MOBISTYLE

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

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Content

Executive Summary

Deliverable D6.5 considers the results of the analyses and validations of the monitoring in the frame work of work package 6, focusing on the practical applications of the tools like the MOBISTYLE game (Denmark and Poland), MOBISTYLE dashboard (Italy, Slovenia) and MOBISTYLE office app, demonstrating their usefulness, validity and practicability in real environments. The methodologies and tools and the business and exploitation models are demonstrated for the addressed demonstration cases in real life operating conditions. These findings are used in this documents for further recommendations for how to take into account 'soft or human factors' like user awareness and information in energy performance calculations and the EPBD. In the meanwhile, during the project duration, also the Smart Readiness Indicator (SRI) was introduced. The 'soft' or 'human' factors are represented in the SRI as one of the three key functionalities (i.e., responsible for 1/3 of the SRI). Yet. these soft factors are not taken into account or quantified in Energy Performance Calculations. MOBISTYLE concluded that the impact of user awareness and information to occupants (both energy, comfort, IEQ and wellbeing) could be taken into account in two ways:

1. Information services leading to a measurable impact on long-lasting positive behaviour e.g. lowering of the indoor temperature and thermostat settings.
2. Information services as prerequisite to guarantee the calculated energy performance, i.e., a prerequisite to bridge the energy performance gap, thus including in the focus actual building performance (energy and more)

However, the monitoring results are based on a small sample and therefore are not sufficient for any statistical significance yet to come to validated quantitative recommendations. However, the monitoring results show that further investigation and especially large-scale monitoring campaigns, in combination with campaigns targeting behavior, in different EU countries, would be useful, meaningful and necessary.

Also an exchange of information and methodologies about performance quality has taken place with other related projects on two levels:

- information exchange and organizing exchange events with similar and related projects (PeakAPP, ENTROPY, GreenSoul, GAIA, encompass, UtilitEE);
- providing input to projects working on new holistic energy performance certifications (TripleA-reno, U-CERT, X-tendo, QualDeEPC). Especially these projects will use the MOBISTYLE findings, to be taken into account in the new generation of EPC's.

1 Introduction

The aim of the MOBISTYLE approach is to show that improving buildings and building technologies is not enough. In order to achieve ambitious goals of EU on energy savings, a different approach is needed where users of the buildings are equally important part of the building ecosystem as building technologies. Therefore, the emphasis should be furthermore on educating users on how to behave in their buildings and how to increase their awareness by combined information on their energy usage, generated IEQ, health and lifestyle.

Despite all, these 'soft factors', defining our daily behavior, are interrelated, complex and therefore difficult to isolate. Studying 'soft factors' (also human factors) can therefore be more challenging than acknowledging the technological 'hard factors'. However, there lies a common understanding that without taking into account both, 'soft' as 'hard' factors, real energy efficiency can not be met. MOBISTYLE is particularly focusing on awareness and behavioral change by combining information on energy use, indoor environment, health, and lifestyle, where human factors can be considered in a much broader way. Oftentimes several operational issues appear due to the soft factors where users are not able to use or control the equipment in a proper, adequate way to ensure its optimal performance (energy efficiency and good IEQ). Oftentimes only hard factors are considered (type of building services and equipment installed), however, it is forgotten to ask whether this systems and equipment are understandable, easy and logically to use, robust etc. for its users, people in the buildings.

The aim of D6.5 is therefore to translate the results of the MOBISTYLE validation into recommendations on how to take into account 'soft factors' like consumer awareness and information in energy performance calculations/EPBD.

*A workshop was planned to be organized at the June scheduled Sustainable Places 2020 to come to an exchange of information and methodologies with other MOBISTYLE sister projects (UtilitEE, eTEACHER, FEEdBACk and inBetween), however, due to the covid-19 pandemic this was cancelled.

2 Policy recommendations

2.1 Boundary conditions

It should be noted that in MOBISTYLE, the sample size was relatively small, which is typical for ethnographic research methods, where small samples are examined in detail to understand behavior of actual people, not generic target groups. The MOBISTYLE approach is innovative in terms of providing mixed method approach – complementation of quantitative and qualitative research. Such method provides a more complete and comprehensive understanding of the problem than using either quantitative or qualitative approaches alone. It provides an approach for developing more context specific instruments where the quantitative data (objective measurements through building's sensors) are supported with qualitative data (in depth analysis of occupants' behavior through anthropological inquiries).

Large enough sample size would be crucial for obtaining statistically significant results, however, due to the project budget restrictions a large set-up of such detailed anthropological investigations was not possible. Furthermore, also limitations in the building sensoring capacity were identified and therefore only the most important indoor environment and energy parameters could be measured.

The *'soft factors'* to be considered in MOBISTYLE were factors related to '*people'*. This is concerning influencing factors of human awareness, organizational structure, consumer choice factors etc. As to the opposite, hard factors are related to the MOBISTYLE buildings, technologies, equipment and products applied in the demonstration cases. This report clearly addresses the soft factors and discusses how to include these in EPBD/ EP calculations.

2.2 The revised EPBD and inclusion of soft factors

The new **Energy Performance of Buildings Directive (EPBD)** Directive aims to lay concrete actions and with a view to achieving the great unrealized potential for energy savings while reducing the large differences between Member States. The EPBD acts as the main legislative instrument to promote the improvement of the overall energy performance of buildings in the EU.

In detail, the EPBD of 2018 underlines that, in assessing energy performance of alternative retrofit measure, impacts on indoor environmental quality (IEQ) must be included. Moreover, it recommends to Member States to set their strategic plan for building retrofit guaranteeing a reliable evaluation of expected energy savings, but also of other benefits related to health, comfort and well being of the occupants[1].

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019H0786&from=EN

The revised EPBD introduces **Smart Readiness Indicator (SRI),** an indicator intended to raise awareness about the benefits of smart technologies and ICT in buildings (from an energy perspective, in particular), motivate consumers to accelerate investments in smart building technologies and support the uptake of technology innovation in the building sector.

In particular, a "whole-system" approach must be encouraged; occupants are recognized as part of a broader system (building-plant-occupant), whose performance must be improved taking advantage of smart innovative technologies. Smart technologies represent an opportunity to make the building interact with the system it belongs to, including occupants, whose needs must be met by the building adjusting its operation. Moreover, to have reliable evaluation of expected energy savings, the gap between theoretical and actual consumption must be coved by increasing knowledge of the real building operation, including occupants' behavior modelling.

Since the SRI is an inherent part of the EPBD, energy efficiency and CO2 reduction in buildings are of course important aspects. Two other significant elements are the "Response to the needs of the occupant" and "Flexibility of a building's overall electricity demand", as they both cover the new elements introduced in the EPBD: demand-side flexibility (also called: demand-response) and the increased focus on health and wellbeing of building users. MOBISTYLE specifically addresses "Response to the needs of the occupant". The relationship between those three elements (energy savings, the needs of the occupants, and demand-side flexibility) is complementary, though does not have the same legal basis. Whereas the energy efficiency aspect is covered by several regulations, including the EPBD's implementation (e.g. energy performance certificates scheme), the occupant's needs is a completely new aspect in the EPBD. The EPBD's implementation covers indirectly to a certain extent indoor climate, however the consideration of the needs of the occupants is (until now) not covered particularly well elsewhere. However, the current H2020 projects on the next generation of EPC definitely address this aspect.

In the recent years it had been widely acknowledged that technological progress alone will not help us achieve the emission reductions for greenhouse gases that we need. Although there is more or less consensus on the need to create more sustainable practices, how to go about it is more complex to define.

In the 2020 pandemics times, people changed their behavior immediately highlighting how health represents a very influencing driver. This shows there is a unique opportunity to create new more sustainable habits fast, in respect to greater threat than COVID-19, as is the climate change. Smart technologies represent an opportunity for occupants' engagement towards more responsible habits, with positive impacts on energy consumptions, IEQ and their own health and well-being[2].

[2] See REHVA-MOBISTYLE webinar on COVID-19 example where people changed their behavior immediately: Youtube link: LINK (MOBISTYLE part at 59:00) & BUILD UP news event LINK

Not by chance, the ranking of building readiness to smartness (through the novel Smart Readiness Indicator (SRI), introduced by the new EPBD itself) includes in between also the criteria the information to occupants. To exploit this opportunity, people needs must be identified, and level of understanding of information assessed. This was one of the topics addressed in MOBISTYLE, where information layer coming from anthropological studies was included to have a better understanding of 'soft factors' influencing people behavior in buildings, complementing the knowledge coming from quantitative data analysis.

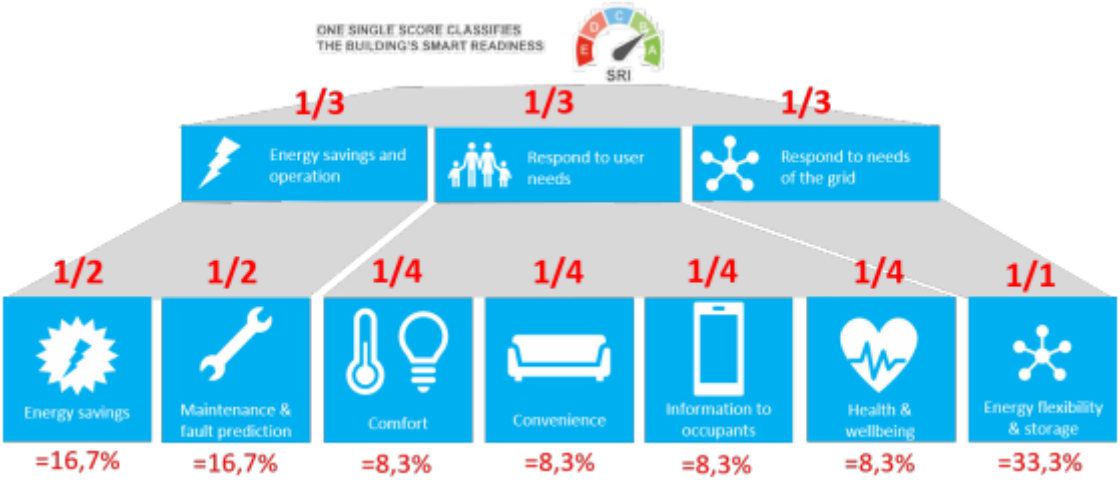
The inclusion of the **Energy Performance Certificates (EPC)** brought certain awareness raising while informing and empowering building owners to make informed choices on the way they use energy[3]. However, this information is too often only understood to building experts and especially not to an average building occupant. Furthermore, there is an issue due to the lack of deeper understanding, transparency and recommendations which are neither tailor-made nor part of a holistic plan of building management.

The calculation of the total smart readiness score of a building or building unit depends on the scores for the following seven impact criteria:

1. Energy savings on site;
2. Maintenance and fault prediction;
3. Comfort;
4. Convenience;
5. Health and wellbeing;
6. Information to occupants;
7. Energy flexibility and storage.

MOBISTYLE investigated in depth how comfort, health and well-being could be included in tailormade information to occupants, (together with information on operational energy performances). These impact criteria are part of one of the three key functionalities, i.e., 'Respond to user needs' forming one third of the total calculated SRI.

[3] https://ec.europa.eu/energy/sites/ener/files/documents/Task2_final%20report_Public%20Consultation%20on%20the%20Evaluation%20of%20the%20EPBD.PDF



The next sections provide some qualitative recommendations on how to consider soft factors such as awareness raising of the occupants within EPBD recommendations.

2.3 Qualitative recommendations for the new revised EPBD

- **Energy efficiency is at the heart of the EU's transition to a resource-efficient economy** and the EU 2020 strategy for sustainable growth.

Unfortunately, it is not at the heart of all EU citizens. With the MOBISTYLE project, we attempt to change the paradigm and show that in fact people use energy for their comfort and convenience. We should therefore **move our focus from buildings and technologies to people** and try to change their habits and influence their behaviors, which contribute to energy consumption. We showed on some cases, that cost-effective long-term campaigns can have an effect on improved IEQ and lower energy use, by regularly targeting building users to improve human building interaction. This could be done with next generation of EPCs that won't be just a paper on the wall, but part of multi-channel continuous campaigns.

- **Feedback campaigns lead to raising awareness.**

MOBISTYLE brought an understanding that feedback campaigns lead to raised awareness (D6.3). However, this does not always mean that energy saving will be obtained. Within MOBISTYLE, feedback campaigns led to a raised awareness of the importance of good indoor climate and wellbeing, however, this did not have a long-term impact on energy saving. Gamification was a way to engage people at the very beginning and make them explore the system, but interest would fade away in few weeks if they cannot see a practical (economic) return. Energy savings and improved IEQ are results of many daily small decisions (human building interaction) where the feedback to these decisions was not always possible to be measured (not all data could be measured/collected).

- **A bottom up approach focusing on daily practices as part of facility management**

Introduce 'good practice' theory to complement facility management programs. Oftentimes people due to own human nature have a misconception about our own energy and human – building interactions read behavior. We see ourselves based on how we wish to be seen even though this might not be the case.

- **Training of building and building systems use should be regularly introduced** for:
  - Building occupants in the frame of some existing training e.g. evacuation drills, occupational hazard prevention drills, health of employees on working spaces in relation to disease spread prevention and building operation (HVAC…);
  - Building designers and installers: prerequisite for creating buildings that facilitate positive behavior and inherently allow close to real-time building performance assessment (energy and more);Building operators (caretakers, building and facility managers): building systems use (operational efficiency + IEQ) practically shown on regular trainings.

When preparing strategies and campaigns for changing habits, we should bear in mind people are not assembly parts of a machine – they have their own free will and make choices on their own. However, by **creating connections and long-term engagement** with people, we can help shaping habits, transforming practices and consequently improve performance of buildings and reduce energy consumption.

- **People take buildings for granted.**

It is similar as when someone starts running: a person believes to know how to do it, since she or he has been doing it for a very long time. When one puts attention on it, significant improvements can be made. Similarly, by focusing on habits in building, by putting them in front and visualising them, important changes can be achieved, especially if attention is given also to health and ergonomics and not only to energy consumption.

Building use should be improved in order to ensure healthy, productive and comfortable living environments. We should make these ways clearly visible to people, so they feel connected to their indoor environment and also to make them feel safe and relaxed, instead of overburdened with information and suggestions. Therefore, **direct, dynamic and comprehensible feedback on energy consumption, indoor environmental quality (IEQ) and related health** implications should be provided to people in a meaningful way, since it assures constant improvements and changes of mindset on a longer run.

Think about smoking. Usually, people don't quit smoking because they save some money; they do it because they become aware how it affects their health and wellbeing. It is similar with energy consumption and IEQ. **People start using stairs to live longer and not to save money.** They decrease temperature in their room to improve their immune system and speed up blood circulation and not to save a fistful of euros at the end of the month (for the employer).

- Finally, we should **keep in mind communities and not only habits of individuals**.

Transformation can happen much quicker if we motivate community in a building and try to change collective mindset. In this way, people start supporting each other and supervising their neighbors' activities (community engagement). The transition to more energy efficient community and society can therefore become exponential and abrupt instead of linear and gradual.

2.4 From qualitative recommendations to quantification for EP calculations

Traditionally energy efficiency policies are evaluated with 'bottom-up' models which describe technology in great detail and derive total energy consumption by summing up the end-uses. However, in economic 'top-down' approaches the approach is to start from aggregated data like national statistics for energy consumption and then going down to more disaggregated data when necessary.

However, in MOBISTYLE the bottom up approach was applied to see how different measures affect the energy consumption. However, this was not an easy task. What could be observed is that if energy efficiency in strict terms is defined, one needs to account a number of factors. Sometimes it was not clear the effect of the different measures where the combined effect of two measures can be greater than the effect of the measures evaluated separately.

The following table aims to provide an insight on the effect of the different MOBISTYLE measures.

MOBISTYLE measure	Connected behavioral change objective	Effect at the applied demonstration	Notes
DK case – social housing			
Notifications in app on room temperature levels	Reduced temperature levels in heating season	In average, a temperature decrease of 0,5°C, (decrease in 68% out of rooms)	
Notification in App on high CO_2 concentrations	Improved indoor air quality	In average reduction in CO_2 concentration of 400 ppm (decrease in 85% of the rooms)	
Notification in the app of energy use	Reduced energy use	Energy use for heating increased in average 6% (increase in 55% and, decrease in 20% of the apartments)	Occupants living in renovated NZEB apartments, and the energy use for heating is much lower than what occupants are used to from previous apartments and from before renovation. So they already have lower energy costs.
PL case – individual private homes			
Information about energy usage with MOBISTYLE game app	Electricity consumption saving	90 % of end users understand information (on energy)	
Information about daily activity, IEQ and energy with MOBISTYLE game app and 'healthy tips'	Reducing overheating and humidity levels by Improving IEQ	Percentage of users self-reporting IEQ improvement thanks to MOBISTYLE - 16,2%	75% of end users understand information on IEQ
IT case – hotel			

RECEPTION - Sticker suggesting to switch off printer instead leaving it on standby RECEPTION- Dashboard displaying daily consumption for printer	Reduced energy use	Energy saving equal to 9.14 %	Referred to electricity consumption for printer over 16 weeks
RECEPTION - Sticker suggesting to ventilate the room RECEPTION - Dashboard displaying current and weekly trend of CO_2 concentration	Improved IEQ reducing CO_2 concentration)	A decrease in CO_2 concentration equal to 7.6%	Referred to mean CO_2 concentration in occupied hours compared to same period of the previous year
RECEPTION - Dashboard displaying current and weekly trend of indoor temperature and relative humidity	Improved IEQ controlling temperature and relative humidity	2% less time spent in comfort category I in terms of temperature; 11% more time spent in comfort category I in terms of relative humidity	Referred to occupied hours compared to same period of the previous year
GUESTS' APARTMENTS – Stickers suggesting to ventilate the room	Improved IEQ reducing CO_2 concentration	11-41% more time spent in comfort category I and II (singles with short stays and families with short and long stays). 8-14% time less spent in comfort category I and II (couples with short stays, singles with medium stays)	Referred to occupied hours from comparison between before and after Stickers deployment.
GUESTS' APARTMENTS – Stickers suggesting to lower the setpoint	Improve IEQ reducing indoor temperature	10-11% less time spent in non-comfort category IV for the guests' clusters constituted by singles. 2% more time spent in non-comfort category IV for the guests' clusters constituted by couples and families	Referred to occupied hours from comparison between before and after stickers deployment
SI case – university			
Temperature adjustment (training) advice in person, in email footers, frames on strategic locations and within the app.	Change thermostat set points in winter and summer	HDD decrease (5%) was lower than heat use decrease (7-12%), Cooling was decreased in all cases (EF 13%, FRI 25%, FKKT 0,5%) even when cooling needs were increased by 21%). Electricity use was increased in all cases.	Gas consumption of FRI FKKT complex was reduces for 7%, district heat on EF for 12,4% and FF 9,1%.

Notifications on public screens and frames regarding the vertical mobility in buildings in regard to health	More stairs use	FKKT large elevator -7,4%, FKKT small -13,2%, X -10,1%, FRI -14,6%. The 2 measured on EF: -32,6 and -4,3%.	Measured monthly elevators use where possible.
Notifications on public screens, app, LED on the sensor and frames regarding the IEQ improvements.	Opening windows more in non-mechanically ventilated rooms	Not observed in all rooms, but some.	Some rooms show significant more window opening and changed behavior was observed by long-term on-site ethnographer. The latter is associated with changed occupancy profiles.
NL case – office			
Dynamic temperature profile applied in Qeske – temperature variation from 18.2 to 22.5 °C	Thermal comfort acceptance with the dynamic conditions	The dynamic temperature profile did reveal comfortable condition, not significantly different from the comfort levels of the fixed scenario. 1 complaint out of 8 participants.	1 out of 8 users (12.5%) felt thermal discomfort.
Dynamic temperature profile applied at Brightlands – temperature variation from 19.5 to 23 °C	Thermal comfort acceptance with the dynamic conditions	The dynamic temperature profile did reveal comfortable condition, not significantly different from the comfort levels of the fixed scenario.	
Dynamic temperature profile applied at Brightlands	Perception of people that dynamic conditions have a positive impact	Percentage of users that felt the dynamic conditions has a positive impact.	5 out of 7 users (57 %) said it has a positive impact, 2 were neutral (28.6 %), 1 slightly disagreed (14.3%) - see D6.3 – 3rd statement
Information about the dynamic conditions with MOBISTYLE Office App	Reducing complaints with the dynamic conditions	Percentage of users that felt the dynamic conditions had a positive impact.	100 % users agreed (see D6.3 – 4th statement; Slightly agree 14.3% and Agree 85.7%)
Energy savings in static vs. dynamic conditions	Reducing energy consumption by applying dynamic conditions	The energy simulations showed an energy saving potential of 21 % for the dynamic conditions compared to static.	Average 21 % = 7% heating energy & 38% cooling energy

Danish Case

The game app made Indoor air quality “visible” for occupants and made them aware of, when and under which conditions it was problematic and thereby giving them a possibility to act. This resulted

in a clear improvement of indoor air quality in a large majority of rooms. Same tendency for temperature, but with much less effect. A similar effect was not seen on energy use for heating, where a decrease was seen in only 20% of the apartments, while an increase was seen in 55% of the apartments despite occupants being notified about the situation. Occupants clearly had a stronger focus on the indoor environmental quality, than on their energy use for heating. **These are renovated NZEB apartments, and the energy use for heating is much lower than most occupants are used to from previous apartments and from before renovation, so they already experience much lower energy cost, which may be an important part of the reason.**

Slovenian Case

In Slovenian demo case, a comprehensive campaign, tailored specifically to each faculty building together with people occupying it, was done. Several communication means were used; from LED changing color to communicate air quality in offices, push suggestion notifications in the app e.g. window opening if CO_2 concentrations were to high, email footers, frames on the walls on relevant locations that were changed regularly to public screens and direct communications with personnel.

The ethnographic research methods were used to obtain information about non directly measurable aspects of human behavior and social dynamics. These were regular focus groups, interviews, surveys and long term participant observation by IRI-UL ethnographer (anthropologist) who worked on site for 3 years. The rooms' occupancy, window opening, temperature settings, energy consumption and air quality was observed in a longitudinal study spanning from 2016 to 2019. Quantitative data, acquired with sensors, helped to identify behavior patterns for each room individually and for the building as a whole. One such "typical" pattern that emerged was that **people mostly open windows between late spring and early autumn**. There were very few instances where people would open the windows in the winter, even though almost all of them said in the interviews that the first thing that they do upon coming to work, was to open the window. This was not the case, as sensors showed.

Most **occupants forgot to mention** that they open the window exclusively when it is sufficiently warm outside. People overestimated their habits of opening windows. This is a typical case of "attitudinal fallacy", where people either intentionally misrepresent their behavior to make them look like they are adhering to the desired behavior or their actions are simply too subconscious to report them accurately. People frequently open windows when they come into their office (normally around 8 am or 9 am), but rarely in the afternoon, even though the air gets quite bad by the end of the day. There was a slight increase in opening windows at 1 pm, because a lot of the occupants returned from lunch and noticed the bad air. This changed significantly when the sensor started showing CO_2 levels with a colored light (green representing good and red bad air quality). Once the light was activated, the frequency of window opening in the afternoon increased. More about the impact of these feedback campaigns can be found in D6.3.

Polish case

In Polish demo case the MOBISTYLE system affected the respondents' knowledge and awareness, which can be indirectly translated into changes in behaviour / habits. The related changes are mainly aimed at achieving savings in energy consumption where the primary case objective was IEQ

monitoring (temperature, relative humidity). The MOBISTYLE enabled internal environment monitoring but it did not cause regular behaviour change focused on making progress in the given area. The data analysis (as reported in D6.2) showed that most of the homes remained 'healthy' where monitored IEQ parameters remained within the healthy recommended upper/lower boundary limits. This led to the fact that not many push notifications/actions were given as the occupants remained within healthy limits. It was not desired to send unnecessary notifications as the app followed the 'calm-technology' principle. Users treated 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 seems that healthy home and gamification elements were the way to motivate people to become aware of the influence of their daily actions at home on the aspect of IEQ, however, these did not necessary lead to energy savings. Seems that to keep the interest on a long run, still the economic benefits should be made visible even if these benefits were not big.** Gamification seems to be a way to engage people at the very beginning and make them explore the system, but interest would fade away in few weeks if they cannot see a practical return.

Italian case

General conclusions about the outcomes of the project in the hotel for each target group (guests and staff members) were reported as part of D6.2 (quantitative data) and D6.3 (focus group outputs). Here the focus is on results which can be directly connected to the MOBISTYLE measures, namely deployed ICT-tools and MOBISTYLE stickers (i.e. stickers providing tips on energy, IEQ and health and well-being), leveraging on people awareness to achieve certain benefits in terms of energy efficiency and IEQ. Benefits were quantified thanks to analyses on quantitative data, which were interpreted thanks to an added layer of information, namely the one coming from users, reported through questionnaires and focus groups.

Targeting staff members, both ICT-tools and MOBISTYLE stickers were intended to increase users' knowledge and awareness to push a behavioral change with positive impacts on energy consumptions and IEQ in reception space. Data analysis performed during the MOBISTYLE solutions deployment (from November 2019 till end February 2020) showed benefits in terms of electricity energy savings (9.14%) and reduction of average CO_2 concentration (7.6%), if compared to same period of the previous winter. Both topics were addressed by MOBISTYLE stickers suggesting switching off the printer before leaving the office and opening the window sometimes, stressing on negative impact of high CO_2 concentration on health and well-being. Information on consumptions (electricity consumption for printer of the previous day) and CO_2 concentration (current and last week trend) were provided also by Dashboard. No benefits were measured in terms of thermal quality of the indoor environment (this topic was addressed only by Dashboard). The stickers (easily visible without the necessity to open an App on a device) were more effective than the ICT-tools.

Targeting guests, only one guest accessed the Dashboard over the duration of the project (argumentations about this are provided as part of D6.3 and D6.4). Consequently, it is quite impossible to make some considerations about effectiveness of feedbacks given via ICT-tools. MOBISTYLE stickers distributed in guests' apartments starting from November 2019 were stressing on two topics in particular:

- Keeping proper setpoints ("*Do you know that excessive indoor temperatures could negatively affect your health? 21°C is a pleasant temperature.*")
- Ventilate the room ("*A high level of CO_2 deteriorates the indoor air quality and can cause headache. Ventilate the room a few minutes can make you feel better.*")

Comparison of relevant KPIs computed before and after MOBISTYLE stickers deployment allowed to observe that overheating phenomenon was slightly reduced improving IEQ in terms of temperature for some clusters of guests. During stickers deployment the time spent in comfort category I and II in terms of CO_2 concentration was increased (25-70% time instead of 14-59%) for some of the analysed clusters of guests. This result is based on 35 stays, so it can be considered quite significant.

From data analysis, interpretation and personal communication, some relevant lessons can be drawn about the effectiveness of soft measures:

- There are some constraints in users' control over the system which are demotivating users in being actively engaged in doing something to improve thermal comfort according to the idea "there is nothing I can do to improve it" → As soft factors should not be ignored, system optimization (hard factor) to reduce complaints is important in order to keep people engaged in interacting with the systems.
- Accessible and appealing stickers can have more immediate impact than complex systems (i.e. ICT-tools), which require the users to be fully willing to start using them → **Low budget measures can represent a prior action to start committing soft factors towards higher EP of buildings.**
- Weekly meeting with staff members were needed to keep them interested → Deployment of some soft measures requires constant personal communication. **MOBISTYLE campaigns can not be seen as stand-alone solutions but should be part of the community building or building facility management.**
- Staff members were not as active as expected in using the services → Beside to the contents provided via soft measures, **integration between services have to be guaranteed** to offer an effective information to users, otherwise it is unlikely that they would pay attention to them.
- Guests were not as interested as expected → **Measures based on people engagement have limitation in hotel context because guests do not want too much information.**

However, both the target groups agreed about the importance of the message brought by the project, and, who was interviewed, did find interest in the information provided. They all agreed on the fact that impacts can be seen only on long-terms.

It is important to keep in mind that results have some limitations:

- Statistical representativeness, as already discussed in section 2.1. For this reason, results on specific stays (addressed in specific focus as part of D6.2) are not included here.
- Uncertain variables. Effective occupancy is unknown, and it can influence CO_2 concentration. This limitation is related to the limitations in the building sensoring capacity already mentioned in section 2.1.

- Missing data. In IEQ evaluation for reception space, missing data are more numerous during the baseline than during the period when MOBISTYLE solutions were deployed.

Dutch case

An important 'soft factor' related lesson learnt from the Dutch case is that comfort is not necessary healthy and that comfort can be adjusted. The experiments for this case showed that dynamic conditions (moderate temperature drifts) do not lead to thermal discomfort. The study indicated that metabolic healthy can be affected positively by dynamic indoor temperature compared to fixed scenario without compromising thermal comfort.

Human comfort as an example of a soft related factor that can be influenced.

It was interesting to note that despite the change in thermal sensation from slightly cool to slightly warm (lab-study), the thermal comfort stayed within the limits of just comfortable and comfortable. This is an important finding because it means that there is in fact no reason for stable control of the indoor climate (current indoor climate standard EN 15251 recommends stable conditions based on Fanger PMV model).

The MOBISTYLE experiments showed that temperature deviation during a daytime of 3.5-5 °C (see D6.2 for Qeske and Brightlands) are perceived acceptable. Such dynamic temperature profile (temperature training) and exposure to mild cold can increase our metabolism and brown fat (healthy fat) activity, increase resilience to cardiovascular diseases (ongoing research at MU), and also it has been shown that regular exposure to mild cold increases insulin sensitivity[4].

The dynamic conditions with such a temperature drift as in MOBISTYLE case may reveal a healthier environment as the thermophysiological literature shows and to some extent is confirmed in the current laboratory study. Secondly, it means energy savings for the buildings, because with less strict control and use of heating and cooling is needed. In addition, it is likely that on the long-term occupants may be feeling better, because there are indications that temperature variation may lead, not only to comfort, but to a higher appreciation or even pleasure. This so-called *alliesthesia* is a phenomenon that occurs when one is temporally in a less comfortable condition and then exposed to an opposing (uncomfortable) condition.[5] The main advantage for health is that under these opposing conditions the bodies' physiology is challenged, leading to a better metabolism and more resilience to temperature extremes. Long-term temperature trainings could help people becoming more resilient to extreme conditions as the bodies would be used to adjust and work slightly harder when exposed to varying conditions.

[4] van Marken Lichtenbelt WD, Pallubinsky H, Te Kulve M. Modulation of thermogenesis and metabolic health: a built environment perspective. Obes Rev. 2018;19 Suppl 1:94-101.

[5] de Dear R. Revisiting an old hypothesis of human thermal perception: alliesthesia. Build Res & Inform. 2011;39(2):108-17.

Human perception as an example of a soft related factor that can be influenced.

MOBISTYLE Dutch case hypothesis was aiming to show that sometimes our human believes are false and should be dropped. The MOBISTYLE approach aimed to show that our basic daily perception that constant temperature in winter is ideal healthy condition might actually be wrong. So instead of focusing on what feels comfortable we should focus on what is healthy. In MOBISTYLE dynamic condition campaigns setting for the Brightlands case, the aim was to take basic human instincts, flaws and habits into consideration and in this way nudge people to change and be OK with dynamic indoor temperatures (see D6.3 Chapter 3.5 for the campaign sticker example).

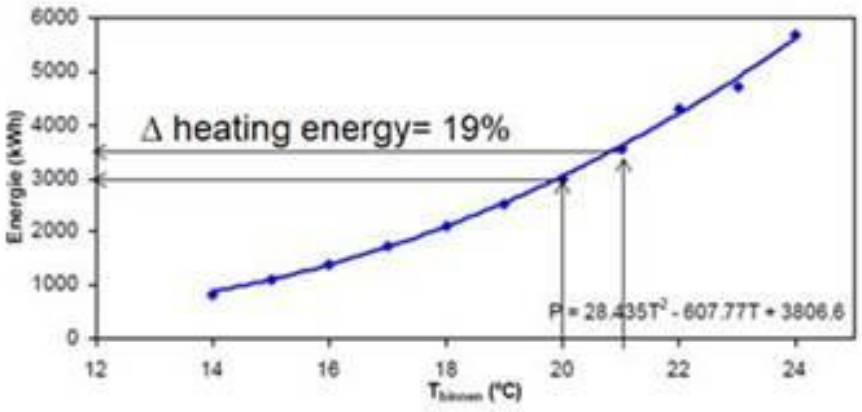
Raising awareness through the Office App application and supported MOBISTYLE Brightlands awareness campaigns proved to help increasing office employees acceptance with the dynamic conditions. This shows that people can change their believes and old habits where they are willing to adopt new habits if information is given them in them understandable and transparent way. It was simulated that such dynamic campaigns can lead to average 21 % energy saving compared to static conditions.

2.5 How to take soft or human factors be taken into account in a new generation of EPC's

The aim of this study was to discuss how to quantify the soft factors in order to be included in the European performance calculation methodologies. None of the current European Commission recommended calculation methods includes method for soft factors inclusion.

Although the 'soft' or 'human' factors are represented in the SRI as one of the three key functionalities (i.e., responsible for 1/3 of the SRI) these are not taken into account or quantified in Energy Performance Calculations. The impact of user awareness and information to occupants (both energy, comfort, IEQ and wellbeing) can be taken into account on several ways.

Previous studies[6] showed that in average Dutch (row) houses a lowering of the average indoor temperature with 1^0C could lead to 19 % energy savings:



[6] National Dutch EOS-LT research project DP2015 (Sustainable real estate development after 2015)

Other studies and monitoring campaigns showed that simple measures as individual metering thermostatic radiator valves in apartment buildings can lead to 15 – 20% energy saving[7].

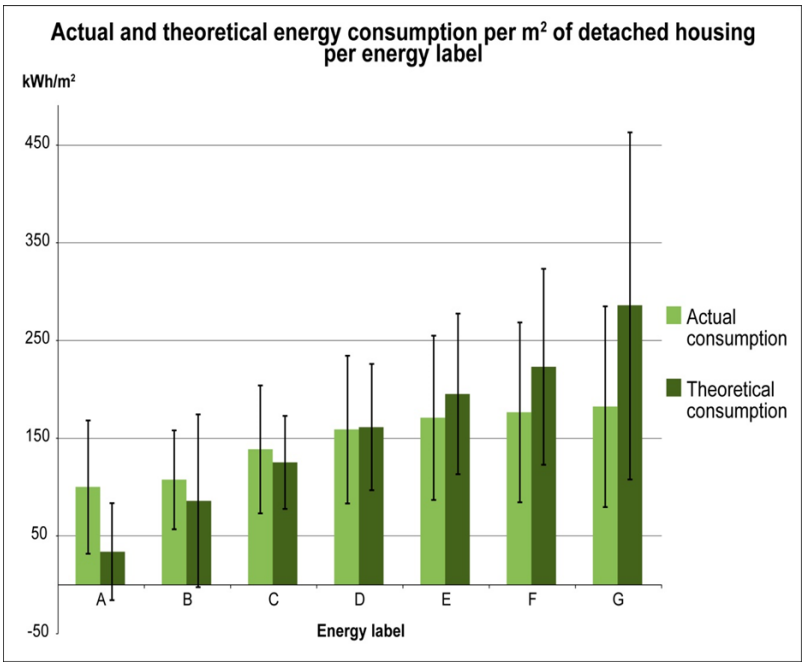
Nevertheless, the monitoring campaigns within the MOBISTYLE project did not show a significant decrease of indoor temperatures and/or thermostat settings per se. One remark should be made that, for proving a significant decrease of indoor temperature and thermostat settings, a much larger and longer monitoring campaign should be organized, especially now it is clear how to design and organize such monitoring campaigns. Moreover, MOBISTYLE had the focus on several types of buildings to see how and what kind information and communication tools could be used, geared to the building type and building function; so within MOBISTYLE the aim was not to focus on just one sector with uniform and large scale monitoring.

Hence, one of the recommendations is to organize large scale monitoring campaigns and analyses, in combination with campaigns targeting behavior, in different EU countries, taking into account the four impact criteria (comfort, convenience, information to occupants and health & wellbeing) of the key functionality '*Respond to user needs'*. Such a campaign should not include the tools and methodologies of MOBISTYLE but also from other related projects.

Another strategy to take the impact of user awareness and information to occupants into account is by considering the presence of the key functionality '*Respond to user needs'* as a prerequisite to guarantee the calculated energy performance in practice. This is directly related to the addressing the energy performance gap as the energy performance gap is (still) present[8], especially for NZEB's:

[7] Like in the Dutch E'novation program, one of the first large scale renovation programs in Europe beginning nineties.

[8] REFERENCE: UserTEC – User Practices, Technologies and Residential Energy Consumption. P. Heiselberg, AAU, Denmark



This could be taken into account not as an extra 'energy saving' but rather as a 'malus' on the EPC. As example, if there are no provisions present for solid information services to occupants this should lower the calculated EPC. Yet, a quantification is not made yet.

2.6 Outcomes of MOBISTYLE used in other H2020 projects

MOBISTYLE is one of the first H2020 projects showing that a different approach is needed as users of the buildings are equally important part of the building ecosystem as building technologies, i.e. people use energy, not buildings. The tools and methodologies emphasized on information and educating users on how to behave in their buildings and how to increase their awareness by combined information on their energy usage, generated IEQ, health and lifestyle. These findings were shared in a number of following H2020 projects, especially these projects where a typical user (or rather people) centered approach in the actions was applied.

Although not to be considered as policy recommendations per se, it can be considered as recommendations for other projects, leading, on their turn, also to new policy recommendations.

TripleA-reno (May 2018 – April 2021):
One of the first projects was TripleA-reno: Attractive, Acceptable and Affordable deep Renovation by a consumers orientated and performance evidence based approach. The overall aim of TripleA-reno is to make acceptation and decision making on deep and nZE renovation attractive for consumers and end-users. This is done by clear, unambiguous and meaningful information and communication on real, proven performances on energy, Indoor Environmental Quality and personal health in practice, strengthened by consumer centred business models. TripleA-reno achieved this aim by having developed an open and end-users centred gamified (application of game-design elements and game

principles) platform for decision support, quality validation and proven quality as well as community building. This is done in three levels:

- Level 1 - Design-phase: gamified and social design by co-creation
- Level 2 - Construction-phase: gamified realization of proven quality in interaction with end-users and a deep renovation community
- Level 3 - In-use-phase: gamified in-use platform for ensuring sustainable quality of building and user experience

Especially in level 3 the MOBISTYLE methodology is used, more specifically on how and what to monitor the overall performances of a home after renovation and how to inform occupants about these performances. Moreover, the gamification components from MOBISTYLE connected very well with the gamified TripleA-reno in-use platform. Based on the MOBISTYLE experiences, also Triple A-Reno will raise consumer awareness by providing attractive personalized information on energy use, indoor environment, health and lifestyle, by ICT-based solutions. Measurable multiple benefits in all three levels (and especially level 3) will raise the awareness and acceptance of deep renovations by consumers and will support and motivate them to well informed pro-active behavior towards energy use and health, and with this, to improve the overall performance and user satisfaction. This will provide confidence of making the use of delivered deep renovation and create learning loops for the solution providers (in use data).

Another important input from MOBISTYLE was given for a specific task: Development of labeling performances on energy, IEQ and well-being. This is one of the first attempts to come to a combined holistic labeling as, until then, the labeling performance on energy, IEQ and well-being is known independently from each other. Yet, sophisticated building certification schemes such as Well, BREEAM enhance provision of good indoor environment which often leads to vast energy usage. The fact that that building's energy use affects indoor environment and indoor environment affects energy use, shows that there is a need for such joint labelling schemes allowing finding optimum energy usage for healthy indoor climate. This allows creation of more energy efficient buildings as well as buildings healthier for the occupants. This task focuses on establishing a labeling scheme(s) which allows such joint assessment of energy, IEQ and health parameters and therefore enables combined insight in building's energy performance, generated IEQ and their effect on occupant's health, productivity and well-being. The combined holistic labelling is now operational and is tested in the TripleA-reno demonstrators.

DRIVE 0 (October 2019 – September 2023):

Also in DRIVE 0: Driving decarbonization of the EU building stock by enhancing a consumer centered and locally based circular renovation process a people centered approach to make circular renovation understandable and attractive to all stakeholders is key. The aim of DRIVE 0 is to come to a to accelerate deep renovation processes by enhancing a consumer centered circular renovation process in order to make deep renovation more attractive for consumers and investors, environmentally friendly and cost effective. DRIVE 0 combines the need for a circular building industry with the identification of specific local drivers to trigger and to motivate end-users for deep renovation, supported by an anthropology based and environmentally friendly approach to make it costumer-

centered. This approach is based on the methodologies developed in MOBISTYLE and reflected in the development of attractive consumer centered business models based on circular renovation concepts supported by digitalization and gamification and the way how occupants are provided with attractive and understandable information on building performances in use. More specifically, one work package is dedicated to performance monitoring and user information whereas there are two specific tasks dealing with this: 1) Creation of attractive and understandable user information and 2) ICT-based solutions to end-users: user centered information services. These tasks directly build upon the outcomes of MOBISTYLE.

U-CERT (September 2019 – August 2022):

The work on new generation of holistic and user-centered Energy Performance Assessment and Certification is now further continued in the H2020 project U-CERT: Towards a new generation of user-centered Energy Performance Assessment and Certification. The main aim of U-CERT is to introduce a next generation of user-centred Energy Performance Certification Schemes to value buildings in a holistic and cost-effective manner. U-CERT aims to:

- Facilitate convergence of quality and reliability, using the EPB standards, developed under the M/480 mandate, enabling a technology neutral approach that is transparently presenting the national and regional choices on a comparable basis using the Annex A/B approach;
- Encourage the development and application of holistic user-centered innovative solutions, including the smart readiness of buildings;
- Encourage and support end-users in decision making (e.g. on deep renovation), nudge for better purchasing and to instill trust by giving clear credits and view on added (building) value, using EPC's.

U-CERT has a focus on strengthening actual implementation of the EPBD by providing and applying insights from a user perspective and creating a level playing field for sharing implementation experience, (Mandate M/480 and product related) to all involved stakeholders.

U-CERT gives support to decision making by end-users on deep renovation by including added value indicators and criteria based on a holistic user-centred perspective (e.g., such as developed in MOBISTYLE and TripleA-reno), and by defining indicators based on CEN standards. These indicators will include:

- Asset rating:
  - Calculated annual final energy use including renewables and eq. CO2-emission;
  - Estimated energy cost;
  - Calculated comfort and IEQ levels.
- Operational rating (the step to the custom-made renovation advice):
  - Measured and normalized annual final energy use and eq. CO2-emission;
  - Actual energy cost;
  - Actual comfort and IEQ levels.
- Smart readiness (indicator) functions enabling operational rating
  - Readiness to adapt in response to the needs of the occupant (specifically linking with MOBISTYLE);
  - Readiness to facilitate maintenance and efficient operation;
  - Readiness to adapt in response to the situation of the energy grid.

Further implementation and testing of the SRI in 11 cases in 11 countries is an important aspect in U-CERT. Moreover, for the set up of an analysis of users' perception about EPC schemes is based on the ethnographic approach as developed in MOBISTYLE.

Collaboration with other projects on new generation of EPC's

Together with U-CERT also two other projects started on developing new generation of EPC's:
X-tendo and QualDeEPC.

- **X-tendo** aims to support public authorities in the transition towards improved next-generation energy performance assessment and certification of buildings, by developing a modular toolbox that covers different features of innovative indicators as well as innovative data handling approaches.
- **QualDeEPC** works on EU-wide convergence of the building assessment and the issuance, design, and use of quality-enhanced EPCs as well as their recommendations for building renovation. The aim is to make these recommendations coherent with deep energy renovation towards a nearly-zero energy building stock by 2050.

These three projects organized a webinar (June 30, https://www.buildup.eu/en/events/webinar-catalysing-eu-renovation-wave-transition-next-generation-energy-performance) were the input from MOBISTYLE will be discussed.

3 Conclusions

The aim of the examples showed in Chapter 2 was to show how 'soft' or 'human' factors impact the quantified data based on the introduced MOBISTYLE measures at the different pilot sites. Nevertheless, as mentioned in Chapter 2.1 it should be noted that these results are based on a small sample and therefore are not sufficient for any statistical significance. Further investigation and especially large scale monitoring campaigns, in combination with campaigns targeting behavior, in different EU countries, would be necessary.

The monitoring and evaluation of the soft factors is not an easy task. The soft measures are aimed to enhance a change in customer behaviour so that awareness, knowledge, habits, attitudes, values, choices etc. lead to energy savings. This was done by several MOBISTYLE communication tools and channels. Setting up this campaign required consideration of several different aspects type of building (residential, public, commercial etc.), type of building users (gender, culture, socio-economic background), type of measures and its severity and the actions taken by the customers. In general, the soft measures address four elements leading to behavioural change namely knowledge, awareness, attitudes and action (see D3.2) but these interrelations are highly complex and it was difficult to find a reliable way to monitor and evaluate the causes and the effects.