed to varying indoor temperature may decrease the risk of cardio-vascular disease, diabetes and obesity."
2. "Your monthly hot water consumption is higher than it used to be. You will save money by reducing your consumption!"	**7.** "If you want to lose some weight due to increased metabolism, you can reduce the temperature and heating in your home!"	**12.** "Be sure to have a lower temperature in your home at night. You will sleep better at colder temperatures."
3. "You will save on heating consumption by wearing warm clothes and lowering radiator valve setpoints."	**8.** "Avoid too much moisture in your home to reduce possible symptoms of asthma and allergies!"	**13.** "The temperature in your apartment is quite high. Adjust the radiators in order to save energy and money."
4. "Always turn off your radiator when you vent the room by opening the windows."	**9.** "CO2 level in your bedroom was very high last night. Improve your sleeping quality by leaving your window open during the night"	**14.** "The temperature in your apartment is very low. Put on more clothes first instead of regulating radiator."
5. "Set the thermostat on the radiators between three and four. Then the temperature will be between 19 and 22 degrees. Each degree means an increase of 5 % in terms of price."	**10.** "Ventilate the room! CO2 level has been above 1800 ppm for 30 minutes, you will likely have a headache and lower focus abilities."	**15.** "Your apartment yesterday was responsible for 5 kg of CO2 emissions into the environment. Save energy and protect the environment!"

Figure 60: List of tips

Results – voting for the tips:

In table below are the evaluation results (No of votes each tip received). According to the results of the total user votes each tip received as the 1st, 2nd or 3rd best/worst tips

		No of votes received for each tip														
		ENERGY CONSUMPTION					HEALTH					INDOOR CLIMATE/ENVIRONMENT				
Tip ID:		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Best tip:	1st	1			1	1	2			2	1		5	1		
	2nd	1			2		1	1	2	2	2	1	1	1		1
	3rd		3	1	3		2	1	1				2	2		
Worst tip:	1st	2				5					1	1			4	2
	2nd	2	1	1		2		4		1		1			3	
	3rd	2		5				2	2			2			1	1

Results – 3 best tips

12.	4.	6.
"Be sure to have a lower temperature in your home at night. You will sleep better at colder temperatures."	"Always turn off your radiator when you vent the room by opening the windows."	"Open the window! The CO2 level is too high and it could cause headaches and reduce your concentration!"

Top 3 best tips: Tip No 12 clearly received the most votes (8 in total), Tip No 4 (6 votes) and Tip No 6 (5 votes). Tip No 9 and No 13 received the same amount of votes (4 in total), so they are worth mentioning here:

9. ''CO2 level in your bedroom was very high last night. Improve your sleeping quality by leaving your window open during the night''

13. ''The temperature in your apartment is quite high. Adjust the radiators in order to save energy and money.

Results – 3 worst advices:

14.	5.	1.
"The temperature in your apartment is very low. Put on more clothes first instead of regulating radiator."	"Set the thermostat on the radiators between three and four. Then the temperature will be between 19 and 22 degrees. Each degree means an increase of 5 % in terms of price."	"Yesterday your neighbours used by 10 % less heating energy than you."

Top 3 worst tips: Tip No 14 (8 votes in total), Tip No 5 (7 votes in total - where 5 votes as the worst tip) and Tip No 1 (6 votes). Similarly, tip No 1 and 7 received 6 votes:

3. ''You will save on heating consumption by wearing warm clothes and lowering radiator valve setpoints.''

7. ''If you want to lose some weight due to increased metabolism, you can reduce the temperature and heating in your home!''

General recommendations on advice text:

Regarding the best advices, generally HEALTH related tips scored good voting results, except the advice about losing weight via increased metabolism and low temperature. Tip 9 and tip 12 were among the best ones. Both of them contain an advice on how to improve the sleeping quality. Also tip No 6 - which is a health related tip - is among the top 3.

From the ENERGY CONSUMPTION related tips, advice No 4 (and also advice No 2) was mostly well received:

4. ''Always turn off your radiator when you vent the room by opening the windows.''

2. ''Your monthly hot water consumption is higher than it used to be. You will save money by reducing your consumption!''

However, energy related advice No 3 - similarly as No 14 - suggest building residents to adjust their clothing level, it seems that this user group don't like that. See both statements here again:

14. ''The temperature in your apartment is very low. Put on more clothes first instead of regulating radiator.''

3. ''You will save on heating consumption by wearing warm clothes and lowering radiator valve setpoints.''

Also problem with the advice No 14 could be the imperative form of the last sentence.

Discussion with users:

Some inhabitants were curious if and when the Game App will be available in Danish language, were we explained that first version will be available in English and the Danish translations will be available later.

Notifications:

- How long time does it take for the message -about that there is something wrong in apartment - to disappear?
- What if I am at work and can't do anything with the problem?
- How often do we receive these notifications?
- What time of the day we receive the messages?
- Some users were expressing that they would not like to see the messages and problems that were accumulated during the day, in situations when they arrive late at home.
- Similar suggestion was to turn of notifications if the users are for example in another location for example a summer vacation house.

Achievements:

- Is it only the positive results that we are being measured for, no that we can get lectured about domething?

Phone configuration:

- Should all of the person in apartment have the same settings – what if I am not agreeing with my wife?

Some building residents were asking if they would be able to control for example windows from the App, were we explained that then additional motor for window would be required.

General recommendations

Future usability testing:

- As mentioned in the beginning of the report (Additional notes:) that the users haven't spent so much time with Game App, therefore AAU (Pernille) will conduct a round of one-on-one interviews with the residents after fully functional Game App will be available to users.
- Therefore HighSkillz can prepare additional questions and inform AAU to include in interviews.

Regarding the comparison with neighbour apartments:

- It could be questionable for this user group. For example, tip No 1 which states comparison) was voted one of the worst advices (6 votes):
  1. ''Yesterday your neighbours used by 10 % less heating energy than you.''
- To the additional question from HSz:
  ''11. Do you find the comparison to your community motivating for you? (Profile section)'' 2 users voted disagree, 5 users voted neutral and 6 that they agree with the comparison.

Annex 5: FG report for the PL case

Date: 10/03/2020
Type: T2.5 Usability testing WP2, meeting with MOBISTYLE users
Facilitator: IPC instytut badawczy
Recorder: IPC instytut badawczy, visual and audio
Duration: 2 hours
Location: Ostrowskiego 9, Wrocław, Poland
Meeting organized by: TAU
Report prepared by: IPC, TAU

Participants:

7 TAU customers engaged in MOBISTYLE project and 1 moderator. All respondents had access to the MOBISTYLE game and declared to actively use the system.

Comments:

TAU presented mock ups of the current version of MOBISTYLE game and other systems required in the project (tauron.lerta.biz and e-Counter). During the discussion the respondents were mainly focused on energy consumption and energy savings. Respondents often commented the lack of functionality offered by smart home devices and applications used in the project and technical issues with e-Counter. In general terms respondents agree that the system can help in meeting short and long term goals.

Additional notes:

SUS was extended with additional questions regarding user perception of their energy use, indoor climate and behavior

Key words:

"Intuitiveness", "Game usability", "Mobile application usability", "Communication", "Advices for users", "User feedback".

Meeting Agenda:

1. Introduction. Evaluation of respondent attitudes and habits concerning utility media monitoring in households prior to joining the MOBISTYLE system testing.
2. Determination of the MOBISTYLE system's impact on user behaviours
3. Determination of the MOBISTYLE system's impact on user awareness and perception in terms of health, internal environment and ecology.
4. Evaluation of the MOBISTYLE system in terms of functionality, serviceability and clarity.
5. Verification of user expectations towards the MOBISTYLE system.
6. Evaluation of the functionality of applications: Tauron.lerta.biz, E-licznik and MOBISTYLE Game.
7. Specification of the MOBISTYLE system's areas that must be modified, streamlined.

Focus Group Interview
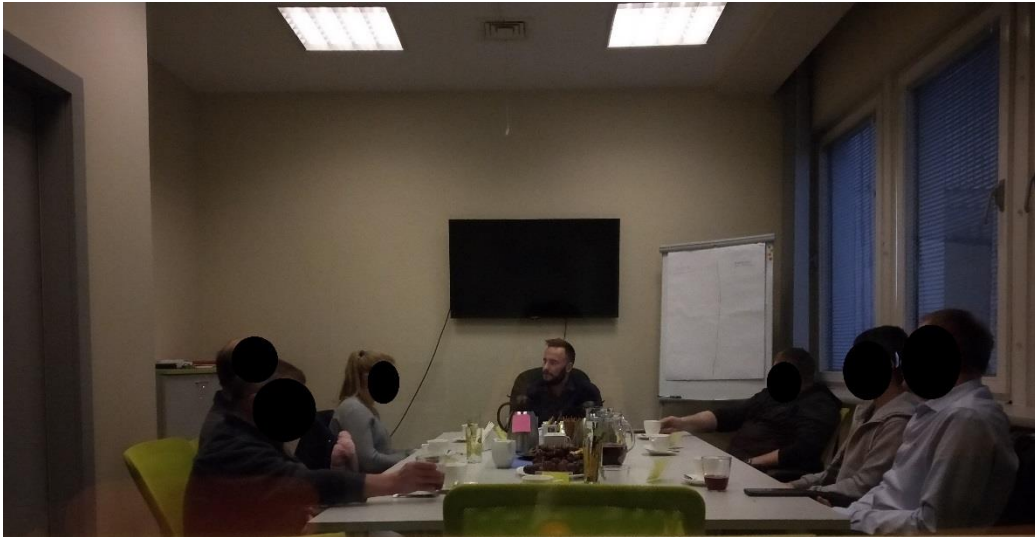
Figure 1 Discussion on users habits and attitudes

The discussion started from describing actual habits and attitudes concerning media consumption monitoring and internal environment.

The respondents state that they monitor the consumption of utility media in their households. They are aware of the impact of internal environment (i.e. temperature, humidity, air quality) on their mood and health. The study participants know what is the consumption of particular utility media in their households. They agree that habits concerning utility media monitoring translate into their consumption and affect the internal environment, savings and ecology.

The respondents state that a huge role in reducing the consumption of particular utility media is played by smart home-based tools and systems. Comfort and convenience were pointed out as the most important factors in this area. Of secondary importance for the users of this type of devices are issues related to savings and ecology.

Impact on user behaviour

The users declared that MOBISTYLE did not directly affect their behaviour. The conducted discussion allows for pointing out that the system affected the respondents' knowledge and awareness, which is indirectly translated into changes in behaviour / stopping habits. They were mainly aimed at achieving savings in energy consumption.

- *In the past I would unplug the charger and when it turned out that it doesn't consume [electricity] when it isn't connected to the phone, I stopped unplugging it. Mainly the awareness*

on consumption. I once thought that the laptop charger consumes a lot, but it turned out that it doesn't. (Res. 6)

- *I started switching off the router and it turned out that it consumes as much as 7 watts and it accumulates over a month. (…) The TV and radio in stand-by mode were connected to the set of outlets. It became a habit that I switched off the router at 10 p.m. (Res. 4)*
- *I had a 5.1 speaker system which I was connecting to the phone to listen to music and it turned out that the speakers consume 34 watts on stand-by within a couple of hours, so I stopped using them. (Res. 6)*

MOBISTYLE enables internal environment monitoring, but does not cause regular behaviour focused on making progress in the given area.

- *We can only monitor the internal environment using the application. (Res. 5)*
- *I became interested in volatile organic compounds and if there are any, I open the window, if not then no. A noticed a certain tendency, i.e. when I had the sensor close to a plant, then there were more volatile organic compounds; they generated either near the plant or the pot. Now, when the sensor is further, the level is lower. (Res. 3)*
- *On the other hand, when I get [notification from the Netatmo system] that I have too much carbon dioxide in the air, I started up MOBISTYLE to see whether there are more VOCs. I noticed that there are more of them in the evening and also which plant cleans the air for me and I will not open the window*

One person stated that thanks to using the system she started to weather the apartment more often, which translated into a health-promoting activity. Other users did not demonstrate changes in related behaviour.

There were instances where information obtained by the users thanks to <u>MOBISTYLE generated negative habits</u>, such as, among others, failure to unplug unused devices or equipment in stand-by from power sources (e.g. phone charger), when the respondent found out that the device's electricity consumption is low.

- Did the MOBISTYLE system's use affect the internal environment? (…)

- *No. (Res. 2)*
- *It did for me. Sealing the windows through vents and the current temperature; they are mounted on top, so I sealed them, all the more that it was the winter season. The heater at the bottom and 15 degrees at the top. (Res. 5)*

After this part of discussion, the respondents were asked to provide a personal evaluation in the scale of 1-5 (where 1 means "I don't agree at all" and 5 – "I completely agree") whether they agree with the following statements:

The Mobistyle system provides comprehensible information / clear notifications	2.86
The Mobistyle system contributed to making my habits environmentally-friendly	3.29
The Mobistyle system helped me reduce energy consumption	3.14
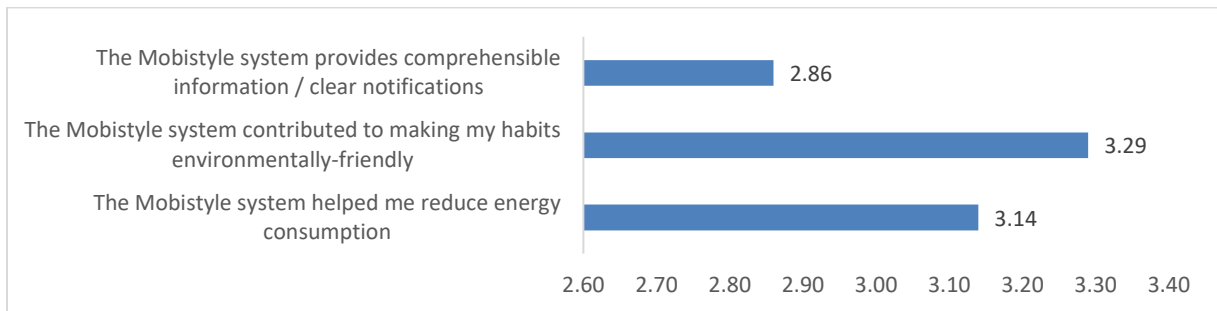
The average score concerning the first issue is 2.86, which means that the notification and information system must be modified. First of all, the respondents pointed out that they don't receive notification, alerts and summaries in the form of a report as well as push-type notifications.

The average score referring to the generation of environmentally-friendly behaviours by MOBISTYLE is 3.29, which means that the discussed system does not demonstrate any substantial dependency between the changes in behaviour / habits motivated by ecological factors.

The average score related to the statement that MOBISTYLE allows for reducing energy consumption is 3.14, which means that the system relatively insignificant in reducing energy consumption. The respondents who agreed with the statement noted that it is possible, among others, thanks to the window opening sensor and by increasing awareness on utility media consumption.

Figure 2 Selection of short and long terms goals

The respondents were asked to specify the short-term and long-term objectives, which in their opinion can be achieved thanks to MOBISTYLE Game. The results are presented below

Short-term objectives	Long-term objectives
Energy consumption control - 4 people	Habits – learning good / elimination of bad habits – 6 people
Remote device operation – 4 people	Savings – 3 people

On-going consumption monitoring – 3 people	Ecology – 2 persons
Air quality control – 2 persons	Data reading – 2 persons
Window and door condition control – 2 persons	Long-term / periodic energy consumption control - 1 person
Internal environment improvement (at the given time) – 1 person	Improved comfort – 1 person
Unique data measurement (volatile air compounds) – 1 person	Temperature control – 1 person
Savings – 1 person	Orderliness – 1 person
	Challenges to be overcome – 1 person

Table 9 Short and long term objectives

The **short-term objectives** defined by the respondents firstly point to the MOBISTYLE system's functionality and utility (i.e. remote consumption control, set control) and only then to aspects related to utility media monitoring and consumption control.

The **long-term objectives** specified by the respondents are mainly related to behavioural aspects aimed at changing behaviour to more environmentally-friendly and generating greater savings. In these terms, of secondary importance are issues related to utility media monitoring, consumption control, and functionality (including comfort deriving from the use of a smart home type solution).

According to the users, the MOBISTYLE has insufficient impact on the creation of short-term and long-term behaviour. The respondents treat MOBISTYLE as an innovative gadget and not a system that actually generates real changes in the use of particular devices and utility media consumption control.

It is also noted that MOBISTYLE increased the users' awareness and self-discipline in terms of utility media consumption (e.g. controlling consumption of a specific device, turning off unused devices) and internal environment control (more frequent apartment / house weathering).
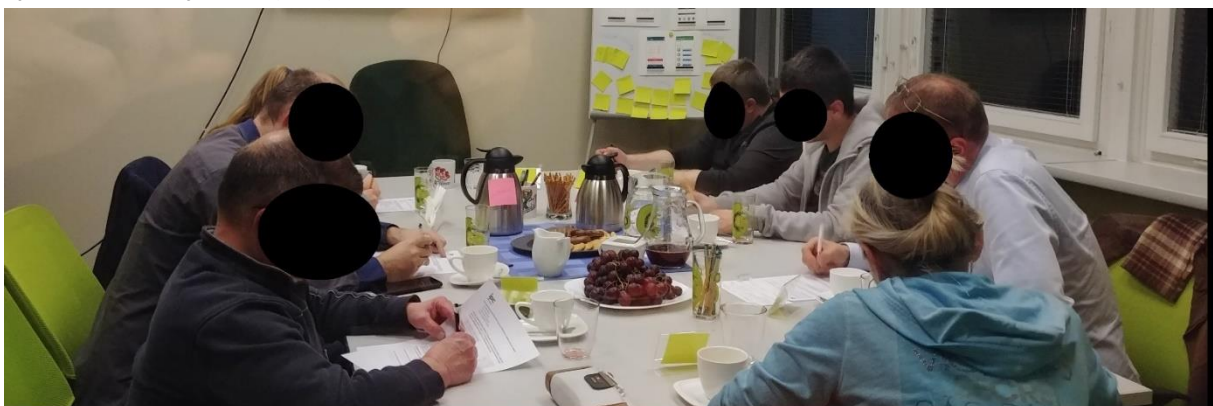
System Usability Scale (SUS)

Figure 3 System Usability Scale (SUS)

Results – answers to SUS

The summary of the answers related to the SUS evaluation protocol are presented below.

SUS Statements	Scale	NO of answears 1	2	3	4	5	Answer distribution
q1 I think that I would like to use this system frequently		0	0	1	3	3	Agree
q2 I found the system unnecessarily complex		3	1	1	2	0	Disagree
q3 I thought the system was easy to use		0	1	0	2	4	Agree
q4 I think that I would need the support of a technical person to be able to use this system		2	4	0	1	0	Disagree
q5 I found the various functions in this system well integrated		0	1	3	3	0	
q6 I thought there was too much inconsistency in this system		1	0	3	2	1	Neutral/ Agree
q7 I would imagine the most people would learn to use this system very quickly		0	0	0	5	2	Agree
q8 I found this system very cumbersome to use		4	1	0	2	0	Disagree
q9 I felt very confident using this system		0	0	2	4	1	Agree
q10 I needed to learn a lot of things before I could get going with this system		4	2	1	0	0	Disagree

Table 2: Results – SUS aswears

* 1 – Strongly disagree; 5 - Strongly agree

** Most of the scale answers marked as 1 and 2 means that users mostly disagree with the statement, 3 – that they have neutral position, 4 and 5 – that they agree with the statement

	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	3	1	5	1	4	1	5	1	5	1	**92.5**
p2	4	3	2	2	3	5	4	4	3	3	**47.5**
p3	4	4	4	2	4	4	4	4	4	2	**60.0**
p4	5	1	5	2	2	3	5	2	4	1	**80.0**
p5	5	4	5	2	3	4	4	1	3	2	**67.5**
p6	4	2	4	1	3	3	4	1	4	1	**77.5**
p7	5	1	5	4	4	3	4	1	4	1	**80.0**
Average SUS score											**72.1**

Table 3 Results of SUS testing in the PL case for the Game after 2-3 months of application

The summary of the answers to the SUS are presented below.

- The MOBISTYLE system made the surveyed users more aware about energy consumption and provides useful information.
- In the respondents' opinion, the system is user-friendly and easy to learn.
- The respondents state that technical support at the level of using the system is not necessary and that learning the MOBISTYLE system is not time-consuming.
- The respondents willingly use the MOBISTYLE system and would still like to use it.

- MOBISTYLE does not contribute to leading a more healthy life style, but moderately contributed to the internal environment's improvement.
- To some extent, the system allowed for reducing the energy consumption and helped to change the habits on energy savings.
- The respondents are of the opinion that when the MOBISTYLE system is improved and extended with other solutions and a notifications system, it will be recommendable, however the determining factor is its price.
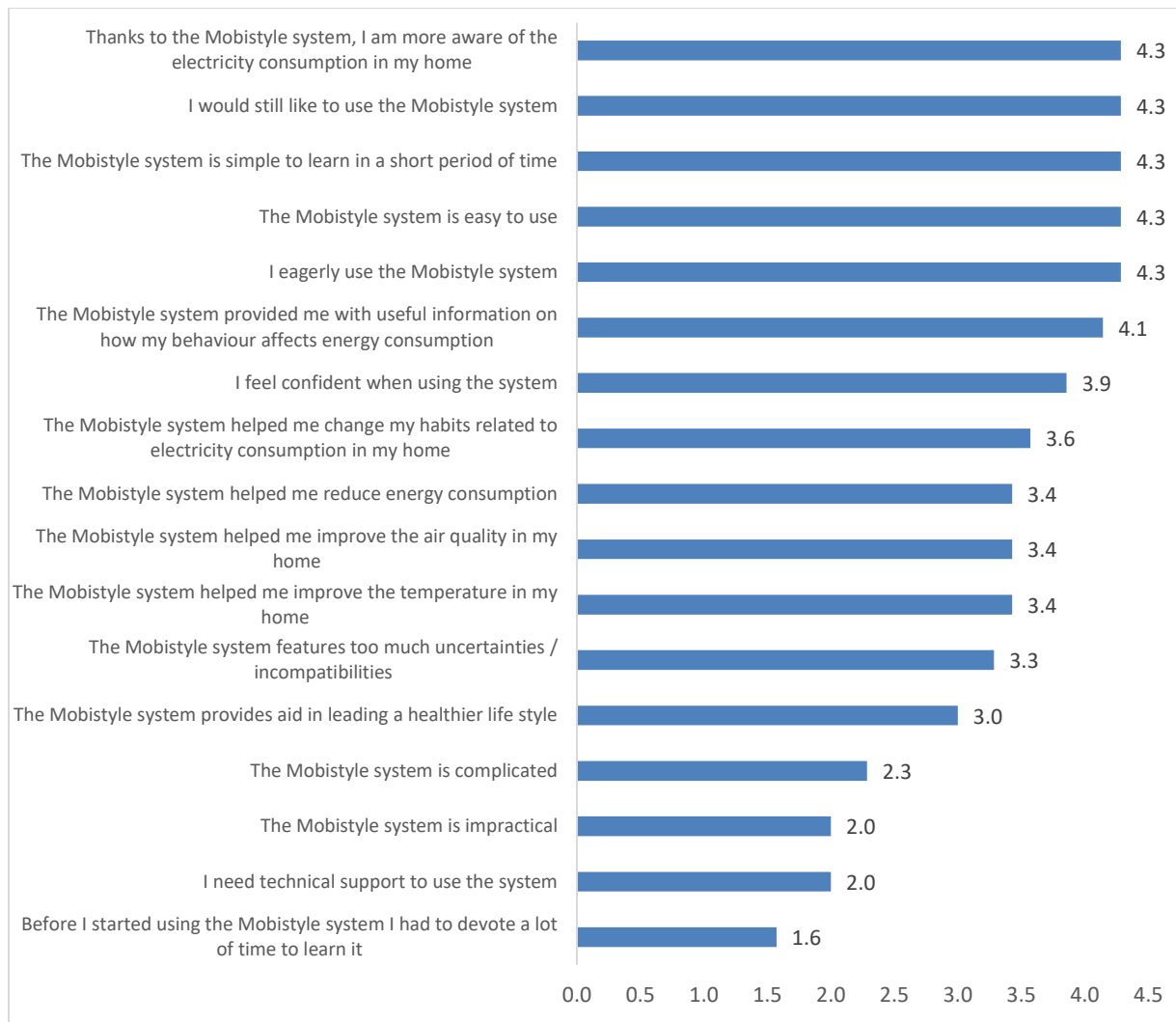
Feedback from the users

The respondents were initially asked to define their expectations towards MOBISTYLE prior to using the system. Then, the respondents were asked which expectations were met and which were not met.

Expectations	Status
Communications / Notifications / Statistics / Reports	**NOT MET**
Control	**MET**
Impact on savings / awareness	**MET**

Most respondents used the MOBISTYLE system several times a week (1 person used it every day, 2 persons – every other day, 3 people – two times a week and 1 person – once a week or less frequently). Some respondents used the discussed system at the beginning of its testing, because they were interested in the system's functioning and learned its operation and capabilities. Then, their interest dwindled, because MOBISTYLE did not meet their expectations and was – in the respondents' opinion – not functional

- *I was waiting what will happen with the Mobigame or MOBISTYLE – there were supposed be some tasks, points (…). At work, I liked to switch off the contacts and check if it was working, e.g. log into the house from work and switch off the outlet for the kettle. Then, I rarely used it, because it made no sense. There are so many oversights (…). For instance, the door opening sensor is useless, it makes no sense to check whether they are open or closed, because I have to log into the application, which is also clunky (…). It seemed to me that it is standard to have a phone notification, even the simplest message, that the door is opened. (Res. 2)*

One of the respondents stated that he used it rarely at the beginning, but more often as time went by:

- *it was more rarely at the beginning, but later I used the application more often. I was checking if it was working – it was working and I didn't need to get deeper into it. Then, I used it more often, because I started to play with it, change various things and check how the consumption drops: was it electricity or humidity and the things I do, i.e. how they impact the internal factors. (Res. 5)*

The respondents did not use the application to its full extent, because the notifications are not displayed, the application is not functional – lack of gamification. They also pointed out the launching disorder and stated it displays rooms that do not exist. They don't have objections against the appearance / graphics.

The respondents point out that the MOBISTYLE Game application has large potential and could contribute to changes in its users' behaviour. However, the determining factor is the introduction of changes in terms of gamification, i.e. implementation of tasks for users, ability to compete with other people, reporting of own and other peoples' results.

- In your opinion, is the MOBISTYLE Game functional or non-functional? (Moderator)

- *No. (Res. 2)*
- *It is difficult to say. If it worked, I would be able to say if it is functional. (Res. 5)*
- *I see energy consumption in particular rooms. I had 90% once, I don't know why the percentile achievements were displayed this way. All images are known to me and I had no problems with them. (Res. 3)*

- Did you encounter tables, lists of your ranking [in the MOBISTYLE Game application]? (Moderator)

- *I encountered them, but it turned out after the fact, the high rankings – I didn't know with whom or why. (Res. 3)*

- Would such gamification elements – if they were functional and if it would be possible to compare your ranking with other users – contribute to more frequent usage of the application? (Moderator)

- *Yes. (Res. 6)*
- *Definitely yes. (Res. 7)*
- *There would have to be prizes to motivate people. (Res. 5)*

- Would the gamification assumptions contribute to changes in your habits? (Moderator)

- *Maybe. It is possible. (Res. 6)*

In the respondents' opinion, the MOBISTYLE Game did not fulfil its role in relation to gamification – the respondents pointed out that they did not receive specific tasks / challenges and that they did not have access for reviewing other users, i.e. they were not able to compete with other users. What is more, the tasks' validity level was almost always high, regardless of the task's execution and whether any task appeared.

- *I always had maximum, it always displayed 100%. (Res. 2)*
- *I had images that the temperature is superb, but nothing else, i.e. no challenges, completely zero. (Res. 5)*

The respondents state that MOBISTYLE Game would be more effective in affecting their behaviour and habits if the following changes were implemented:

- introduction of push-type notifications;
- learning through a behaviour / habits system; it would be the basis for generating notifications about sudden temperature changes or on non-standard increase in the consumption of particular devices;
- ability to remotely set the activation / de-activation of selected devices / outlets at specific times;

Conclusions
1. The MOBISTYLE system affects the respondents' knowledge and awareness, which is indirectly translated into changes in behaviour / habits. The related changes are mainly aimed at achieving savings in energy consumption.
2. The MOBISTYLE system allows for controlling utility media consumption and internal environment elements as well as moderately contributes to savings. However, MOBISTYLE does not directly affect health-promoting of environmentally-friendly attitudes
3. MOBISTYLE has insufficient impact on the creation of short-term and long-term behaviour, because it is underdeveloped. Despite the fact that the respondents point to changes in their behaviour, the changes are incidental. The respondents treat MOBISTYLE as an innovative gadget and not a system that actually generates real changes in the use of particular devices and utility media consumption control.
4. MOBISTYLE enables internal environment monitoring, but does not cause regular behaviour focused on making progress in the given area. I does not demonstrate any substantial dependency between the changes in behaviour / habits motivated by ecological factors.
5. Lack of notifications and gamification elements makes the MOBISTYLE system become not functional. The respondents opinion bases on the users experiences from the period when severe technical issues with data flow, data lag (delay 15-30min) and install issues occurred. The respondents also refer to lack of automation and possibility of managing the smart home

devices which has never been the objective in MOBISTYLE project. This can lead to negative conclusions in the overall perception of the functionality of the MOBISTYLE Game.

6. Users recommendation
7. The group was asked to point out what could be done in the future to meet the expectations they had before joining the MOBISTYLE project and so it could have bigger impact on their behaviour while using the system.
8.

Users recommendation

1. In order to enable the MOBISTYLE system to affect the users' behaviour and habits, it is recommended to introduce the following changes: introduction of a system of weekly, monthly, periodic reports; introduction of communications and push-type notifications as well as the ability to manage these notifications; the system's learning of user behaviour and habits; ability to remotely activate / de-activate selected devices / outlets at times specified earlier.
2. It is recommended to refine the gamification elements of the MOBISTYLE application, this would make it possible to generate the desirable changes in habits – both short-term and long-term.

Annex A: SUS Score calculation

User	Answers										SUS Score
	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	
p1	5	1	5	2	5	2	5	1	5	2	92.5
p2	5	2	3	1	3	3	4	2	3	2	70.0
p3	4	4	4	1	3	3	4	1	3	3	65.0
p4	5	1	4	1	5	1	4	1	5	1	95.0
p5	5	1	5	2	5	3	5	1	5	1	92.5
p6	5	5	5	1	4	3	5	1	5	1	82.5
p7	5	5	5	1	5	1	5	1	4	4	80.0
p8	5	1	5	1	5	1	5	1	5	1	100.0
p9	5	1	4	2	4	3	5	1	5	1	87.5
p10	4	5	4	2	5	2	5	2	4	2	72.5
p11	5	1	5	1	4	1	5	1	5	3	92.5
p12	5	1	5	1	5	1	5	1	5	1	100.0
p13	3	2	5	3	4	2	4	2	4	3	70.0
Average SUS score											**84.6%**

* 1 – Strongly disagree; 5 - Strongly agree
** Most of the scale answers marked as 1 and 2 means that users mostly disagree with the statement, 3 – which they have neutral position, 4 and 5 – that they agree with the statement

SUS Score	Grade	Adjective Ranking
> 80.3	A	Excellent
68-80.3	B	Good
68	C	Okay
51-68	D	Poor
< 51	F	Awful

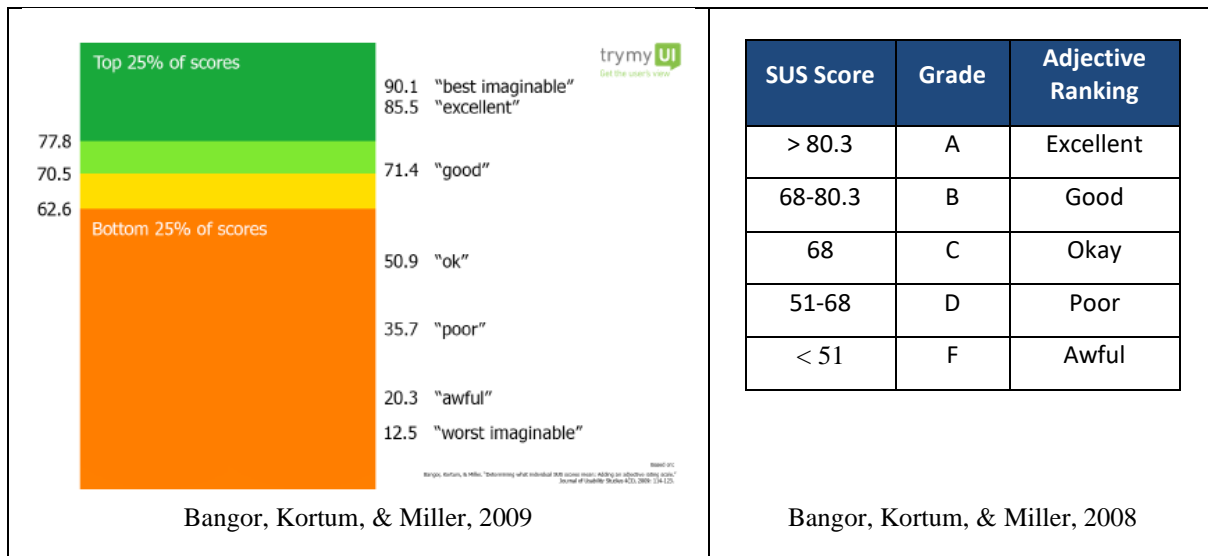Bangor, Kortum, & Miller, 2009   Bangor, Kortum, & Miller, 2008

Figure 61: SUS Score interpretation

Annex B: Evaluation Questionnaire – Benchmark definition E1

Address:_____

Guidance: You must answer the questions about your perception of energy use and indoor climate in your home by ticking the answers that best suit you. You can only tick one question for each question, for example:

Very unsatisfied	Dissatisfied	Slightly dissatisfied	Neutral	Slightly satisfied	Satisfied	Very satisfied
				✗		

PERCEPTION OF COMFORT IN YOUR HOME

How satisfied are you generally with the surrounding environment in terms of:

1) Temperature

Very unsatisfied	Dissatisfied	Slightly dissatisfied	Neutral	Slightly satisfied	Satisfied	Very satisfied

Please specify and describe causes of your dissatisfaction related to the thermal environment:

_____
_____

2) Air quality

Very unsatisfied	Dissatisfied	Slightly dissatisfied	Neutral	Slightly satisfied	Satisfied	Very satisfied

Please specify and describe causes of your dissatisfaction related to the indoor air quality:

_____
_____

3) Amount of light

Very unsatisfied	Dissatisfied	Slightly dissatisfied	Neutral	Slightly satisfied	Satisfied	Very satisfied

Please specify and describe causes of your dissatisfaction related to the visual environment:

_____
_____

PERCEPTION OF ENERGY CONSUMPTION

How much do you agree/disagree with the following statements?

I think I am aware of how my daily routines and actions affect building energy use.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

I would like to improve my behaviour in order to reduce energy consumption.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

I would like to improve my behaviour in order to reduce energy costs.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

I would like to improve my behaviour in order to reduce my impact on the environment.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

PERCEPTION OF HEALTH

How much do you agree/disagree with the following statements?

I think that the indoor environment has a negative impact on my health.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

Please specify and describe why:

_____

_____

PERCEPTION OF FEEDBACK PROVISION AND MOBISTYLE PROJECT

How much do you agree/disagree with the following statements?

I am aware of the objectives of the MOBISTYLE project.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

I think that the objectives of the MOBISTYLE project are important.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

Please specify and describe why:

_____

_____

I want to know how my behaviour affects building energy use/costs/indoor environment/my health.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

I would like to change my behaviour in order to reduce energy use and save energy costs.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

I would like to change my energy-related behaviour by adopting a healthier lifestyle.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

A healthier lifestyle can help me to reduce energy consumption.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree