Ref. Ares(2020)5484609 - 14/10/2020

EXCESS

FleXible user-CEntric Energy poSitive houseS

Deliverable 3.1: EXCESS ICT Architecture Blueprint

LC-EEB-03-2019

New developments in plus energy houses (IA),

Proposal No. 870157

Title	Document Version
D3.1 EXCESS ICT Architecture Blueprint	1.0

Project Number	Project Acronym	Project Title
H2020-870157	EXCESS	FleXible user-CEntric Energy poSitive houseS

Contractual Delivery Date	Actual Delivery Date	Deliverable Type*-Security**
31 August 2020	09 October 2020	R-PU

*Type: P: Prototype; R: Report; D: Demonstrator; O: Other.

Security Class: PU: Public; PP: Restricted to other programme participants (including the Commission); RE: Restricted to a group defined by the consortium (including the Commission); CO: **Confidential, only for members of the consortium (including the Commission).

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Abstract
This deliverable describes the blueprint EXCESS ICT Architecture and the specifications of the related ICT components. It presents the methodology of extraction of end users needs through the creation and circulation of questionnaires along with the elaboration of business scenarios and use cases that drive the definition of ICT components requirements. This set of requirements facilitate the description of functionalities of the EXCESS ICT components that comprise through their operation and interconnection the universe of the EXCESS ICT Architecture. The timeplan for the development of the ICT components is also provided. The current deliverable will be the guide for the implementation, integration and deployment of the ICT components during the next phases of the EXCESS project based on the definition of their specifications.

Keywords
EXCESS ICT Architecture, ICT components, Questionnaires, Business Scenarios, Use Cases, Requirements, Technical Specifications, Functionalities, Interfaces, Implementation, Integration, Deployment

Revision	Date	Description	Author (Organisation)
V0.7	29.09.2020	*Ready for internal review*	Konstantinos Latanis, Tasos Tsitsanis (S5), Koen Allaerts (VITO), Francesco Reda, Rehman Hassam (VTT), Thomas Ramschak, Michael Gumhalter (AEE), Thomas Schwarzl (TSI), Miltos Gakis (CGS), Andreas Tuerk, Michael Kernitzkyi (JR), Javier LLorente Yoldi, Victoria Lara Garcia (CENER)
V0.8	05.10.2020	*Internal review completed*	Miltos Gakis (CGS), Thomas Schwarzl (TSI)
V1.0	09.10.2020	*Final version submitted to EC*	Konstantinos Latanis, Tasos Tsitsanis (S5)

This project has received funding from the
European Union's Horizon 2020 Research and Innovation Programme
under Grant Agreement № 870157.
More information available at www.positive-energy-buildings.eu

EXECUTIVE SUMMARY

The deliverable D3.1 "EXCESS ICT Architecture Blueprint" documents the detailed design of the conceptual architecture and technical specifications of the ICT components of the EXCESS system in the context of the Work Package 3 "Technology and User Integration via ICT". This deliverable comprises a direct outcome of the Task 3.1 "Blueprint architecture design and specification of the EXCESS ICT components", which aims to:

- Define the EXCESS Conceptual Architecture Design
- Specify the functional and technical requirements of the EXCESS components
- Design the individual components of the EXCESS system
- Define the specifications for the wireless sensor/ actuator network topology to be used in the 4 demo sites for intra-building optimization in a human-centric way

Towards the definition of the EXCESS ICT Architecture, the business scenarios have been initially specified covering the high-level operations of the EXCESS system. Based on these business scenarios, the detailed use cases have been derived, containing the thorough descriptions of the different functionalities of the EXCESS system. In this context, the four business user groups, namely the building occupants, the building managers, the architects and the aggregators have been defined. In order to further refine the use cases, questionnaires have been circulated to the different user groups and their corresponding answers have been accommodated to the description of the technical specifications of the EXCESS system.

The EXCESS system targets at the realization of the PEB concept in the buildings of the four demo sites and its architecture includes the following ICT components:

a) the EXCESS Data Management Platform, which will collect various types of data coming from the distributed information systems of the demo sites using several ways of ingestion, such as file uploading, acquisition through the APIs of the local demo site building management systems, etc. It will facilitate the mapping of the data elements to the concepts of the Common Information Model to enable the interoperability and homogeneity of the ingested data and it will finally store the data in its secure data storage space.
b) the EXCESS Data Analytics Framework, which will enable the performance of various types of analytics using the ingested data that will provide meaningful results to other EXCESS ICT components. The comfort preferences of the building occupants will be extracted, while the generation short/ mid-term forecasts of the energy components of the demo buildings will be elaborated. Moreover, the demand short/ mid-term forecasts of the devices and loads of the demo buildings will be created. The above analytical outputs will drive the extraction of the context-aware flexibility profiles of the devices and loads of the building occupants. In addition, the configuration of dynamic Virtual Power Plants (VPPs) will take place in order to find the optimal demand response schemes for satisfying grid flexibility requests.
c) the Model Predictive Control component, which will use the context-aware flexibility profiles from the Data Analytics Framework in order to perform multiple alternative scenarios towards finding the optimal control strategy for the various devices, loads and energy components in the building and district level leading to the realization of the PEB concept.
d) the EXCESS Data Visualizations Framework, which will provide appropriate visualizations applications to the building managers and the aggregators, so that the former can view and

understand their energy consumptions and behaviours and the latter can monitor their VPP configurations and the flexibilities offered by the prosumers.

e) the EXCESS Blockchain Infrastructure and Applications, which will create the necessary blockchain environment where the Objective Benefit Sharing application and the Explicit Demand Response application will reside. The first application will support the proportional sharing of monetary gains coming from the energy savings of building occupants, while the second application will enable prosumers to offer their flexibilities to aggregators for trading in the local energy market and make corresponding profits.

The deliverable D3.1 will provide input to all other tasks of WP3, as it will define the specifications of the ICT components that will be implemented in the context of Task 3.2, Task 3.3, Task 3.4, Task 3.5 and Task 3.6. Further analysis of the technical details of the various ICT components will be performed in the corresponding deliverables D3.2, D3.3, D3.4 and D3.5.

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Glossary

Acronym	Full name
API	Application Programming Interface
BEPS	Building Energy Performance Simulation
BIM	Building Information Modelling
BTES	Boreholes Thermal Energy Storage
CIM	Common Information Model
CSV	Comma-separated Values
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DSO	Distribution System Operator
DoA	Description of Action
DX.Y	Deliverable X.Y
EBC	EXCESS blockchain
EDR App	Explicit Demand Response Application
EXCESS	FlEXible user-CEntric Energy poSitive houseS
HP	Heat Pump
HVAC	Heating Ventilation and Air-conditioning
IAQ	Indoor Air Quality
ICT	Information, Communication and Technology
IoT	Internet of Things
JSON	JavaScript Object Notation
MHE	Moving Horizon Estimation
MPC	Model Predictive Control
NWP	Numerical Weather Prediction
OBS App	Objective Benefit Sharing Application
PEB(s)	Positive Energy Building(s)
PV	Photovoltaic
PV/T	Photovoltaic/ Thermal
UC(s)	Use Case(s)
UI	User Interface
VPP	Virtual Power Plant
WP	Work Package
WSN	Wireless Sensor Network

1 Introduction

1.1 Purpose of the document

This deliverable aims at the definition of the EXCESS ICT Architecture including the specifications of the different EXCESS ICT components which will drive through their operation in the realization of the PEB concept in the four demo sites of the EXCESS project.

In the context of the definition of the EXCESS ICT Architecture, the user requirements of the EXCESS end users have been derived through the circulation of questionnaires. In addition, the Business Scenarios that describe the main business aspects of the EXCESS project have been specified and the subsequent Use Cases that draw the high-level technical orientations of the EXCESS project have been defined. Through the detailed descriptions of the Use Cases, the functional, non-functional and technical requirements of the EXCESS ICT components have been described, leading to the specification of the EXCESS High-Level Architecture that presents the overview of the operation of the EXCESS ICT components, namely the EXCESS Data Management Platform, the EXCESS Data Analytics Framework, the Model Predictive Control Component, the EXCESS Data Visualizations Framework and the EXCESS Blockchain Infrastructure and Applications. Moreover, the detailed descriptions of the EXCESS ICT components and their subcomponents are provided. The initial plans for the implementation, integration and deployment of the various EXCESS ICT components are also defined.

The deliverable D3.1 is a direct outcome of the Task 3.1 "Blueprint architecture design and specification of the EXCESS ICT components". It is related with Task 6.1 "Stakeholder and user identification" and Task 6.2 "User engagement" for the definition of user needs and will provide input to the rest of the tasks and deliverables of WP3 "Technology and user integration via ICT" for the description of detailed technical specifications of the EXCESS ICT components. The deliverable D3.1 will also provide input to Task 4.2 "Demonstration Case Studies in main EU climatic zones" for the operation of the EXCESS ICT components in the 4 demo sites of the EXCESS project.

All technical and demo leading partners have contributed to this deliverable. S5 has described the Data Management Platform and its subcomponents, the Comfort Profiling component, the Context-Aware Flexibility Profiling and Analytics component and the Data Visualizations Framework and its applications. VTT has described the baseline Model Predictive Control component and the specificities for the MPC in the Finnish demo site. AEE, CENER and VITO have defined the MPC specificities for the Austrian, the Spanish and the Belgian demo sites respectively. JR has defined the Generation Forecasting component and CGS has specified the Demand Forecasting component. TSI has described the EXCESS Blockchain Infrastructure and the Objective Benefit Sharing application. VITO has specified the Dynamic VPP Configuration component and along with S5 have described the Explicit Demand Response application.

1.2 Scope of the document

The deliverable D3.1 covers the definition of the high-level technical specifications of the various EXCESS ICT components that constitute the blueprint EXCESS ICT Architecture, which will facilitate the realization of the PEB concept in the four demo sites of the EXCESS project. Within this deliverable, the base architecture of the different ICT components of the EXCESS system is described, while more detailed elaboration of their technical characteristics and specifications will be performed in the respective dedicated deliverables D3.2 "EXCESS Data Management Framework", D3.3 "EXCESS

Flexibility Analytics Module", D3.4 "EXCESS Model-Predictive Control Algorithms" and D3.5 "EXCESS Block chain Infrastructure and Applications".

1.3 Structure of the document

In order to address all the aspects relevant to the scope of T3.1, the present deliverable has been structured as follows:

- Section 1 introduces the work performed and the scope of this deliverable along with the deliverable's structure.
- Section 2 presents the definition of the EXCESS Business Scenarios and Use Cases in order to screen the landscape for the EXCESS technical specifications. An overall methodology for the engagement of the EXCESS end users towards the identification of their needs is also described, along with a non-exhaustive list of the extracted EXCESS end users' needs for the refinement of the EXCESS technical specifications.
- Section 3 presents the extracted EXCESS technical specifications along with their mapping to the various EXCESS components, Business Scenarios and Use Cases.
- Section 4 presents the high-level architecture of the EXCESS system along with the associated components, i.e. the EXCESS Data Management Platform, the EXCESS Data Analytics Framework, the Baseline Model Predictive Control component, the EXCESS Data Visualizations Framework and the EXCESS Blockchain Enabled Applications.
- Section 5 provides a comprehensive documentation of the different components and subcomponents forming the EXCESS ICT framework.
- Section 6 presents a preliminary plan for the implementation, integration and deployment of each different ICT component of the EXCESS system.
- Finally, in section 7, the main conclusions of the work are reported.

2 Methodology for elicitation and consolidation of EXCESS requirements

2.1 EXCESS Business Scenarios and Use Cases

Towards the definition and design of EXCESS ICT Architecture and the specification of the high-level technical characteristics of the different ICT components of the EXCESS system, a top down approach was used in order to specify the Business Scenarios and Use Cases of the EXCESS system that were also validated by the demo related partners. The business scenarios describe the high-level business impacts of the EXCESS system designating the different business users, namely the building managers, the architects and the aggregators and also the active end users, who are the building occupants. The list of business scenarios is presented below.

Table 2-1: EXCESS Business Scenarios

BS#	Business Scenario Title
BS1	Construction companies to increase the attractiveness of PEB investments, through enhancing the accuracy of Energy Performance Simulations at the design phase and as a means to reduce the gap between anticipated and actual energy performance of buildings
BS2	Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings
BS3	Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand)
BS4	Building Occupants to enjoy significant energy savings without sacrificing their comfort preferences and well being
BS5	Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations
BS6	Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
BS7	Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions

The list of Use Cases has followed, where each use case has been derived from one or more business scenarios, describing in a high level the technical aspects of the EXCESS system. A combination of demo specific use cases and more general use cases that apply to all demo sites has been defined. The list of use cases is presented below.

Table 2-2: List of EXCESS Use Cases

UC#	Use Case Title
UC1	Comprehensive modelling of new/ innovative building components, materials and energy systems towards their introduction in Building Energy Performance Simulation Tools

UC2	Enhancement of control routines in Building Energy Performance Simulation Tools with the adaptation of advanced Control logic and respective algorithms based on flexibility
UC3	Adapt design to the actual building use, including accurate information about occupancy schedules, comfort requirements/ preferences and energy uses.
UC4	Satisfying energy and hot water needs of occupants through the development of appropriate façade technologies (PVT panels with enhanced connectivity to be installed in balconies)
UC5	Utilizing the excess energy from PVT components as input for other building systems (charging the ground for ground-source heat pumps operation)
UC6	Maximizing the use of RES in satisfying heating and cooling needs of occupants (Integration of PV and Heating Cooling distribution systems in vertical walls)
UC7	Increasing the efficiency and controllability of heating/ cooling devices for minimizing energy use (Development of a high COP multisource heat pump for deep borehole application for DHW use)
UC8	Introducing novel virtual energy storage capabilities in buildings and building devices for flexibility enhancement (Integration of DHW storage units with P2H elements and IoT controls for additional sources of flexibility)
UC9	Enabling the communication with multiple devices (different protocols and data models) through integrated controllers enabling the simultaneous status monitoring and set-point control of heating/ cooling, lighting devices and appliances
UC10	Increasing the accuracy of Generation and Demand Forecasting for enabling the optimal definition of short-term control strategies
UC11	Real-time Monitoring of Building Operation (and per prosumer)
UC12	Flexibility analytics and forecasting for identifying the control capabilities (in terms of flexibility) of each device under different control strategies
UC13	Real-time Building Energy Performance Optimization through Simulation-based control (alternative scenarios) considering flexibility potential
UC14	Monitoring in real-time the energy performance and monetary gains at community level
UC15	Optimizing the energy performance of districts through orchestrated control of district-level and building-level assets
UC16	Non-intrusive monitoring of ambient conditions and load activation in buildings
UC17	Smart correlation of ambient conditions and load control actions for identifying comfort preferences of occupants
UC18	Building devices automated control for comfort preservation
UC19	Building devices automated control for Indoor Air Quality requirements satisfaction
UC20	Trading of the excess flexibility not used for self-consumption in the energy markets

UC21	Local Flexibility negotiation over marketplaces between prosumers and aggregators
UC22	On the fly configuration of dynamic VPPs through classification and clustering of individual prosumers flexibilities
UC23	Involvement of prosumers in Explicit Demand Response schemes (automated control) and transparent/ objective remuneration of utilized flexibility
UC24	Understanding consumption patterns and flexibility dynamics through visualizations of key energy/ flexibility metrics
UC25	Proportional sharing of gains achieved at the community level to individual occupants
UC26	Visualizing flexibility contributions for increasing transparency and behavioural motivation of under-performing occupants to improve their energy performance

Finally, the detailed description of each Use Case has taken place, where a common Use Case template was utilized in order to define in further detail each use case scenario, the related EXCESS energy components, the involved business users, the target demo sites where each use case will be performed and the pre-conditions and post-conditions of the use cases. The detailed descriptions of use cases will drive the specification of EXCESS functional, non-functional and technical requirements that are presented in chapter 3. The EXCESS Use Case template is presented below, while the Detailed Descriptions of Use Cases are presented in Annex I: Use Cases.

Table 2-3: EXCESS Use Case template

EXCESS Use Case ##	
Use Case ID	The ID of the Use Case
Use Case Name	The name of the Use Case
Related Business Scenario(s)	The Business Scenarios that are related to this Use Case
Related Use Case(s)	Other Use Cases that are related to this Use Case
Description	A short description of the Use Case
Involved Users	The business users that are involved to this Use Case
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	The EXCESS energy components that are involved in the fulfilment of this Use Case
Pre-Conditions	The pre-conditions that should be met for the fulfilment of this Use Case
Use Case Scenario	The steps of the Use Case scenario
Post Conditions	The post-conditions after the completion of this Use Case
Business Impact	The business impact from the completion of this Use Case

2.2 EXCESS End Users' engagement approach

The end users' engagement in the project's activities is a necessary starting point to identify their needs and lead to the refinement of the technical specifications, as extracted from the detailed descriptions of Use Cases, for the development of the EXCESS ICT architecture.

To ensure their active participation and useful contribution, EXCESS business end users (i.e. Architects, Aggregators, Building Managers) with deep knowledge about their needs were engaged in this process. In addition, building occupants were also approached, considered also as active end users of the EXCESS system. The requirements definition derives through the EXCESS end users' participation in appropriate questionnaires coordinated by the demo site representative partners. As such, the participation of the project's end users is deemed of primary importance for collecting their needs.

Four main types of questionnaires have been created and circulated to the prospect end users of the EXCESS system. In more detail, the input from Architects, Aggregators, Building Managers and Building Occupants of the EXCESS demo sites in Spain, Finland, Belgium and Austria was requested through individual questionnaires, which will serve as further input to the specifications extraction of the EXCESS system architecture.

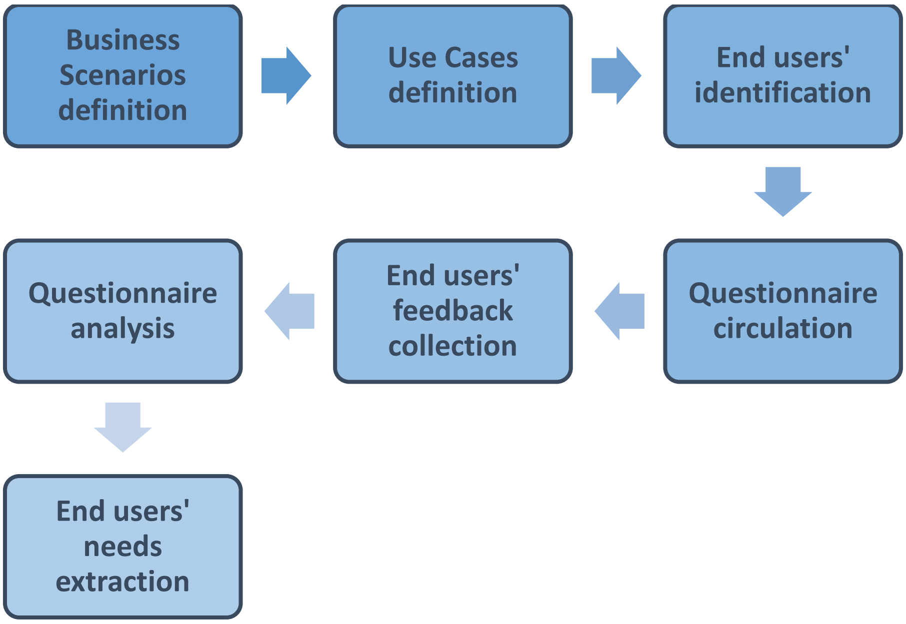

Figure 2-1: EXCESS end users' engagement methodology

The details about the end users' engagement methodology is presented.

EXCESS End Users' Questionnaires

Focused questionnaires were considered for gathering feedback from a large pool of end users. The selected questionnaires were compiled in such a way to engage the targeted end users in the project's activities and further retrieve their valuable feedback towards the extraction of their needs while taking into account the different types of end users, the location of the demo site and the applied EXCESS interventions.

The questions asked, were filtered and polished to avoid too technical questions and confusion of the participants that are not familiar with the concepts introduced. The questionnaires were mainly formed of multiple-choice questions, narrowing down the amount and quality of the information to a limited number of options in each question. An additional field was available in each question for other choices with comments, allowing flexibility for personal comments or options. This way, the survey is faster to respond, and the analysis is also facilitated.

Toward ensuring that the questionnaires fulfil all demo site needs, draft versions of the questionnaires were initially circulated among the demo site representative partners to test the acceptability of the questions and help refine the wording and layout. Once feedback was received from the partners, the questionnaires were reformed and updated according to the comments and thereafter translated to each demo site language (by each respective partner), prior to being circulated in the proposed demo sites. The questionnaires also included a short introduction about the project's concept. The intended type of information to be gathered is classified into the following groups varying in content depending on the end user's role:

- Building Occupants
  - **Generic information** such as gender data, household composition and internet connectivity at their apartments. This information is useful for segmentation and statistical analysis.
  - **Familiarity with technologies and energy consumption metering questions,** trying to capture the current knowledge of the occupants and their willingness to apply advance control systems for optimizing energy performance.
  - **Community energy sharing and trading questions** trying to capture the current knowledge of the occupants on concepts such as energy self-consumption as well as their attitude towards participation in collective schemes for self-consumption maximization at community level.

- Building Managers, Architects, Aggregators
  - **Generic information** such as preferred wireless devices and operating systems used for work.
  - **Work specific questions** varying according to each business user's role, trying to capture their current work patterns, needs and available information.

All the above information will gather the intended requirements and aspects of EXCESS system as identified from each different end-user considering their own needs.

2.3 Timeline Framework for Questionnaire Analysis

Considering the role of the demo site representative partners and their contribution in this deliverable, the following work-allocation was performed in regard to the questionnaires:

- Suite5 compiled the questionnaires for all intended end users in English and was responsible for the questionnaire analysis.
- VTT was the partner responsible to translate the questionnaires in Finnish and circulate the questionnaires in the Finish demo site to the tentative end users of the project.
- CENER were the partners responsible to translate the questionnaires in Spanish and circulate the questionnaires in the Spanish demo site to the tentative end users of the project.
- VITO was the partner responsible to translate the questionnaires in Dutch, circulate the questionnaires in the Belgium demo site to the tentative end users of the project.
- JR was the partner responsible to translate the questionnaires in German and circulate the questionnaires in the Austrian demo site to the tentative end users of the project.

Following the above work allocation among the involved partners, an action plan for the EXCESS end users' engagement was outlined and agreed with the demo sites representative partners. The details of this action plan are presented in the following figure.

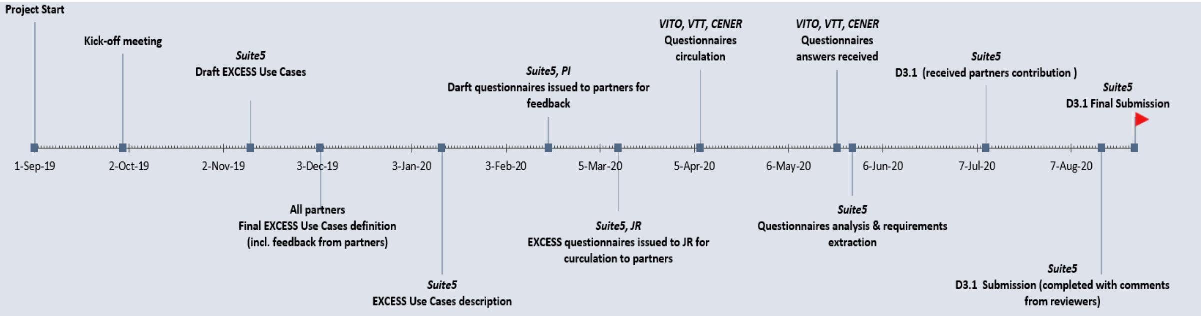

Figure 2- 2 EXCESS Timeline for questionnaires analysis

Having presented in brief the overall methodology for the EXCESS end users' engagement and their feedback gathering, the following section presents the results from the Questionnaires analysis per demo site, towards the extraction of the list of requirements of the EXCESS platform.

2.4 Questionnaires Analysis

By presenting the methodology for the end users' engagement, the next step of the work consisted of the extraction of their needs. Interaction with the demo site end users (i.e. Building Occupants), as well as with the EXCESS Business end users (i.e. Architects, Aggregators, Building Managers) at this point is a main prerequisite for the extraction of their needs. As mentioned previously and towards this direction, the aforementioned end users of the EXCESS solutions, were engaged to provide feedback in suitable questionnaires, in order to ensure their active involvement. The results from this questionnaire analysis are presented in the following subchapters.

2.4.1 Summary of Questionnaires Analysis results

Four different translated versions of the questionnaires were circulated to gather end users' feedback in the preselected EXCESS demonstration sites of Austria, Belgium, Finland, and Spain. In total, 43 questionnaires were answered; 23 for Building Occupants, 13 for Architects, 6 for Building Managers, 1 for Aggregators and the most important insights are presented per demo site; a detailed presentation of the questionnaire results can be found in Annex II: EXCESS End Users Questionnaires Results.

2.4.1.1 Austrian Demo Site Analysis

The results from the Austrian Questionnaire analysis are available below for all identified EXCESS end users. In total, 11 questionnaires were answered from the Austrian Demo site (7 for Building Occupants, 3 for Architects, 1 for Building Managers). The outcomes are first presented for the **Building Occupants**.

Starting with some generic questions, the majority of the respondents are *Males* (71.4%), while the indicated age group of all respondents is between *18-30 years old*. The majority of the respondents reported that they live in *single-person households* (57.1%), followed by a *household of 3 people or more (28.6%) and two-person households* (14.3%). Lastly the majority of the respondents reported to be *renting* their apartment (85.7%), while only one occupant reported to *own* the apartment and currently living in it.

Continuing with the technology familiarity and preference questions, the Austrian building occupants reported to be normally using mainly their *smartphones*, followed by *laptop* and *tablet* usage; while *Wi-Fi* internet connectivity is mostly available in their premises; followed by the *fixed* and *cellular* internet connectivity. In regard to any restrictions in their internet connection the majority reported *speed* restrictions, followed by *download/upload data quota* restrictions.

The majority of the building Occupants reported to *understand little* about PEBs concept; only two out of the seven respondents reported to have *never heard of this concept*. Four out of the seven respondent reported that saving energy and use of renewable energy sources in their building is *important*, two consider this as *very important* and one occupant reported that it is *slightly important*.

All of the respondents expressed their *willingness to apply advance control systems* for optimizing energy performance, with the majority preferring *Intelligent guidance allowing manual control*, followed by *Automated control system* and equally *favoured Intelligent guidance supported by remote controls and scheduling*.

The most preferred type of devices and assets that occupants would introduce into an advance control framework for self-consumption, as reported is *Heating devices* (7 votes), followed by *Local Generation (Renewable Energy sources)* and *Storage Systems* (5 votes). Following *Domestic Hot Water* (3 votes) is preferred and the least voted were *Cooling*, *Lighting devices* and *Smart appliances* (2 votes).

According to the responses, all of the building Occupants *are interested in reducing their energy demand and dependence on grid energy*, through the installation of novel smart-ready energy technologies; while only one respondent *expressed concerns* regarding the installation of smart-ready energy technologies in his house/building.

In the next question asking building occupants, how much they are willing to pay for sensors to be installed inside their houses to measure their living preferences and help them decide on what changes best address their needs, the majority of the respondents (5 votes) reported that they are willing to pay no more the 500€ and two occupants reported their willingness to pay no more than 100€.

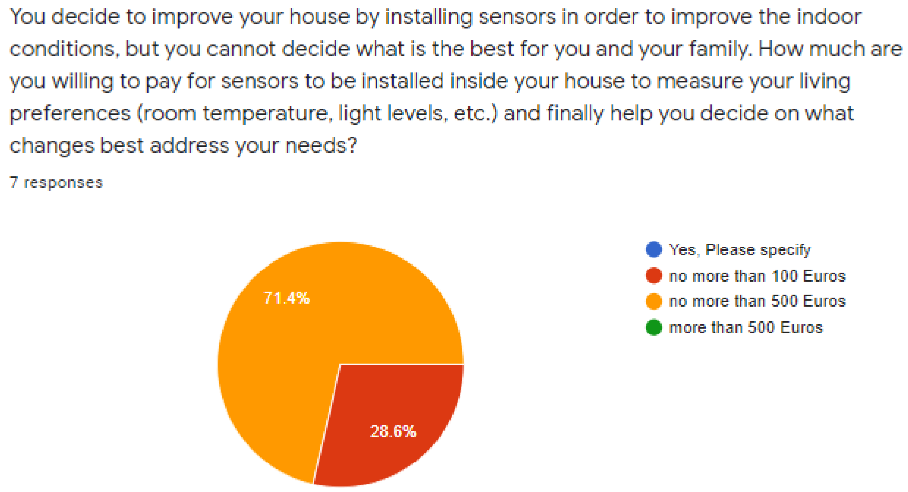

Figure 2-3 Austrian Demo – Building Occupants' willingness to pay for installing sensors in their houses to measure their living preferences

While all respondents reported that they have *never been involved in a project that assesses their living comfort and/or indoor air quality*, the majority (6 votes) *see a value in having a building tailored to their needs in terms of comfort preferences*.

Three out of the seven occupants questioned, e*xpressed their objection in having low powered IoT devices installed for a period of time to determine their energy consumption, flexibility and comfort preferences, if privacy was respected*; while five out of the seven respondents *agreed to the installation of data sensors at their property for more than a yea*r. The rest two respondents reported that the longest period they are willing to have such monitoring devices installed in their apartments is *12 months*.

Overall, the building occupants indicated as *Very Important* aspects for their living comfort the *Indoor Temperature* (4 votes); I*ndoor Air Quality* (4 votes) as *Somewhat Important,* followed by *Indoor Humidity* (3 votes) and *Indoor Luminance* (2 votes). All of the respondents showed a *positive interest to monitor their energy consumption and flexibility* through visualization applications. The most favourable way for monitoring their energy consumption and flexibility is via *Mobile app* (4 votes) followed by use of a *Web- based platform* (3 votes) and *Desktop app* (1 vote).

Going into the third part of the Austrian occupants' questionnaire comprising of community energy sharing and trading questions, only two respondents reported to *fully understand the concept of electricity self-consumption*, three occupants reported to *understand it with the exception of some concepts* and the rest two respondents *understand it partially*. All seven occupants indicated their *positive interest in monitoring their individual performance in terms of energy consumption and flexibility in comparison with the district/ community level performance.* Three respondents reported that they *somewhat agree* the statement that visualization of their own consumption/energy savings against community level can inspire them towards reducing their energy consumption, leading also to financial profits and environmental benefits. Two respondents *strongly agreed* with the aforementioned statement and one respondent *somewhat disagreed*.

In the following question, the majority of the building occupants indicated the use of a *Mobile app* (4 votes) as the most preferred way for monitoring their position against the district/community level energy consumption and flexibility, followed by the use of *Web-based platform* (3 votes).

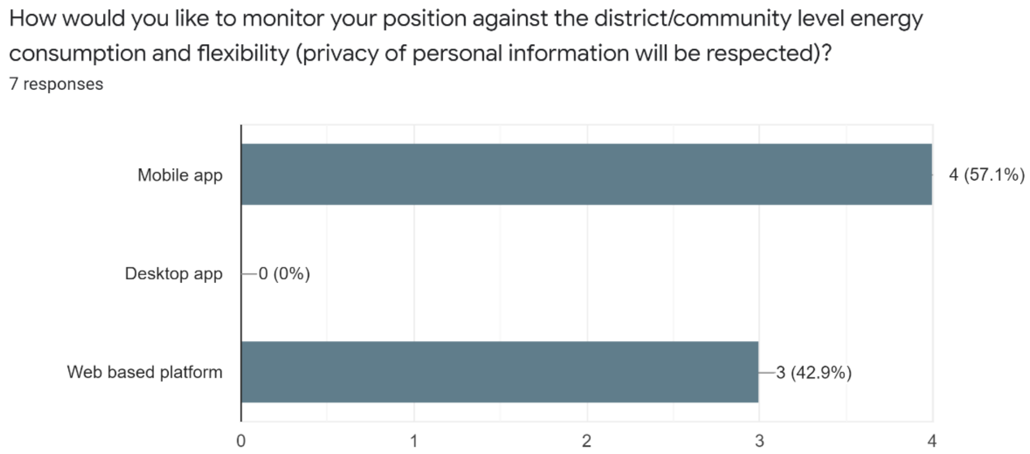

Figure 2-4 Austrian Demo – Building occupants' preferred means for monitoring their position against the district/community level energy consumption and flexibility.

Following, three out of the seven respondents reported that they *will object in sharing their individual flexibility for optimizing the performance of their neighbourhood/ district and maximizing self-*

consumption even if privacy of personal information are respected; while the rest four Austrian occupants *indicated no objection*.

The building occupants indicated as *Very Important* for considering participating in collective schemes for self-consumption maximization at community level, aspects such as "*Full respect of private information (not disclosed)"* (6 votes), "*Clear and transparent monitoring and verification mechanisms"* (5 votes) and "*Fair renumeration"* (4 votes). As *Somewhat Important* towards their participation in such schemes occupants indicated aspects such as "*Contribution to the sustainability and greenness of the community"* (5 votes) *Positive experience and feedback given by early entrants to gain confidence"* (3 votes).

In the next question, asking occupants to rate aspects that would make them feel more uneasy to participate in the local self-consumption schemes at community level; occupants indicated as *Very Important* aspects such as "*Possible misuse of personal information by third parties*" (4 votes) and as *Somewhat Important* aspect such as "*Possible new technology failure or malfunctioning*" (4 votes), *"Financial benefits lower than expected"* (2 votes), *"Lack of previous user experience in a new service or collaboration scheme"* (2 votes), *"Negative reputation in case of low performance in comparison with other peers in the community"* (2 votes).

Overall, all respondents indicated a *positive interest* in having an automated control of their building's devices towards reducing energy consumption without sacrificing their comfort preferences, while all questioned occupants indicated also *a positive interest* in trading their non-self-consumed energy/ flexibility in local flexibility and energy markets towards monetary gains without affecting their comfort. Towards this direction, the majority of the respondents reported that the most preferable means for communicating with Aggregators regarding the exploitation/trading of their flexibility is the through a *Mobile app* and a *Web-based platform* (equally voted). The preference of using a *Desktop app* was reported by one occupant.

In regard to having and using smart devices at their homes, five building occupants reported that they *like having them but do not usually use* them and two occupants reported that they *like them and they use them.* When asked if they would object in allowing external stakeholders (i.e. aggregators) to control their devices remotely (based on specific agreements) at specific points in time to optimize their participation in energy/ flexibility trading, four occupants *reported their objection* two occupants *indicated no objection,* and one occupant specified that he *would not object if a preview of the contract is provided.*

Following building occupants were asked to indicate the type of their devices they would allow an aggregator to monitor and operate automatically, without affecting their comfort, so they can provide service to the grid and get a remuneration for it. Six out of the seven respondents indicated that they would allow it for *electric heating* and *cooling devices*; while only two occupants reported that they would allow it in the case of *smart devices*. The remaining four reported to be *undecided* and one occupant reported that he *would not allow the use of smart devices*.

When it comes to the frequency of receiving alerts/instructions regarding their unconsumed energy available for trading; five respondents reported that they prefer to receive it *weekly*, while the other two occupants preferred daily and at *monthly* intervals.

Five of the seven respondents are interested in monitoring the monetary gains generated from trading their flexibility, while in order for them to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, the occupants indicated as *Very Important* aspects such as: (results are presented in a descending order of preference votes)

- *Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules* (6 votes)
- *Clear, transparent and bilateral contracting with the market representative or service provider company that ensures customer confidence and resolves any potential conflicts* (6 votes)
- *Savings in the energy bills for moving consumptions from high cost periods to low cost periods* (5 votes)
- *Full respect to private information (not disclosed)* (5 votes),
- *Contribution to the sustainability and greenness of the National and European electricity system* (3 votes)
- *Full respect of my comfort standards* (3 votes)
- *Be among the first to participate in a new technologically advanced initiative and give feedback to improve it* (2 votes)
- *Use of high level inter-communicated smart technologies for automated control of home appliances and devices* (1 vote)

Finally, a similar question, asked occupants to rate aspects that would make them feel more uneasy to participate in the demand flexibility markets described before. The occupants indicated as *Very Important* aspect as: (results are presented in a descending order of preference votes)

- *Lack of transparency of the contract and the remuneration* (6 votes)
- *Possible misuse of personal information by third parties* (4 votes)
- *Possible occasional economic penalties in case of failure to deliver the committed demand flexibility* (4 votes)
- *Possible new technology failure or malfunctioning* (3 votes)
- *Lack of previous user experience in a new business market* (3 votes)
- *Initial investment on smart monitoring and control equipment* (3 votes)
- Possible occasional variation of usual comfort preferences (2 votes)
- *Financial remuneration lower than initially expected* (1 vote)

As similar approach is undertaken for the Austrian **Architects**, starting with some generic profiling information.
The respondents Architects indicated that they usually design *Industrial, Residential and Commercial buildings*, while most of them (two out of the three) questioned work with both *public* and *private* clients. In terms of internet connectivity at their offices the majority reported to have fixed internet connectivity and one respondent to have *Wi-Fi,* while *Desktop* is the most common device used for work; followed by the use of a *laptop*. Lastly, two of the respondents reported to be using *Windows* as their operating system and one reported to be using *macOS*.

Going over to the second part of the questionnaire, containing work-specific questions the Austrian Architects reported to be using *ArchiCAD*, *Autodesk Revit* and *AllPlan* typically in their everyday job. The majority of the respondents reported that their applications support export functionality as files (3 votes), and through APIs (1 vote). As further reported by the Arhitects, the most typical data formats for exporting data from these applications are: *IFC, IFCXML, IFCZIP, BCF, NWC, SMC, C4D, 3DM, 3DS, ATL, KML, KMZ, SKP, DAE, EPX, FACT, OBJ, STL, U3D, FBX, TMA, WRL, BIMX, DWG, DXF, DWF, gbXML.*

In the case of tools/systems for handling Building Information Modelling (BIM) model, Architects reported that they typically use the following systems: *AutoCAD*, *ArchiCAD*, *BIM360* and *Autodesk*

Forge, while one respondent specified that he *does not use BIM models*; while the most common data formats exported from their BIM models are: *IFC, IFCXML, BIMX, DWG, DXF, DWF* and *gbXML*.

In order to properly complete their work, one Architect reported to be using *sensing data*; while they find the data they need mostly *by requesting the data needed from other stakeholders* (2 votes) or *trying to work by trusting their own work experience* (1 vote). In regard to the tools used by the Architects to model energy performance, all respondents specified that they *do not model energy performance*. In regard to the security and privacy requirements that Architects have for the building data/ information they manage, most of the respondents reported to be using mostly *protected data* (2 votes), *fully encrypted data* (1 vote) and open data (1 vote).

In the following question, the respondents specified that data of high interest during the energy performance modelling are: *energy consumption data* (2 votes), orientation data (2 votes), materials data (2 votes), operational data (2 votes). Additionally, one Architect specified *Component properties* and *U-values* as data of high interest. When asked if operational energy data are considered during the design phase; the respondents reported that they consider: *building inertia* (1 vote), *number of occupants* (1 vote), *empirical values form realized buildings* (1 vote), while one Architect specified that he *does not take into account operational energy data.*

Two out of the three Architects questioned, reported that they *do not consider occupant's comfort in their calculations,* while only one respondent reported *to be considering occupant's comfort.* Following, two out of the three respondents specified that they *do not consider use of Smart IoT solutions* to monitor indoor comfort and energy consumption; while one Architect reported that utilisation of smart IoT solutions *would not be beneficial for his work*.

Architects reported that in the tools they use for energy performance modelling and simulation, they *do not know* the building control routines applied (2 votes) while one respondent reported that he *is not sure*. Finally, in the last question of the Architects questionnaire, two respondents indicated that they are *not open at all* to adopt more advanced building systems control routines in their tools as a means to increase performance prediction accuracy, while one respondent indicated that makes no difference to him.

Following the summary of the questionnaire analysis for the Austrian **Building Managers** is presented.

Starting with the general questions, the Austrian Building Manager, reported to be equally using his Smartphone, Tablet and Laptop. A Cellular (2G,3G,4G) internet connectivity is available at his building, while only speed restrictions apply to his internet connection.

Going over to the second part of the Building Managers questionnaire, including energy consumption metering and saving questions, the respondent indicated that he *understands a little about the concept of PEBs*; while saving energy and use of renewable energy sources in his building are considered as *important*. The Austrian Building Manager reported that *he is interested* in reducing the energy demand and dependence of his building on grid energy, through the installation of novel smart-ready energy technologies; while he has no specific concerns regarding the installation of smart-ready energy technologies in his building. In addition, the respondent reported that he *would like to monitor his building energy consumption and flexibility,* through a *Mobile application*.

In the third part of the questionnaire including energy sharing and trading questions, the Austrian Building Manager indicated that he *understands the concept of electricity self-consumption, with the exception of some concepts* and that he *wouldn't object* to share his building's flexibility for optimizing the performance of his neighbourhood/ district and maximizing self-consumption.

In the following question the respondent indicated a *positive interest in monitoring* his building's performance in terms of energy consumption and flexibility against the district/community level performance and would prefer to monitor it via a *Mobile app*.

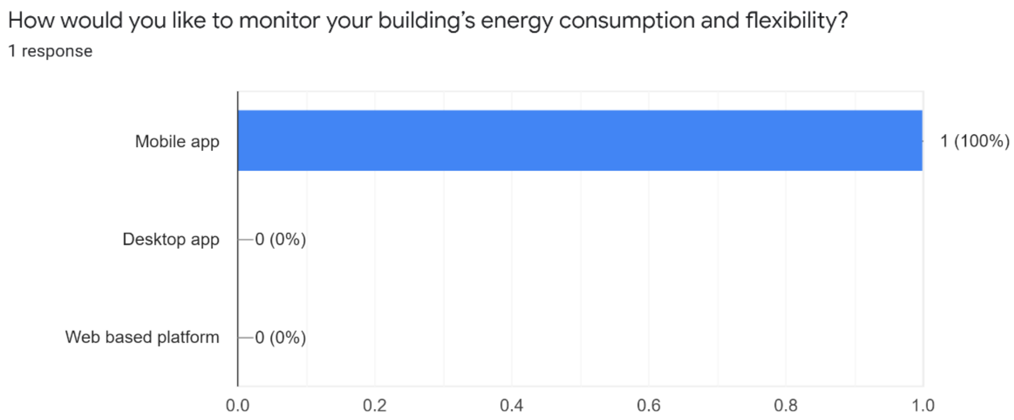

Figure 2-5 Austrian Demo – Building Managers' preferred means to monitor his building's energy consumption and flexibility

In addition, the Austrian Building Manager specified that he *agrees in sharing his building's flexibility and energy consumption* (real-time data) with Aggregators towards participating in flexibility trading.

When asked what aspects are important for the Building Manager towards participating in collective schemes for self-consumption maximization at community level, the respondent rated the following aspects as *Very Important: "Full respect to private information of occupants (not disclosed)*; as *Somewhat Important: "Clear and transparent monitoring and verification mechanisms", "Fair remuneration"* and *"Contribution to the sustainability and greenness of the community;* and as *Neutral* aspects such as*: "Positive experience and feedback given by early entrants to gain confidence".*

In the next question the Austrian Building Manager was asked to rate which aspects would make him feel more uneasy to participate in the local self-consumption schemes at community level. The respondent reported as *Very Important: "Possible misuse of personal information by third parties"* & *"Financial benefits lower than initially expected"; as Somewhat Important: Possible new technology failure or malfunctioning";* and as *Neutral* aspects such as: *"Local exposure and negative reputation effect in case of low performance in comparison with other peers"* and *"Lack of previous user experience in a new service or collaboration scheme".*

Following, the respondent reported that he *is interested in trading his building's non-self-consumed energy in local flexibility* and energy markets towards monetary gains, while the preferred way for communication with the Aggregators regarding the exploitation/trading of his building flexibility is via a *Mobile app*. In regard to the time intervals for receiving alerts/instructions regarding his building unconsumed energy available and flexibility the respondent specified that he prefers to receive notifications *daily*.

The Austrian Building Manager reported that he *would not object* in allowing external stakeholders (i.e. aggregators) to control his devices remotely (based on specific agreements) at specific points in time to optimize his participation in energy/ flexibility trading.

When asked to rate which aspects are important for participating in the demand flexibility remuneration programmes through a demand aggregator, the respondent reported as *Very important aspects such as :"Full respect to comfort standards as stated by the consumer*", "*Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules*" and "*Savings in the energy bills for moving consumptions from high cost periods to low cost periods"*.

Lastly the Austrian Building Manager was asked to rate which aspects would make him feel more uneasy to participate in the demand flexibility markets described above. "Lack of transparency of the contract and the remuneration", *"Possible occasional economic penalties in case of failure to deliver the committed demand flexibility", "Possible misuse of personal information by third parties"* were rated as *Very Important* aspects. As *Somewhat Important* the Building Manager considered the: *"Initial investment on smart monitoring and control equipment"*, *"Possible occasional variation of usual comfort preferences"*; *"Financial remuneration lower than initially expected*" and *"Possible new technology failure or malfunctioning"*; while as a *Neutral* aspect is considered the *"Lack of previous user experience in a new business market*".

2.4.1.2 Belgian Demo Site Analysis

The results from the Belgian Questionnaire analysis are available below for all identified EXCESS end users. In total, 13 questionnaires were answered from the Belgian demo site (1 for Building Occupants, 3 for Architects, 3 for Building Managers, 1 for Aggregators). The outcomes of the questionnaires analysis are first presented for the **Building Occupants**.

For the case of the Belgian demo, answers to the Building Occupants questionnaire were provided by the EXCESS consortium partner Cordium. Cordium is a social housing company responsible for the Belgian demo site, who provided an overview of the 'average' prospect occupant of the Belgian demo site. The responses are presented as follows:

Starting with the generic questions, the prospect Belgian demo's occupants consist of both *males* and *females*, while the indicated age group of the occupants as reported by Cordium is around *47 years* old. The current households are composed of *single-person households*, *two-person households* and *household of 3 people or more* (e.g. family with two or more children). All of the prospect occupants are *renting* their apartments.

Continuing with the technology familiarity and preference questions, Cordium indicated that the main wireless technology devices used by the building occupants are *smartphones* and *tablets*; while *fixed*, *Wi-Fi* and *cellular* internet connectivity is available in the Belgian demo's apartments. In regard to any restrictions in occupants' internet connection, *speed* and *download/upload data quota* restrictions are applied.

As reported by Cordium, the Belgian demo site occupants have often never owned a home, thus they probably never had the need to delve into the concept of PEBs. It is expect that the majority of the Belgian demo occupnats are *unfamiliar with the concept of PEBs*. Nevertheless, saving energy and use of renewable energy sources in their building is reported to be considered from the occupants as *very important.*

Cordium reported that with sufficient explanation and preparation a large part of Belgian demo occupants will *be willing* to apply advance control systems for optimizing energy performance. In regards to what type of system they are willing to accept; Cordium reported *all systems can be possibly accepted*; however it has to be considered that as the occupants do not own their apartments they would probably be interested only in systems that can provide them with advantages and where no extra work for them is expected (eg. allowing people into their home, passing on data,etc).

The most preferred type of devices and assets that occupants would introduce into an advance control framework for self-consumption, as reported is *Heating devices*, *Domestic Hot Water*, *Storage Systems* and *Smart appliances.*

According to Cordium, all of the building Occupants will be interested in reducing their energy demand and dependence on grid energy, through the installation of novel smart-ready energy technologies; while the main concerns regarding the installation of smart-ready energy technologies in the occupants apartments/building will probably have to do with *extra effort* required from the occupants for the installation of such system, *what will be their advantage* and *who will pay for such system*.

In the question asking building occupants, how much they are willing to pay for sensors to be installed inside their houses to measure their living preferences and help them decide on what changes best address their needs, Cordium reported that as the average income of the Belgian demo site occupants' is rather low, they would probably *not want/be able to invest money* in a rental property.

Cordium reported that the Belgian demo site occupants *have never been involved in a project* that assesses their living comfort and/or indoor air quality, however the occupants will *see a value* in having a building tailored to their needs in terms of comfort preferences, as long as guidance and explanation to them is provided.

In regard to the installation of low powered IoT devices installed for a period of time to determine their energy consumption, flexibility and comfort preferences, if privacy was respected; Cordium reported that *occupants may object*, however with appropriate guidance and details they will not. Furthermore, the Belgian demo site occupants will most probably *agree to have such data sensors installed* at their property from more than a year, while in the case of occupants that may disagree, the longest period that they will be willing to have such sensors installed at their apartments is *12 months*.

In the next question regarding aspects that affect occupants living comfort, Cordium indicated indoor temperature as a *very important* aspect, followed by *indoor Luminance* and *IAQ* as *somewhat import* a lastly *indoor humidity* considered as a *neutral* aspect.

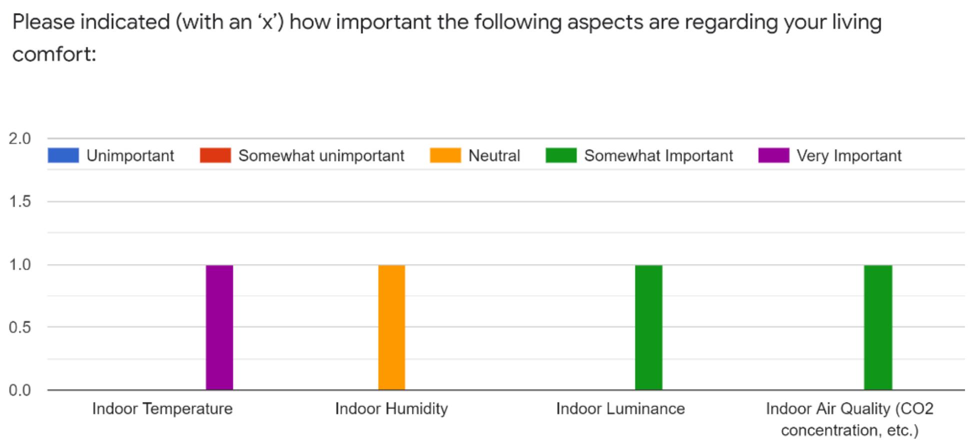

Figure 2-6 Belgian demo - Occupant's indication of aspects considered important for their living comfort

The Belgian demo site occupants *are interested* to monitor their energy consumption and flexibility through visualization applications, via *mobile app*, *desktop* or *web-based platform*. As Cordium further reported the occupants that may not be familiar with such technologies should not be excluded and may be interested in having appointments where their energy consumption and flexibility can be explained to them.

Going into the third part of the building occupants' questionnaire comprising of community energy sharing and trading questions, Cordium indicated that the Belgian demo site occupants will most probably *not understand the concept of electricity self-consumption at all* or *understand it partially*.

In addition, Cordium reported that occupants will most probably *strongly or somewhat agree* with the statement that visualization of their own consumption/energy savings against community level can inspire them towards reducing their energy consumption, leading also to financial profits and environmental benefits. Cordium specified that the Belgian demo site occupants will initially look at the personal financial benefits rather than the social benefits. When occupants basic needs around their comfort is met and there is room to look further, the social benefit will come into consideration from the occupants.

In the following question, Cordium indicated the use of *a mobile application*, *desktop app* and *use of web-based platform* as the most preferred devices for monitoring their position against the district/community level energy consumption and flexibility. Following, building occupants are *not expected to object* in sharing their individual flexibility for optimizing the performance of their neighbourhood/ district and maximizing self-consumption

According to Cordium, the Belgian building occupants recognise as *very important* for considering participating in collective schemes for self-consumption maximization at community level the following aspects: "*Clear and transparent monitoring and verification mechanisms", "Full respect of private information (not disclosed)*", "*Fair renumeration and Positive experience and feedback given by early entrants to gain confidence". "Contribution to the sustainability and greenness of the community"* is considered as *Somewhat Important* towards occupants' participation in such schemes.

In the following question, Cordium indicated aspects considered as important for occupants that would make them feel more uneasy to participate in the local self-consumption schemes at community level. *Very important* aspects include: "Negative reputation in case of low performance in comparison with other peers in the community", "*Possible misuse of personal information by third parties"*, "Financial benefits lower than initially expected". In addition, aspects such as: "*Possible new technology failure or malfunctioning"* and "*Lack of previous user experience in a new service or collaboration scheme"* are considered as *Somewhat Important*.

Overall, all of the Belgian demo site occupants are interest in having an automated control of their building's devices towards reducing energy consumption without sacrificing their comfort preferences, while a *positive interest* in trading their non-self-consumed energy/ flexibility in local flexibility and energy markets towards monetary gains without affecting their comfort is. Towards this direction, Cordium indicated that he most preferable means for communicating with Aggregators regarding the exploitation/trading of their flexibility is the through a *mobile app*, desktop app and a *web-based platform*. Nevertheless, occupants not familiar with the use of such devises should not be excluded.

In regard to having and using smart devices at their homes, Cordium indicated that the building occupants reported that they *like having them but do not usually use them*. Furthermore, Cordium reported that the Belgian demo site occupants *would not object* in allowing external stakeholders (i.e. aggregators) to control their devices remotely (based on specific agreements) at specific points in time to optimize their participation in energy/ flexibility trading, as long as they are informed about how this system works.

Following, Cordium indicated the type of devices that the Belgian demo site occupants would allow an aggregator to monitor and operate automatically, without affecting their comfort, so they can provide service to the grid and get a remuneration for it; such devices include *heating*, *cooling devices* as well as *smart devices*.

When it comes to the frequency of receiving alerts/instructions regarding their unconsumed energy available for trading, Cordium indicated that this will depend on how the occupants can use this system. Those familiar with such technologies will often want to follow this up *daily* on a tablet, *mobile phone, desktop*, but those who need extra explanation will have to receive this *monthly*, for example, through *personal appointments or in groups*.

Cordium reported that all of the Belgian demo site occupants, *are interested* in monitoring the monetary gains generated from trading their flexibility. In order for them to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, Cordium indicated as V*ery Important* aspects such as: "*Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules", "Clear transparent and bilateral contracting with the market representative or service provider company that ensures customer confidence and resolves any potential conflicts"*, "*Full respect to private information (not disclosed)"*, *"Full respect of my comfort standards"*, *"Savings in the energy bills for moving consumptions from high cost periods to low cost periods"* and *"Positive experience and feedback given by early market players to gain confidence".*

As *Somewhat Important* is considered the "*Use of high level inter-communicated smart technologies for automated control of home appliances and devices"*. As *Somewhat Unimportant* are considered aspects such as: "*Contribution to the sustainability and greenness of the National and European electricity system", "Empowerment of small domestic consumers in electricity markets and balancing markets*", while "*Being among the first to participate in a new technologically advanced initiative and give feedback to improve it"* is considered as *Neutral* aspect.

Finally, a similar question, asked occupants to rate aspects that would make them feel more uneasy to participate in the demand flexibility markets described before; Cordium responding on behalf of the Belgian demo site occupants indicated as *Very Important aspects such as*: "Initial investment on smart monitoring and control equipment", "*Financial remuneration lower than initially expected", "Lack of transparency of the contract and the remuneration, business market and Initial investment on smart monitoring and control equipment".* As *Somewhat Important* are considered aspects such as*: "Possible occasional economic penalties in case of failure to deliver the committed demand flexibility", "Possible new technology failure or malfunctioning".* Lastly the *"Lack of previous user experience in a new business market"* is considered as a *Neutral* aspect.

A similar analysis is undertaken for the Belgian **Architects**, starting with some generic profiling information.
The respondents Architects indicated that they usually design all kind of buildings (*Industrial, Commercial, Residential and Public)*, while both of the respondents reported to be working with *both private and public* clients. In terms of internet connectivity at their offices the Belgian Architects reported to have *fixed* and *Wi-Fi* internet connectivity while *laptops* and *smartphone* are the most common device used in their work; Lastly, both of the respondents reported to be using *macOS* as their operating system.

Going over to the second part of the questionnaire, containing work-specific questions the Belgian Architects reported to be using mainly *ArchiCAD* in their everyday job. Both of the respondents reported that their applications support export functionality as files, while the most typical data formats for exporting data from these applications are *IFC* and *DWG.*

In the case of tools/systems for handling Building Information Modelling (BIM) model, both of the Belgian Architects reported that they typically use *ArchiCAD*, while the most common data formats exported from their BIM models are *IFC* files.

In order to properly complete their work, both Architects reported to be using information from other stakeholders; while they find the data, they need mostly *by searching it online in Open BIM libraries.* In regard to the tools used by the Architects to model energy performance, both respondents specified that they *do not model energy performance*. In regard to the security and privacy requirements that Architects have for the building data/ information they manage, both reported to be using mostly *protected data*. Lastly, both Architects questioned, reported that they *do not consider occupant's comfort in their calculations and they do not consider the use of Smart IoT solutions* to monitor indoor comfort and energy consumption.

Following the summary of the questionnaire analysis for the Belgian **Building Managers** is presented, staring with the general questions.
The Belgian Building Managers, reported to be equally using *Smartphones*, *Tablets* and *Laptops*. A *Wi-Fi* internet connectivity is available at their buildings, while only speed restrictions apply to their internet connection.

Going over to the second part of the Building Managers questionnaire, including energy consumption metering and saving questions, two of the respondents indicated that they *understand a lot about the concept of PEBs* and the third one understands *a little about the concept*. The majority of the respondents indicated that saving energy and use of renewable energy sources in their buildings is *very important* and one respondent considers this as *important.* All of the Belgian Building Managers reported that *they are interested* in reducing the energy demand and dependence of their building on grid energy, through the installation of novel smart-ready energy technologies; while none of the respondents reported to have any specific concerns regarding the installation of smart-ready energy technologies in their building. In addition, the respondents reported that they *would like to monitor their building's energy consumption and flexibility,* through a *Mobile application* (3 votes) and via a *web-based platform* (1 vote).

In the third part of the questionnaire including energy sharing and trading questions, two of the respondents indicated that they fully *understand the concept of electricity self-consumption, while one respondent reported to not understand it at all.* Only one of the three respondents indicated that he *would object* to share his building's flexibility for optimizing the performance of his neighbourhood/ district and maximizing self-consumption.

In the next question all respondents specified that they *are interested in monitoring* their building's performance in terms of energy consumption and flexibility against the district/community level performance; while all of the Building Managers would prefer to monitor via a *Mobile app*. In addition, all three Belgian Building Managers questioned specified that they *agree in sharing their building's flexibility and energy consumption* (real-time data) with Aggregators towards participating in flexibility trading.

When asked what aspects are important for the Building Managers towards participating in collective schemes for self-consumption maximization at community level, the respondents rated as Very

Important aspects such as: *"Contribution to the sustainability and greenness of the community* and *Fair renumeration"* (3 votes)*, as Somewhat Important* aspects such as: *"Positive experience and feedback given by early entrants to gain confidence"* (3 votes) *and "Clear and transparent monitoring and verification mechanisms"* (2 votes) *and as Somewhat Unimportant* aspects such as *"Full respect to private information of occupants"* (2 votes).

In the next question Building Managers were asked to rate which aspects would make them feel more uneasy to participate in the local self-consumption schemes at community level. The respondent reported as S*omewhat Important* aspects such as: "*Possible misuse of personal information by third parties"* (3 votes), *as Neutral aspects such as "Lack of previous user experience in a new service or collaboration scheme"* (2 votes), *"Possible new technology failure or malfunctioning*" (2 votes), *"Financial benefits lower than initially expected"* (2 votes). The *"Lack of previous user experience in a new service or collaboration scheme"* is considered by all three respondents as *Somewhat Unimportant.*

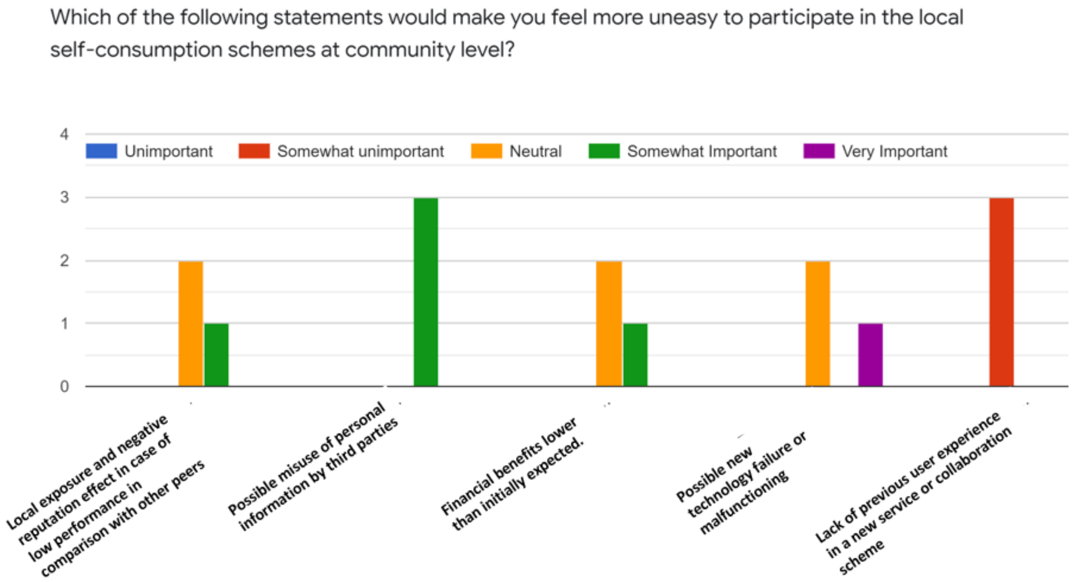

Figure 2-7 Belgian demo – Building Managers' consideration of aspects important in order for them to feel more uneasy to participate in the local self-consumption schemes at community level

Following, all three respondents reported that they are *interested in trading his building's non-self-consumed energy in local flexibility* and energy markets towards monetary gains, while the preferred way for communication with the Aggregators regarding the exploitation/trading of their building flexibility is via a *Mobile app*. In regard to the time intervals for receiving alerts/instructions regarding their building's unconsumed energy available and flexibility the respondents specified that they would prefer to receive *weekly* notifications.

All three Belgian Building Managers reported that they are *interested in monitoring the monetary gains generated from trading their building's flexibility* and *would not object* in allowing external stakeholders (i.e. aggregators) to control their devices remotely (based on specific agreements) at specific points in time to optimize their participation in energy/ flexibility trading. Additionally, two of the three respondents strongly *agreed* that visualization of their building's consumption/energy savings against community level can inspire the building occupants towards reducing their energy consumption, leading also to financial profits and environmental benefits. The third respondent *somewhat agreed* with the above statement.

When asked to rate which aspects are important for participating in the demand flexibility remuneration programmes through a demand aggregator, the respondents reported as: *Very important: "Savings in the energy bills for moving consumptions from high cost periods to low cost periods"* (3 votes)*; "Contribution to the sustainability and greenness of the National and European electricity system by providing clean grid balancing solutions based on demand response and reducing the electricity system gas emissions"* (2 votes); "*Be among the first to participate in a new technologically advanced initiative and give feedback to improve it"* (2 votes*)* and the *"Use of high level inter-communicated smart technologies for automated control of home appliances and devices"* (2 votes). As *Somewhat Important* the questioned building managers indicated the following aspects: *"Full respect to comfort standards as stated by the consumer"* (3 votes)*, "Fair renumeration"* (3 votes) *"Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules*, *"Clear, transparent and unequivocal bilateral contracting with the market representative or service provider company that ensuring customer confidence and conflict resolution mechanisms"* (3 votes) and *"Full respect to private information non-disclosure"* (2 votes)

Lastly the Belgian Building Managers were asked to rate which aspects would make them feel more uneasy to participate in the aforementioned demand flexibility markets. Aspects such as *"Possible occasional economic penalties in case of failure to deliver the committed demand flexibility"* (1 vote) and *"Possible new technology failure or malfunctioning"* were considered as *Very Important.* The Building Managers indicated as *Somewhat Important* aspects such as: "*Possible misuse of personal information by third parties* (3 votes)*,* the *"Lack of transparency of the contract and the remuneration"* (3 votes) and the *"Lack of previous user experience in a new business market"* (2 votes). As *Neutral* aspects the respondents indicated the *"Financial remuneration lower than initially expected"* (3 votes), *"Initial investment on smart monitoring and control equipment"* (2 votes), *"Possible occasional economic penalties in case of failure to deliver the committed demand flexibility"* (2 votes) and *"Possible new technology failure or malfunctioning"* (2 votes). The respondents considered as *Somewhat Unimportant*, the *"Possible occasional variation of usual comfort preferences"* (2 votes). and were rated as *Very Important aspects.*

Lastly the outcomes of the questionnaire analysis of the Belgian **Aggregator** is presented.

Starting with some generic question, the Belgian Aggregator reported to be mainly using wireless devices such as *Laptop*, *Smartphone* and *Tablet*; while *Windows* and *Android* are the operating systems that these devices use.

Going over to the work-specific questions, the Belgian Aggregator reported to be *monitoring their clients electricity consumption both on real time and at periodic basis* and to *have direct access to some of the electricity meters* of their clients. Moreover, the Belgian Aggregator reported to have only personal data information available in his database, while *no information is available* about his clients' electrical devices and equipment at home. In order to identify the flexibility that each client can provide, *Machine Learning techniques* are reported to be used, while human comfort aspects when quantifying flexibility is *not considered* by the Aggregator. The respondent reported to currently providing *Explicit Demand Response through automated controls*, while the provided service offerings respect human well-being in the built environment *in a very accurate and acceptable manner*.

In regard to the types of flexibility sources provided to his clients; the Belgian Aggregator reported to usually contracting *Heating/Cooling loads* and *Domestic Hot Water loads*.

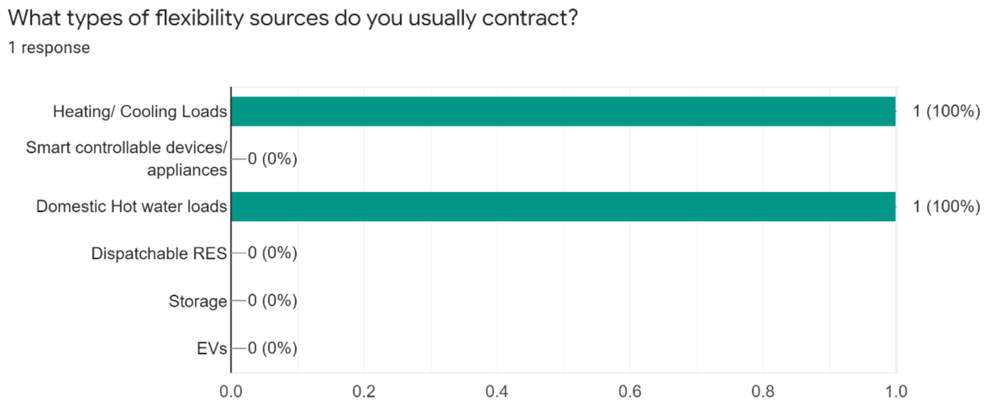

Figure 2-8 Belgian Demo - Aggregators' typical flexibility sources contracts

Following the Belgian Aggregator rated the following aspects regarding demand flexibility for domestic users as *Very Important*: "*Contribute to the electricity system balancing services by means of demand response mechanisms"*. As *Somewhat Important* aspects such as *"Fair remuneration from the participation in DR"*, "*Participate in newly open demand response markets and give access to small domestic consumers*" and *"Improve your control and management over your clients energy consumption and available DERs"*. While aspect such as *"Diversify your business portfolio to mitigate business risks"* is reported as *Somewhat Unimportant*.

Moreover, the Belgian Aggregator rated the following aspects regarding demand flexibility for domestic users, from the aggregators' point of view. As Very Important are considered aspects such as *"Possible new technology failure or malfunctioning"; as Somewhat Important* aspects such as *"*Initial investment on sensoring, and smart monitoring and control equipment" and the *"Lack of transparency of market rules and remuneration settlements"* While aspects such as "Financial remuneration lower than initially expected" and *"Possible economic penalties in case of failure to deliver the committed demand flexibility"* are considered as neutral.

The Belgian Aggregator reported *to be willing to participate in demand response markets as an aggregator of domestic end users' demand flexibility* and rated the following capabilities that a tool for aggregators should integrate:
As *Very Important* the Belgian Aggregator considers "*Security and Data Protection"* capabilities; as *Somewhat Important,* capabilities such as "*Monitoring and data processing of aggregated units",",* "*Demand-response market participation of aggregated units"* and *"Demand-response remuneration system capabilities".*
As *Neutral*, capabilities such as "*Clients Profiling", "Triggering of Demand Response events", "User's communication and feedback management", "Flexibility Analysis, "Flexibility Segmentation", "Flexibility Clustering/VPP"* and "*Signal overrides detection and VPP dynamic re-configuration"*. And lastly as *Somewhat Unimportant* capability the "*Short term accurate generation forecasting"*.

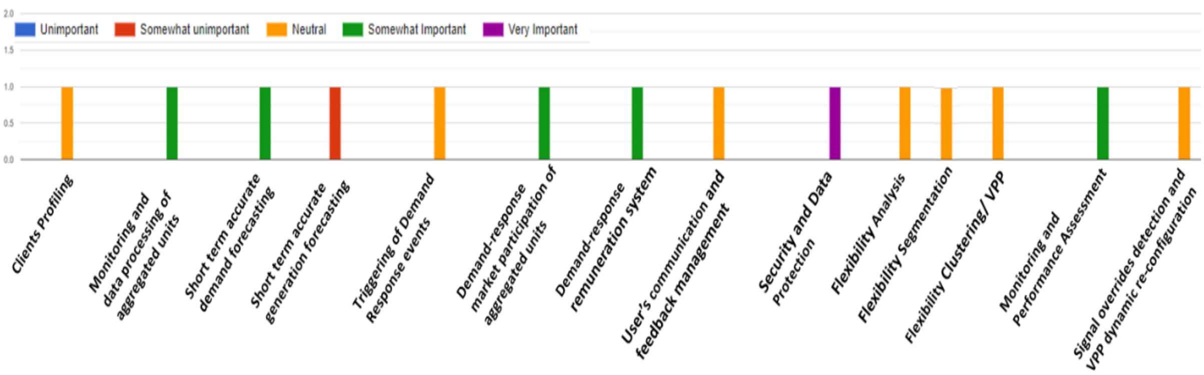

Figure 2-9 Belgian demo - Aggregator's rating of capabilities that a tool for aggregators should integrate

2.4.1.3 Finnish Demo Site Analysis

The results from the Finnish Questionnaire analysis are available below. In total, three questionnaires were answered from the Finnish demo site for Architects. The outcomes of the Finnish **Architects** questionnaire analysis are presented starting with some generic questions.

The respondents Architects indicated that they mostly design *Residential* buildings (3 votes) followed by *Commercial* (2 votes) and *Public* (1 vote), while all three respondents reported to be working with *both private and public* clients. In terms of internet connectivity at their offices the Finnish Architects reported to have *fixed* and *Wi-Fi* internet connectivity while L*aptop* (3 votes) and *Smartphone* (2 votes) are the most common device used in their work followed by *Desktop* (1 vote); Lastly, all of the respondents reported to be using *Windows* as their operating system and one Architect reported to be also using *Android*.

Going over to the second part of the questionnaire, containing work-specific questions the Finnish Architects reported to be using mainly Autodesk Revit (2 votes) as well as *AutoCAD Architecture* (1 vote) and other software such as *Magi CAD, and IDA* in their everyday job. Both of the respondents reported that their applications support export functionality as mainly *as files* (3 votes) and *through* APIs (1 vote), while the most typical data formats for exporting data from these applications are *IFC DWG, FBX.* In the case of tools/systems for handling Building Information Modelling (BIM) model, the Finnish Architects reported that they typically use *Revit* (2 votes) followed by the use of *AutoCAD* (1 vote) and *Solibri Model Checker* (1 vote) while the most common data formats exported from their BIM models are *IFC* files*.*

In order to properly complete their work, the Finnish Architects reported to be using *sensing data* (1 vote); while they find the data they need mostly *by requesting it from other stakeholders* (3 votes) *searching it online in Open BIM libraries* (1 vote), *running surveys* (1 vote) and *trying to work without it trusting their own work experience* (1 vote). In regard to the tools used by the Finnish Architects to model energy performance, one architect specified to be using *TRNSYS* and *IDA, ICE and RIUSKA* while two of the respondents specified that they *do not model energy performance*. In regard to the security and privacy requirements that Architects have for the building data/ information they manage, *open data (available to all involved parties)* are typically used (2 votes) followed by *protected data* (1 vote), and *fully encrypted data* (1 vote). One Architect specified that such systems support import functionality *as APIs*, while the most common data formats supported are *IFC*, *DWG* and *3DS*.

The Finnish Architects consider data of high interest during the energy performance: *energy consumption* (2 votes), *orientation* (2 votes), *materials* (2 votes), *operational data* (1 vote), while one Architect reported to not model energy performance. One of the three Architects questioned, reported that he *does consider occupant's comfort in their calculations* and quantifies it *by using temperature degrees, operating temperature* and *PMV, PPD indices,* while only one of the three respondents specified to *consider the use of Smart IoT solutions* to monitor indoor comfort and energy consumption. Only one Architect reported that the use of smart IoT solutions to monitor indoor comfort and energy consumption *is beneficial for his work,* reporting that *"IDA, ICE or RIUSKA energy simulation tools do not include energy monitoring or control methods"*

In the following question the respondent Architect, reported that he is not sure about the building control routines applied in the energy performance modelling and simulation tools he uses. In the last question, one Architect reported to be rather positive in adopting more advanced building systems control routines in their tools as a means to increase performance prediction accuracy; one architect reported to that this makes no difference, while the third respondent that he is open and that this critical.

2.4.1.4 Spanish Demo Site Analysis

The results from the Spanish Questionnaire analysis are available below for all identified EXCESS end users. In total, 21 questionnaires were answered from the Spanish demo site (15 Building Occupants, 4 for Architects, 2 for Building Managers). The outcomes of the Spanish questionnaire analysis are first presented for the **Building Occupants**:

Starting with the generic questions, the majority of the respondents were *Females*, while most of the building occupants (60%) are *31-49* years old. The majority of the respondents reported that they live in two-*person household* (66.7%), followed by *single-person household* (20%) and *household of 3 people or more* (13.3%). Lastly the majority of the respondents reported *to own their apartment and currently living in it*, while the remaining are *renting* their apartment (46.7%).

Continuing with the technology familiarity and preference questions, the Spanish building occupants reported to be normally using mainly their *Smartphones* (15 votes), followed by Laptop (11 votes) and *Tablet* (10 votes) usage. One occupant reported to be also using his *Smart TV*. *Wi-Fi* internet connectivity (13 votes) is mostly available in their premises; followed by the *fixed* (7 votes) and *cellular* (6 votes) internet connectivity. In regard to any restrictions in their internet connection the majority reported *speed* restrictions (46.2%), while *no other restrictions* were specified from the remaining occupants.

The majority of the building Occupants reported to *have never heard of* about the concept of PEBs (53.3%); while the remaining respondents reported that they *have heard a little of it but don't understand* it (20%) or *understand a little about the concept* (20%). Eight out of the fifteen respondents reported that saving energy and use of renewable energy sources in their building is *very important*, while the remaining seven occupants consider it as *important*.

Twelve of the respondents expressed a *positive willingness to apply advance control systems* for optimizing energy performance, with the majority preferring *Intelligent guidance supported by remote controls and scheduling* (41.7%), followed by *Intelligent guidance allowing manual control* (33.3%) and *Automated control system* (25%). The remaining three Spanish occupants are *not willing advance control systems*.

The most preferred type of devices and assets that occupants would introduce into an advance control framework for self-consumption, as reported is *Heating devices* (10 votes), Cooling devices (10 votes) and *Lighting devices* (10 votes); followed by *Local Generation* (9 votes) and *Storage Systems* (8 votes), *Smart appliances* (8 votes) and lastly *Domestic Hot Water* (7 votes).

According to the responses, eight of the Spanish occupants are *interested in reducing their energy demand and dependence on grid energy*, through the installation of novel smart-ready energy technologies; while the remaining seven occupants expressed concerns regarding the installation of smart-ready energy technologies in his house/building.

In the question asking building occupants, how much they are willing to pay for sensors to be installed inside their houses to measure their living preferences and help them decide on what changes best address their needs, the majority of the respondents (11 votes) reported that they are willing to pay no more the 500€, two occupants reported their willingness to pay no more than 100€ and one occupant is not willing to pay anything. While all respondents reported that they have never been involved in a project that assesses their living comfort and/or indoor air quality, all of them (15 votes) see a value in having a building tailored to their needs in terms of comfort preferences.

Eight out of the fifteen occupants questioned, *expressed their obje*ction in having low powered IoT devices installed for a period of time to determine their energy consumption, flexibility and comfort preferences, if privacy was respected; while five out of the respondents *would not agree* to the installation of data sensors at their property for more than a year. The longest period these five occupants would agree to have such monitoring devices installed at their premises is *6 months* (3 votes) and *1 month* (2 votes)

Overall, the building occupants indicated as *Very Important* regarding their living comfort the *indoor temperature* (14 votes), *indoor air quality* (11 votes), followed by *indoor luminance* (7 votes) and *indoor humidity* (6 votes). The majority of the respondents (93.9%) showed a *positive interest* to monitor their energy consumption and flexibility through visualization applications, with *Mobile app* (11 votes) been reported as the most favourable device for monitoring their energy consumption and flexibility; followed by the use of *Desktop app* (4 votes) and through a *Web- based platform* (1 vote).

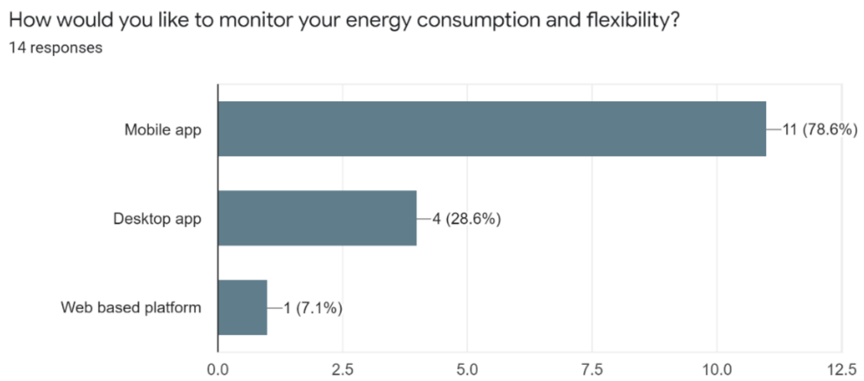

Figure 2-10 Spanish Demo – Building occupants' preferred devices for monitoring their energy consumption and flexibility

Going into the third part of the building occupants' questionnaire comprising of community energy sharing and trading questions, mixed answers were reported. Only four respondents reported to *fully understand the concept of electricity self-consumption*, four occupants reported to *understand it with the exception of some concepts*, four occupants *do not understand it at all*, two respondents *understand it partially* and one occupant *does not understand it but does not mind*. The majority of the Spanish occupants (73.3%) indicated a *positive interest in monitoring their individual performance in terms of energy consumption and flexibility,* in comparison with the district/community level performance. Out of those, nine respondents reported that they *strongly agree* with the statement that visualization of their own consumption/energy savings against community level can inspire them towards reducing their energy consumption, leading also to financial profits and environmental benefits; and the remaining two respondents *somewhat agreed* with the aforementioned statement.

In the following question, the majority of the building occupants indicated the use of a *Mobile app* (8 votes) as the most preferred device for monitoring their position against the district/community level energy consumption and flexibility, followed by the use of *Desktop app* (4 votes) and lastly via a *Web-based platform* (1 vote). Following, two out of the eleven respondents reported that they *will object in sharing their individual flexibility* for optimizing the performance of their neighbourhood/ district and maximizing self-consumption even if privacy of personal information will be respected; while the rest nine indicated no objection.

The building occupants indicated as *Very Important* aspects for considering participating in collective schemes for self-consumption maximization at community level: "*Full respect of private information (not disclosed)"* (10 votes), "*Fair renumeration"* (9 votes), "*Contribution to the sustainability and greenness of the community"* (9 votes), "*Clear and transparent monitoring and verification mechanisms"* (8 votes) and "*Positive experience and feedback given by early entrants to gain confidence*" (5 votes).

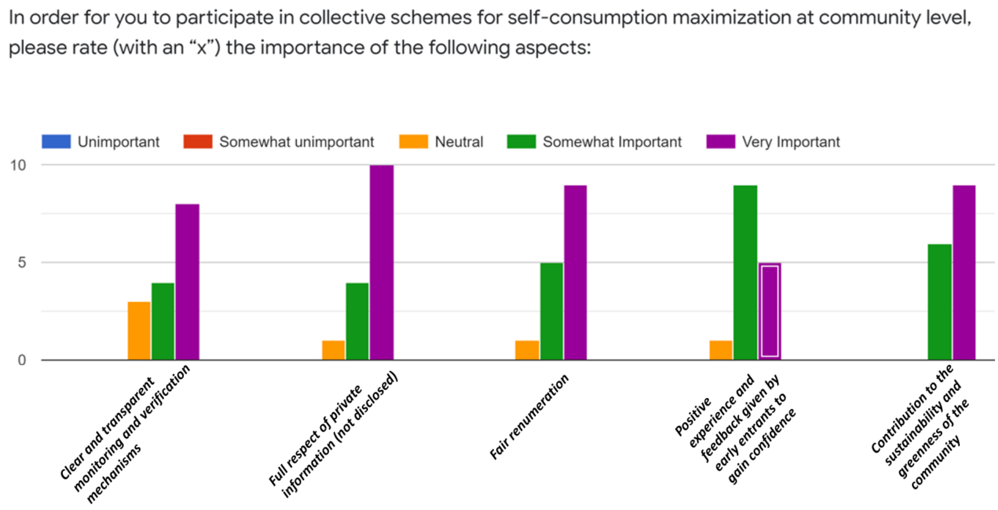

Figure 2-2 Spanish Demo – Building Occupants' indication of aspects important for their participation in collective schemes for self-consumption maximization at community level.

In the following question, asking occupants to rate aspects that would make them feel more uneasy to participate in local self-consumption schemes at community level; occupants indicated as *Very Important* aspects such as "*Possible misuse of personal information by third parties"* (8 votes) and "*Possible new technology failure or malfunctioning"* (6 votes), while as *Somewhat Important* aspects such *"Financial benefits lower than initially expected"* (9 votes), *"Lack of previous user experience in a new service or collaboration scheme"* (9 votes), followed by *"Negative reputation in case of low performance in comparison with other peers in the community*" (7 votes).

Overall, the majority of the respondents (86.7%), indicated their *positive interest in having an automated control of their building's devices* towards reducing energy consumption without sacrificing their comfort preferences, while all questioned occupants indicated a *positive interest in* *trading their non-self-consumed energy/flexibility* in local flexibility and energy markets towards monetary gains without affecting their comfort. Towards this direction, the majority of the respondents reported that the most preferable means for communicating with Aggregators regarding the exploitation/trading of their flexibility is the through a M*obile app* (14 votes) followed by use of a *Desktop app* (4 votes) and via a W*eb-based platform* (2 votes).

In regard to having and using smart devices at their homes, eight of the fifteen building occupants reported that they *like having them but do not usually use them*, five occupants reported that they *like them and they use them*, while the one occupant indicated that *do not like them, but he uses them* and the last occupant reported that he *does not like them and never use them*. When asked if they would object in allowing external stakeholders (i.e. aggregators) to control their devices remotely (based on specific agreements) at specific points in time to optimize their participation in energy/ flexibility trading, six occupants reported that they *would object*, while the rest eight indicated *no objection*.

Following building occupants were asked to indicate the type of their devices they would allow an aggregator to monitor and operate automatically, without affecting their comfort, so they can provide service to the grid and get a remuneration for it. For *electric heating devices*, nine out of the fourteen respondents indicated that they *would allow it,* three occupants would *not allow* it and 2 occupants were *undecided*. For *electric coolin*g devices; nine out of the fourteen respondents indicated that they *would allow it,* four occupants would *not allow* it and one occupant was *undecided*. For *smart devices* eight out of the fourteen respondents indicated that they *would allow* it, while the rest six three occupants would *not allow* it.

When it comes to the frequency of receiving alerts/instructions regarding their unconsumed energy available for trading; *weekly* intervals are the most preferred (8 votes), followed by *monthly* intervals (5 votes) and *daily* intervals (1 vote).

The majority of the respondents are *interested in monitoring the monetary gains generated from trading their flexibility* (86.7%), while in order for them to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, the occupants indicated as *Very important* aspects such as: *"Savings in the energy bills for moving consumptions from high cost periods to low cost periods"* (14 votes), "*Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules"* (13 votes), *"Clear, transparent and bilateral contracting with the market representative or service provider company that ensures customer confidence and resolves any potential conflicts"* (13 votes), *"Fair renumeration based on transparent, clearly communicated methodologies"* (13 votes), "*Full respect to private information (not disclosed)"* (12 votes), "*Full respect of my comfort standards"* (9 votes), "*Empowerment of small domestic consumers in electricity markets and balancing markets*" (7 votes),*"Use of high level inter-communicated smart technologies for automated control of home appliances and devices"* (6 votes), *"Positive experience and feedback given by early market players to gain confidence"* (4 votes), *"Contribution to the sustainability and greenness of the National and European electricity system"* (3 votes) and lastly *"Be among the first to participate in a new technologically advanced initiative and give feedback to improve it"* (2 votes).

Finally, a similar question, asked Spanish occupants to rate aspects that would make them feel more uneasy to participate in the demand flexibility markets described before. The occupants indicated as *Very Important* aspects such as: *"Initial investment on smart monitoring and control equipment"* (10 votes), "L*ack of transparency of the contract and the remuneration*" (10 votes), *"Possible new technology failure or malfunctioning"* (10 votes), *"Possible occasional economic penalties in case of failure to deliver the committed demand flexibility"* (7 votes)*, "Possible misuse of personal information* *by third parties"* (7 votes), "*Lack of previous user experience in a new business market* and *Initial investment on smart monitoring and control equipment*" (5 votes), "*Financial remuneration lower than initially expected"* (4 votes) and *"Possible occasional variation of usual comfort preferences"* (2 votes).

A similar analysis is undertaken for the Spanish **Architects**, starting with some generic profiling information.
The respondents Architects indicated that they usually design all kinds of buildings such as *Industrial, Residential, Commercial buildings and Public buildings*, while the majority work with *private* clients (75%) and the remaining with both *public* and *private* clients. In regard to the internet connectivity available at their offices, the Spanish Architects reported to have *fixed* internet connectivity (3 votes), *Wi-Fi* (2 votes) and one respondent to have *cellular*. The most common device used for work is the *Desktop* (3 votes), followed by the use of a *Laptop (*2 votes). Lastly the respondents reported to be mainly using *Windows* (3 votes) as their operating system, followed by use *macOS* (1 vote) and *Android* (1 vote).

Going over to the second part of the questionnaire, containing work-specific questions the Spanish Architects reported to be using *AutoCAD Architecture (4 votes)*, *Autodesk Revit* (3 votes) and *SketchUp, Design, Photoshop, Presto, Lumion, CYPE, Photoshop* (1 vote) typically in their everyday job. The majority of the respondents reported that their applications support export functionality *as files* (4 votes). As further reported by the Architects, the most typical data formats for exporting data from these applications are: *DWG, DXF, XSI, VRML, FBX, OBJ, 3DS, KMZ, IFC, PSD.*

In the case of tools/systems for handling BIM model, the Spanish Architects reported that they typically use *AutoCAD* (2 votes), one respondent *does not use BIM models* and one uses *CYPE building services program.* The most common data format exported from their BIM models are *IFC*.

In order to properly complete their work, Architects reported to be using *information from occupant surveys* (3 votes), *predefined occupancy schedules from libraries* (2 votes) and *CTE data and passive house standard values* (1 vote). In order to find the required data, the respondents reported to find the data they need mostly *by requesting the data needed from other stakeholders* (3 votes) or *search for it online in Open BIM libraries* (4 votes) and *trying to work by trusting their own work experience* (1 vote).

In regard to the security and privacy requirements that Architects have for the building data/ information they manage, most of the respondents reported to be using *protected data* (4 votes).

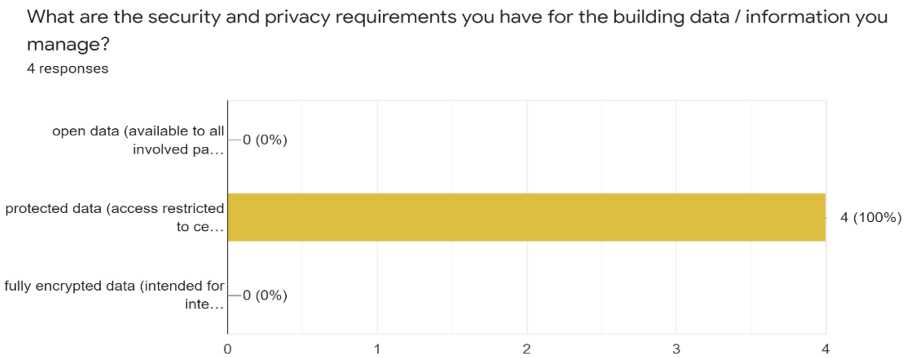

Figure 2-3 Spanish Demo – Architects' security and privacy requirements for their information

In regard to the tools used by the Architects to model energy performance, the Spanish Architects specified that they use *EnergyPlus* (2 votes), the remaining architects reported to *subcontract such* *work.* The respondent reported to be importing data *as files* to these tools, while the data formats supported are *IFC*, *DWG* and *XML*.

In the following question, the respondents specified that data of high interest during the energy performance modelling are: *energy consumption data* (4 votes), *orientation data* (4 votes), *materials data* (4 votes), *operational data (*1 vote), *air tightness and ventilation systems* (1 vote).

When asked if operational energy data are considered during the design phase; the respondents reported that they consider: *building inertia* (4 votes), *occupants' patterns and habits* (3 votes), *number of occupants* (2 votes) and *air tightness and circulation of air* (1 vote).

Three out of the four Architects questioned, reported that they quantify occupant's comfort *with user profiles,* while one respondent reported *to not considering occupant's comfort.* Following, half of the respondents specified that they *do not consider use of Smart IoT solutions* to monitor indoor comfort and energy consumption; while the rest are unsure. Only half of the respondents believe that use of smarty IoT device would be beneficial for their work, reporting that it will be beneficial "to facilitate decision-making in building design".

Three of the four Architects reported that in the tools they use for energy performance modelling and simulation, they *know the building control routines applied*, while one respondent *does not know the routines applied*. Nevertheless, all of the respondents reported to be satisfied with the accuracy of the applied control routines.

Finally, in the last question of the Spanish Architects' questionnaire, two respondents indicated that they are *rather positive* to adopt more advanced building systems control routines in their tools as a means to increase performance prediction accuracy, for one respondent it *makes no difference* and for one considered it *really critical*.

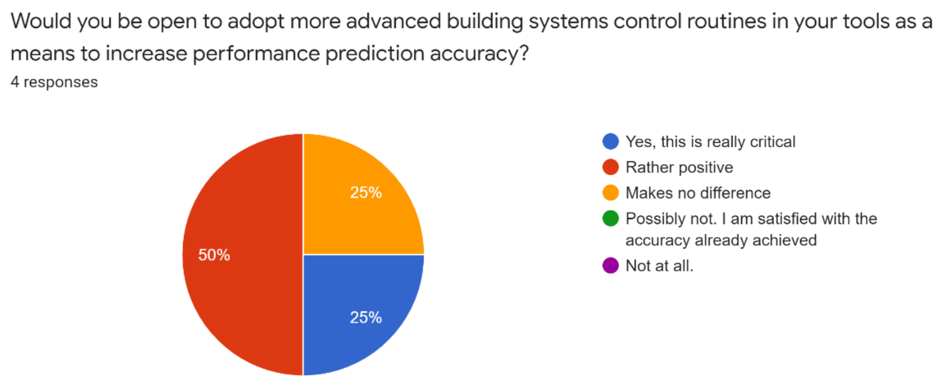

Figure 2-4 Spanish Demo – Architects willingness to adopt more advanced building systems control routines in their tools as a mean to increase performance prediction accuracy.

Following the summary of the questionnaire analysis for the Spanish **Building Managers** is presented, starting with the general questions.

The Spanish Building Managers, reported to be equally using mainly their *Smartphone* (2 votes), followed by use of their *Tablet, Laptop* and *Smart TV* (1 vote). Both *cellular (2G,3G,4G)* and *Wi-Fi* internet connectivity is available at their building, while only *speed* restrictions, *download/upload data quota* and *access time* restrictions apply to their internet connections.

Going over to the second part of the Building Managers' questionnaire, including energy consumption metering and saving questions, one respondent indicated that he *understands a little* about the concept of PEBs and the other respondent understand a lot about the concept of PEBs. Saving energy and use of renewable energy sources in their buildings is considered as *important* and *very important* for the Spanish building Managers. Both the Spanish Building Managers reported that t*hey are interested* in reducing the energy demand and dependence of his building on grid energy, through the installation of novel smart-ready energy technologies; while no one has any specific concerns regarding the installation of smart-ready energy technologies in their building. In addition, the respondent reported that they *would like to monitor their buildings' energy consumption and flexibility*, both through the use of *Mobile app* and *Desktop app*.

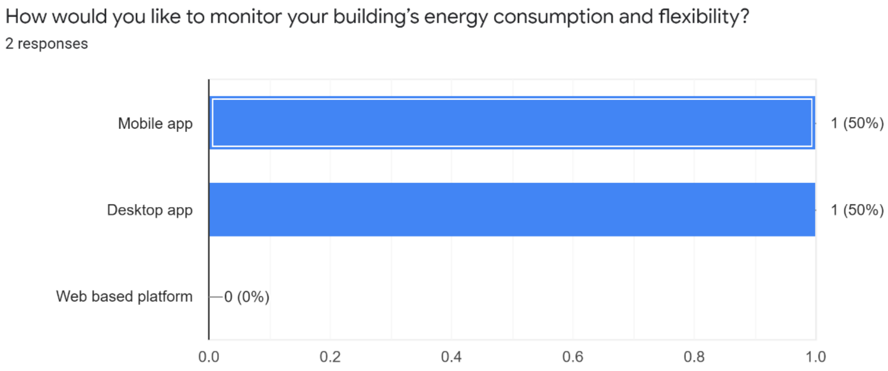

Figure 2-5 Spanish Demo – Building Managers preferred means for monitoring their building's' energy consumption and flexibility

In the third part of the questionnaire including energy sharing and trading questions, the Spanish Building Managers indicated that they *understand the concept of electricity self-consumption and one understands it, with the exception of some concepts.* Out of the two respondents, only one *wouldn't object* to share his building's flexibility for optimizing the performance of his neighbourhood/ district and maximizing self-consumption; while both respondents specified that t*hey are interested in monitoring* their building's performance in terms of energy consumption and flexibility against the district/community level performance. The most preferred means to monitor their building's position against the district/community level is via a *Mobile app* and via a *Desktop app.* In addition, both the Spanish Building Managers specified that they would agree *in sharing their building's flexibility and energy consumption* (real-time data) with Aggregators towards participating in flexibility trading.

When asked what aspects are important for the Building Managers towards participating in collective schemes for self-consumption maximization at community level, the respondents rated as *Very Important* aspects such as : "Full *respect to private information of occupants (not disclosed)"* (2 votes), "*Clear and transparent monitoring and verification mechanisms"* (2 votes)*, "Fair remuneration"* (1 vote), *"Contribution to the sustainability and greenness of the community"* (1 vote) and "*Positive experience and feedback given by early entrants to gain confidence"* (1 vote).

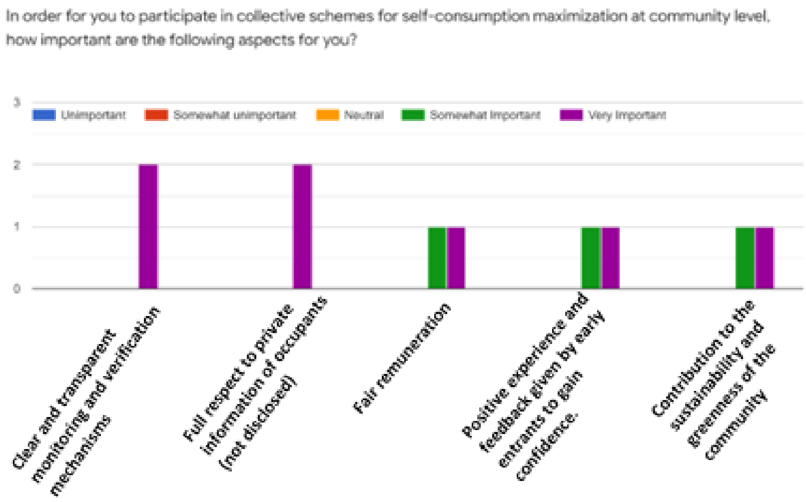

Figure 2-6 Spanish Demo – Building Managers indication of aspects considered important for considering participating *in collective schemes for self-consumption maximization at community level*

In the next question Building Managers are asked to rate which aspects would make them feel more uneasy to participate in the local self-consumption schemes at community level. The respondent reported as *Very Important* aspects such as "*Possible misuse of personal information by third parties"* (2 votes)*, "Financial benefits lower than initially expected"* (1 vote), "*Possible new technology failure or malfunctioning"* (1 vote), "*Local exposure and negative reputation effect in case of low performance in comparison with other peers"* (1 vote) *"Lack of previous user experience in a new service or collaboration scheme"* (1 vote)*.*

Following, the respondents reported that they are both *interested in trading their building's non-self-consumed energy in local flexibility* and energy markets towards monetary gains, while the preferred way for communication with the Aggregators regarding the exploitation/trading of his building flexibility is via a *Web based platform* (2 votes), followed by the use of a *Mobile app* (1 vote). In regard to the time intervals for receiving alerts/instructions regarding their building's unconsumed energy available and flexibility the respondents specified that they prefer at *Daily, Weekly* and *Monthly* intervals.

One of the two Spanish Building Managers reported that he *would not object* in allowing external stakeholders (i.e. aggregators) to control his devices remotely (based on specific agreements) at specific points in time to optimize his participation in energy/ flexibility trading. One respondent *strongly agreed* with the statement that "Visualization of my building's consumption/energy savings against community level can inspire the building occupants towards reducing their energy consumption, leading also to financial profits and environmental benefits", while the other respondent *somewhat agreed*. In the next question both of the Spanish Building Managers reported that they *would not object* in allowing external stakeholders (i.e. aggregators) to control their devices remotely (based on specific agreements) at specific points in time to optimize their participation in energy/ flexibility trading.

When asked to rate which aspects are important for participating in the demand flexibility remuneration programmes through a demand aggregator, the respondent reported as *Very important* aspects such as *"Full respect to comfort standards as stated by the consumer"* (2 votes), "*Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules*" (2 votes), followed by *"Savings in the energy bills for moving consumptions from high cost periods to low cost periods*" (1 vote), "*Clear, transparent and unequivocal bilateral contracting with the market representative or service provider company that ensuring customer confidence and conflict resolution mechanisms* " (1 vote), "Full respect to private information non-disclosure (1 vote), "*Empowerment of small domestic consumers in electricity markets and balancing markets"* (1 vote), "*Fair remuneration* *based on transparent, clearly communicated methodologies"* (1 vote)¸ *"Positive experience and feedback given by early market players to gain confidence"* (1 vote), *"Contribution to the sustainability and greenness of the National and European electricity system by providing clean grid balancing solutions based on demand response and reducing the electricity system gas emissions"* (1 vote), *"Use of high level inter-communicated smart technologies for automated control of home appliances and devices"* (1 vote) and *"Be among the first to participate in a new technologically advanced initiative and give feedback to improve it"* (1 vote).

Lastly the Building Managers were asked to rate which aspects would make them feel more uneasy to consider participating in the demand flexibility markets described above. The Spanish Building Managers consider as *Very Important* aspects such as: *"Possible occasional economic penalties in case of failure to deliver the committed demand flexibility"* (2 votes) *"Possible misuse of personal information by third parties* and *Lack of transparency of the contract and the remuneration"* (2 votes), *"Lack of transparency of the contract and the remuneration"* (2 votes), "*Initial investment on smart monitoring and control equipment"* (1 vote), *"Possible occasional variation of usual comfort preferences"* (1 vote) , *"Financial remuneration lower than initially expected"* (1 vote), *"Possible new technology failure or malfunctioning"* (1 vote), *"Lack of previous user experience in a new business market"* (1 vote).

2.5 EXCESS End Users' needs

In this section, the EXCESS End Users' needs are defined. A non-exhaustive list of needs has been derived following the methodology explained in section 2.2 and the analysis of the questionnaires as described in section 2.4. Before presenting the list of needs, the description of the methodological framework for the taxonomy of the needs is also presented below in order to set a structured way for the management of needs.

2.5.1 Needs Elicitation Phase

The first step of the work as mentioned above is the needs extraction following the analysis of the questionnaires. As a next step, the needs elicitation phase follows. During this phase the requirements, conditions, as well as the constraints of EXCESS are considered and clarified in order to focus only at meaningful and to the point needs.

Undoubtedly, the most reliable method of needs elicitation effort is the one that gets information directly from the proposed end users of the system. Therefore, by considering the questionnaire review phase and further analyzing the different viewpoints of the end users of the demo sites, a non-exhaustive list of end users' needs is derived by taking into account the results of the questionnaires.

2.5.2 Needs Prioritization Phase

Following the end users' needs elicitation phase and once an initial list of end users' needs is defined, a hierarchy and prioritization is performed. The prioritization phase is achieved by considering the responses on the questionnaires and by using the following priority scale to define the most "critical" needs.

- **High**: Needs in this category as defined are a key innovation of the project. These needs are essential in order to achieve the goals of the project and fulfil the end users' objectives.
- **Medium**: These needs are necessary or very helpful in order to set the application prototypes, but not crucial one for the whole system operation.
- **Low**: Needs in this class are not necessary for the EXCESS system. However, they may be considering as important for the fine-tuned operation of the system examined.

Having defined the needs analysis methodology, the following step comprises the extraction of end users' needs as seen in the following section.

2.5.3 EXCESS End Users list of needs

In this section, the final list of the end users' needs for the EXCESS project is presented. Since, a multidimensional analysis has been performed, a taxonomy is considered, presenting initially, the high-level segmentation of the needs to the different type of end users. Moreover, specific segments of needs are also identified (e.g. technical, non-functional needs) in order to complement the list of functional needs in this section.

The template for needs presentation is shown in the following table.

Table 2-4: End User's Needs template

ID	A unique ID for needs taxonomy
End User	Building Occupant, Architect, Building Manager, Aggregator
Description	A Short description of the need
Type	Functional, Non-functional, Technical
Priority	Need Prioritization Level (High, Medium, Low)

A non-exhaustive list of needs as identified from the EXCESS End Users' questionnaire analysis is presented in the next table. The list of extracted needs covers: a) functional needs where the focus of the analysis is on the way the end users are going to experience the core functionalities provided by the EXCESS system and the associated applications available to their use; b) non -functional needs which mainly have to do with the look and feel and the design (i.e. quality characteristics) of the applications along with some technical limitations that have to apply, and c) technical needs which set the basis for the development of the EXCESS framework.

This list of EXCESS end users' needs will facilitate the refinement of the technical specifications as extracted by the detailed description of the Use Cases, leading to the definition of the EXCESS High-Level Architecture and the ICT components specifications in the next chapters.

Table 2-5: EXCESS End Users' Needs

EXCESS End Users' Needs				
ID	End User	Description	Type	Priority
BO-01	Building occupant	Building occupant should be able **to monitor** their **energy consumption** and **flexibility** via a **Mobile app**.	Functional	High
BO-02	Building occupant	Building occupant should be able to **apply advance control** systems, through ***intelligent guidance supported by remote controls and scheduling.***	Functional	High
BO-03	Building occupant	Building occupant should be able to **apply advance control** systems, through ***intelligent guidance allowing manual control*.**	Functional	Medium

BO-04	Building occupant	Building occupant should be able to **apply advance control** systems, through an a***utomated control system***	Functional	Low
BO-05	Building occupant	Building occupant should be able to **apply advance control** systems, through ***automated control*** of their building's devices towards ***reducing energy consumption without sacrificing their comfort preferences***.	Functional	High
BO-06	Building occupant	Building occupant should be able to introduce into an advance control framework for self-consumption **heating devices, *local generation (renewable energy sources)***, ***storage systems*** and ***domestic hot water***.	Functional	High
BO-07	Building occupant	Building occupant should be able to introduce into an advance control framework for self-consumption ***Cooling***, ***Lighting devices*** and ***Smart appliances***.	Functional	Medium
BO-08	Building occupant	Building occupants are interested in **reducing their energy demand and dependence on grid energy**, through the **installation of novel smart-ready energy technologies**.	Functional	Medium
BO-09	Building occupant	Building occupants are interested in having a building tailored to their needs in terms of **comfort preferences**.	Non-Functional	Medium
BO-10	Building occupant	Building occupant should be able to reduce their energy demand and dependence on grid energy, through the **installation of novel smart-ready energy technologies**.	Functional	High
BO-11	Building occupant	Building occupants are interested to get **updates of their comfort preferences**.	Functional	High
BO-12	Building occupant	Building occupants are interested to have knowledge about **indoor temperature**, **IAQ**, **indoor humidity** with lower interest about **indoor luminance**.	Functional	High
BO-13	Building occupant	Building occupants are interested to **monitor** their **energy consumption** and **flexibility** via a **Mobile app**.	Functional	High
BO-14	Building occupant	Building occupants are interested to **monitor** their **energy consumption** and **flexibility** via a **Desktop app**.	Functional	Medium

BO-15	Building occupant	Building occupants are interested to **monitor** their **energy consumption** and **flexibility** through a **Web based platform**.	Functional	Low
BO-16	Building occupant	Building occupants are interested to **monitor** their **individual performance** in terms of energy consumption and flexibility, in **comparison with the district/community level performance.**	Functional	High
BO-17	Building occupant	Building occupants are interested to **monitor** their **individual performance,** in comparison with th**e district/community level performance** via a **Mobile app**.	Functional	High
BO-18	Building occupant	Building occupants are interested to **monitor** their **individual performance,** in comparison with th**e district/community level performance** via a **Desktop app**.	Functional	Medium
BO-19	Building occupant	Building occupants are interested to **monitor** their **individual performance,** in comparison with th**e district/community level performance** through a **Web based platform**.	Functional	Low
BO-20	Building occupant	Building occupants are interested in **sharing their individual flexibility** for optimizing the performance of their neighbourhood/ district and maximizing self-consumption.	Functional	High
BO-21	Building occupant	EXCESS solutions should **fully respect private information**; provide **clear and transparent monitoring and verification mechanisms,** ensure **fair renumeration** and contribute to the **sustainability and greenness of the community**.	Non-functional	High
BO-22	Building occupant	Building occupants are interested in **trading their non-self-consumed energy/flexibility** in local flexibility and energy markets towards monetary gains **without affecting their comfort**.	Functional	High
BO-23	Building occupant	Building occupants should be able to **communicate with Aggregators** regarding the exploitation/trading of their flexibility via a ***Mobile app***	Functional	High
BO-24	Building occupant	Building occupants should be able to **communicate with Aggregators** regarding the exploitation/trading of their flexibility via a ***Desktop app***	Functional	Medium

BO-25	Building occupant	Building occupants should be able to **communicate with Aggregators** regarding the exploitation/trading of their flexibility via a ***Web-based platform***.	Functional	Low
BO-26	Building occupant	Building occupants are willing to allow aggregators to monitor and operate automatically, without affecting their comfort their **electric heating and cooling devices**; so they can provide service to the grid and get a remuneration for it.	Functional	High
BO-27	Building occupant	Building occupants are willing to allow aggregators to monitor and operate automatically, without affecting their comfort their **smart devices**; so they can provide service to the grid and get a remuneration for it.	Functional	Medium
BO-28	Building occupant	Building occupants are interested in getting **alerts/instructions** regarding their unconsumed energy available for trading at **weekly** intervals.	Functional	High
BO-29	Building occupant	Building occupants are interested in **monitoring** the **monetary gains generated from trading their flexibilit**y.	Functional	High
BO-30	Building occupant	Building occupants are interested **in saving energy and use of renewable energy sources** in their building	Functional	High
BO-31	Building occupant	An **internet connection** should be **available in all demo sites** to ensure the interconnection of the demo site and access of the users to the relevant information.	Technical	High
BO-32	Building occupant	A **wireless sensor network** should be available to set the data gathering framework of EXCESS.	Technical	Medium
BO-33	Building occupant	**Low-cost sensors** should be available to monitor **building's indoor environment**, **occupant's comfort conditions** and **buildings' energy consumption**.	Technical	High
BO-34	Building occupant	**Security measures and access policies** should be incorporated at the EXCESS platform in order to ensure the privacy of the data gathered by the users in their premises.	Technical	High
BO-35	Building occupant	EXCESS solutions should **fully respect** building occupants **comfort standards**.	Technical	High

BO-36	Building occupant	EXCESS solutions should **support savings** in the energy bills for **moving consumptions** from high cost periods to low cost periods.	Non-functional	High
BO-37	Building occupant	EXCESS solutions should **contribute to the sustainability** and **greenness** of the National and European electricity system.	Non-functional	Medium
BO-38	Building occupant	EXCESS solutions should ensure **transparency of the contract and the remuneration** and prevent any **possible misuse of personal information by third parties**.	Non-functional	High
AR-1	Architect	EXCESS solutions should be available for both **desktop** and **laptop** use.	Technical	High
AR-2	Architect	EXCESS solutions should be available for **Windows operating systems.**	Technical	High
AR-3	Architect	EXCESS solutions should be available for both **Android** and **macOS** operating systems**.**	Technical	Medium
AR-4	Architect	EXCESS solutions should support export/import functionalities for **files** and through **APIs**.	Technical	High
AR-5	Architect	EXCESS solutions should support data formats such as: *IFC, IFCXML, IFCZIP, BCF, NWC, SMC, C4D, 3DM, 3DS, ATL, KML, KMZ, SKP, DAE, EPX, FACT, OBJ, STL, U3D, FBX, TMA, WRL, BIMX, DWG, DXF, DWF, gbXML.*	Technical	High
AR-6	Architect	Architect should be able to **request the data needed from other stakeholders.**	Functional	Medium
AR-7	Architect	EXCESS solutions should respect privacy of data, supporting **protected data** and **fully encrypted data** through the establishment of an **access policy framework**.	Technical	High
AR-8	Architect	Architects should be able to get insights of **energy consumption data**.	Functional	High
AR-9	Architect	Architects are should be able to get insights of **occupants' comfort data**.	Functional	Medium
BM-1	Building Manager	Building Managers are interested in **saving energy** and **use of renewable energy sources** in their buildings.	Functional	High
BM-2	Building Manager	Building Managers are interested in **installing novel smart-ready energy technologies**, to	Functional	High

		reducing the energy demand and dependence of their building on grid energy.		
BM-3	Building Manager	Building Managers are interested in **monitoring** their **buildings' energy consumption** and **flexibility**, both through the use of **Mobile app** and **Desktop app**.	Functional	High
BM-4	Building Manager	Building Managers are interested in **sharing his building's flexibility** for optimizing the performance of their neighbourhood/ district and maximizing self-consumption.	Functional	High
BM-5	Building Manager	Building Managers are interested via a **Mobile or Desktop app** to **monitor** their **building's performance** in terms of energy consumption and flexibility against the district/community level.	Functional	High
BM-6	Building Manager	Building Managers are interested in **sharing** their **building's flexibility and energy consumption** (real-time data) with Aggregators towards **participating in flexibility trading**.	Functional	High
BM-7	Building Manager	EXCESS solutions should **fully respect private information of occupants**; provide **clear and transparent monitoring and verification mechanisms** and ensure **fair remuneration**.	Non-functional	High
BM-8	Building Manager	Building Managers are interested in **trading** their **building's non-self-consumed energy** in local flexibility and energy markets towards monetary gains.	Functional	High
BM-9	Building Manager	Building Managers should be able via a **Mobile app** or **Desktop app** to **communicate with the Aggregator** regarding the exploitation/trading of their building's flexibility.	Functional	High
BM-10	Building Manager	Building Managers are interested in getting mainly **daily alerts/instructions** regarding their building's unconsumed energy available and flexibility, followed by **weekly** and **monthly** intervals.	Functional	High
BM-11	Building Manager	Building Managers are interested in allowing aggregators to **remotely control** their devices (based on specific agreements) at specific points in time to optimize his participation in energy/flexibility trading.	Functional	High

BM-12	Building Manager	EXCESS solutions should **fully respect *comfort standards as stated by the consumer***, guarantee ***consumer-protecting regulations that ensure customer rights and market rules*** and support **savings in the energy bills for moving consumptions from high cost periods to low cost periods.**	Non-functional	High
AG-1	Aggregator	EXCESS solutions should be available for **laptop, smartphone and tablet** use.	Technical	High
AG-2	Aggregator	EXCESS solutions should be available for both **Windows** and **Android** operating systems**.**	Technical	High
AG-3	Aggregator	EXCESS solutions should **contribute to the electricity system balancing services by means of demand response mechanisms.**	Functional	High
AG-4	Aggregator	Aggregator is interested to participating in demand response markets as an aggregator of **domestic end users' demand flexibility.**	Functional	High
AG-5	Aggregator	EXCESS solutions should provide **security and data protection;** enable ***monitoring and data processing of aggregated units; short term accurate demand forecasting; demand-response market participation of aggregated units*** and provide ***demand-response remuneration system capabilities***.	Functional	High
AG-6	Aggregator	EXCESS solutions should allow **clients profiling; triggering of Demand Response events;** provide ***User's communication and feedback management;*** *provide* **flexibility analysis, flexibility segmentation, flexibility clustering/VPP** and **signal overrides detection and VPP dynamic re-configuration**	Non-functional	Medium
AG-7	Aggregator	EXCESS solutions should enable ***short term accurate generation forecasting***.	Non-functional	Low

In total, 66 "need items" derived from the analysis of the EXCESS end users' questionnaires. The definition of needs will further facilitate the design of the EXCESS ICT system and associated components.

3 EXCESS ICT Components Requirements

In this chapter, the EXCESS ICT components requirements are presented as extracted from the detailed descriptions of the Use Cases in Annex I: Use Cases. From each Use Case, a series of requirements has been derived following the template shown in Table 3-1.

Table 3-1: EXCESS ICT Components Requirements Template

EXCESS ICT Components Requirements Template	
ID	The ID of the requirement (e.g. EXCESS-01, EXCESS-02, etc.)
Component/Framework	The related component or framework to the requirement (e.g. Data Management Platform, Model Predictive Control, etc.)
Partner	The partner that filled-in the requirement
Related Use Case	The Use Case from which the requirement has been extracted.
Description	The description of the requirement.
Type	The type of the requirement (i.e. Functional, Non-Functional, Technical)
Priority	The priority for the realization of the requirement by the EXCESS ICT components (i.e. High, Medium, Low)

The list of the EXCESS ICT components requirements is presented in the following table. These requirements, after also their refinement by incorporating the EXCESS end users' needs defined in the previous chapter, will comprise the basis for the description of the EXCESS High-Level Architecture and the related ICT components in the next chapters.

Table 3-2: EXCESS ICT Components Requirements

EXCESS ICT Components Requirements						
ID	Component/ Framework	Partner	Related UC	Description	Type	Priority
EXCESS-01	Data Analytics Framework (Comfort Profiling component)	CGS	UC10	EXCESS should enable the extraction of accurate user/zone comfort profiles	Functional	High
EXCESS-02	Data Analytics Framework (Comfort Profiling component)	CGS	UC10	EXCESS should enable the extraction of accurate energy behaviour profiles	Functional	High
EXCESS-03	Data Analytics Framework (Demand Forecasting component)	CGS	UC10	EXCESS should correlate weather data with comfort profiles and energy behaviour profiles to deliver demand forecasts	Functional	High
EXCESS-04	Data Management Platform (Data Collection component)	S5	UC11	EXCESS should collect data of different formats (JSON, CSV)	Functional	High

EXCESS-05	Data Management Platform (Data Mapping component)	S5	UC11	EXCESS should map data to the Common Information Model concepts	Functional	High
EXCESS-06	Data Management Platform (Data Collection component)	S5	UC11	EXCESS should collect data about the energy consumption of the building	Functional	High
EXCESS-07	Data Visualizations Framework (Building Managers Visualizations)	S5	UC11	EXCESS should visualize energy-related metrics through dashboards	Functional	High
EXCESS-08	Data Visualizations Framework (Building Managers Visualizations)	S5	UC11	EXCESS should offer comprehensive personalized energy analytics	Technical	High
EXCESS-09	Data Visualizations Framework (Building Managers Visualizations)	S5	UC11	EXCESS should offer comprehensive aggregated (building-level) energy analytics	Technical	High
EXCESS-10	Data Visualisations Framework (Building Managers Visualizations)	S5	UC11	EXCESS should provide energy behaviour analytics through visualizations	Functional	High
EXCESS-11	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	S5	UC12	EXCESS should extract demand flexibility profiling parameters following a training process	Functional	High
EXCESS-12	Data Analytics Framework (Context-Aware Flexibility Analytics and	S5	UC12	EXCESS should acquire historical data regarding devices' operation	Functional	High

	Profiling component)					
EXCESS-13	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	S5	UC12	EXCESS should acquire historical data regarding environmental conditions	Functional	High
EXCESS-14	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	S5	UC12	EXCESS should perform real time calculation of demand flexibility potential at device level	Functional	High
EXCESS-15	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	S5	UC12	EXCESS should perform real time calculation of demand flexibility potential at asset or portfolio level	Functional	High
EXCESS-16	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	S5	UC12	EXCESS should perform short-term forecasting calculation of demand flexibility potential at device level	Functional	High
EXCESS-17	Data Analytics Framework (Comfort Profiling component)	S5	UC16	EXCESS should collect data about indoor temperature through sensors	Technical	High
EXCESS-18	Data Analytics Framework (Comfort Profiling component)	S5	UC16	EXCESS should collect data about air quality through sensors	Technical	High
EXCESS-19	Data Analytics Framework (Comfort Profiling component)	S5	UC16	EXCESS should collect data about control actions by occupants through actuators	Technical	High

EXCESS-20	Data Analytics Framework (Comfort Profiling component)	S5	UC16	EXCESS should monitor the comfort preferences of occupants in a non-intrusive way	Non-functional	High
EXCESS-21	Data Analytics Framework (Comfort Profiling component)	S5	UC17	EXCESS should extract comfort profiles of occupants through analytics algorithms	Functional	High
EXCESS-22	Data Analytics Framework (Comfort Profiling component)	S5	UC17	EXCESS should correlate data streams from ambience sensors and load control actions for comfort profiling	Functional	High
EXCESS-23	Data Analytics Framework (Comfort Profiling component), MPC	S5	UC17	EXCESS should integrate comfort models in building's control system	Functional	High
EXCESS-24	Data Visualizations Framework (Aggregators Visualizations)	S5	UC20	EXCESS should provide comprehensive flexibility analytics at device level	Technical	High
EXCESS-25	Data Visualizations Framework (Aggregators Visualizations)	S5	UC20	EXCESS should provide comprehensive flexibility analytics at portfolio level	Technical	High
EXCESS-26	Data Visualizations Framework (Aggregators Visualizations)	S5	UC20	EXCESS should allow aggregators to configure dynamic VPPs to address network operator's requirements	Functional	High
EXCESS-27	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC20, UC22	EXCESS should verify VPPs against their flexibility capabilities	Functional	High
EXCESS-28	Blockchain applications (EDR app)	S5	UC20	EXCESS should verify VPPs against contractual terms between aggregators and building occupants	Functional	High
EXCESS-29	Blockchain applications (EDR app)	S5	UC20	EXCESS should communicate the completion of a flexibility activation event to aggregators	Functional	High
EXCESS-30	Blockchain applications (EDR app)	S5	UC20	EXCESS should communicate the remuneration details to building	Functional	High

				occupants once a flexibility activation event is settled		
EXCESS-31	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC20, UC22	EXCESS should enable optimal VPP configuration	Functional	High
EXCESS-32	Blockchain applications (EDR app)	S5	UC21	EXCESS should enable building occupants to offer their flexibility for trading in local energy market	Functional	High
EXCESS-33	Blockchain applications (EDR app)	S5	UC21	EXCESS should enable aggregators to search upon assets that offer their flexibility with specific criteria	Functional	High
EXCESS-34	Blockchain applications (EDR app)	S5	UC21	EXCESS should enable the creation of blockchain flexibility contracts between aggregators and building occupants	Functional	High
EXCESS-35	Blockchain applications (EDR app)	S5	UC21	EXCESS should allow building occupants to accept blockchain flexibility contracts	Functional	High
EXCESS-36	Blockchain applications (EDR app)	S5	UC21	EXCESS should allow building occupants to decline blockchain flexibility contracts	Functional	High
EXCESS-37	Blockchain applications (EDR app)	S5	UC21	EXCESS should allow building occupants to negotiate blockchain flexibility contracts	Functional	High
EXCESS-38	Blockchain applications (EDR app)	S5	UC23	EXCESS should enable building occupants to view their potential offered flexibility per device	Functional	High
EXCESS-39	Blockchain applications (EDR app)	S5	UC23	EXCESS should enable building occupants to view the activation frequency of their contracted flexibility	Functional	High
EXCESS-40	Blockchain applications (EDR app)	S5	UC23	EXCESS should enable building occupants to view the activation duration of their contracted flexibility	Functional	High
EXCESS-41	Blockchain applications (EDR app)	S5	UC23	EXCESS should enable building occupants to view the remuneration of their contracted flexibility	Functional	High
EXCESS-42	Blockchain applications (EDR app)	S5	UC23	EXCESS should inform building occupants about the details of an expected demand response event	Functional	High
EXCESS-43	Blockchain applications (EDR app)	S5	UC23	EXCESS should inform building occupants about the anticipated automated device control actions of an expected demand response event	Functional	High

EXCESS-44	Blockchain applications (EDR app)	S5	UC23	EXCESS should allow building occupants to accept the participation in an expected demand response event	Functional	High
EXCESS-45	Blockchain applications (EDR app)	S5	UC23	EXCESS should allow building occupants to decline the participation in an expected demand response event	Functional	High
EXCESS-46	Blockchain applications (EDR app)	S5	UC23	EXCESS should enable building occupants to monitor the evolution of a demand response event	Functional	High
EXCESS-47	Data Visualizations Framework (Building Managers Visualizations)	S5	UC24	EXCESS should enable building occupants to understand their flexibility characteristics through appropriate dashboards and visualizations	Functional	High
EXCESS-48	Data Visualizations Framework (Building Managers Visualizations)	S5	UC24	EXCESS should present analytics to the building occupants over historical data regarding their individual devices and assets	Functional	High
EXCESS-49	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	S5	UC24	EXCESS should reveal patterns on the flexibility of each of the individual devices and assets of building occupants	Functional	High
EXCESS-50	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)		UC24	EXCESS should gather data streams for processing and profiling flexibilities of individual devices and assets	Functional	High
EXCESS-51	Data Visualizations Framework (Building Managers Visualizations)	S5	UC24	EXCESS should present to building occupants generation forecasts for the short-term	Functional	High
EXCESS-52	Data Visualizations Framework (Building	S5	UC24	EXCESS should present to building occupants generation forecasts for the mid-term	Functional	High

	Managers Visualizations)					
EXCESS-53	Data Visualizations Framework (Building Managers Visualizations)	S5	UC24	EXCESS should present to building occupants demand forecasts for the short-term	Functional	High
EXCESS-54	Data Visualizations Framework (Building Managers Visualizations)	S5	UC24	EXCESS should present to building occupants demand forecasts for the mid-term	Functional	High
EXCESS-55	Data Management Platform (Data Mapping component)	VITO	UC11	EXCESS should provide the transformation of demo site specific data models to the Common Information Model concepts	Technical	High
EXCESS-56	Data Management Platform	VITO	General	EXCESS should support inter-platform interaction (components running on different platforms)	Technical	High
EXCESS-57	Data Management Platform (Data Collection component)	VITO	General	EXCESS should support data updated at a per minute granularity	Technical	High
EXCESS-58	Data Management Platform	VITO	General	EXCESS should allow only secure communication.	Non-functional	High
EXCESS-59	Data Management Platform	VITO	General	EXCESS should provide an authentication and authorization mechanism.	Technical	High
EXCESS-60	Data Management Platform	VITO	General	EXCESS should be able to handle authentication and authorization mechanisms provided by remote platforms (for instance to access the remote REST API in the distributed information system).	Technical	High
EXCESS-61	Data Analytics Framework (Generation Forecasting component)	VITO	UC10	EXCESS should provide PV-T thermal energy forecasts.	Functional	High
EXCESS-62	Data Analytics Framework (Generation Forecasting component)	VITO	UC10	EXCESS should provide PV-T electrical energy forecasts.	Functional	High

EXCESS-63	Data Analytics Framework (Generation Forecasting component)	VITO	UC10	EXCESS should provide wind turbine energy production forecasts.	Functional	High
EXCESS-64	Data Management Platform (Data Collection component)	VITO	UC10	EXCESS should provide weather forecast data (outside temperature).	Functional	High
EXCESS-65	Data Analytics Framework (Demand Forecasting component)	VITO	UC10	EXCESS should provide heat demand (consumer demand) forecasts	Functional	High
EXCESS-66	MPC	VITO	UC13, UC15	EXCESS should support tracking of potential deviation of an agreed control plan at a minute rate	Functional	High
EXCESS-67	Data Analytics Framework (Context-Aware Flexibility Analytics and Profiling component)	VITO	UC12	EXCESS should provide flexibility profiles	Functional	High
EXCESS-68	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different input values of PVT	Technical	High
EXCESS-69	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different output values of PVT	Technical	High
EXCESS-70	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different input values of multi-façade elements	Technical	High
EXCESS-71	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different output values of multi-façade elements	Technical	High

EXCESS-72	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different input values of Multi-Ground-Source Heat Pumps	Technical	High
EXCESS-73	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different output values of Multi-Ground-Source Heat Pumps	Technical	High
EXCESS-74	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different input values of Thermal Storage with Power to Heat elements	Technical	High
EXCESS-75	Data Management Platform (Data Storage component)	CENER (and simulation partners)	UC1, UC2, UC3	EXCESS should provide access to the different output values of Thermal Storage with Power to Heat elements	Technical	High
EXCESS-76	MPC	CENER (and simulation partners)	UC15	EXCESS should provide access to the status of the different control elements in the energy installation	Technical	High
EXCESS-77	MPC	CENER (and simulation partners)	UC15	EXCESS should provide access to the historical data of the different control elements in the energy installation	Technical	High
EXCESS-78	MPC	CENER (and simulation partners)	UC15	EXCESS should define a control strategy that will lead to achieve the PEB objectives	Functional	High
EXCESS-79	MPC	CENER (and simulation partners)	UC15	EXCESS should enable the communication between the MPC and the control devices in the energy installation	Technical	High

EXCESS-80	MPC	CENER (and simulation partners)	UC15	EXCESS should provide access to the set-point conditions on the different elements in the energy installation	Technical	High
EXCESS-81	MPC	CENER (and simulation partners)	UC15	EXCESS should provide access to the operational status of the different elements in the energy installation	Technical	High
EXCESS-82	MPC	CENER (and simulation partners)	UC15	EXCESS should store the set-point indoor conditions	Functional	High
EXCESS-83	MPC	CENER (and simulation partners)	UC15	EXCESS should store the operating indoor conditions	Functional	High
EXCESS-84	MPC	CENER (and simulation partners)	UC15	EXCESS should store the user occupancy in the apartments	Functional	High
EXCESS-85	MPC	CENER (and simulation partners)	UC15	EXCESS should store the energy consumption of HVAC	Functional	High
EXCESS-86	MPC	CENER (and simulation partners)	UC15	EXCESS should store the energy consumption of DHW	Functional	High
EXCESS-87	MPC	CENER (and simulation partners)	UC15	EXCESS should provide the user occupancy behaviour forecasting	Functional	High
EXCESS-88	MPC	CENER (and simulat	UC15	EXCESS should provide access to weather forecasts	Functional	High

		ion partner s)				
EXCESS-89	Data Management Platform (Data Collection component)	CENER	UC12	EXCESS should enable the upload of data in .csv format	Technical	High
EXCESS-90	Data Management Platform	CENER	UC15	EXCESS should enable the communication with Ethernet TCP/IP protocols	Technical	High
EXCESS-91	Data Analytics Framework (Generation Forecasting component)	JR	UC10	EXCESS should use weather data to deliver high resolution generation forecasts	Functional	High
EXCESS-92	Data Analytics Framework (Demand Forecasting component)	JR	UC10	EXCESS should use weather data to deliver high resolution demand forecasts	Functional	High
EXCESS-93	Data Management Platform (Data Collection component)	TSI	UC14	EXCESS should provide real time (e.g. every minute) consumption values at dwelling level	Functional	High
EXCESS-94	Data Management Platform (Data Collection component)	TSI	UC14	EXCESS should provide real time (e.g. every minute) consumption values at community level	Functional	High
EXCESS-95	Data Management Platform (Data Collection component)	TSI	UC14	EXCESS should provide real time (e.g. every minute) production values at community level	Functional	High
EXCESS-96	Data Analytics Framework (Demand Forecasting component)	TSI	UC14	EXCESS should provide short-term (e.g. 1h to 2h) consumption forecasts at community level	Functional	High
EXCESS-97	Data Analytics Framework (Demand Forecasting component)	TSI	UC14	EXCESS should provide mid-term (e.g. 6h to 12h) consumption forecasts at community level	Functional	High

EXCESS-98	Data Analytics Framework (Generation Forecasting component)	TSI	UC14	EXCESS should provide short-term (e.g. 1h to 2h) production forecasts at community level	Functional	High
EXCESS-99	Data Analytics Platform (Generation Forecasting component)	TSI	UC14	EXCESS should provide mid-term (e.g. 6h to 12h) production forecasts at community level	Functional	High
EXCESS-100	Blockchain applications (OBS App)	TSI	UC14	EXCESS should visualize consumption rates	Functional	High
EXCESS-101	Blockchain applications (OBS App)	TSI	UC14	EXCESS should visualize production rates	Functional	High
EXCESS-102	Blockchain applications (OBS App)	TSI	UC14	EXCESS should visualize consumption forecasts	Functional	High
EXCESS-103	Blockchain applications (OBS App)	TSI	UC14	EXCESS should visualize production forecasts	Functional	High
EXCESS-104	Blockchain applications (OBS App)	TSI	UC25	EXCESS should provide information on internal energy pricing to project monetary gains	Functional	High
EXCESS-105	Blockchain applications (OBS App)	TSI	UC25	EXCESS should provide information on external energy pricing to project monetary gains	Functional	High
EXCESS-106	Blockchain applications (OBS App)	TSI	UC25	EXCESS should enable prosumers to define incentives and distribution of profits	Functional	High
EXCESS-107	Blockchain applications (OBS App)	TSI	UC25, UC26	EXCESS should display indicators of occupants' energy optimization	Functional	High
EXCESS-108	Blockchain applications (OBS App)	TSI	UC25	EXCESS should display information about incentives for occupants	Functional	High
EXCESS-109	Blockchain applications (OBS App)	TSI	UC25	EXCESS should display information about profits for prosumers	Functional	High
EXCESS-110	Blockchain applications (OBS App)	TSI	UC25, UC26	EXCESS should display information on energy rankings	Functional	High
EXCESS-111	Blockchain applications (OBS App)	TSI	UC25, UC26	EXCESS should display information on energy scores	Functional	High
EXCESS-112	Data Management Platform (Data	VTT	UC1, UC2, UC3	EXCESS should provide the input data of all the components used	Functional	High

	Collection component)					
EXCESS-113	Data Management Platform (Data Storage component)	VTT	UC1, UC2, UC3	EXCESS should provide the output data of all the components used	Functional	High
EXCESS-114	MPC	VTT	UC4	EXCESS should enable the PVT control for better control of the thermal storage	Functional	High
EXCESS-115	MPC	VTT	UC5	EXCESS should enable the excess energy from the PVT to be stored or exported to the grid	Technical	High
EXCESS-116	MPC	VTT	UC6	EXCESS should enable the energy system to maximize the renewable energy generation	Technical	High
EXCESS-117	MPC	VTT	UC6, UC7	EXCESS should enable the energy storage to maximize the renewable energy generation	Technical	High
EXCESS-118	MPC	VTT	UC9	EXCESS should monitor the set points of storages	Functional	High
EXCESS-119	MPC	VTT	UC9	EXCESS should control the set points of storages	Functional	High
EXCESS-120	MPC	VTT	UC9	EXCESS should monitor the set points of the building's demands	Functional	High
EXCESS-121	MPC	VTT	UC9	EXCESS should control the set points of the building's demands	Functional	High
EXCESS-122	MPC	VTT	UC10, UC11, UC13	EXCESS should provide forecasts based on the weather, generation, cost and demand for flexibility	Functional	High
EXCESS-123	MPC	VTT	UC10, UC11, UC13	EXCESS should provide data on the weather, generation, cost and demand for flexibility	Functional	High
EXCESS-124	MPC	VTT	UC10, UC11, UC13	EXCESS should modulate the system based on the weather, generation, cost and demand for flexibility	Functional	High
EXCESS-125	MPC	VTT	UC18, UC19	EXCESS should monitor the indoor environment	Functional	High
EXCESS-126	MPC	VTT	UC18, UC19	EXCESS should control the indoor environment	Functional	High
EXCESS-127	MPC	AEE	UC10	EXCESS should provide PV electrical energy forecasts for partially shaded façade integrated PV areas	Functional	High
EXCESS-128	MPC	S5	UC8	EXCESS should enable storing excess electricity DHW tanks for later use (transforming power/ electricity to heat/ hot water)	Technical	High

EXCESS-129	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC22	EXCESS should enable aggregators to evidently create clusters of flexibility	Functional	High
EXCESS-130	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC22	EXCESS should enable aggregators to address grid requirements set by DSOs	Functional	High
EXCESS-131	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC22	EXCESS should allow aggregators through the UI of the application to constantly monitor the performance of their established clusters/ VPPs	Functional	High
EXCESS-132	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC22	EXCESS should enable aggregators to identify potential overrides over flexibility triggers addressed to specific customers	Functional	High
EXCESS-133	Data Analytics Framework (Dynamic VPP Configuration component)	S5	UC22	EXCESS should enable the dynamic re-configuration of VPPs	Functional	High

3.1 Requirements mapping to EXCESS Components, Business Scenarios and Use Cases

The mapping of the different EXCESS ICT components requirements to the different EXCESS Business Scenarios (BSs), Use Cases (UCs) and EXCESS components/frameworks is depicted in the following figures, using as input the information depicted in Table 3-2. Upon the definition and selection of the final EXCESS BSs, these were mapped to one or more UCs, which define in detail the technical perspective of the business needs. Following each UC is mapped to one or more EXCESS components which in turn are associated with a list of requirements to be met. Figure 3-1 below presents the total number of requirements associated with the seven Business Scenarios identified from the consortium.

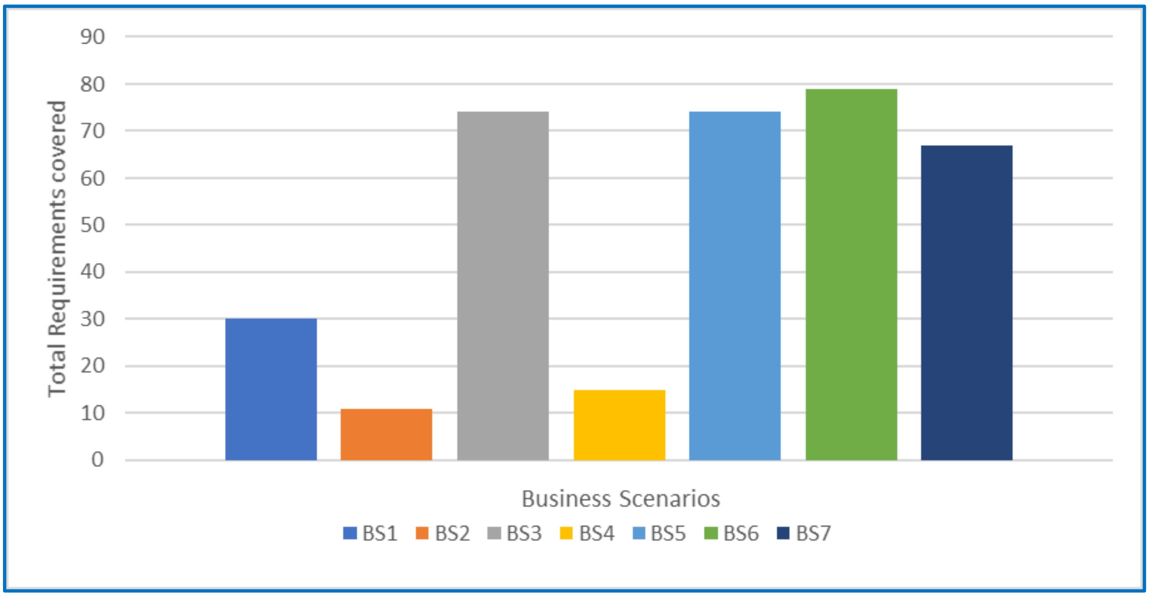

Figure 3-1: Total no. of EXCESS requirements mapped to each Business Scenario (BS)

The total number of requirements derived from each of the twenty six Use Cases is presented in Figure 3-2; while Figure 3-3 presents the total number of requirements associated with each of the five EXCESS ICT components namely the Data Management Platform, the Data Analytics Framework, the Data Visualisation Framework, the Blockchain Applications and the MPC. Also, in Figure 3-4, the total number of Business Scenarios and Use Cases associated with each different EXCESS user is depicted.

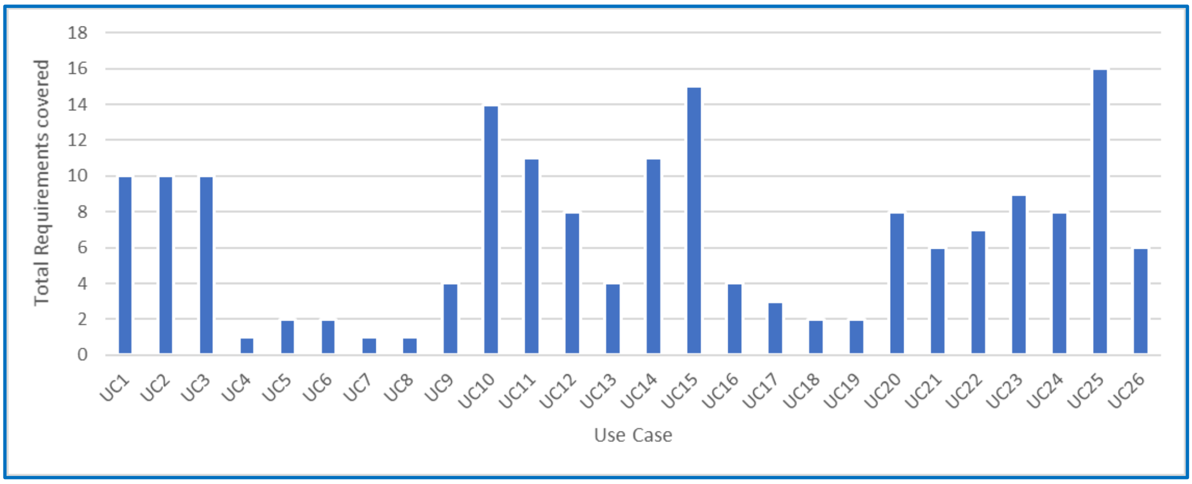

Figure 3-2: Total no. of EXCESS requirements mapped to each Use Case (UC)

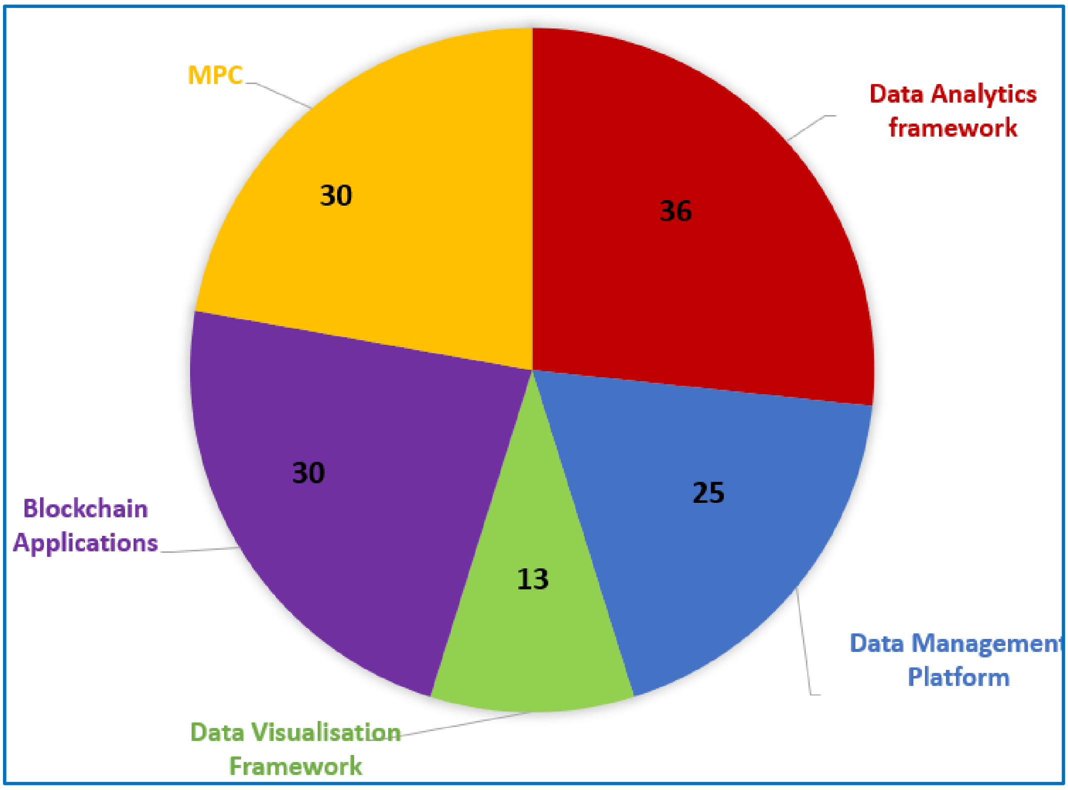

Figure 3-3: Total no. of EXCESS requirements mapped to each EXCESS ICT component

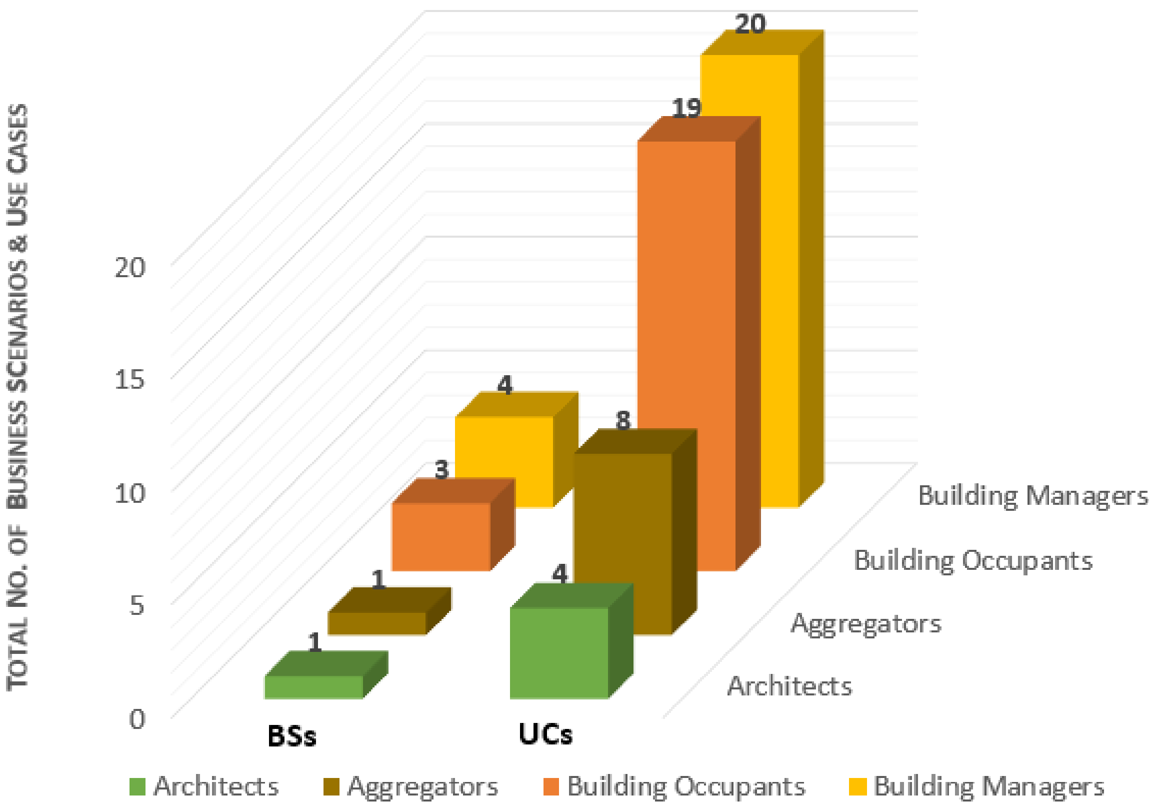

Figure 3-4: Total number of Business Scenarios and Use Cases per associated EXCESS user

In more detail, Figure 3-5 illustrates the overall mappings between the BSs and the UCs along with the links of each UC to the EXCESS ICT components; whereas each component is associated with a list of EXCESS specific requirements.

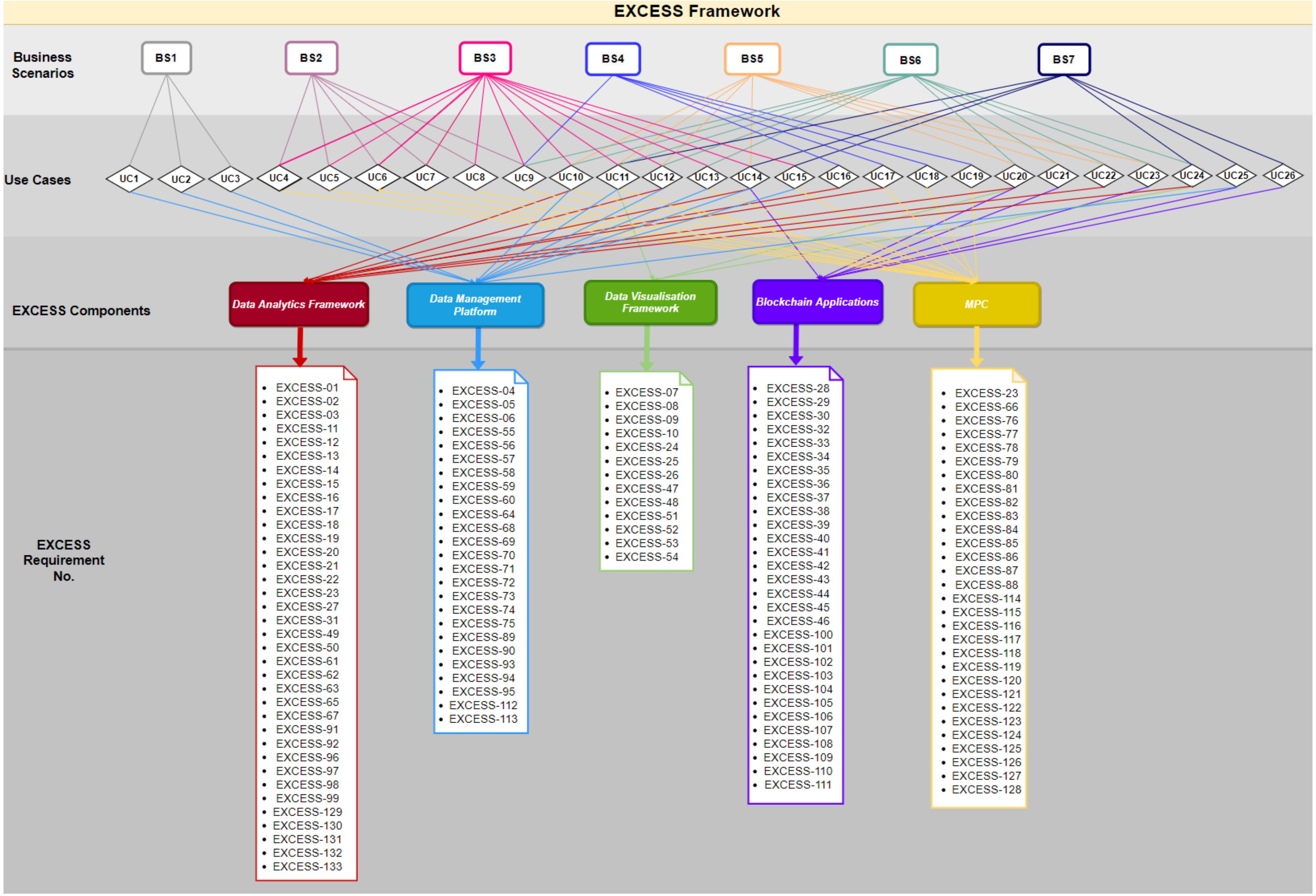

Figure 3-5: Mappings of Business Scenarios to Use Cases and EXCESS Components along with the associated Requirements

4 EXCESS High-Level Architecture

4.1 Architectural Overview

The EXCESS system shall manage data coming from various devices and energy components in order to perform its operations and lead to the achievement of PEB concept in the demo site buildings. The necessary data for the operations of the EXCESS system will be provided by the **Distributed Information Systems** of each demo site, which will communicate with the various energy components, submeters and sensors installed in the demo site buildings. In general, the main technologies of the energy components that will be involved in the EXCESS project are:

- PVT balcony
- PVT with Ground-Source Heat Pumps
- Multi-façade elements
- Ground-Source Heat Pumps with Boreholes
- Heat Pump with Domestic Hot Water
- Thermal Storage with Power to Heat elements

The data that the Distributed Information Systems will provide will regard energy demand, energy generation, energy storage and energy components operation along with buildings' ambient indoor conditions and weather conditions (e.g. both indoor and outdoor temperature, humidity, luminance, etc.).

The EXCESS ICT Architecture, which will manage the data coming from the Distributed Information Systems of the demo sites, is depicted in the following image and includes the **EXCESS Data Management Platform**, the **EXCESS Data Analytics Framework**, the **Model Predictive Control Component**, the **EXCESS Data Visualizations Framework** and the **EXCESS Blockchain Infrastructure and Applications**. These main components of the EXCESS ICT Architecture will be described in the following sections.

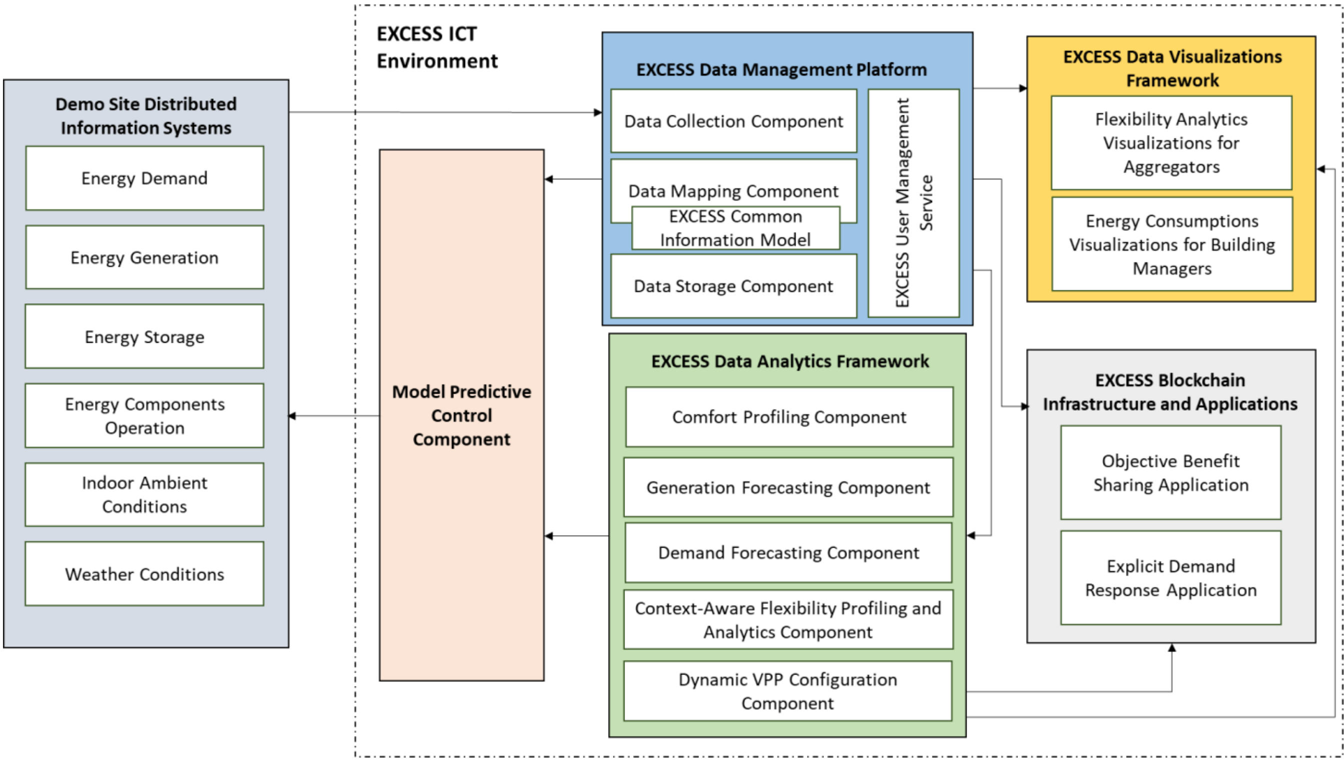

Figure 4-1: EXCESS High-Level ICT Architecture

4.2 EXCESS Data Management Platform

The EXCESS Data Management Platform comprises the cornerstone of the EXCESS ICT Architecture as it will be responsible for the collection and management of all types of data coming from the various sensors, submeters and energy components of the Distributed Information Systems in the four demo sites. The Data Management Platform will consist of different components that will perform the different necessary data management processes, so that the collected data can then be used for analytical purposes by the Data Analytics Framework, for control strategies optimization by the MPC component and for the operations of the visualization and blockchain applications.

The **EXCESS User Management Service** facilitates the authentication and authorization of users in the EXCESS Data Management Platform. It performs the necessary authentication mechanisms for entering the platform, while setting the different types of users and user groups. It also defines the access rights control in the EXCESS Data Management Platform, specifying in this way which datasets can be accessed by certain users or user roles and ensuring that no unauthorized data access is performed. The EXCESS User Management Service also includes a bundle of usage analytics and activity logs for presenting information regarding the actions of the users in the EXCESS Data Management Platform.

The **Data Collection component** enables the ingestion of data through various ways, such as (a) uploading of files, (b) acquisition through external APIs offered by the local platforms of the demo sites and (c) Pub/Sub messaging. The Data Collection component facilitates the ingestion of different types of data, such as energy consumption data, weather data and indoor ambient conditions data, with various formats. In addition, the Data Collection component enables the curation of datasets in case of any erroneous data.

In the context of the Data Management Platform, the **EXCESS Common Information Model** will be developed in order to semantically model all the necessary information regarding the development, installation, deployment and operation of the EXCESS system. The EXCESS Common Information Model will constitute a common language for all the different datasets that will reside in the EXCESS Data Management Platform enhancing their alignment and interoperability. Using the Common Information Model, the **Data Mapping component** will enable the mapping of the elements of the ingested datasets to the equivalent concepts of the Common Information Model, facilitating in this way the further processing of data for analytical and other purposes.

After passing through these pre-processing activities, the data will be stored in the **Data Storage component**, ensuring data privacy and security. All other EXCESS ICT components will retrieve data from the Data Storage component in order to perform their operations towards the realization of the PEB concept.

4.3 EXCESS Data Analytics Framework

The EXCESS Data Analytics Framework will be responsible for the performance of analysis activities using the data residing in the EXCESS Data Management Platform. It will exploit a series of mostly pre-trained algorithms in order to exclude meaningful analytical results that will be used by the Model Predictive Control component and the various visualization and blockchain applications.

In the context of the Data Analytics framework, the **Comfort Profiling component** will create the comfort profiles of building occupants. More specifically, the comfort preferences of the building occupants will be extracted based on the sensor measurements and other metrics of the buildings and subsequently through the performance of profiling analytics, their comfort profiles will be derived.

In addition, the **Generation Forecasting component** will produce accurate time series forecasts for the energy generated by the PV and wind production components for the short and mid-term period taking into consideration the weather conditions that affect the energy generation.

Moreover, the **Demand Forecasting component** will provide accurate time series forecasts on the energy demand of the devices and loads of the building according to the behaviour of the building occupants and also taking into account the weather conditions that affect the energy demand.

The combination of the comfort profiles with the energy and demand forecasts for the building provides the context-aware flexibility profiles of the energy components, devices and loads in the building through the respective profiling mechanisms of the **Context-Aware Flexibility Profiling and Analytics component**. These are actually the flexibilities of the energy components, devices and loads, such as a small change in the temperature setpoint of a HVAC, that are created due to a dynamic adaptation of the energy demand according to a corresponding slight change of comfort preferences of building occupants without actually affecting their comfort. The small change in demand is the flexibility of an energy component in the context of the comfort profiles of the building occupants.

These context-aware flexibility profiles will also be utilized by the **Dynamic VPP Configuration component** that will run multiple alternative scenarios in order to find the optimal flexibility-based surplus energy scheme (eventually the building operating as a Virtual Power Plant) that can be communicated in the aggregator for possible trading in the energy market.

4.4 Model Predictive Control Component

Model predictive control (MPC) is a technology in which the constrained and various variables are controlled to achieve certain outcome [1]. The MPC can provide the solution for controlling the multi-dimensional and dynamic system. A typical block diagram of the MPC is shown in Figure 4-2. A process model is used to predict the current values of the output variables. The residuals, the differences between the actual and predicted outputs, serve as the feedback signal to a prediction block. The predictions are used in two types of MPC calculations that are performed at each sampling instant: set-point calculations and control calculations. The set points for the control calculations, also called targets, are calculated from an economic optimization based on a steady-state model of the process, traditionally, a linear model. The optimum values of set points change frequently due to varying process conditions [2]. The main components of the energy systems in EXCESS project are photovoltaic-thermal (PV/T) panels, photovoltaic, wind turbines, buffer tanks, boreholes thermal energy storage (BTES), heat pumps (HP) and electrical grid and in the building, the main components are heat recovery units, ventilation, lighting, plug loads, space heating, cooling and domestic hot water demand. These are the components that may need to be controlled in an optimized manner to maximize the performance.

Different simulation software can be used to model the energy system for instance IDA-ICE, Apros, TRNSYS etc. The prediction, set points controls and MPC algorithms can be written for example in Python, etc. while the optimizer and solvers (for example MOBO, Matlab) can be used to provide the optimal controls and variables for the real system, both at the building and energy system level. This software can be both commercial and/or open source. The MPC can be used as a plug-in to optimize the energy flows and maximize the energy savings. The main system and subsystems are taking input and giving output data for the controls needed at various levels. The MPC can assist in taking the data as input and based on the data and prediction it can give certain control signals for different components such as photovoltaic-thermal (PV/T) panels, PV, wind turbines, buffer tanks, boreholes thermal energy storage (BTES), heat pumps (HP) and electrical grid for better performance and user satisfaction. The building's main components are heat recovery units, ventilation, lighting, plug loads, space heating, cooling, domestic hot water demand. The generation data is coming from the generation components while the demand data is coming from the building. With the weather station the forecasting could be carried out. The weather can be forecasted based on which PV/T can be controlled and charging set points of the storage tanks and seasonal storage could be controlled for better performance of the PV/T, heat pump and storage. The electricity price signals can be used to control the heat pump operation. With lower electricity price, the heat pump can charge the tank at higher temperature and vice versa. The demand side data can be used to predict the demand based on the user behaviour and preferences. This data can be used to control the demand or shift the demand based on the availability of the onsite generated energy. The data could be stored in the cloud server, the controller can be located on site, while the end user and contractor can monitor the data remotely and on the user interface monitor.

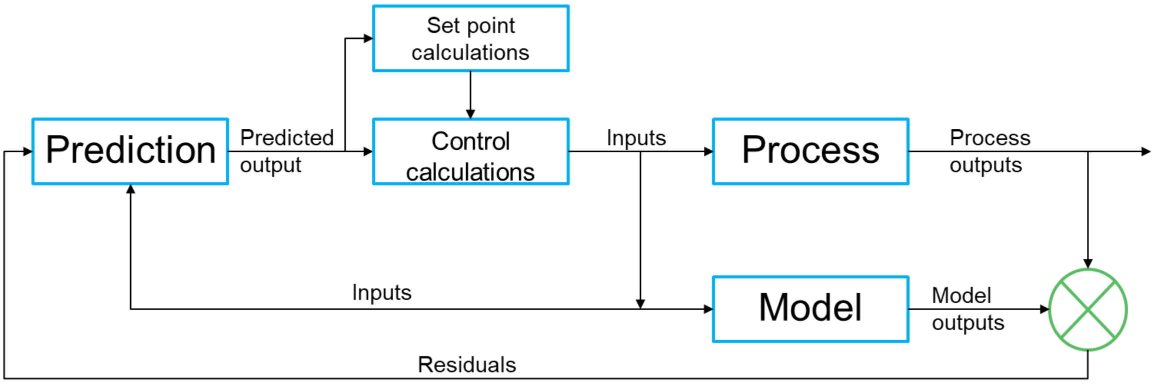

Figure 4-2: Basic diagram of a typical model predictive control (Ref: Seborg, Dale E., et al. Process dynamics and control. John Wiley & Sons, 2010)

4.5 EXCESS Data Visualizations Framework

The EXCESS Data Visualizations Framework encapsulates the visualization applications that will be provided to aggregators and building managers, using data coming either directly from the EXCESS Data Management Platform or from the analytical results of the EXCESS Data Analytics Framework.

The **Flexibility Analytics Visualizations** will enable aggregators to view demand flexibility and energy generation forecasts from buildings through corresponding analysis of data, allowing them to understand which buildings can provide flexibilities and select the optimal VPP configuration for provision in the energy grid. The aggregators will address in that way the grid requirements set by DSOs through the constant monitoring of the performance of their established clusters/VPPs and identification of potential flexibility overrides that are tackled by the according modification of VPP schemes.

The **Energy Consumptions Visualizations** will give the opportunity to building managers to monitor through dashboards and enriched energy analytics the energy behaviours and patterns in the building. The visualizations will be produced by data coming from sensors and submeters regarding the building energy consumption and demand based on the building occupants' energy behaviours. In that way, the building managers will understand what energy behaviours and patterns can lead to the achievement of energy savings in the building.

4.6 EXCESS Blockchain Infrastructure & Applications

The EXCESS blockchain (EBC) provides a verifiable, tamper proof record of interactions among prosumers and potentially including consumers at dwelling level, aggregators, open market, and others. These interactions can refer to value transfers, automated and voting based decisions or other processes enabling automated settlement and verification of events. Two distinct applications will utilize the EBC, namely the Objective Benefit Sharing Application (OBS App) and the Explicit Demand Response Application (EDR App).

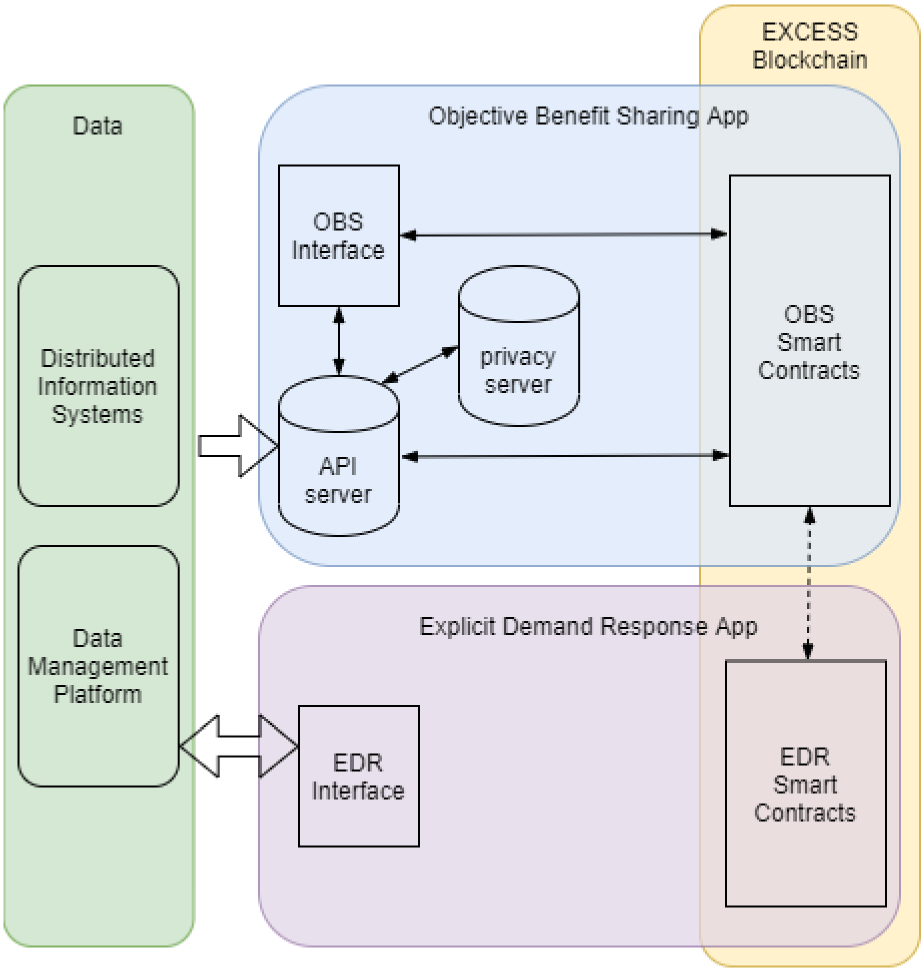

Figure 4-3: Blockchain infrastructure, applications and interactions

The OBS App enables collaborative and collective energy optimization at the community level by depicting the energy status at community and dwelling level, and, at dwelling level, the consumer's energy savings and current energy score. Prosumers are awarded based on community level energy performance and, additionally, can incentivize energy optimized behaviour at dwelling level based on the consumer's energy score.

The OBS App consists of four components:

- the OBS Interface, a web-based interface for human interaction
- an API server for computer interaction
- a privacy server for pseudoanonymization mapping
- smart contracts for decision processing and settlements.

The **OBS Interface** depicts the energy performance and financial indicators at dwelling level and provides additional financial information and voting options for prosumers.

The **API server** is the communication node interfacing with the Distributed Information Systems, the Data Management Platform, the OBS Interface, the privacy server, and the OSB Smart Contracts deployed on the EXCESS Blockchain.

The **privacy server** provides the mapping of the personal data of the prosumers to their pseudoanonymized blockchain identity.

The **OBS Smart Contracts** process stakeholder contract rules, shareholder decisions, share management, accounting, and calculation of gains and incentives on the EXCESS Blockchain.

The **EDR App** enables the prosumers to view the potential flexibilities of their devices and loads and get aware of their duration, their frequency and their remuneration. In this sense, they can decide whether they would like to offer their flexibilities to the aggregators in order to trade them subsequently in the energy market, covering in this way the grid requests. Blockchain contracts are created between the prosumers and the aggregators that contain the terms for the flexibility transactions and result in monetary gains for the prosumers upon completion of flexibility requests by the grid.

Details on the **EBC** are still under review, focusing on smart contracts, low transaction fees at high transaction throughput, and possible connection to current or future stable coins.

5 Detailed Architectural Descriptions

In this section the detailed descriptions of the different ICT components/ frameworks that comprise the EXCESS ICT Architecture as shown in the previous section are presented. The specific subcomponents of each of the five ICT components/ frameworks are analyzed regarding their functionalities and information are provided about the connections between components, the corresponding connection methods and the data that are exchanged.

5.1 EXCESS Data Management Platform

5.1.1 EXCESS User Management Service

The EXCESS User Management Service will offer a bundle of features pertaining to user actions of and usage over the Data Management Platform of the project. In more detail, it will offer the necessary mechanisms for user registration, authentication, login and analysis of the actions they perform over the different sub-components involved in the EXCESS Data Management Platform while allowing for the specification of different user roles and groups in the EXCESS Data Management Platform. Moreover, the EXCESS User Management Service will employ the appropriate authorization and access control functionalities for the verification of access rights of users over specific datasets as per the restrictions imposed by the data providers. This will enable the assignment of specific rights to the different users of the EXCESS Data Management Platform for accessing the data that are stored and are made available through the platform, ensuring in parallel that no data will be accessed by a non-authorized user or user type. Furthermore, the EXCESS User Management Service will offer a series of usage analytics that will present in a comprehensive manner information about the use of datasets by specific users and user groups, such as which datasets are search or accessed more, how many datasets a user is accessing, etc., along with information and activity logs of the users over the different components and datasets (e.g. new dataset creation, modification of an existing dataset).

5.1.2 EXCESS Common Information Model

The datasets that will be collected from the different distributed information system of the demo sites by the EXCESS Data Management Platform should be finally stored in an interoperable and uniform way in order to be available for subsequent analysis and visualization purposes. In this sense, the EXCESS Data Management Platform will be based on the design and development of the EXCESS Common Information Model (CIM) which will comprise the common language for the various datasets that will be ingested, pre-processed and stored in the Data Management Platform. The Common Information Model will be created based on the meticulous study and analysis of the data that the distribution information systems of the demo sites will acquire through the installed sensors, submeters and actuators along with all deployed devices and energy components residing in the demo site buildings.

These data, in general, cover the operation, monitoring and control of building assets and district-wide systems, the building occupants' comfort and health preferences, the information regarding the local energy marketplaces and the contractual details between prosumers and aggregators for demand response activation events.

The Common Information Model will be based also on existing data models and standards and will align with widely-accepted open standards for smart building communication and interoperable information exchange, prioritizing on the recently published version of the ETSI Smart M2M incorporating the SAREF ontology for machine to machine communication.

The Common Information Model will constitute the cornerstone of the Data Mapping component (see also section 5.1.4), as the elements of the ingested datasets will be mapped against the equivalent concepts of the Common Information Model, resulting in an homogeneous form of data stored in the EXCESS Data Management Platform.

5.1.3 Data Collection Component

The Data Collection component is responsible for the ingestion and cleaning of data coming from various sources and with different formats in the EXCESS Data Management Platform. By providing a user-friendly interface, the Data Collection component enables the data provider to select the desired options for the data collection process. The Data Collection component can collect data either through uploading of files (e.g. uploading of historical data in the EXCESS Data Management Platform) or through APIs that will be offered by the distributed information systems of the demo sites. Pub/Sub messaging may also be envisaged depending on the specificities of each demo site. In addition, the Data Collection component allows the configuration of quality checks and performs the curation of any erroneous data.

The functionalities of the Data Collection component are described below:

- **Definition of the data collection process in a user-friendly way:** The Data Collection component enables the data provider to configure the data ingestion process in the desired way through an easy-to-use interface, by selecting for example the collection options, the retrieval schedule, the authentication specifications and other related details.
- **Configuration management of data collection process:** The Data Collection component facilitates the creation of a configuration file for each different data collection process, which contains all the data collection details as selected by the data provider. As long as the configuration file is not finalized, the data collection details can be modified freely by the data provider. However, after the finalization of the configuration file only specific details can be updated so that the data collection process is performed in a seamless way.
- **Data ingestion through file uploading:** The Data Collection component enables the uploading of files of different formats, such as (i) tabular (e.g. CSV, TSV), (ii) non-tabular (e.g. XML, JSON) and (iii) others. The uploading of data samples of files is also provided, which drives the creation of the configuration files, including the data collection details defined by the data provider.
- **Data acquisition through APIs:** The Data Collection component enables the collection of data through the APIs that will be offered by the local platforms of the demo sites by providing a comprehensive interface for the definition of the API details, such as the method, the path and the retrieval settings. Moreover, the already configured API connection is tested and in case of success, sample data are collected. In addition, the management of data update through the APIs is facilitated by configuring the corresponding details (e.g. time rule-based updates, event rule-based updates, etc.).
- **Management of API authentication details:** The Data Collection component allows the data provider to define the authentication details of an API connection by setting the type of authentication and the related information, such as tokens or credentials. The Data Collection component uses these authentication details to verify the API connection, while saving any sensitive information for future API calls in a secure repository.

- **Option for storage of specific data:** The Data Collection component allows the data provider to define during the data collection the desired part of the data sample that s/he would like to be stored in the EXCESS Data Management Platform. In that context, only the chosen data will be further processed, while the rest of them will be rejected and not be stored eventually in the EXCESS Data Management Platform.
- **Elaboration of data ingestion status messages:** The Data Collection component sends the appropriate feedback messages in order to communicate the status of the data collection processes (e.g. failed API connection due to wrong credentials).
- **Quality checks and cleaning of data:** The Data Collection component offers an intuitive interface that enables the data provider to select the desired validation checks that will discover any erroneous or inconsistent data in an ingested dataset. Subsequently, if any errors are found, the cleaning of the data is performed in order to have curated datasets in the EXCESS Data Management Platform.

Input Connections & Interfaces: It will be connected through various means (APIs, Pub/Sub messaging, etc.) with the building management system of each of the four demo sites.

Output Connections & Interfaces: It will send its output to Data Mapping component.

Input Parameters: The below information should be collected from the distributed information systems of the four demo sites by the Data Collection component:

Setpoint of HVAC (target temperature) HVAC Operational State (Heating/Cooling) HVAC Status (ON/OFF) HVAC Energy consumption room temperature room humidity room luminance room CO2 concentration occupancy status (yes/no) lighting devices setpoint (dimming level) lighting devices energy consumption energy consumption at apartment level (electricity/thermal) energy consumption at building level (electricity/thermal) local generation data (energy output) local storage data (charging level, status, capacity available) EV charging level data (if available) EV charging stations status (charging/not charging) EV charging stations consumption (energy metering data) Local weather data

Output Parameters: The above input parameters will be sent after data collection to the Data Mapping component.

Software Development Language: Python

Communications: APIs, Pub/Sub messaging, etc. with the distributed information systems of the four demo sites. Internal APIs with Data Mapping and Data Storage components.

The internal base architecture of the Data Collection component is presented below:

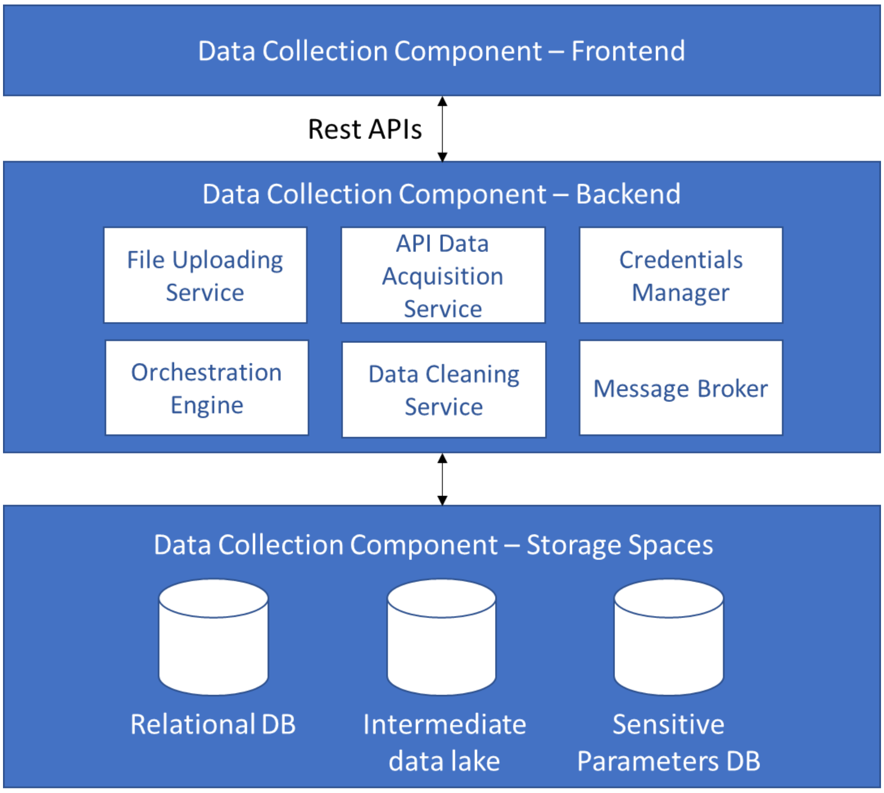

Figure 5-1: Data Collection component internal base architecture

The frontend comprises the user interface of the Data Collection component. The backend includes the different data collection options and the data cleaning service. The orchestration engine manages the containerized services of the different processes in the EXCESS Data Management Platform, while the message broker sends the necessary messages/triggers to the services of EXCESS Data Management Platform. The Data Collection component uses a relational database for storage purposes, along with an intermediate data lake for temporary storage needs and a secure database for the sensitive parameters of API connections. RESTful interfaces are utilized for the communication between the frontend and the backend of the Data Collection component.

5.1.4 Data Mapping Component

The Data Mapping component is responsible for the mapping of the elements of the collected datasets to the equivalent concepts of the EXCESS Common Information Model, enabling in that way the elaboration of interoperable and consistent datasets that can be easily understood by the EXCESS users and utilized for further analytical processes towards producing meaningful results. The EXCESS Common Information Model will be constructed by analyzing and extracting the different entities from the datasets coming from the various distributed information systems of the four demo sites and will be updated as long as new elements are needed to be mapped.

The functionalities of the Data Mapping component are described below:

- **Exploitation of various matching techniques for automated mapping predictions:** The Data Mapping component maps the data elements of the ingested dataset to the related concepts of the EXCESS Common Information Model. The automated mapping predictions are executed using a series of fuzzy matching techniques.

- **Manual configuration of proposed mapping predictions:** Through a user-friendly interface the Data Mapping component enables the data provider to check the proposed automated mappings and choose whether they should be maintained, updated or deleted. In addition, any unidentified concepts can be mapped manually to related concepts of the EXCESS Common Information Model. Moreover, the data types, measurement units and any other data transformations may be specified. All final mapping choices are saved in the configuration file.
- **Intuitive exploration of the EXCESS Common Information Model:** The Data Mapping component enables the data provider to explore the Common Information Model, view its structure and get deeper knowledge of its concepts, allowing him/her in that way to choose if any manual mappings are more suitable for the data elements of his/her dataset.
- **Life-cycle management of the EXCESS Common Information Model:** The Data Mapping component allows the data provider to propose additions and updates of the data concepts of the EXCESS Common Information Model through an intuitive user interface, which are handled accordingly by the EXCESS CIM administrator.
- **Option for storage of specific data:** The Data Mapping component facilitates the data provider to specify during the data mapping process which data s/he would like to store in EXCESS Data Management Platform. Since only the mapped data elements of a dataset to the EXCESS Common Information Model will be further processed, the rest of them that remain unmapped will be rejected and not be stored eventually in the EXCESS Data Management Platform.

Input Connections & Interfaces: It will receive input from the Data Collection component.

Output Connections & Interfaces: It will send its output to the Data Storage component.

Input Parameters: They will be the output parameters of the Data Collection component (see section 5.1.3).

Output Parameters: The input parameters that will have been mapped to the concepts of the Common Information Model.

Software Development Language: Python

Communications: Internal APIs with the Data Collection and Data Storage components.

The internal base architecture of the Data Mapping component is presented below:

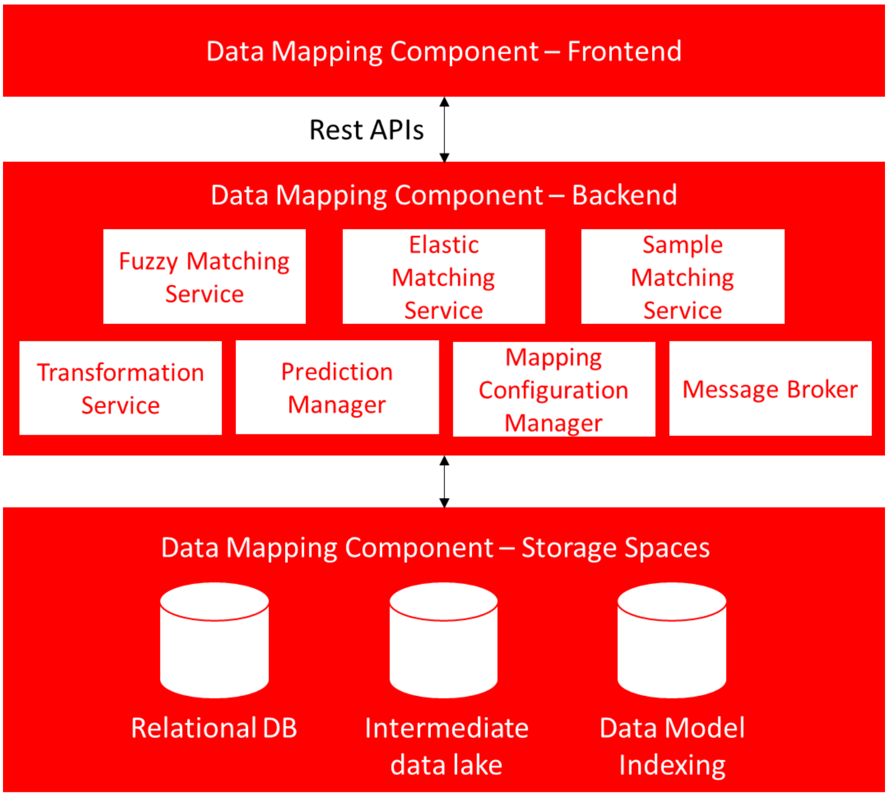

Figure 5-2: Data Mapping component internal base architecture

The frontend comprises the user interface of the Data Mapping component. The backend includes the different data mapping services, namely fuzzy matching, elastic matching and sample-based matching. The transformation service realizes the unit and any other data transformations, the prediction manager facilitates the automatic mapping process and the mapping configuration manager enables the manual modification of mapping predictions and the storage of final mapping selections in the configuration file. The message broker sends the necessary messages/triggers to the services of EXCESS Data Management Platform. The Data Mapping component uses a relational database for storage purposes, along with an intermediate data lake for temporary storage needs and an indexing engine for the Common Information Model. RESTful interfaces are utilized for the communication between the frontend and the backend of the Data Mapping component.

5.1.5 Data Storage Component

The Data Storage component is responsible for storing data coming from the distributed information systems of the four demo sites. As soon as the data have been collected and mapped to the EXCESS Common Information Model, they are stored in a secure storage space in the EXCESS Data Management Platform. The Data Storage component stores the data in a non-relational database for scalability and big data management optimization purposes. Data indexing is also used for search performance improvement.

The functionalities of the Data Storage component are described below:

- **Storage of data collection tasks and related configurations:** The Data Storage component stores the properties of the data collection task along with the corresponding settings of the configuration file during the data collection configuration process.

- **Data persistence:** The Data Storage component stores the dataset along with the data sample, as soon as the data collection and data mapping process have been completed.
- **Metadata storage:** The Data Storage component stores additionally the metadata of a dataset, maintaining the necessary connection between the stored data and their corresponding metadata.
- **Data indexing:** Following the storage of data, the Data Storage component creates the necessary indexes for the stored data in order to facilitate faster data searching.
- **Metadata indexing:** Following the storage of metadata, the Data Storage component creates the necessary indexes for the stored metadata in order to optimize metadata searching.
- **Intermediate data storage:** The Data Storage component offers a temporary storage space, where the intermediate configuration and data files that are produced during the data collection and data mapping processes are stored, allowing in this way the pause and continuation of these processes. This approach enhances the fast resuming of these processes and supports traceability in case a data collection or data mapping process fails.
- **Sensitive data storage:** The Data Storage component provides a distinct secure space where the sensitive information of API connections, such as tokens and credentials, are stored assuring data privacy and security.

Input Connections & Interfaces: It will receive input from the Data Mapping component.

Output Connections & Interfaces: It will send input to any component that needs to further process data, such as the Data Analytics Framework, the Data Visualizations Framework, the MPC component and the blockchain applications.

Input Parameters: These will be the output of the Data Mapping component (see section 5.1.4).

Output Parameters: All the data that will have been stored after the data mapping process to the Data Storage component.

Software Development Language: Python

Communications: Internal APIs with the Data Collection and Data Mapping components and any other component that needs data for further processing, such as the Data Analytics Framework, the Data Visualizations Framework, the MPC component and the blockchain applications.

The internal base architecture of the Data Storage component is presented below:

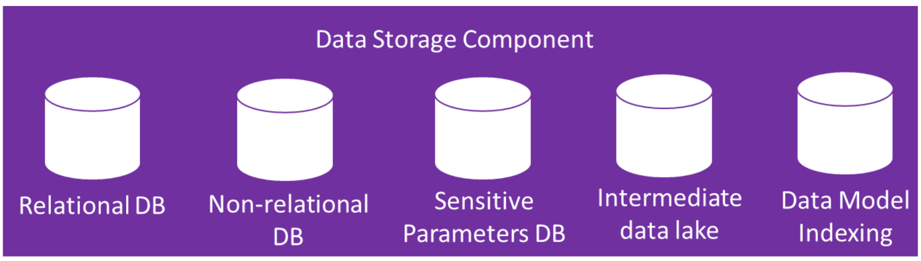

Figure 5-3: Data Storage component internal base architecture

The Data Storage component includes for the realization of its functionalities a relational and a non-relational database, a secure database for sensitive parameters, a temporary storage data lake and an indexing engine.

5.2 EXCESS Data Analytics Framework

5.2.1 Comfort Profiling Component

Common centrally controlled building devices (e.g. HVAC) operate with predefined operational settings and a set of assumptions without taking into consideration occupants' preferences, resulting in both occupants' discomfort and high energy consumption. Under this context, by integrating the occupants' preferences and comfort profiles (collected through an IoT sensor network) in the devices control system, the fine-tuning of the indoor environment can be achieved to the extent allowed by the available installations of building amenities.

In this sense, the Comfort Profiling component enables the definition of the comfort preferences of the building occupants. The sensors that are installed in the interior of the building will measure the temperature, illuminance, humidity and air quality, while the deployed actuators will monitor the switching and setpoints of devices, such as HVACs, lights, etc. In addition, the environmental conditions in the building area will be measured by local weather stations.

By employing relevant analytic profiling algorithms, the Comfort Profiling component will specify the energy behaviour and comfort preferences of the building occupants through the modelling of the data streams coming from the local weather stations and the sensors and actuators installed inside the building.

The definition of the comfort preferences of the building occupants will take place without intruding or affecting the living conditions and comfort of the building occupants.

Input Connections & Interfaces: It will receive input from the Data Storage component.

Output Connections & Interfaces: It will send output to the Demand Forecasting component and the Context-Aware Flexibility Profiling and Analytics component.

Input Parameters: The below mapped data that will reside in the Data Storage component coming from sensors, actuators and local weather stations:

Setpoint of HVAC (target temperature)
HVAC Operational State (Heating/Cooling)
HVAC Status (ON/OFF)
room temperature
room humidity
room luminance
room CO2 concentration
occupancy status (yes/no)
lighting devices setpoint (dimming level)
Local weather data

Output Parameters: The extracted comfort preferences of the building occupants.

Software Development Language: Python

Communications: Internal APIs with Data Storage component, the Demand Forecasting component and the Context-Aware Flexibility Profiling and Analytics component.

The base architecture of the Comfort Profiling component is presented below:

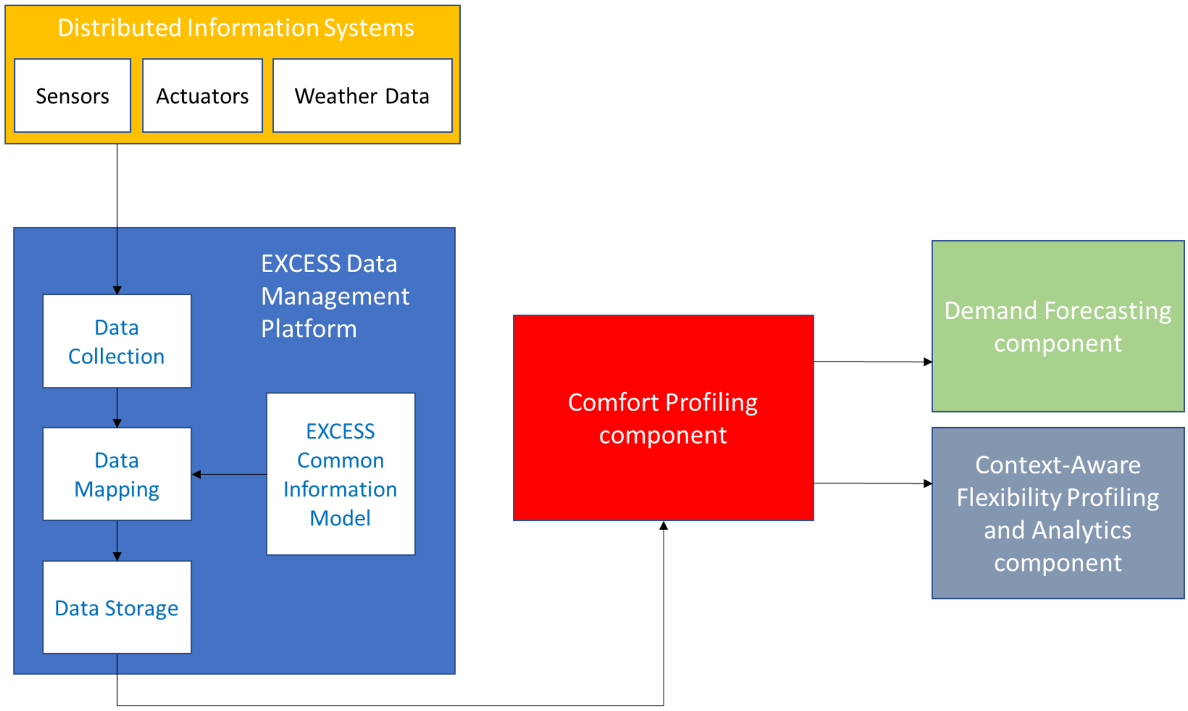

Figure 5-4: Comfort Profiling component base architecture

5.2.2 Generation Forecasting Component

The methods used for solar energy forecasting (solar thermal and photovoltaic power) depend heavily on the lead-time of the forecast. For forecast with a lead time of more than 6 hours usually the best forecasts are forecasts that use Numerical Weather Prediction (NWP) only. For shorter lead times a method combining NWP with statistical methods that use intraday data is beneficial.

For day ahead forecasts usually a model is used that calculates the produced energy from variables like direct radiation, indirect radiation and temperature. This model can be either a physical model or a statistical model, or a combination of both. In this project we will try purely statistical models as well as models that first use physical models (i.e. calculate the produced energy from the input data for a reference plant) and then use statistical methods to improve the quality of the forecast. Since usually NWP do not provide forecasts for direct radiation and indirect radiation these quantities have to be derived from variables that are provided by the NWP which are usually global radiation or cloudiness. To calculate direct radiation and indirect radiation we will use models that are calibrated using satellite data.

The main error source of forecasting solar energy is usually the forecasts of direct radiation, indirect radiation and temperature, therefore not errors in the model, which calculates the produced energy from these quantities. Hence, for shorter lead times it is beneficial to use the persistence in the weather system to improve on the forecasting of the produced energy. There are several methods that can be used for this task. The simplest (and often times quite good method) is so called persistence method, which assumes that the weather conditions stay the same over the forecasting horizon and from this calculate the future produced energy. Another method is calculating future energy output with the help of models from time series analysis, like ARIMA processes. This method has the advantage that also data from offsite measurements or the forecasts from an NWP can be in cooperated in the model. Further using Copula Methods can be used in this context as a more flexible way to combine data from different data sources.

The time series models in this method can also be replaced by methods from computer learning (e.g. support vector machines or neural networks). Unfortunately, for this kind of methods a large data set is needed. Finally, there is also a method that is mainly applied in the prediction of wind power forecasting. This method consists in calculating the error of the forecasts which uses only data from the NWP and then extrapolates this error to the future, also in this method offsite data and date from satellite images can be used. For all of these methods it is beneficial to use statistical methods to combine them with forecasts from NWP. In this project, we will mainly be using the persistence forecasts and the forecast that extrapolates the error of the NWP. Finally, we should note that when we use online data to improve the forecasts for short lead times, then this is only possible if meaningful online data is available. Especially in the case of solar energy forecasting, there is the problem that during the night no energy is produced and hence no meaningful online data is produced. This means that improvements over NWP using methods for short lead times is only possible for times when at the time of the forecasts the sun is already shining. This is mainly important for early hours of the day.

The production of hydropower mainly depends on the available water resources. From a time series of the rainfall in the catchment area of the power plant, we will generate a statistical model (using either time series data or methods from computer learning) that calculates the available water resources from predicted/measured data on rainfall in the catchment area. In addition, in this case the forecasts will be improved with online data similar to the case of solar energy forecasting.

Input Connections & Interfaces: It will receive input from the Data Storage component and if needed data from external sources (e.g. satellite images, weather forecasts)

Output Connections & Interfaces: Energy performance optimization tools and Data storage component.

Input Parameters: Characteristics of the power plants (e.g. alignment, capacity, power curves), local weather and forecast data, satellite images, current production.

Output Parameters: These will be the short and mid-term production forecasts of the plants

Software Development Language: R and Python

Communications: Internal API with Data Storage component and other components for external data

5.2.3 Demand Forecasting Component

In order to achieve energy performance optimization, a continuous accurate real-time and future (short-term) picture of the building performance is necessary so that the operation of the building is constantly adapted to the anticipated generation. In this context, forecasting the energy demand should provide highly accurate results that will feed energy performance optimization tools as inputs for the definition of optimal control strategies of the different devices with the aim to improve the energy performance of buildings towards achieving the PEB concept.

In this sense, the Demand Forecasting component will be responsible for the delivery of the short and mid-term demand forecasts of the different energy components and devices in the building. This component will collect the comfort profiles of the building occupants as derived by the Comfort

Profiling component, specifying the zones of the indoor ambient conditions in which the building occupants feel comfortable. The weather forecasts for short and mid-term period will be correlated with the comfort profiles in order to predict the demand for the different energy components and devices in the building. These demand forecasts will present the energy demand of these components and devices based on the energy behaviour and comfort preferences of the building occupants and the related external ambient conditions, as described by the collected weather data.

These demand forecasts will continuously feed the MPC component along with flexibility capabilities to define optimal control strategies that match and balance generation and demand in a proactive manner.

Input Connections & Interfaces: It will receive input from the Comfort Profiling component and the Data Storage component.

Output Connections & Interfaces: It will send output to the Context-Aware Flexibility Profiling and Analytics component and the Energy Consumptions Visualizations application.

Input Parameters: These will be the comfort profiles of the building occupants and the local weather data.

Output Parameters: These will be the short and mid-term demand forecasts of the devices and energy components.

Software Development Language: Python

Communications: Internal APIs with the Comfort Profiling component, the Data Storage component, the Context-Aware Flexibility Profiling and Analytics component and the Energy Consumptions Visualizations application.

The base architecture of the Demand Forecasting component is presented below:

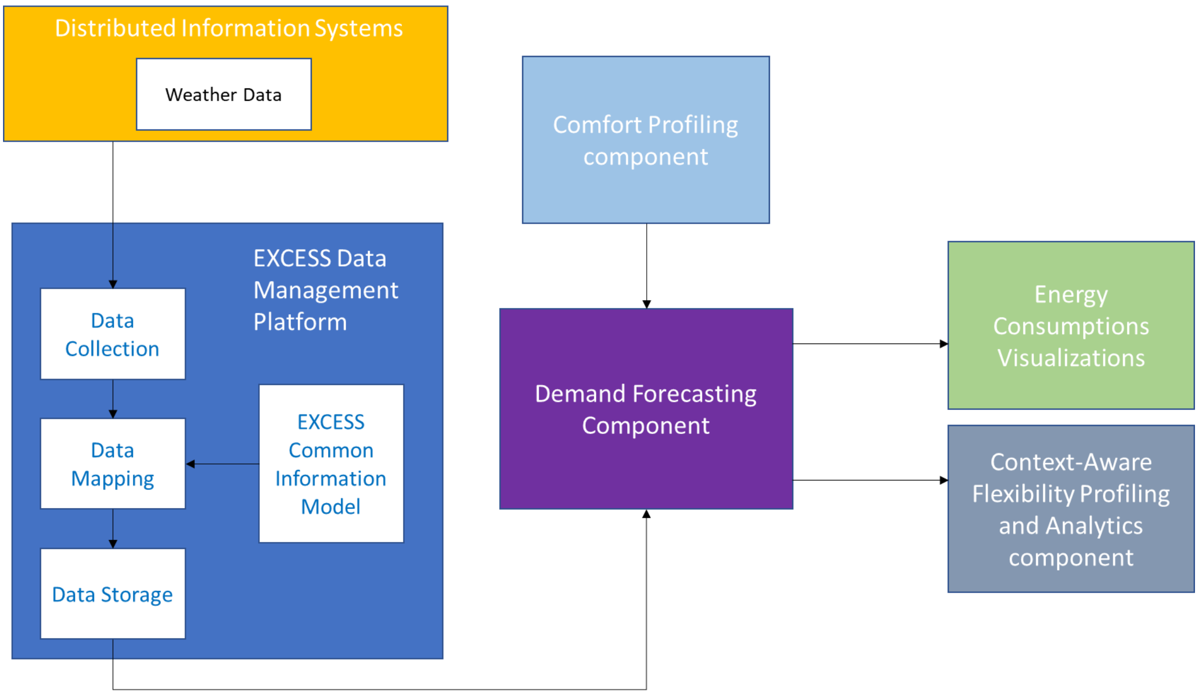

Figure 5-5: Demand Forecasting component base architecture

5.2.4 Context-Aware Flexibility Profiling and Analytics Component

The Context-Aware Flexibility Profiling and Analytics component will produce through powerful analytic algorithms the context-aware flexibility profiles that will be used subsequently as input by the Model Predictive Control component for the performance of its controlling operations.

The context-aware demand flexibility profiles need to be extracted out of the data streams coming from building assets and considering user preferences for comfort, indoor environmental quality and daily schedules, even in the short and very short term, towards integrating the extracted flexibility in the optimization of control strategies of individual devices enabling a human-centric energy performance optimization. The extraction of demand flexibility profiles should be delivered in real time taking into account current operational status of devices and a short-term projection about environmental and operational conditions in premises. More specifically, the process for the extraction of context-aware demand flexibility profiles is twofold:

a) Extraction of demand flexibility profiling parameters following a training process. Historical data (device operational data & environmental conditions) are required towards the extraction of accurate profiling parameters (DER modelling)
b) After the training process, real time and short-term forecasting calculation of demand flexibility potential at device level and further aggregation at asset or portfolio level is performed.

Using the comfort profiles of the building occupants along with the generation and demand forecasts of the energy components and devices of the building, the Context-Aware Flexibility Profiling and Analytics component analyzes potential slight changes in the comfort preferences of the occupants that will not affect actually their comfort, as they will insignificantly deviate from their ideal preferences but still make them feel comfortable (e.g. changing the setpoint temperature of an HVAC from 21° C to 22° C in summer). Such slight changes in the comfort preferences of occupants will lead through specific algorithms to the creation of demand flexibilities for the energy components and devices of the building, due to reduction of their energy consumption. Taking into account the generation forecasts of the energy components, potential amounts of excess generated energy may occur. These created context-aware flexibility profiles of the energy components and devices will be exploited by the MPC component in order to run multiple control scenarios and find the optimal strategy for the achievement of the PEB concept.

Input Connections & Interfaces: It will receive input from the Comfort Profiling component, the Generation Forecasting component and the Demand Forecasting component.

Output Connections & Interfaces: It will send output to the MPC component, the Flexibility Analytics Visualizations and the Explicit Demand Response application.

Input Parameters: These will be the comfort profiles of the building occupants along with the short/ mid-term generation and demand forecasts of the devices and energy components of the building.

Output Parameters: These will be the context-aware flexibility profiles of the devices and energy components of the building.

Software Development Language: Python

Communications: Internal APIs with the Comfort Profiling, Generation and Demand Forecasting components, the MPC component, the Flexibility Analytics Visualizations application and the Explicit Demand Response application.

The base architecture of the Context-Aware Flexibility Profiling and Analytics component is presented below:

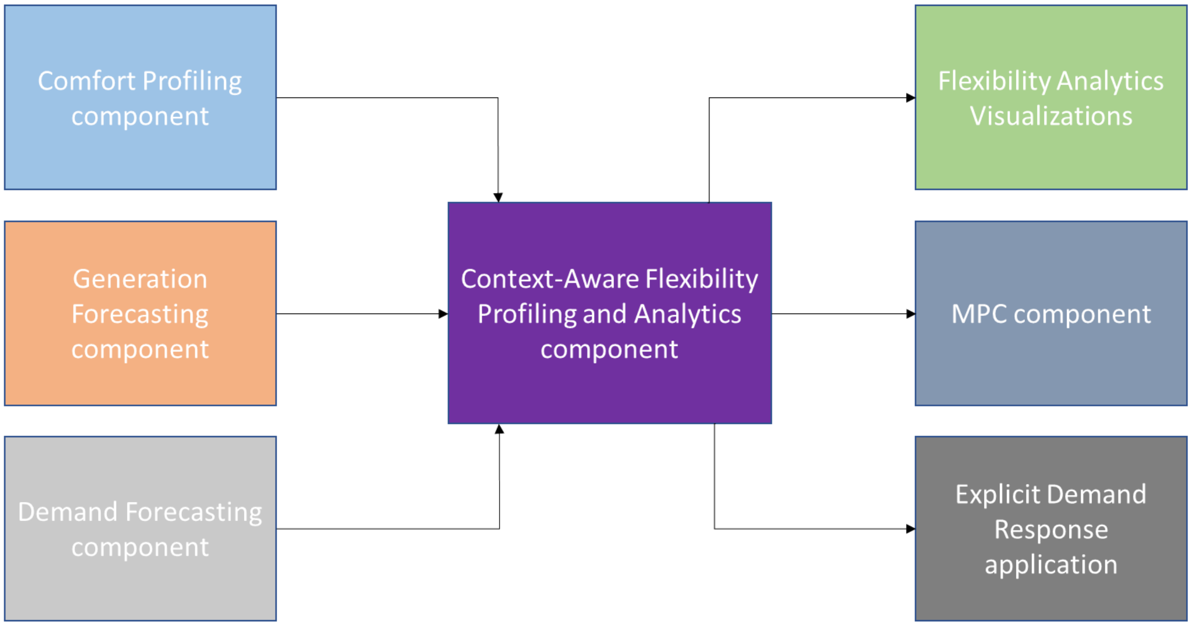

Figure 5-6: Context-Aware Flexibility Profiling and Analytics base architecture

5.2.5 Dynamic VPP Configuration Component

The description of the Dynamic VPP Configuration component is presented below:

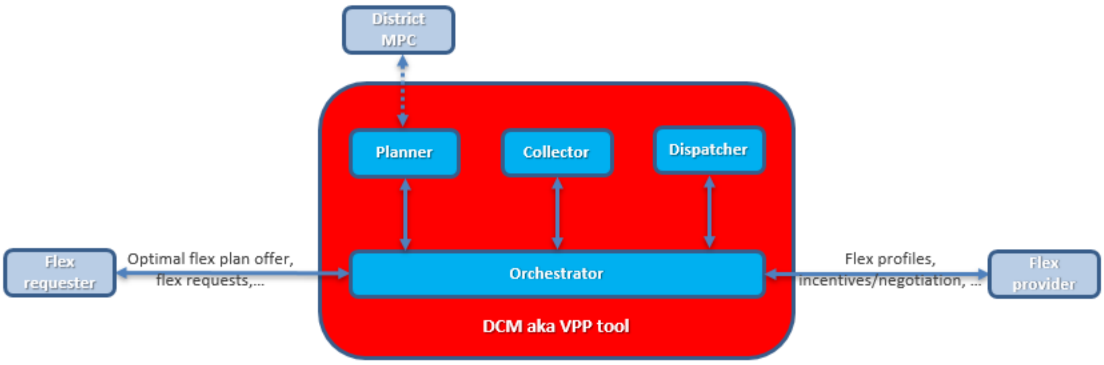

Figure 5-7: Dynamic VPP Configuration component base architecture

- **Orchestrator**: the heart of the system. All message dispatching between the different internal components and system in- and outputs is performed by this component.
- **Collector:** receives a baseline plan and upper bound and lower bound flex forecast of electricity or heat consumption of all the connected flexibility providers. The received baseline plans and flex forecasts are aggregated and forwarded to the Planner.
- **Planner:** receives the aggregated baseline plans and flex forecasts from the collector. Through its District MPC, it determines an optimal flex activation and use this as the basis for a market trading interaction (e.g. bidding excess PV energy). The market response (i.e. no, partial, full

acceptance of the bid) is then received as a flex activation request, which is passed on to the Dispatcher.

- **Dispatcher:** based on the received flex activation request, the Tracker disaggregates this request amongst the connected flexibility providers by sending them an incentive offer to which it will receive an incentive response (ADMM cycle). Once this has converged, all incentive responses will be taken into account in order to make a formal flexibility offer to the flex requestor (e.g. market or DSO or BRP). If this flexibility offer is OK for the flex requestor, this one will send a flexibility order which will be translated in an activate incentives message that will impose a power profile on the connected flexibility providers.

To be decided: this is the functionality the system offers as built in a previous project. Depending on the requested functionality:

- *the orchestrator may need to be reconfigured,*
- *functionality like provided by the collector or dispatcher may be enabled or disabled,*
- *heat and electricity profiles may need to be treated differently,*
- *depending on the type of flexibility profiles exchanged with the flexibility providers, the system may need to be adapted. Currently the system expects a baseline plan and upper bound and lower bound flex forecast, also called flex graphs. The system can be adapted to handle a set of power/heat profiles alternatives (sometimes also called fundamentals and traces), with or without probability information.*
- *Optionally a digital twin of the flex providers can be modelled in the system. The negotiation between the dispatcher and the flex providers can then be handled within the system, and only the final incentive messages to activate the flexibility must be exchanged with the flex providers.*
- *Currently the system implementation handles only one project (flex providers and related flex requesters) at a time. To handle multiple 'projects' at the same time the system needs to be adapted. This can be done by instantiating the system multiple times, or by instantiating (some of) the components per project. The orchestrator will then route inside the different projects.*

Input Connections & Interfaces: The VPP component will receive flexibility profiles from the Flex Providers' Context-Aware Flexibility profiling component, and potentially from MPC components (like the building MPC component).

The VPP component will receive tentative bid acceptance information (no, partial, full) as flex request from the flex requestor (= market in this case).

The VPP component will receive final bid order information from the flex requestor (= market in this case).

Optionally, the VPP component will receive proposed baseline plan updates from flex providers in response to proposed incentives as part of a flexibility negotiation session to dispatch the optimal plan in an optimal way to the different flex providers.

Output Connections & Interfaces: The VPP component will provide a bid to the flex requestor (energy market in this case) as output of the VPP level optimization, that can be used by the EDR (and OBS) app. Optionally it can engage in a flexibility request/offer interaction towards a flexibility requester.

Optionally, the VPP tool can send proposed incentives to the flex providers to receive back corresponding baseline plans as part of a flexibility negotiation session to dispatch the optimal plan in an optimal way to the different flex providers.

Optionally, when calculating an optimal plan the VPP component may interact with the district MPC to include local (district) optimization objectives.

Input Parameters:

- **Flexibility profiles.** *Currently the system expects a baseline plan and upper bound and lower bound flex forecast, also called flex graphs. The system can be adapted to handle a set of power/heat profiles alternatives (sometimes also called fundamentals and traces), with or without probability information.*
- Optionally, input regarding flex requests by the flex requester
- Optionally, input regarding the negotiation with the flex providers.
- Optionally, input regarding optimization at community/district level from the MPC controller, to calculate the optimal plan.

JSON is used as the format.

Output Parameters:

- **Optimal plan,** in the form of an overall flex profile plan.
- Optionally, output regarding the flex negotiation towards the flex providers.
- Optionally, output regarding optimization at community/district level, towards the MPC controller.

JSON is used as the format.

Software Development Language: Development is in python. For deployment we are currently considering python packaging and docker containers.

Communications: REST API. Internal communication between the different components is currently REST API based. For more dense traffic, switching to message brokers based on protocols like MQTT, AMQP (Kafka could also be an option) is considered.

5.3 Baseline Model Predictive Control Component

The model predictive control can provide active control of various technologies and components that would be integrated with the building in EXCESS. The baseline MPC can take into account for instance, the dynamic and the static interaction between different components and signals. The baseline MPC can control the generation and the demand. As this baseline MPC can try to optimize the generation based on the demand, cost and weather signals. Here is the detailed presentation of the base ground MPC with its three core functionalities that can be used in the EXCESS system:

A. Weather forecasting

Input Connections & Interfaces: It will receive input from the weather station.

Output Connections & Interfaces: It will send output to the weather forecasting component and renewable energy system control system.

Input Parameters: The below mapped data that will reside in the data storage component:

Radiation

Ambient temperature PVT control and set point of HVAC (target temperature) Tank temperature Heat pump (ON/OFF) Demand of the building, space heating, cooling and HVAC (target temperature)

Output Parameters: The control of the PVT module and heat pumps.

Software Development Language: Java, Python, Modelica or any other software

Communications: Internal APIs with data storage component and the forecasting component, PV/T, tanks, heat pumps and demand controller and analytics component.

B. Generation controls

Input Connections & Interfaces: It will receive input from the weather station and forecast, energy cost signal (Fingrid, etc.), demand and storages set points.

Output Connections & Interfaces: It will send output to the generation and storages control systems.

Input Parameters: The below mapped data that will reside in the data storage component:

Radiation Ambient temperature PV/T generation (real time) PVT control and set point of HVAC (target temperature) Tank temperature Heat pump (ON/OFF) Demand of the building, space heating, cooling and HVAC (target temperature)

Output Parameters: The control of the PVT module, storage and heat pumps.

Software Development Language: Java, Python, Modelica or any other software

Communications: Internal APIs with data storage component and the forecasting component, PV/T, tanks, heat pumps and demand controller and analytics component.

C. ***Demand side controls***

Input Connections & Interfaces: It will receive input from the demand's data base, weather forecast, generation and energy cost signal.

Output Connections & Interfaces: It will send output to the building management system and controller for the building.

Input Parameters: The below mapped data that will reside in the data storage component:

Space heating set points HVAC Operational State (Heating/Cooling) HVAC Status (ON/OFF) room temperature room humidity room luminance room CO2 concentration occupancy status (yes/no) lighting devices

Output Parameters: The control of the space heating and cooling, HVAC system and lighting.

Software Development Language: Java, Python, Modelica or any other software

Communications: Internal APIs with data storage component and the forecasting component, PV/T, tanks, heat pumps and demand controller and analytics component.

5.3.1 Adapted MPC component for Finland

In the Finnish demo case of PEB, there are two main systems, one is the building and the second one is the energy system. As both of these district systems are integrated together therefore there has to be control that can maximize the performance of the energy system. The main framework and components of the energy systems are shown in Figure 5-8. The main components of the energy systems are photovoltaic-thermal (PV/T) panels, buffer tanks, boreholes thermal energy storage (BTES), heat pumps (HP) and electrical grid. The building's main components are heat recovery units, ventilation, lighting, plug loads, space heating, cooling, domestic hot water demand. The MPC is only needed if it is feasible and has added value on the performance of the overall system, otherwise the rule-based control should work fine.

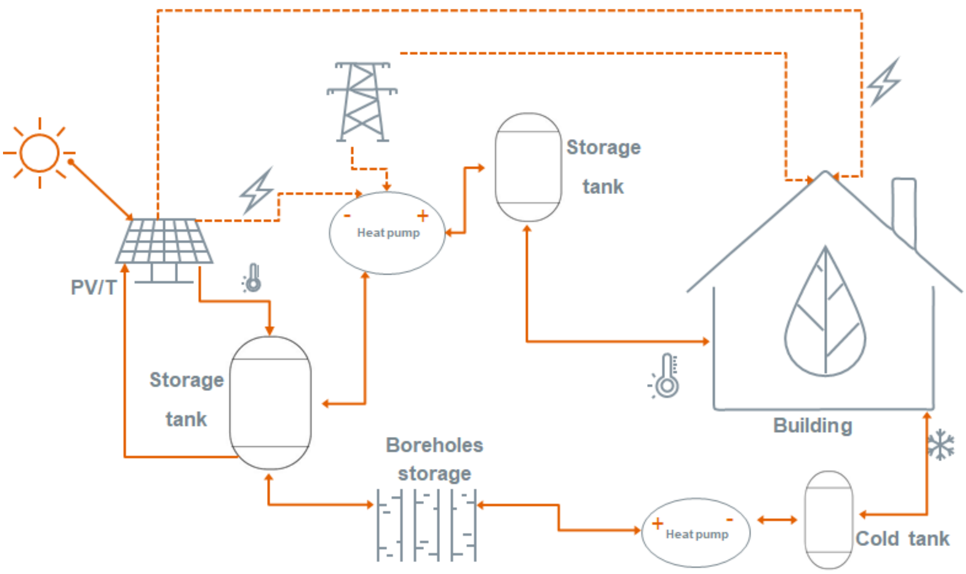

Figure 5-8: The energy system model, framework and components (Finnish case)

The energy system is designed to provide and meet the heating, cooling, domestic hot water and electrical energy demands of the building. It is assumed that an onsite energy system is designed to provide maximum energy to the building and any excess electricity is exported to the grid and any shortfall is met by importing electricity from the grid.

The control framework of the energy system is designed so that, PV/T is cooled down by providing cold water from the buffer tank in order to maximize the electrical and thermal production from the PV/T. When the buffer tank is charged at certain level the excess heat energy is dumped in the BTES. The HP takes the energy from the buffer tank or from the BTES to provide space heating and domestic hot water to the building at higher temperature. The cooling is provided to the building by using HP, cold tank and ventilation unit. The heat from the building is recovered in the cold tank and heat pump takes the heat from the cold tank and dump the heat energy in the BTES, rather than wasting the heat from the building.

The building has floor heating that provide the heating in the building, depending on the outdoor temperature. The ventilation is based on the indoor climate and CO2 concentration in the zones. The heat recovery unit is used to optimize the ventilation performance. The indoor lights are based on the illuminance and occupancy behaviour in the building. The demand response is used to shift the electrical appliances demand from peak hour or low peak hours or during the peak radiation time. The user feedback and occupancy behaviour are needed to optimize the indoor climate and environment and also to optimize the appliance use in the building.

In order to control the energy system and to optimize the performance here are some of the data needed for the MPC control (shown in Table 5-1). The data can be provided through the cloud service to the MPC controller for optimization of the component operation.

Table 5-1: The MPC components in the energy system

Component to control	Type of control	Data needed from source	Type of operation/functionality (description)	Location of the data and controller	Reason
PVT	Tank temperature and set points	Radiation and ambient temperature, its prediction	Set points of the tank and/or BTES has to be adjusted in order to optimize the heat generation	Cloud+MPC+component controller	Energy and cost savings
Tanks	Tank set points	Demand of the building and user behaviour of the building, its prediction	The Final tank temperature can be adjusted based on the demand	Cloud+MPC+component controller	Energy and cost savings
Heat pump	Source for the heat pump	Tank and BTES	The heat pump can change the	Cloud+MPC+component controller	Energy and cost savings

		temperature level	source either from the tank or from the BTES in order to have higher COP		

At the building level these MPC controls (as shown in Table 5-2) are needed in order to improve the performance of the building and for increased user satisfaction.

Table 5-2: The MPC components in the building automation system

Component to control	Type of control	Data needed from source	Type of operation/functionality (description)	Location of the data and controller	Reason
HVAC	On/off	Occupancy in the building, prediction	To switch off or on the HVAC system depending on the occupancy behaviour	Cloud+MPC+component controller	Energy and cost savings
Zones temperature, air flow, lights	Control the indoor temperature, airflows, lighting based on preferences	Occupancy prediction, user behaviour prediction, illuminance, CO2 level, temperature level of zone	Control the indoor environment and climate for user satisfaction	Cloud+MPC+component controller	Energy and cost savings
Electrical appliances	Control the appliances (on/off), suggestions	User behaviour and PV production prediction, electricity price	The electrical appliances can be switched on/off or controls can be suggested based on the PV production and electricity pricing	Cloud+MPC+component controller	Energy and cost savings

The main functionalities of the MPC as described above can be broadly divided into two categories. The first category is at the energy system level, while the second category is at the building level.

At the energy system level, the main components that have to be controlled are the PV/T, heat pump and tanks.

At the building level, the main components that can be controlled are the HVAC system, the indoor climate of the rooms, the indoor ambiance and lights of the room and lastly the electrical appliances.

Input Connections & Interfaces:

At the energy system level, data on weather, set points of the generation and storage components, and building demand is collected by the Data Management Platform. The EXCESS Data Management Platform and MPC will be connected by a Rest-API.

At the building level, data on occupancy, illuminance, CO2 level, temperature level of zone, PV/T production and energy cost is collected by the Data Management Platform. The EXCESS Data Management Platform and MPC will be connected by a Rest-API.

Output Connections & Interfaces: The MPC output is available also by a Rest-API. Actions on the building level can be triggered via the Data Management Platform.

Input Parameters:

Radiation Ambient temperature PV/T data and set points Storage tanks set points and data Heat pump status and set points HVAC system Occupancy Indoor temperature and humidity Illuminance CO2 concentration Space heating, domestic hot water and space cooling demand Appliances and plug load demand User behaviour or profiles Energy cost

Output Parameters:

Set points of tanks and seasonal storage Set point of the PV/T Set point of heat pumps Set points of the space heating, domestic hot water and space cooling Appliance and plug load control HVAC system control

Software Development Language: Java, Python, Modelica, TRNSYS or any other feasible software

Communications: Rest- API

5.3.2 Adapted MPC component for Austria

For Austria two layers of MPC will be developed. One which is located at the building level and one which is responsible for areal as energy community which encompasses the newly build PEB and several existing buildings.

The MPC will be developed by AEE in cooperation with JR. At the Austrian demo the realized PEB is modelled by a grey-box model by AEE. This physics-based building model constantly receives parameter updates from a real time Moving Horizon Estimation (MHE). The other buildings located at the areal will be implemented as a grey- or black-box model, depended on the data availability for each building, led by JR. The optimisation function is developed by AEE and JR, who is responsible also for the development of business models for the demos that will be reflected in the control strategies.

In the optimization process, the Predictor provides information about external influences such as the weather. For the Austrian demo demand and generation forecasts are calculated by a prediction server, which is based on WEDDA-S-Framework (weather driven demand and supply analysis), which was developed by JR.

The optimization is enhanced by profiling of occupants providing a better understanding of flexibility boundaries considering the comfort zones of residents. The comfort profiling will be included in the MPC.

An Emulator model is required to simulate a virtual building. These virtual buildings are used to design and train the controller integrated models. Available toolboxes for this are Modelica [3], EnergyPlus [4], IDA [5] and OpenModelica [6]. OMPython [7] can be used as Python interface to the freely usable OpenModelica.

Input Connections & Interfaces: Data on demand, supply and state of the buildings is collected by the Data Management Platform. The EXCESS Data Management Platform and MPC will be connected by a Rest-API.

Output Connections & Interfaces: The MPC output is available also by a Rest-API. Actions on the building level can be triggered via the Data Management Platform.

Input Parameters:

Input Data	Granularity
Setpoint of HVAC (target temperature)	on change
HVAC Operational State (Heating/Cooling)	adjustable Intervall (>= 1sec)
HVAC Status (ON/OFF)	adjustable Intervall (>= 1sec)
HVAC Energy consumption	adjustable Intervall (>= 1sec)
room temperature	adjustable Intervall (>= 1sec)
room humidity	adjustable Intervall (>= 1sec)
room CO2 concentration	adjustable Intervall (>= 1sec)
energy consumption at appartment level (electricity/thermal)	13 Watt steps
energy consumption at building level (electricity/thermal)	13 Watt steps
local generation data (energy output)	adjustable Intervall (>= 1sec)
local storage data (charging level, status, capacity available)	adjustable Intervall (>= 1sec)
Local weather data	15 min

Output Parameters:

Output Data	Granularity
Thermal Power Setpoint (Heating/Cooling Control)	15 min
Shading Control (if available)	15 min

Software Development Language: The MPC for the Austrian Demo will be implemented in Python on the basis of available open-source MPC libraries. A promising library for the level of the areal with regards to functionality, topicality and quality of documentation is MPCPy [8]. For the building level of the realized PEB the Gekko [9] optimization suite is used.

Library	Functionality	Topicality	Stackoverflow Tags	Documentation	Total
Do-mpc	2	2	0	3	**7**
python-dmpc	1	0	0	1	**2**
pyMPC	2	2	0	2	**3**
pympc	1	1	0	1	**3**
mpcpy	1	1	0	0	**2**
mpc	0	0	0	0	**0**
pyDMPC	2	2	0	2	**6**
MPCPy	3	3	3	3	**9**
FastSim	3	3	0	0	**3**

Communications: Rest-API

5.3.3 Adapted MPC component for Spain

In the Spanish demo case of PEB, there are three main energy systems that work together. The control system is under study, and a first version will be defined after the simulation results from T2.6.

The following figure shows briefly some of the components involved in the different systems.

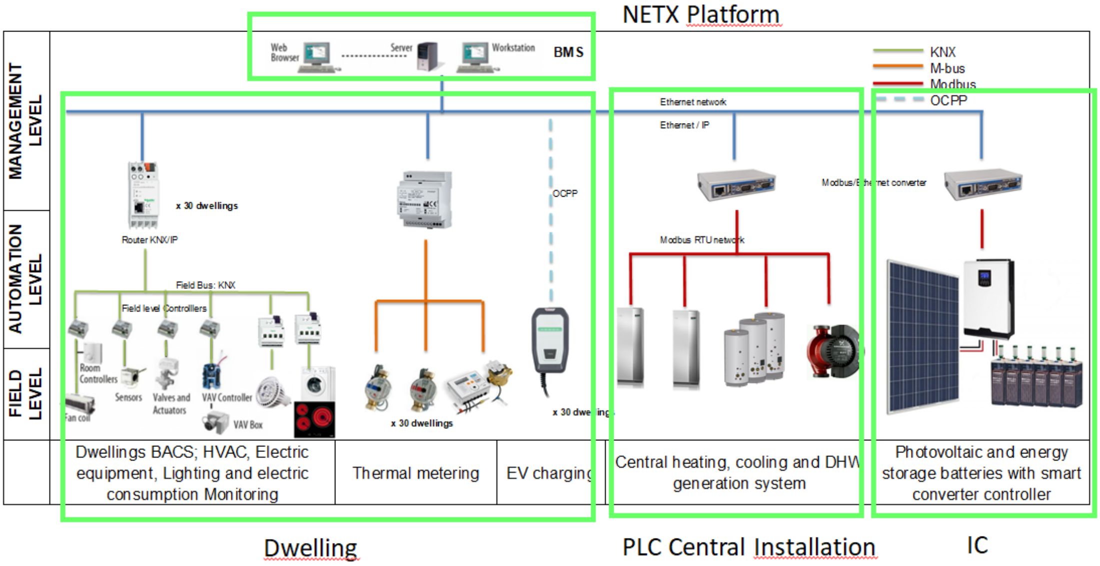

Figure 5-9: Three main energy systems in the Spanish demo

The first energy system is referred to the Integrated Controller which controls the PV production and the electrical flux based on energy needs. The following figure shows the scheme of this energy system. The IC is at the centre of the system, and maximizing the PV production, decides how to manage the electricity generated. This way, based on weather and energy consumption predictions takes the decision to store it in the batteries installed to be used later maximizing self-consumption; or can supply energy to the heat pump based to be fed only from the PV production (existing the possibility to store heat in the tank storages) or finally, put the electricity on the grid.

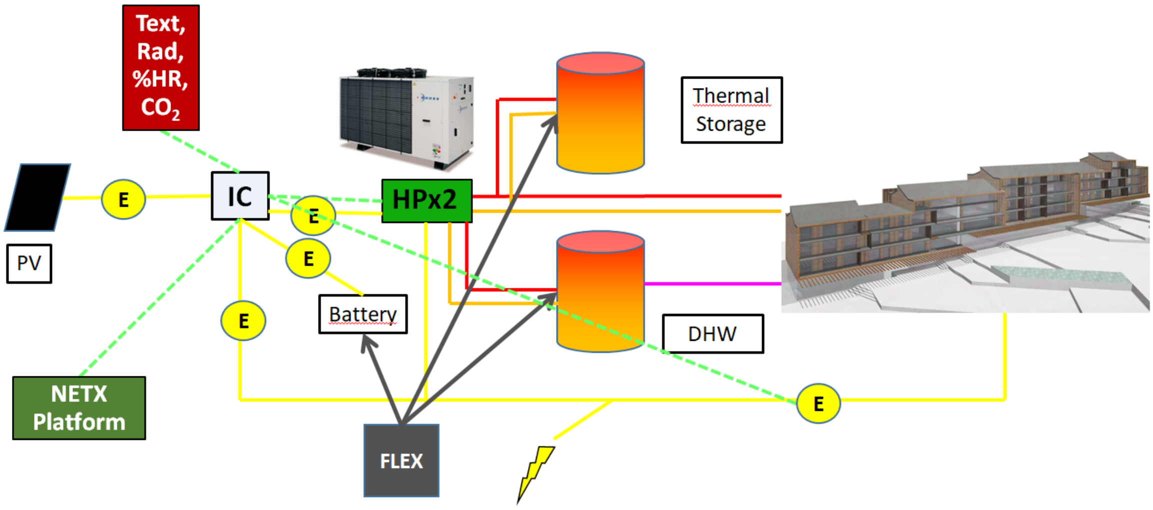

Figure 5-10: Integrated controller system

The second main energy system is referred to the apartments, and controls the energy consumption in the dwellings. The following figure shows a brief description of the elements in the system. The building users set some indoor conditions setpoints (temperature, humidity, CO2, luminance…) and the apartment system supply the energy to feed the user needs. In this sense, it is important to know the user's presence in the apartment and the setpoints they define. The inertia of the apartments is also a key factor so that the energy system can react quickly so guarantee the indoor conditions, and this could be further analysed. The energy consumption (electrical and thermal) at dwelling level will be monitored and in certain apartment the ventilation efficiency will be measured to be able to manage the system efficiently.

The thermal supply at the apartment level is to be decided but the initial idea is to install on radiant floor for heating purposes, and through fan-coils for cooling purposes. Based on CO2 levels, and with the presence of the users, the ventilation system (with heat recovery unit) will be activated at different speed levels. Regarding lighting levels, it is under technical-economic study to install luminance sensors.

There is an option to control the electrical supply to home appliances in order to control the demand response, but it is under debate, and probably it will not be implemented due to user complexities. However, certain suggestions to the building users to move towards demand response mode is really important to engage the user. Then, the option to promote the demand response can be done through the thermal system, having the possibility to cool the apartment down or to heat it up in case there is availability of energy or in case it is scarce. The setpoint conditions and presence of the user is required for this purpose.

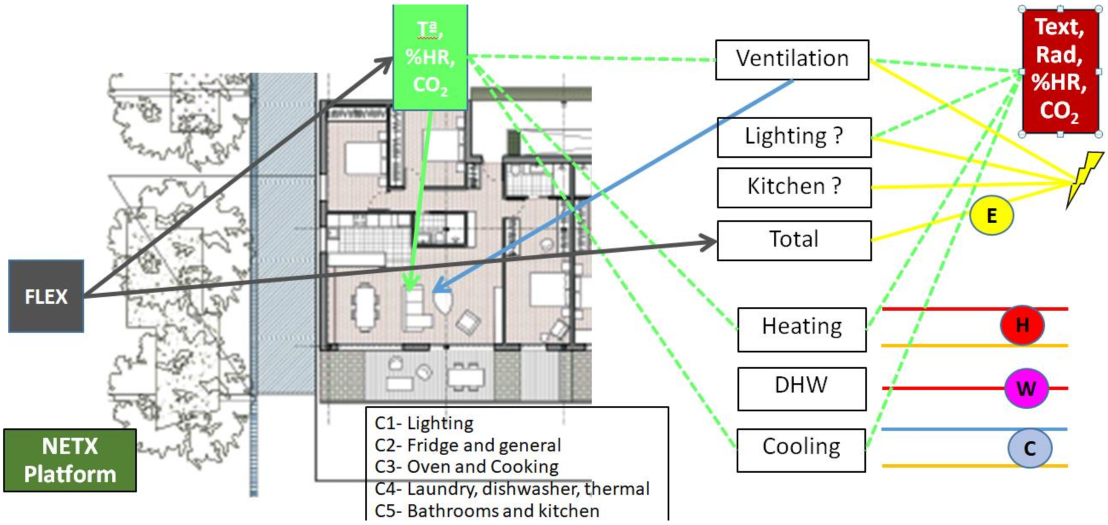

Figure 5-11: Apartment energy system

The third system is focused at building level, and controls the HVAC and DHW production to supply energy to be consumed at the apartment level. This system is controlled by a PLC that manages the installation. There is a group of heat pumps that produce the thermal energy required for domestic hot water, heating and cooling. These HPs are water-to-water HPs and exchange energy with the ground borehole system. There are storage tanks (under sizing definition) to storage energy for heating, cooling and domestic hot water systems, which based on the energy consumption in the building the control system will decide to storage energy in the tanks or to consume it. They are also important to reduce the number of ON/OFF of the HPs. It is important to calculate the efficiency of the system based on external conditions to manage it efficiently.

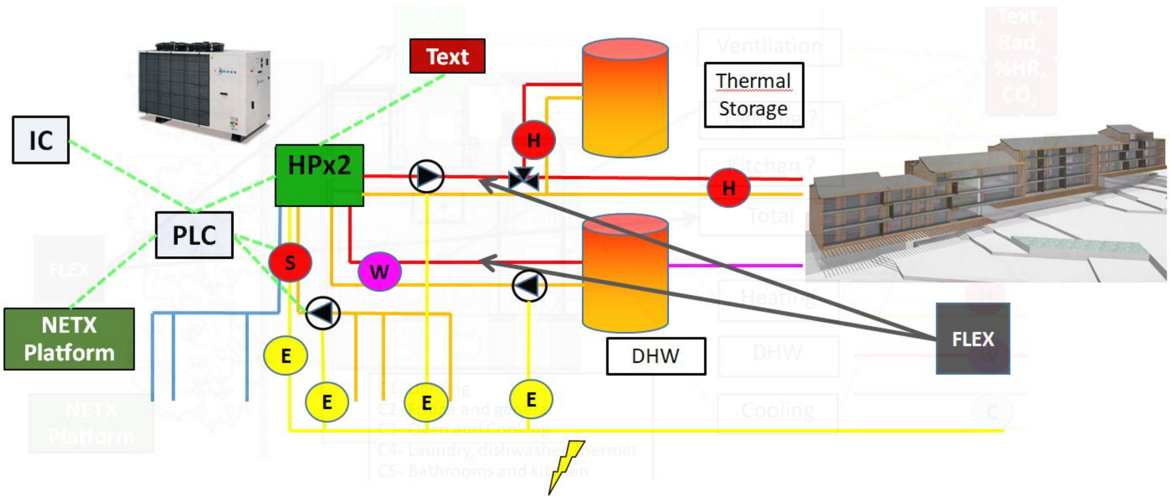

Figure 5-12: Building energy system

The three main energy systems are connected through an upper layer of communication.

The energy simulation model is under development, so the MPC connection is at an early stage. Based on the control definition and the energy simulation, the following data are required for the MPC to be defined in the Spanish demo.

Table 5-3: MPC components in the Integrated Controller

Component	Type of controls	Data required	Action	Data flux	Purpose
PV panels and converter	Power, Current and Voltage	Solar radiation and external temperature based on weather forecast	Optimization of PV production, and output for the rest of the systems	Cloud+MPC+ Integrated controller	PV generation maximization
Batteries	Level of charge in the batteries	Electrical demand of the building based on energy forecast	Manage the State of Charge in the batteries to maximize the self-consumption in the PEB	Cloud+MPC+ Integrated controller	Self-consumption
Heat pump	Define the working regime or the HP.	Building demand, prediction	To increase the overall COP of the system and to increase the self-consumption in the building, the working regime of the HP can vary depending on the availability of energy generation from PV and building demand.	Cloud+MPC+ Integrated controller	Self-consumption

At the apartment level the following controls in the MPC are needed:

Table 5-4: MPC components in the apartment energy system

Component	Type of controls	Data required	Action	Data flux	Purpose
HVAC	Switch ON or switch OFF the HVAC	Occupancy in the apartments, prediction	To switch off or on the HVAC system depending on the occupancy behaviour	Cloud+MPC+Netx platform	Energy and cost savings
Indoor air temperature, humidity, air flow and lighting levels (possible)	Control the indoor temperature, airflows, lighting based on preferences	Occupancy prediction, user behaviour prediction, illuminance, CO2 level,	Control the indoor environment and climate for user satisfaction	Cloud+MPC+Netx platform	Energy and cost savings

		temperature level of zone			

Table 5-5: MPC components in the building automation system

Component	Type of controls	Data required	Action	Data flux	Purpose
Heat Pumps	Outlet temperature, Water flow.	Availability of electricity, thermal demand, and DHW demand, Temperature in tanks	To define the most suitable temperature, and management of the storage tanks	Cloud+MPC+PLC	Energy and cost savings
DHW	ON/OFF	DHW prediction (water daily profile prediction)	Storage DHW in water tanks at high temperature based on DHW prediction and availability of electricity	Cloud+MPC+PLC	Energy and cost savings

Input Connections & Interfaces: The definition of MPC in Spanish Demo is still under development. However, it is likely that MPC could need inputs such as PV electricity production and weather forecast (solar radiation and outdoor temperature).

Besides, it could be useful that the MPC gets information users preferences predictions from the indoor setpoints (temperature, illuminance, air quality) and about household appliances use as well as the water daily profile and the occupancy.

These inputs could be received from the “Comfort Profiling component”, the “Generation Forecasting component” and the “Context-Aware Flexibility Profiling and Analytics component”.

Output Connections & Interfaces: The control system and its strategies are still under development. However, it is expected that the MPC could send its outputs to the following components:

- Lighting Devices Controller.
- Shading Devices Controller.
- Thermal Generation System Controller.

Input Parameters: The MPC could need the following parameters:

DHW Water consumption forecasting (in building)
Occupancy status (yes/no) forecasting (in apartment)
Lighting devices Setpoints forecasting (dimming level) (in apartment) (if available)
Lighting devices status (ON/OFF) forecasting (in apartment)

Fan Unit Status (ON/OFF) forecasting (in apartment)
Fan Units Consumption forecasting (in apartment)
Household appliances and other electrical devices status (ON/OFF) forecasting (in apartment)
Household appliances and other electrical devices consumption forecasting (in apartment)
Temperature Setpoints defined by users (in apartment) forecasting (in apartment)
Local weather data (Outdoor Temperature, Total Radiation, Beam Radiation, Diffuse Radiation) forecasting
Temperature in Storage Tank (Heating) (real-data from sensor)
Temperature in Storage Tank (Cooling) (real-data from sensor)
Temperature in Storage Tank (DHW) (real-data from sensor)

The parameters shown in the table above, have been included as a first definition of the input parameters of MPC. However, some of them could be not included or even other could be added during the development of project.

Output Parameters: The control system and its strategies are still under development. However, it is expected that the output parameters of the MPC could be:

- Switch (ON/OFF) Lights (if available)
- Open/Close (ON/OFF) Motorized blinds (if available)
- Related to Thermal System:
    - Switch (ON/OFF) Heat Pumps and Water Pumps
    - Temperature(s) Setpoint(s)

Software Development Language: To be determined.

Communications: To be determined. It could be REST-API

5.3.4 Adapted MPC component for Belgium

In accordance with use case 13 (building level) mentioned in Annex I: Use Cases, a MPC component will be foreseen per building/apartment to identify and apply the optimal energy performance of the building. It will provide a thermal consumption plan and flexibility profile (flexgraphs) towards the district level.

In accordance with use case 15 (district level) mentioned in Annex I: Use Cases, a MPC component will be foreseen at district level to identify the optimal energy performance strategy for the district. It will obtain this by reducing the DHN operating temperature through optimal control of the heat pumps, making optimal use of the thermal flexibility provided by the apartments and by the big buffer in the DHN. To provide the higher temperature needed for the DHW, it will activate the electric heaters of the DHW buffers in the thermal substations at the apartments, preferably at moments when there is sufficient local green energy. Moreover, the controller will apply a control strategy for the heat pumps and electric heater to maximize the self-consumption of the thermal and electrical energy provided by the local PVT and wind turbines.

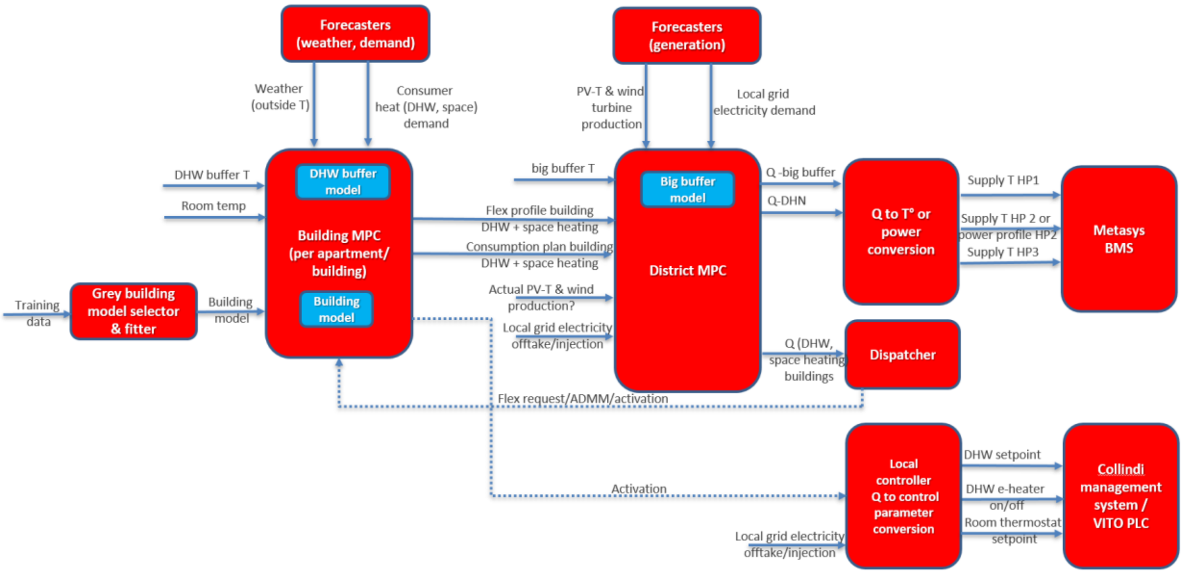

Figure 5-13: Adapted MPC component for Belgium – base architecture

The district MPC performs the control at district level, mainly controlling the heat pumps and requesting the necessary flexibility from the buildings. By carefully selecting and setting the heat pump(s) supply temperature value, the controller can direct the produced heat into the big buffer or into the DHN network. Similarly, it can also discharge the big buffer by selecting a low supply temperature or deactivating the heat pumps.

The building MPC performs the control at building level, primarily providing flexibility profiles and consumption plans to the district level, and negotiating with the dispatcher to agree on and activate the requested/agreed flexibility.

The dispatcher disaggregates the requested flexibility at district level over the different buildings via ADMM. For this, it interacts with the different MPCs at building level.

The MPC output in the form of heat Q activation will be converted into specific control parameters, determined by the device type and device model.

The local controller will convert the heat Q activation into specific control parameter settings, taking into account comfort settings and local constraints. To only activate (in the real-time timeframe) the electric heater for the DHW buffer when appropriate (abundant renewable energy) it will monitor and take into account the actual common (district level) grid injection.

Input Connections & Interfaces: The MPC connects to the generation forecaster for forecasts on PV-T thermal energy and electricity production and on wind turbine electricity production. It connects also to a weather forecaster to get outdoor temperature and solar radiation forecasts. It needs also a forecast of the global electrical demand at local common grid (all devices like pumps, valves, monitoring systems, controllers, technical systems supplied by the common (district) grid connection).

The building MPC gets regular updates of the building model for the 'Grey building model creator & fitter'.

Other inputs are real-time parameters like the temperature of the DHW buffers, the room (thermostat) temperature, the actual PV & wind production and the local grid production measurements.

Additionally, the district MPC collects the flexibility profiles of the buildings and their consumption plans.

The MPC needs several models which are elaborated in section 5.3.4.1.

Output Connections & Interfaces: The district MPC will provide the control signals in the form of expected heat Q for charging/discharging the big warm buffer and heat Q towards the DHN and heat Q in the form of flexibility requests to the MPCs at building level.

The building MPC provides flexibility profiles and consumption plans to the district level, and requests/activates heat consumption at building level (DHW buffer and space heating).

Input Parameters:

MPC building level:

- DHW temperature T
- Thermostat actual room temperature
- Potentially TRV room temperatures
- Building model
- Forecast outside temperature T, solar irradiation
- Flexibility request/activation
- ADMM vectors
- Green energy forecast (to schedule the electric heaters)

MPC district level:

- Big buffer temperature T
- Flexibility profiles of the buildings
- Preferred/baseline consumption plans of the buildings
- Actual PVT & wind production (TBD)
- Local grid offtake/injection limits(TBD)
- Forecast for PV-T & wind production
- Forecast of local grid electricity demand

JSON is used as the format.

Output Parameters:

MPC building level:

- Flexibility profile of the building
- Consumption plan of the building
- Activation signal

MPC district level:

- Heat demand Q for the big buffer
- Heat demand Q for the DHN
- Heat demand Q (DHW, space heating) for the buildings

JSON is used as the format.

Software Development Language: Development is in python. For deployment we are currently considering python packaging and docker containers.

Communications: REST API

5.3.4.1 DHW Buffer model

Within the EXCESS project, a Collindi substation - buffer - sized 90 liters is installed in several apartments. The substation provides domestic hot water and space heating to each one of the apartments.

Hot water coming from the district heating can be used directly to heat up (through an internal coil) the buffer or in the floor heating system. A motorized 3-way switch valve is used to select among these two operating modes. Additionally, an electrical resistor (ER) in the buffer can be used to charge the tank. Priority is always given to the DHN and the resistor is only used if needed.

A 1-dimensional model which considers mixing and buoyancy dynamics using a smooth and continuous function will be used to determine the SoC of the 90 liters buffer [10]. Since some physical parameters crucial for the state estimation are missing, experimental campaigns will be conducted to gather data. The gathered data will mainly consist of temperature profiles and setpoints, charge/discharge flow rates, and the relevant control signals (e.g. electrical resistor on/off). The experimental data should cover the tank charge, discharge, and static loss phases.

The thermal buffer state of charge (SOC) will be defined based on the useful energy present in the tank. Useful energy is defined in this context as the amount of water above the useable temperature for DHW usage (>50 °C).

Control

The district heating network can charge the buffer up to a certain temperature, after which the electrical resistor might be switched on to reach the tank SOC of 1, i.e., the minimum useful temperature for the DHW delivery. Accordingly, the stopping criterion for the DH end of charge will be based on the temperature difference between the supply and return DH temperature read by the energy meter. Although the value for this temperature difference is defined as 2°C, it will still be tuned during the preliminary tests campaign.

5.3.4.2 Big Buffer model

Depending on the mode of control for the big buffer, we may need to estimate a SOC model for the large buffer, which will be similar to the model explained in the previous subsection.

5.3.4.3 Building Models

Building models characterize the thermal mass of the buildings, i.e., given the ambient conditions (outdoor temperature, solar irradiation, etc.) and the various inputs to the building, the model predicts the internal state evolution (e.g., indoor temperature). There are several choices available for modelling the thermal behaviour, and these are broadly categorized into white box models, grey box models and black box models. White box models characterize the building in great detail, taking into account all the physical interactions and detailed composition of the building. While they are very accurate, customizing them for different buildings can be time consuming. Black box models, on the other hand are completely data driven, and attempt to model the building, purely based on data collected from various sensors placed with in the building. Grey box models achieve a midway between the white and black box models: they work with a simplified physical model of the building, with various components of the building lumped together, and use data collected from the building to identify the model parameters of the lumped model. We will be using grey box models in this project. More specifically, we use *RC* models, where the building components are modelled using thermal capacitors and resistors. The figure below shows one possible network structure for modelling a thermal zone. In practice, a library of several such model structures is created, and the structure that explains the collected data best, is identified as the RC model for the zone.

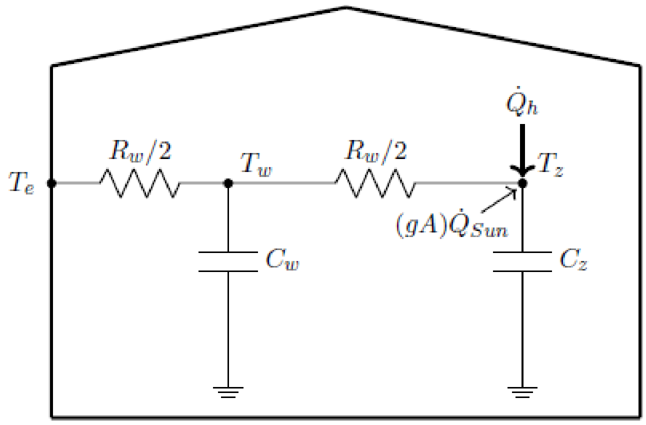

Figure 5-14 Example of a RC model

The demo buildings in Belgium can be modelled in the following two approaches:

- 4 building models with 5 thermal zones each (This accounts for the 5 apartments in each building). It is assumed that the 5 thermal zones (apartments) in a building interact with each other due to shared walls.
- 20 independent single zone thermal models. This approach assumes that there is no thermal interaction between the apartments that are in the same building, and each apartment is assumed to be connected to the heat network independently.

Analysis will be done on the thermal conductivity between apartments that share walls, and an appropriate choice will then be made.

5.4 EXCESS Data Visualizations Framework

5.4.1 Flexibility Analytics Visualizations for Aggregators

Aggregators need to continuously have a clear picture and understanding of their portfolio's performance, in order to constantly devise control strategies over aggregated clusters of customers and hedge against any overrides of control triggers that may lead to penalization by network operators. Thus, they need the means to monitor how flexibility events evolve at an individual customer level and modify pre-defined strategies through rapid re-configuration of dynamic VPPs to provide the required flexibility to the grid.

In this context, the aggregators will have access to the Flexibility Analytics Visualizations application in order to create flexibility clusters towards addressing the grid requirements of the network operators. Through the user interface and the appropriate dashboards, the aggregators will monitor the performance of the established clusters/ VPPs and identify potential overrides over flexibility triggers addressed to specific customers. As soon as such overrides are allocated (based on real-time data streams from the customers/ buildings/ flexibility assets), the application immediately performs an optimization function so as to effectively tackle the override by introducing additional flexibility sources into a modified VPP configuration and the aggregators can view the updated VPP schemes in the dashboards of the application. This process runs continuously until the end of a flexibility event allowing aggregators to avoid being penalized by the network operator for failing to provide the requested flexibility.

Input Connections & Interfaces: It will receive input from the Context-Aware Flexibility Profiling and Analytics component, the Dynamic VPP Configuration component and the Demand Forecasting component.

Output Connections & Interfaces: As a visualization application, it will not provide any output to other components.

Input Parameters: These will be the context-aware flexibility profiles of the devices and loads of building occupants.

Output Parameters: As a visualization application, it will not provide any output to other components.

Software Development Language: To be decided.

Communications: Internal APIs with the Context-Aware Flexibility Profiling and Analytics component, the Dynamic VPP Configuration component and the Demand Forecasting component.

The base architecture of the Flexibility Analytics Visualizations application is presented below:

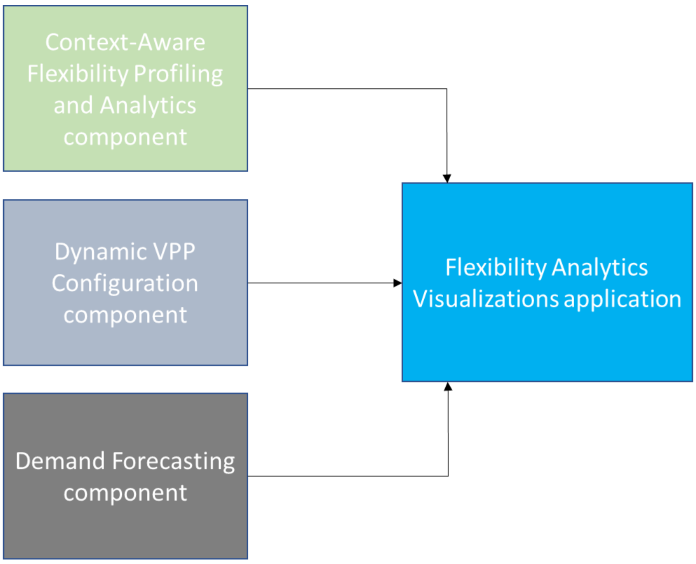

Figure 5-15: Flexibility Analytics Visualizations base architecture

5.4.2 Energy Consumptions Visualizations for Building Managers

Real-time monitoring of the building performance can provide building managers with the means to understand the consumptions, as well as the flexibilities of the building in terms of energy generation and demand. In addition, real-time monitoring will provide enhanced controllability through remote maintenance and more accurate fault and operating diagnostics, thus enabling a better building operation and performance.

The submeters, sensors and actuators that are installed in the building collect various real-time data regarding the energy consumption and demand of the building based on the behaviour of the occupants. These data are ingested and cleaned by the Data Collection component, they are mapped to the Common Information Model and are finally stored in the EXCESS Data Management Platform.

The Data Visualizations Framework will enable the building managers to view the energy consumption of their buildings through the related Energy Consumptions Visualizations application. Through appropriately configured dashboards and by using intuitive analytics that process these collected data along with short and mid-term demand forecasts, the Energy Consumptions Visualizations application allows the building managers to monitor the energy consumption of the building in real-time and become aware of its operation and potential capabilities for energy savings.

Input Connections & Interfaces: It will receive input from the Data Management Platform and the Demand Forecasting component.

Output Connections & Interfaces: As a visualization application, it will not provide any output to other components.

Input Parameters: These will be the energy consumptions at the apartment and building level and short and mid-term demand forecasts.

Output Parameters: As a visualization application, it will not provide any output to other components.

Software Development Language: To be decided.

Communications: Internal API with the Data Management Platform and the Demand Forecasting component.

The base architecture of the Energy Consumptions Visualizations application is presented below:

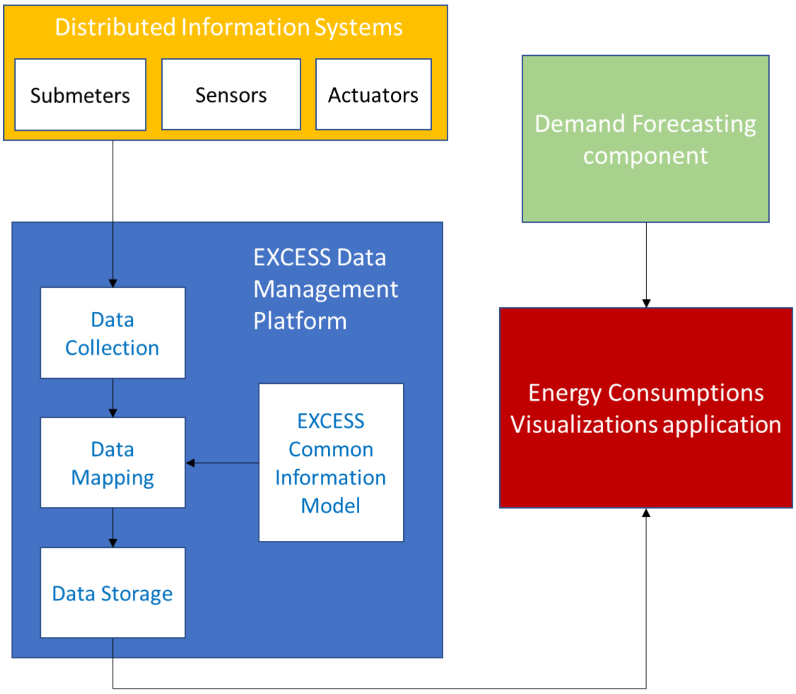

Figure 5-16: Energy Consumptions Visualizations base architecture

5.5 EXCESS Blockchain Enabled Applications

The EXCESS Blockchain Enabled Applications aim at increasing energy awareness, facilitating energy optimized behaviour, and automation of settlements and accounting. Two distinct applications, namely the Objective Benefit Sharing (OBS) and the Explicit Demand Response (EDR) Applications will utilize the EXCESS Blockchain (EBC). The OBS App enables the deployment of energy optimization strategies, processing contract rules for stakeholder, managing shares and shareholder decisions, and accounting. The EDR App executes explicit demand response programs through flexibility trading with energy market actors. Both applications share an underlying blockchain component, the EBC.

The three base components, OBS App, EDR App, and EBC interface each other and receive data from the Distributed Information Systems and the Data Management Platform. The occupants interact with the OBS App via the OBS Web-Interface either online or via suitable interface devices which would be required at dwelling level on the demo sites. The OBS App requires metering data, which can be provided by the Data Management Platform or directly from Distributed Information Systems, benefits from forecasting data, provided possibly by the Data Analytics Platform and can provide shareholders with an invoicing module.

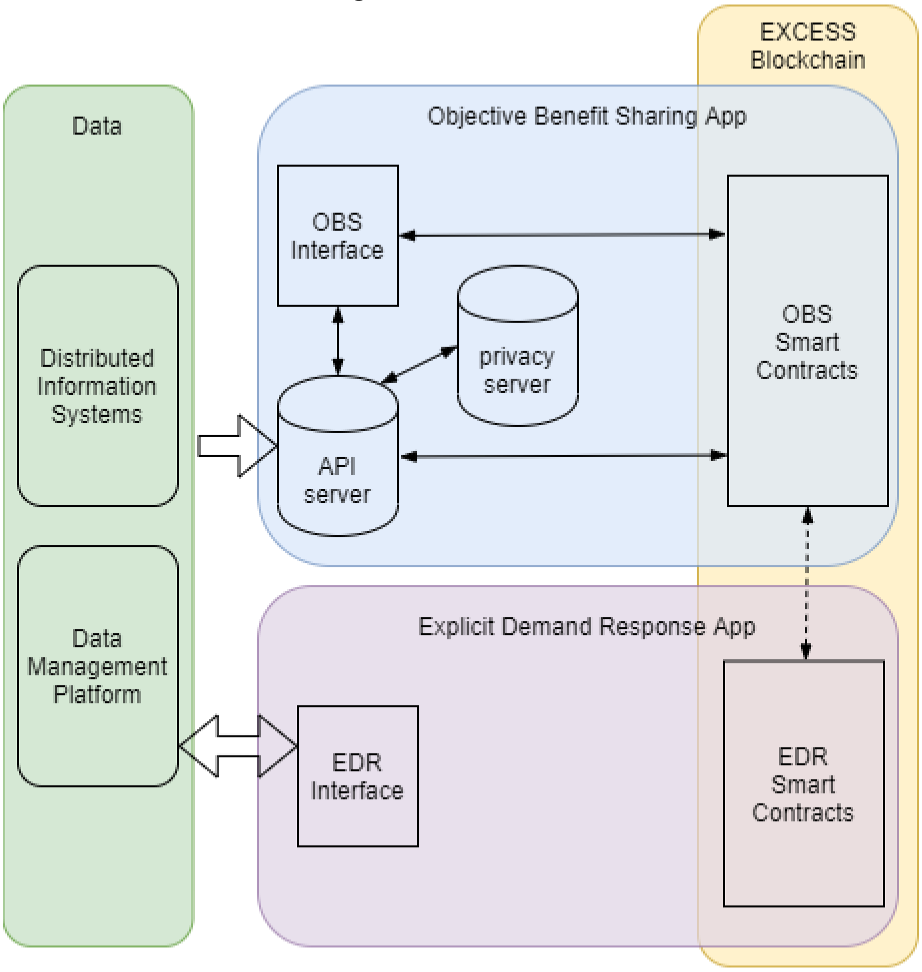

Figure 5-17: EXCESS Blockchain applications

5.5.1 EXCESS Blockchain Infrastructure

The EXCESS Blockchain Infrastructure include the EXCESS Blockchain (EBC) nodes, the server infrastructure for the OBS App, and the server infrastructure for the EDR App. While the OBS and EDR

App are explicitly described in the corresponding chapters, the EBC will be discussed in the following. Currently, different blockchains and distributed ledgers are still under review aiming at a long term commercial solution. The EBC will allow processing smart contracts and token transactions, fulfilling the base requirements of the blockchain enabled applications. Furthermore, an open market connection preferably connected to stable coins, thus, linking the virtual values to currency in a non-volatile manner, is a desired feature. Due to recent developments especially at European level, the former plan to base the EBC on Ethereum might be adapted.

5.5.2 Objective Benefit Sharing Application

The Objective Benefit Sharing (OBS) App will incorporate the following features and functionalities:

- energy awareness: the OBS Interface depicts energy performance indicators to stimulate ecological and economical energy consumption. These indicators can be production and consumption values, energy score, energy savings, and corresponding monetary values where applicable. Displaying the production and consumption values at community level facilitates economical behavior by stimulating energy consumption in times of overproduction. Based on these production values, the current energy score is defined, indicating the rate of self-consumption. The average energy score at dwelling level for a billing cycle in combination with an anonymous ranking within the community stimulates increased self-consumption rates. By comparing the current period to a reference period, energy savings at dwelling level can be calculated and, projected to annual consumption, the resulting monetary savings can motivate reduced consumption. The debits and credits of the current billing cycle give an overview of the expected costs.
- stakeholder contract rules: the OBS Smart Contracts apply rule sets on input data. These rule sets can include assessing maintenance reserve, incentive pool, specifying decision level thresholds, and others.
- shareholder decisions: shareholder of the community installation can vote on decisions required for smooth operation of the community installation. By enabling delegated and automated voting, shareholder can specify their level of involvement in the decision making process. These decisions cover energy pricing for future billing cycles, establishing a maintenance reserve and an incentive pool, awarding service contracts, adapting stakeholder contract rules, and similar.
- share management: shares of the community installation can be traded.
- accounting: every billing cycle, the required data is shifted into the OBS Smart Contracts. This data contains meter data at community and dwelling level, the average energy score at dwelling level and the energy price. The OBS Smart Contract applies the rules defined by the shareholders, in return the payable amount, the incentive based discount, and the dividend, if applicable, are retrievable.

The OBS App comprises the following components:

- OBS Interface: the OBS Interface enables user interaction via a web-based interface. Users are categorized in two groups, consumers and producers. Consumers represent occupants at dwelling level, receiving information to increase their energy awareness. Producers are shareholders of the community installation. As shareholders, producers get information at community level and can get involved in the decision making process, share trading, and definition of contract rules. Users can also be part of both groups, consumers and producers, hence, categorized as prosumers. The OBS Interface communicates with the API Server and possibly directly with the blockchain, when applicable.

- API Server: the API Server provides a REST-API for data exchange. The API allows permissioned interaction with data used or gathered by the OBS App and provides an interface to the EXCESS Blockchain. The API Server might also fetch data on demand from the Distributed Information Systems or the Data Management Platform, preferably also provided by a REST API.
- privacy server: especially at the Austrian demo, an accounting system will be implemented, requiring the personal data of occupants. These personal data will be handled in a shielded database only exposed via the permissioned API providing GDPR conform usage.
- OBS Smart Contracts: the OBS Smart Contracts (SC) manage accounting, shares, and contract rules. The OBS SCs interface with the API Server, providing an easy to use interaction with the SCs, with the OBS Interface, where direct SC interaction is required and deemed necessary, and with other SCs on the blockchain, where applicable.

Input Connections & Interfaces: The OBS App interfaces primarily with the Distributed Information Systems or the Data Management Platform via a REST API provided by the API Server:

- meter data: real-time meter data at community and dwelling level are required. Both, a passive interface to push meter data to the API Server, as well as an active pull driven system might be implemented, preferably acquiring data from a REST-API provided by the Distributed Information Systems. Data granularity depends on the utilization of the OBS components. To implement basic accounting at the demo site, at least one data set per billing cycle is required, to increase energy awareness at dwelling level, a high, close to real-time granularity is preferable.
- forecasting data: energy forecasts for energy production and consumption at community level are required in order to raise awareness concerning self-consumption rates of occupants. The forecasting data should include short term (1-2h) and mid-term forecasts (6-12h) enabling occupants to schedule energy-intensive processes to optimize self-consumption rates.
- personal information: the personal data of occupants at dwelling level are required, if the accounting component is used at the demo site. Depending on the demo site's privacy handling, a unique identifier (UID) linking the on-chain account to an occupant's UID is sufficient. Personal data will be handled according to GDPR, providing the possibility of complete removal of personal data from the privacy server via the permissioned API.
- accounting information: methods for retrieving billing information consisting of debits and credits of the current billing cycle.
- stakeholder and shareholder interaction: methods of the OBS Smart Contracts are passed through the API Server for easy access, where applicable.

Output Connections & Interfaces: The OBS application will not provide output to other components.

Input parameters:

meter data at community and dwelling level in real-time down to once per billing cycle energy forecasts at community level, production and demand at similar granularity as meter data energy price at similar granularity as meter data (if variable)

personal data/unique identifier stakeholder invoicing shareholder decisions

Output parameter:

accounting information

Communications: REST API

5.5.3 Explicit Demand Response Application

The Explicit Demand Response (EDR) application will facilitate the involvement of prosumers/ building occupants/ building managers in local flexibility markets, mainly intending to the utilization of the offered flexibility for the realization of the business goals of aggregators towards providing services to grid operators in the form of explicit demand response over aggregated clusters of demand assets. In order to minimize uncertainties and reduce risks, aggregators tend to be more favourable to the deployment of automated demand response strategies (explicit demand response) on the basis of well-established contracts with prosumers/ building occupants/ building managers that define in detail the flexibility to be offered, the loads that will offer it, the duration of each event, the timing of each event and the remuneration provisions.

In this sense, the Explicit Demand Response application will enable the prosumers to trade flexibilities in the local energy markets and receive monetary gains. The prosumers will firstly get aware of the flexibilities their devices can provide and the time and duration these flexibilities can be utilized through registration to the EDR application. By utilizing the corresponding visualizations, they can have access to analytics over historical data that reveal patterns and insights on the flexibility each of their controllable assets can offer, facilitating in this way their bidding actions. Thus, they will be enabled to select any flexibilities they would like to offer to aggregators in the local flexibility market. Through a negotiation between the prosumer and the aggregator, a flexibility contract is created and is also written in the EXCESS blockchain infrastructure. When the demand response event is ready to begin, the prosumers that are selected for the VPP configuration receive a notification from the EDR application regarding the details of the event and the envisaged automated control actions over their specific devices and loads. The prosumers have the option to accept or reject the demand response activation over their loads. In case of acceptance, through the EDR application they can monitor the evolution of the event and as soon as the demand response action is completed, the EDR application informs about the settlement of the event and the remuneration received for the provided flexibility.

Input Connections & Interfaces: It will receive input from the Context-Aware Flexibility Profiling and Analytics component and the Dynamic VPP Configuration component.

Output Connections & Interfaces: The EDR application will not provide output to other components.

Input Parameters: The demand responses of the assets of building occupants.

Output Parameters: The EDR application will not provide output to other components.

Software Development Language: To be decided.

Communications: Internal APIs with the Context-Aware Flexibility Profiling and Analytics component and the Dynamic VPP Configuration component.

The base architecture of the Explicit Demand Response applications is presented below:

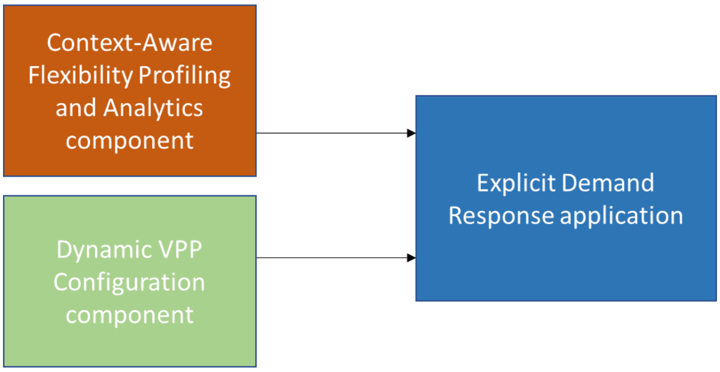

Figure 5-18: Explicit Demand Response application base architecture

6 Implementation, Integration and Deployment Plans

In the following subchapters, an initial plan regarding the implementation, integration and deployment of each different ICT component of the EXCESS system is presented based on the current knowledge of the general project planning. As far as the development of EXCESS ICT components is concerned, the development activities are envisaged to last according to the development plan. Regarding the deployment and integration activities, the corresponding plan may be updated due to any covid-19 constraints and specificities on constructions works of each demo site. In this case, an updated deployment and integration plan will be included in the corresponding WP4 deliverables.

6.1 Overall Integration Approach and Implementation Responsibilities

The integration of the EXCESS Data Management Platform with the Building Management System of each of the four demo sites will be crucial in order to collect the data from the sensors, actuators, submeters and other energy components of the demo sites and perform the necessary data processing for further analytical purposes. The EXCESS Data Management Platform will reside in a cloud server and depending on the Building Management System of each demo site, the connection is defined below.

Finnish demo site: The local building automation unit will collect data from the demo building and will push them in a cloud platform. This cloud platform will be exchange information with the EXCESS Data Management Platform through a single integration point. The envisaged connection method that is yet to be finalized is a REST API available by the cloud platform and the provided data will be in JSON format.

Austrian demo site: A local platform (in the form of a building automation system or building energy management system) will collect the data from the demo building. The data collected from the local platform will be sent through a REST API interface of the local platform (single integration point) to the EXCESS Data Management Platform in JSON format.

Spanish demo site: A central building management system will collect the data from the demo building and through a single integration point will exchange these data with the EXCESS Data Management Platform. The envisaged connection will be performed through OPC UA standard and the data will be sent in JSON format.

Belgian demo site: A central building management system will collect the data from the demo building and through a REST API that it will provide (single integration point), it will exchange these data with the EXCESS Data Management Platform in JSON format.

For all demo sites, in case real time data are available, there might be the need for a Kafka implementation to be deployed where the EXCESS Data Management Platform will subscribe following a Pub/Sub approach for collecting such real time information.

Regarding the implementation of the different components, each technical partner will be responsible for the implementation of the components presented in the following table:

Table 6-1: Implementation responsibilities of partners

Partner	Components
S5	• Data Management Platform with its subcomponents • Comfort Profiling component • Context-Aware Flexibility Profiling and Analytics component

	• Data Visualizations Framework with its applications • Explicit Demand Response application (along with VITO)
VTT	• Baseline Model Predictive Control component • Adapted MPC component for the Finnish demo site • The connection interface between the Finnish demo building management system and the EXCESS Data Management Platform
AEE	• Adapted MPC component for the Austrian demo site • The connection interface between the Austrian demo building management system and the EXCESS Data Management Platform
CENER	• Adapted MPC component for the Spanish demo site • The connection interface between the Spanish demo building management system and the EXCESS Data Management Platform
VITO	• Adapted MPC component for the Belgian demo site • Dynamic VPP Configuration component • Explicit Demand Response application (along with S5) • The connection interface between the Belgian demo building management system and the EXCESS Data Management Platform
JR	• Generation Forecasting component
CGS	• Demand Forecasting component
TSI	• EXCESS Blockchain Infrastructure • Objective Benefit Sharing application

6.2 Overall Timeline for Implementation, Integration and Deployment

The overall timeline for the implementation, integration and deployment of the various EXCESS components is depicted in the following Gantt chart.

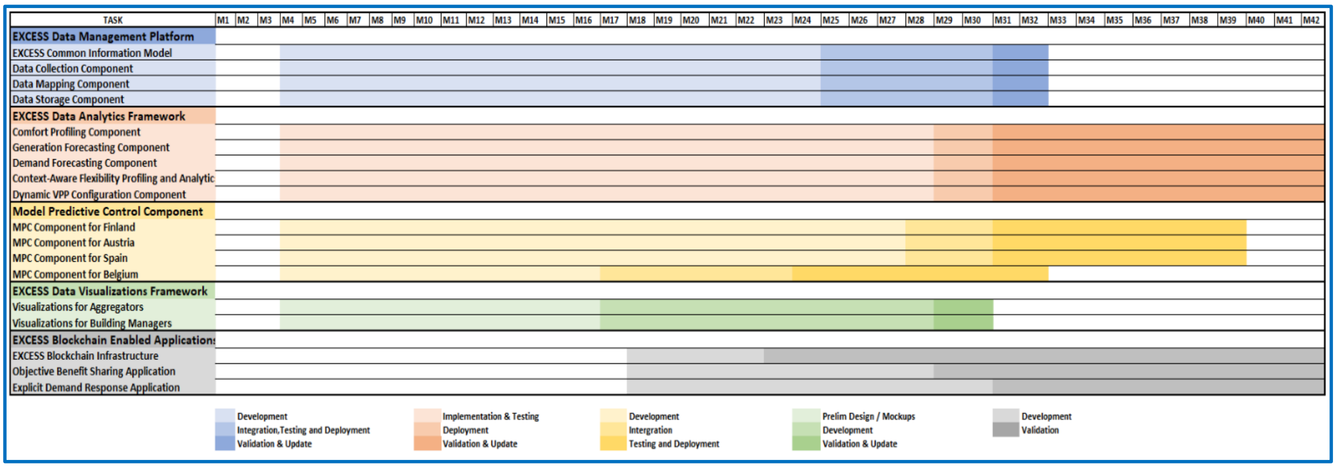

Figure 7- 1 Overall timeline for the implementation, integration and deployment of the EXCESS components

The specificities for the implementation, integration and deployment plan of each individual EXCESS component can be found in the following sections.

6.3 EXCESS Data Management Platform

6.3.1 EXCESS Common Information Model

The EXCESS Common Information Model will be delivered upon M24 of the project to facilitate the performance of the Data Mapping component. An updated version of the CIM will be available in M32.

6.3.2 Data Collection Component

The Data Collection Component will be developed upon M24 of the project. It will be integrated in the Data Management Platform in the M24-M30 period and after testing, it will be deployed until M30 as part of the Data Management Platform in order to initiate the validation phase in the demo sites. Based on the preliminary findings from the operation of the demo sites, any necessary updates on the Data Collection component will be ready in M32.

6.3.3 Data Mapping Component

The Data Mapping Component will be developed upon M24 of the project. It will be integrated in the Data Management Platform in the M24-M30 period and after testing, it will be deployed until M30 as part of the Data Management Platform in order to initiate the validation phase in the demo sites. Based on the preliminary findings from the operation of the demo sites, any necessary updates on the Data Mapping component will be ready in M32.

6.3.4 Data Storage Component

The Data Storage Component will be developed upon M24 of the project. It will be integrated in the Data Management Platform in the M24-M30 period and after testing, it will be deployed until M30 as part of the Data Management Platform in order to initiate the validation phase in the demo sites. Based on the preliminary findings from the operation of the demo sites, any necessary updates on the Data Storage component will be ready in M32.

6.4 EXCESS Data Analytics Framework

6.4.1 Comfort Profiling Component

The Comfort Profiling component should be implemented and tested until M28 of the project and deployed as part of the Data Analytics Framework until M30 in order to initiate the validation of the different demo sites. According to the first results of the operation of the demo sites, the necessary updates on the Comfort Profiling component will be developed until M42.

6.4.2 Generation Forecasting Component

Generation forecasts are made for PV-Power plants and for a small hydro power plant. For generation forecasting of PV two different time horizons can be differentiated, short-term forecasts for the next few hours and long-term forecasts longer forecast horizons. Long-term forecasts rely to a large extend on Numerical Weather Predictions (NWP) for the forecasting period, whereas short-term forecasts relay also on on-site measurements and/or satellite images.

For long-term forecasts we will consider two modelling principles. First, we use a purely statistical model that links the output of a NWP to the generated energy. Experience shows that these models work well when long time series of data is available (approximately 1 year). An advantage of the purely statistical model is that shadowing, alignment or the characteristics of a solar panel are all modelled implicitly from the data and need not to be known explicitly. The second approach is to use a physical model that use the alignment information about shadowing and the characteristics of the panel to calculate the generated power from direct and diffuse radiation and temperature. Since the physical model will be prone to errors in the specification, statistical models can be used to improve the generation forecasts as soon as data is available. The big advantage of physical models is that they can be applied also without the availability of data. In the demonstration, we will allow for both types of models and pick the one that performs better.

For short-term forecasts of PV there are two possible ways. First, persistence forecasts can be used. Persistence forecast assumes that the cloud cover stays the same for the forecast time horizon. This method works quite well on days with stable weather conditions and can correct errors in the long-term forecasts. Nevertheless, persistence forecasts only consider the condition on one site and will not work well on days with changing conditions. In this case, satellite data can be used to consider the current weather conditions of a wider area. With the help of two consecutive taken satellite images a cloud motion vector can be extracted that is used to predict the future cloud cover.

The main resource for the generation of hydropower is the available water. We will focus on two modelling approaches. First, we will use a (statistical) model to relate the gauge level at a measurement station to the generation of hydropower. For the predicting of future gauge levels we will use a neural network or similar method from machine learning with precipitation data of the catchment area and if data is available also from upstream measurement stations as input variables. The second approach is to directly model the generated power with a neural network with precipitation data of the catchment area and if data is available also from upstream measurement stations as input variables. Depending on the available resources, we will choose the model that provides the best fit. The generation forecasting component will be implemented and tested until M28. It will be deployed as part of the Data Analytics Framework until M30 in order to initiate the validation of the different demo sites. According to the first results of the operation of the demo sites, the necessary updates will be developed until M42.

6.4.3 Demand Forecasting Component

The Demand Forecasting component should be implemented and tested until M28 of the project and deployed as part of the Data Analytics Framework until M30 in order to initiate the validation of the different demo sites. According to the first results of the operation of the demo sites, the necessary updates on the Demand Forecasting component will be developed until M42.

6.4.4 Context-Aware Flexibility Profiling and Analytics Component

The Context-Aware Flexibility Profiling and Analytics component should be implemented and tested until M28 of the project and deployed as part of the Data Analytics Framework until M30 in order to initiate the validation of the different demo sites. According to the first results of the operation of the demo sites, the necessary updates on the Context-Aware Flexibility Profiling and Analytics component will be developed until M42.

6.4.5 Dynamic VPP Configuration Component

Regarding the requirements of the Belgian demo site for the VPP component:

- The necessary hardware for the demo site will be installed in 2020.
- In 2021 the control system will start operating in a basic control mode. Data will be collected from the different control systems on site, and a basic control strategy (rule based) will be applied.
- By the end of 2021 (M32 (April 2022) the latest) the VPP component should be implemented, tested and deployed.

In the rest of the demo sites, the Dynamic VPP configuration component will be implemented until M30, it will be deployed in M32 and it will be fine-tuned based on demo sites feedback until M42.

6.5 Baseline Model Predictive Control Component

6.5.1 Adapted MPC component for Finland

The MPC is needed if it is feasible and has added value on the performance of the system, otherwise the rule based control should work fine. The MPC can be developed during the building and energy system construction phase. This MPC and the controller box would be implemented on the site during the construction. The important aspect that has to be checked is the smooth integration of the MPC with the components, data acquisition and the cloud server. This is needed in order to provide the data to MPC algorithm. The joint effort is needed between the automation, construction and implementation team in order to integrate and test the MPC onsite. Here are the tentative milestones:

- Building is expected to be completed by 2021
- The renewable energy systems, storages, heating and cooling systems and other components and controllers are expected to be implemented by end of 2021or beginning of 2022
- The MPC (if needed) is expected to be implemented and tested by end of 2022

6.5.2 Adapted MPC component for Austria

The developed MPC model on building level is being tested in connection with a virtual simulation model of the building considering the HAVC components in IDA ICE for running optimization control algorithms of the multifunctional façade until M15. The MPC for the building will be further improved with additional functionalities (user context-aware flexibility profiles, weather and PV production forecast) and finalized for on-site deployment. By the beginning of 2022 the MPC control components should be implemented and tested in the Austrian demo.

For the Austrian demo and possibly for the Spain demo demand and generation forecasts are compiled with the WEDDA-S framework by JR.

6.5.3 Adapted MPC component for Spain

The starting point of the MPC will be the initial principles of the MPC in T3.5. It will work together with the advanced energy simulation model of the Spanish demo in T2.6. With the inputs from VTT, it will be integrated in the energy simulation model, during the construction phase of the building. Therefore, the first phase will try to have an operational version of the MPC from simulation (or virtual) results. Then, a communication will be stablished between the MPC and the NETX Platform with the corresponding controllers of the three different energy installations listed above. The process to do the integration of both systems will be extended in time to ensure that the MPC algorithm works as required.

The development project is still under development and the construction phase of the building is to be planned to start in July 2021, as per the latest news from UrbAtelier. Because of that, it is very difficult to set some milestone at this early stage.

6.5.4 Adapted MPC component for Belgium

Regarding the requirements of the Belgian demo site for the MPC component:

- The necessary hardware for the demo site will be installed in 2020.

- In 2021 the control system will start operating in a basic control mode. Data will be collected from the different control systems on site, and a basic control strategy (rule based) will be applied.
- By the end of 2021 (M32 (April 2022) the latest) the MPC control components should be implemented, tested and deployed.

6.6 EXCESS Data Visualizations Framework

6.6.1 Flexibility Analytics Visualizations for Aggregators

The first mockups will be created until M16 in order to receive comments from aggregators regarding the designed user interface of the visualizations application. In M28, a web based application will be available for aggregators in order to navigate and check its functionalities (user acceptance testing) and the finalised application will be ready in M30 accommodating the feedback from aggregators.

6.6.2 Energy Consumptions Visualizations for Building Managers

The first mockups will be created until M16 in order to receive comments from building managers regarding the designed user interface of the visualizations application. In M28, a web based application will be available for building managers in order to navigate and check its functionalities (user acceptance testing) and the finalised application will be ready in M30 accommodating the feedback from building managers.

6.7 EXCESS Blockchain Enabled Applications

Since Task 3.6 (i.e. Block chain-enabled applications for local energy communities and flexibility trading) is scheduled to start at M18, the current focus lies on reviewing eligible blockchain and distributed ledger solutions.

6.7.1 EXCESS Blockchain Infrastructure

A commitment to a specific blockchain solution will be expected until M18. The EXCESS Blockchain Infrastructure will be setup until M22.

6.7.2 Objective Benefit Sharing Application

The work will start at M18, preparations might start earlier. OBS consumer interface, accounting, and basic shareholder interface are developed until M28, including the underlying API and smart contracts. Refinement and adaptation including extended shareholder and stakeholder implementations are evaluated and implemented until M42.

6.7.3 Explicit Demand Response Application

The EDR application will be developed until M30 of the project. Based on the feedback from the prosumers during the validation phase of the demo sites, any updates on the EDR application will be ready until M42.

7 Conclusions

This deliverable has documented the activities of the Task 3.1 towards the definition of the EXCESS ICT Architecture and the high-level functionalities of the related ICT components. In this context, the methodology for the creation and circulation of user questionnaires and the subsequent extraction of EXCESS end users' needs have been described, while the EXCESS Business Scenarios and Use Cases have been presented, covering respectively the high-level business aspects and the functional characteristics of the EXCESS project. The detailed descriptions of the Use Cases have driven the elicitation of ICT components requirements and the high-level overview of the EXCESS ICT Architecture, where the main ICT components have been presented, namely the Data Management Platform, the Data Analytics Framework, the Model Predictive Control Component, the Data Visualizations Framework and the Blockchain Infrastructure and Applications. This has been followed by a detailed description of the EXCESS ICT components and their subcomponents, where their functionalities, connection interfaces and input and output data have been defined. In addition, the timeplan for the implementation, integration and deployment of each ICT component has been provided.

This deliverable will constitute the cornerstone for the ICT developments of the EXCESS project, as it will set the directions for the implementation of the various ICT components based on the defined requirements and technical specifications. Any necessary refinements and further details on the functionalities of the different ICT components will be documented in the rest of the deliverables of the WP3, D3.2 "EXCESS Data Management Framework", D3.3 "EXCESS Flexibility Analytics Module", D3.4 "EXCESS Model-Predictive Control Algorithms" and D3.5 "EXCESS Block chain Infrastructure and Applications", which will be dedicated in the description of specific ICT components and subcomponents.

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Annex I: Use Cases

EXCESS Use Case 1	
Use Case ID	UC1
Use Case Name	Comprehensive modelling of new/innovative building components, materials and energy systems towards their introduction in Building Energy Performance Simulation Tools.
Related Business Scenario(s)	BS1: Construction companies to increase the attractiveness of PEB investments, through enhancing the accuracy of Energy Performance Simulations at the design phase and as a means to reduce the gap between anticipated and actual energy performance of buildings.
Related Use Case(s)	UC2, UC3
Description	Towards improving the overall performance of buildings, the construction industry has experienced lately a rise in the use of new building components, materials and energy systems integrated into the building envelope which play an important role in the operation of the building during its whole lifecycle. It is thus clear that, in order to generate reliable building energy simulations, it is instrumental during the design stage of PEBs to accurate extract and model both static (i.e. building elements and materials) and dynamic components (such HVAC and other energy equipment). Having all this knowledge in hand, will enable to adapt the proposed design to the actual building usage; thus, acquiring more accurate results between predicted and actual building energy performance.
Involved Users	BIM Modelers, Technology Vendors
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	• PVT solution integrated with multi-source heat pumps • Prefabricated components for multifunctional facades, combining PV, insulation and heating/ cooling distribution pipe • Deep drilling (borehole) solutions for geothermal energy including borehole heat exchanger/heat collector • Multi-source heat pumps integrated with high performance domestic hot water systems
Pre-Conditions	• Thorough identification and detailed specifications on the (energy simulation) modelling of all new building components, materials and energy systems should be available (incorporating also LCA-LCC). • Additionally, modelling should comply with well-known and widely used standards (e.g. IFC) and be able to assess building performance from an LCA-LCC perspective.
Use Case Scenario	1) The BIM Modeler sets the rules, guidance for the BIM model. 2) The Technology Vendor provides the energy component specifications according to the guidance provided in model-compatible format (first tuning). 3) The BIM Modeler extracts the above info from the BIM after performing compatibility checks and refinements (final tuning).
Post Conditions	• The component/ system model is ready for use by the Energy Performance Simulation tool.

Business Impact	Increasing the accuracy of predictions reduces the uncertainty and risk that is imposed by the existing gap between predicted and actual building energy performance (affecting considerably energy savings and respective cash flows). More accurate simulations achieved by modelling the building as-is incorporating all available energy systems will significantly impact the viability of PEBs energy simulations and further enable the realization of highly attractive payback periods, which in turn will contribute in promoting the PEB concept and increase the attractiveness of PEBs investments.

EXCESS Use Case 2	
Use Case ID	UC2
Use Case Name	Enhancement of control routines in Building Energy Performance Simulation Tools with the adaptation of advanced Control logic and respective algorithms based on flexibility.
Related Business Scenario(s)	BS1: Construction companies to increase the attractiveness of PEB investments, through enhancing the accuracy of Energy Performance Simulations at the design phase and as a means to reduce the gap between anticipated and actual energy performance of buildings.
Related Use Case(s)	UC1, UC3
Description	Building energy performance simulations need to be performed through the integration of energy performance simulation tools with control logic algorithms in order to introduce novel control approaches into simulation, contrary to current generalized routines. In this way, control logic simulations shall prioritize on human-centric flexibility utilization extracted from the various building components and energy behaviours extracted from buildings in question to ensure the prediction of realistic energy performances that do not compromise comfort in the indoor environment.
Involved Users	BIM Modelers, Architect/Construction Companies, Technology vendors
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	• PVT solution integrated with multi-source heat pumps • Prefabricated components for multifunctional facades, combining PV, insulation and heating/ cooling distribution pipe • Deep drilling (borehole) solutions for geothermal energy including borehole heat exchanger/heat collector • Multi-source heat pumps integrated with high performance domestic hot water systems
Pre-Conditions	• Reference energy behaviour flexibility profiles, energy component flexibility models and sample data for indoor environment are available for the simulations. • The energy performance simulation tool is improved with the control logic algorithms.
Use Case Scenario	1) The BIM Modeler uses the energy performance simulation tool and consolidates reference occupant/ energy behaviour flexibility profiles from actual (or representative/ proxy) building occupants and flexibility properties of energy component stereotypes. 2) The BIM Modeler ensures that building components available in the BIM model incorporate the main control attributes that are required for simulating control strategies with the use of flexibility profiles.

	3) The Architect through the simulation tool executes multiple simulations combining all the above integrated profiles powered with model predictive control logic. 4) The simulation tool defines the optimal design of the building regarding energy performance (without compromising comfort of occupants). This design is followed by the construction company in the building development.
Post Conditions	• The blueprints for the optimal construction/renovation of the building are available.
Business Impact	The energy performance simulation tools through their improvement with predictive control algorithms can define the optimal design of buildings leading to their positive energy balance and subsequently to financial and environmental benefits.

EXCESS Use Case 3	
Use Case ID	UC3
Use Case Name	Adapt design to the actual building use, including accurate information about occupancy schedules, comfort requirements/ preferences and energy uses.
Related Business Scenario(s)	BS1: Construction companies to increase the attractiveness of PEB investments, through enhancing the accuracy of Energy Performance Simulations at the design phase and as a means to reduce the gap between anticipated and actual energy performance of buildings
Related Use Case(s)	UC1, UC2
Description	On the way to generate accurate building energy performance simulations during the design stage, the actual energy usage of the building should be modelled and profiled; it is thus critical to identify all building's energy uses and the reasons behind it. To accomplish this, supplementing the modelling of the building's energy and static components, designers should integrate reliable information regarding the occupant's behavioural patterns and their comfort zones. Having this information in hand will provide the means to reduce the gap between predicted and actual building usage.
Involved Users	Building occupants, BIM modeler, Architect, Building Surveyor
Target Demo Site	☐Spain ☐Finland ☒Austria ☒Belgium
EXCESS Components Involved	All available energy components in Austrian and Belgian sites.
Pre-Conditions	• Thorough identification of building occupants' specific comfort related preferences through sensors/ actuators and their occupancy schedules. • The constraints in data availability (e.g. limited number of users involved in the information extraction) and any ethical requirements arising (due to installation of sensors/actuators in the building premises) should be assessed and properly addressed.
Use Case Scenario	1) The building surveyor installs the sensors/actuators in the building for the collection of data, after several interactions with building occupants to eliminate concerns.

	2) The data streams from sensors and actuators feed the mechanism for the extraction of accurate comfort and energy behaviour profiles of occupants 3) The BIM Modeler incorporates the extracted profiles into the building's energy performance simulation tool, feeding both scheduling templates and control logic. 4) The Architect performs alternative simulation scenarios in the simulation tool towards predicting the expected (post renovation) building energy performance (based on accurate occupancy schedules and profiles) in balance with occupants' comfort.
Post Conditions	• Collection of accurate occupants' profiles in respect to comfort, occupancy, energy uses within the buildings • Accurate building design based on precise estimates of energy performance and execution of alternative design scenarios. • Accurate forecasting of building energy performance
Business Impact	Incorporation of occupants' behavioural patterns, their real schedules and their actual energy use preferences in Building Energy Performance simulations, will provide the means to reduce the gap between predicted and actual energy performance of buildings (usually generated through inaccurate representation of the building's energy uses and use of generic schedules) More accurate Energy Performance Simulations will reduce the uncertainty and risk created by the aforementioned gap at the design phase; this in turn will enhance the attractiveness of PEB investments since construction companies will be able to accurately estimate the anticipated energy performance of buildings.

EXCESS Use Case 4	
Use Case ID	UC4
Use Case Name	Satisfying energy and hot water needs of occupants through the development of appropriate façade technologies (PVT panels with enhanced connectivity to be installed in balconies).
Related Business Scenario(s)	BS2: Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand)
Related Use Case(s)	UC5, UC6, UC9, UC13
Description	The building's functional envelope elements such as its balconies will accommodate PVT panels for harvesting solar energy which can be used for the energy and hot water needs of the building's occupants. Through better controllability and optimization of the PVT panels functionality it will be possible to cover the building's occupants real-time needs in terms of energy and hot water; thus achieve optimum performance of the PVT while on the

	same time, conserve energy which can be turned into monetary savings for the occupants themselves.
Involved Users	Building occupants /owners/managers, Installer, Technology Vendors
Target Demo Site	☐Spain ☒Finland ☐Austria ☐Belgium
EXCESS Components Involved	PV/T integrated into building envelope element
Pre-Conditions	• Identification of building occupants' real time energy and hot water needs • Adaptive control of PVT panel
Use Case Scenario	1) The installer installs the PVT panel in the balcony and setups the interface for its communication with the MPC component, based on specifications provided by the technology vendor. 2) Energy from PVT operation in the balcony is produced. 3) Through the use of control logic of MPC component that considers the occupants' schedules, energy needs and comfort levels, PVT adjusts its production (between electricity and hot water) to address the actual needs of the occupants (e.g. by covering in real-time electricity consumption in full if hot water is not needed, or by using excess produced energy to pre-heat water for later use) in the short-term. 4) Any unconsumed energy is stored in any PEB or community-wide storage device for later use.
Post Conditions	• The stored energy may be used either for later self needs or distributed in other PEBs in the local community or traded in the energy market.
Business Impact	Through the optimization of operation of PVT infrastructure in balconies, the occupants enjoy lower energy consumption, comfort indoor environment and hot water and can even take back profits from trading of non-self-consumed energy.

EXCESS Use Case 5	
Use Case ID	UC5
Use Case Name	Utilizing the excess energy from PVT components as input for other building systems (charging the ground for ground-source heat pumps operation)
Related Business Scenario(s)	BS2: Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand)
Related Use Case(s)	UC4, UC6, UC7, UC9, UC13
Description	Depending on the climate and on the period of the year, conventional residential buildings with integrated RES can produce more energy than required, which -unless consumed- is eventually "wasted". As such, the utilization of the PVT excess energy (heat and electricity) can supply other

	devices of a building through the introduction of control logic. More specifically, the PVT heat surplus can charge the ground (utilizing deep boreholes during transitional months), and during summer a Heat Pump (HP) condenser can use the PVT as thermal source to dump heat to the ground. In addition, the photovoltaic part of the PVT collector generates electric energy that can be directly used to satisfy the electric demand of the building or to cover the HP electric consumption, or to be stored for future demands.
Involved Users	Building occupants /owners/managers, Installer, Technology Vendors
Target Demo Site	☐Spain ☒Finland ☐Austria ☒Belgium
EXCESS Components Involved	• PVT panels • Ground-source heat pump • Seasonal borehole storage and heat exchanger/collector • Multisource ground source heat pump
Pre-Conditions	• Availability of PVT panel, multisource ground source heat pump and coupling with deep boreholes. • Availability of PVT-HP combined technology • Availability of IoT integrated components for advanced automated control and monitoring system
Use Case Scenario	1) The installers install the PVT components and the ground-source heat pumps and setup the interfaces for their communication with the MPC component 2) The appropriately configured control logic of MPC component is applied to ensure optimal balance between thermal and electric energy generation in the PVT component based on real-time data streams and occupants' requirements for energy. 3) The PVT component utilises its heat surplus to heat the ground during transitional months and during summer the HP condenser utilizes the PVT as thermal source to dump heat to the ground. 4) In parallel, electricity generated from the PV component of the PVT is utilised to cover the building's demand or HP's electricity consumption or stored locally in periods of low demand.
Post Conditions	• The stored energy may be used either for later self needs or distributed in other PEBs in the local community or traded in the energy market.
Business Impact	Utilisation of the surplus energy (heat and electricity) generated from installed smart-ready energy technologies in new construction/ renovated buildings during months with low demand enables building owners/managers to decrease their reliance from the grid and achieve monetary gains through energy savings.

EXCESS Use Case 6	
Use Case ID	UC6
Use Case Name	Maximizing the use of RES in satisfying heating and cooling needs of occupants (Integration of PV and Heating Cooling distribution systems in vertical walls)
Related Business Scenario(s)	BS2: Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings BS3:

	Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand)
Related Use Case(s)	UC4, UC9, UC13
Description	Currently, the available RES solutions in buildings are installed as standalone items, which require increased costs for their installation/integration in the building's envelope as well as for their management and control increasing the burden of customers. In this context, a Multifunctional Façade element is introduced to increase building's RES capacity and performance by providing through control logic a combined electricity and heating/ cooling solution capable of fulfilling the building's needs for heating (in winter) and cooling (in summer), thus minimizing energy consumption while on the same time reducing installation, management costs.
Involved Users	Building occupants /owners/managers, Installer, Technology Vendors
Target Demo Site	☐Spain ☐Finland ☒Austria ☐Belgium
EXCESS Components Involved	Multifunctional Façade element
Pre-Conditions	• Availability of the PV and Heating Cooling distribution systems for building's external vertical walls • Availability of IoT integrated components for advanced automated control and monitoring system
Use Case Scenario	1) The installer integrates the multifunctional façade element on the building's envelope and setup its interface for its communication with the MPC component based on specifications provided by the technology vendor. 2) The outer PV layer generates electricity, while the inner activation layer (a heating and cooling distribution system provided in the form of a hydraulic pipping system) delivers heat or cooling energy to the building's external walls 3) The energy transmitted to the internal of the building covers its seasonal cooling/heating and energy needs. 4) Through the use of control logic of MPC component that calculates the occupants' schedules, energy needs and comfort levels, the energy produced by the multifunctional façade is consumed by the building occupants or stored -in cases of lower demand- as surplus in the distributed storage devices of the local community.
Post Conditions	• Reduced dependence of building from the local energy grid through the delivery of electricity and heating/cooling energy from the outer shell of the building.
Business Impact	Utilisation of the energy (heat and electricity) generated from the Multifunctional Façade element in new construction/ renovated buildings thus reduced building owners/managers reliance from the grid and achievement of monetary gains from the corresponding energy savings.

EXCESS Use Case 7	
Use Case ID	UC7

Use Case Name	Increasing the efficiency and controllability of heating/ cooling devices for minimizing energy use (Development of a high COP multisource heat pump for deep borehole application for DHW use)
Related Business Scenario(s)	BS2: Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand)
Related Use Case(s)	UC5, UC9, UC13
Description	The configuration and design of the internal components of the multisource heat pump (HP) are improved in order to achieve high temperature difference and lower flow rate through its connection with deep boreholes. In addition, by modifying the multisource heat pump's system architecture and incorporating smart components enabling cloud-based services and IoT control, its life span will increase resulting also in reduced maintenance and service costs while satisfying occupants' needs. Moreover, the automatic adjustment of HP through remote control will ensure its operation at best possible efficiency and subsequent improved COP.
Involved Users	Building occupants /owners/managers, Installer, /Technology Vendors
Target Demo Site	☐Spain ☒Finland ☐Austria ☐Belgium
EXCESS Components Involved	• Multisource heat pumps • Deep boreholes
Pre-Conditions	• Availability of the Multisource heat pump for coupling with deep boreholes
Use Case Scenario	1) The installer reconfigures the internal components of the multisource heat pump and setup the interface for its communication with the MPC component based on the specifications provided by the technology vendor. 2) The installer integrates the reconfigured multisource heat pump and connects it with deep boreholes. 3) Through the use of control logic of MPC component that calculates the occupants' schedules, energy needs and comfort levels, the multisource heat pump parameters are adjusted leading to its improved energy performance and operation.
Post Conditions	• Enhanced controllability and performance of heating/cooling devices.
Business Impact	Reduced energy consumption and less reliance on energy grid resulting in monetary gains for consumers through enhanced control and improved design of heating/cooling devices.

EXCESS Use Case 8	
Use Case ID	UC8

Use Case Name	Introducing novel virtual energy storage capabilities in buildings and building devices for flexibility enhancement (Integration of DHW storage units with P2H elements and IoT controls for additional sources of flexibility)
Related Business Scenario(s)	BS2: Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand)
Related Use Case(s)	UC9, UC13
Description	Complementarily to other typical types of energy storage to accommodate excess energy produced by stochastic renewables, the deployment of P2H Virtual Energy Storage concepts for storing excess electricity in Domestic Hot Water Tanks could further increase self-consumption in a cost-efficient manner, through the application of water pre-heating strategies based on the individual needs of building occupants and considering the storage capacity and capabilities of the respective tanks.
Involved Users	Building occupants /owners/managers, Technology Vendors, Installer
Target Demo Site	☐Spain ☐Finland ☐Austria ☒Belgium
EXCESS Components Involved	• DHW storage units • IoT controls • P2H elements
Pre-Conditions	• All energy components are installed in the Belgian demo site.
Use Case Scenario	1) The installer integrates the DHW storage units with IoT controls and sensing devices to enable the application of novel virtual storage schemes based on actual data coming from the occupants of the buildings (preferences and profiles) and status data from the DHW tanks. 2) The RES components of the building produce energy. 3) Through the use of IoT controls, a part of the energy produced but not necessary for immediate consumption due to flexibility activation (e.g. peak shaving) is stored to the DHW storage units (pre-heating of water) for later use. 4) The water in DHW storage units is heated by the unconsumed distributed energy considering the schedule of the occupants (for use), the required quantity and the thermal inertia/ storage capabilities of the tank to make sure that once needed the required hot water will be provided at the right temperature and quantity to the occupants and no need for additional energy consumption (for heating extra water) will come up.
Post Conditions	• The DHW tanks of the building are filled with hot water and in this way excess electricity is stored in water tanks for later use (transforming power/ electricity to heat/ hot water).
Business Impact	Hot water in DHW storage units constitutes actually an alternative source of flexibility forming a virtual way of energy storage. More specifically, the excess energy from RES components that would be otherwise wasted if not used immediately, through the use of control logic is distributed in the DHW

	tanks and offers hot water in the occupants, thus resulting in energy savings that benefit the environment and the income of occupants.

EXCESS Use Case 9	
Use Case ID	UC9
Use Case Name	Enabling the communication with multiple devices (different protocols and data models) through integrated controllers enabling the simultaneous status monitoring and set-point control of heating/ cooling, lighting devices and appliances
Related Business Scenario(s)	BS2: Building owners/ managers to significantly reduce the energy demand and dependence on grid energy through the installation of novel smart-ready energy technologies in new construction/ renovated buildings BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS4: Building Occupants to enjoy significant energy savings without sacrificing their comfort preferences and well being BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC4, UC5, UC6, UC7, UC8
Description	In order to optimize building performance and achieve the PEB concept, we need ways to communicate and exchange data with the building's RES components, while also being able to control them. Through the development of Integrated Controllers, we will enable simpler integration and management of the onsite energy generation, demand and storage devices in a protocol agnostic and interoperable manner, in order to utilize and further exploit these data for the execution of advanced analytics for energy performance optimization Centralizing all data from the controllers through a Building Management System (BMS) will enhance the communication and better controllability of the different devices, as well as monitoring of their status and control of their set-points. This in turn will allow automatization of demand side load management of the building, according to control strategies resulting from a control optimization decision support system, resulting in energy demand reduction.
Involved Users	Building occupants /owners/managers, Surveyor, Installer, Technology Vendors
Target Demo Site	☒Spain ☐Finland ☐Austria ☐Belgium
EXCESS Components Involved	• Integrated Controller • Building Management System (BMS)
Pre-Conditions	• Availability of integrated controller and centralised BMS in buildings • Connection of integrated controller with all available devices
Use Case Scenario	1) Building owners/ managers define the different devices of the building with the help of a surveyor.

	2) Vendors define the connectivity capabilities of the building's devices. 3) A gateway-enabled integrated controller is developed by the respective vendor to enable connectivity and communication (bi-directional) with building loads and devices. 4) Installer connects the different devices with the integrated controller. 5) Energy performance optimization based on real data streams is realised with the use of the MPC component, which orchestrates the operation of the different building's devices in order to fulfil occupants' needs and optimal energy performance of the building.
Post Conditions	• Communication of building's devices through the integrated controller(s) and automated control and management based on demand response and according to control functionalities
Business Impact	Increased attractiveness of PEBs and market uptake due to energy savings from automated control and management of building's devices based on control demand system, thus reducing reliance from the local energy grid.

EXCESS Use Case 10	
Use Case ID	UC10
Use Case Name	Increasing the accuracy of Generation and Demand Forecasting for enabling the optimal definition of short-term control strategies
Related Business Scenario(s)	BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC11, UC12, UC13, UC14, UC15
Description	In order to achieve energy performance optimization we need to continuously have an accurate real-time and future (short-term) picture of the building performance so that we constantly adapt the operation of the building, to the anticipated generation. In this context, forecasting energy generation and demand need to be provide highly accurate results that will feed energy performance optimization tools as inputs for the definition of optimal control strategies of the different devices with the aim to improve the energy performance of buildings towards PEB.
Involved Users	Building occupants/ owners/ managers, technology vendors
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• The Model Predictive Control component has been implemented.

Use Case Scenario	1) Data are collected from sensors and actuators allowing for the extraction of accurate user/zone comfort profiles and energy behaviour profiles. 2) Profiles are correlated with external data (e.g. weather) to deliver accurate forecasts of demand in the short-term 3) Similarly, generation information is analysed together with weather data in a forecasting engine, in order to deliver respective generation forecasts. 4) Forecasts continuously feed an MPC component along with flexibility capabilities to define optimal control strategies that match and balance generation and demand in a proactive manner.
Post Conditions	• The accurate demand and generation forecasts can be used for the formulation of energy consumption strategies in the short-term that will lead in substantial energy savings without sacrificing the comfort levels of occupants.
Business Impact	Fine tuning of demand-generation forecasts and short-term control strategies through detailed analysis of occupants' demand profiles and components generation performance.

EXCESS Use Case 11	
Use Case ID	UC11
Use Case Name	Real-time Monitoring of Building Operation (and per prosumer)
Related Business Scenario(s)	BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions BS7: Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions
Related Use Case(s)	UC10, UC12, UC13, UC14, UC15
Description	Real-time monitoring of the building performance and of the various systems will provide prosumers with the means to understand their consumption, as well as their flexibility in terms of energy generation and consumption. Real-time monitoring will provide enhanced controllability through remote maintenance and more accurate fault and operating diagnostics, thus enable a better building operation and performance.
Involved Users	Building Owners /Managers/ Occupants
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium

EXCESS Components Involved	Depending on the demo site, all related energy components will be involved.
Pre-Conditions	• Installation of metering devices for energy consumption and actuators for energy demand. • Provision of a user-friendly application/dashboard with intuitive design for monitoring building's operation. • Database to store all metering data
Use Case Scenario	1) Meters, sensors and actuators collect information/data about building's energy consumption and demand based on occupants' actions 2) All information is inserted into the building's monitoring and management system database 3) Visualisation of the building's operation through appropriately configured dashboards and energy analytics enables better understanding of energy behaviours and patterns to the occupants and building managers
Post Conditions	• Collected information/data is available for the monitoring (and analysis) of the building's operation through a comprehensive dashboard.
Business Impact	Real time monitoring of the Building's operation provides the means for building owners/managers to identify their energy consumption and demand, thus understand their self-consumption capabilities which in turn can result in energy savings through individual and coordinated flexibility-based control of adaptive facades and energy systems

EXCESS Use Case 12	
Use Case ID	UC12
Use Case Name	Flexibility analytics and forecasting for identifying the control capabilities (in terms of flexibility) of each device under different control strategies
Related Business Scenario(s)	BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC10, UC11, UC13, UC14, UC15
Description	Context-aware demand flexibility profiles need to be extracted out of the data streams coming from building assets and considering user preferences for comfort, IEQ and daily schedules, even in the short and very short term, towards integrating the extracted flexibility in the optimization of control strategies of individual devices enabling a human-centric energy performance optimization.

	The extraction of demand flexibility profiles should be delivered in real time taking into account current operational status of devices and a short-term projection about environmental and operational conditions in premises.
Involved Users	Building occupants/ owners/ managers
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	All energy components that may be involved from each demo site.
Pre-Conditions	• Flexibility profiles of occupants have been defined.
Use Case Scenario	The process for the extraction of context-aware demand flexibility profiles is twofold: 1) Extraction of demand flexibility profiling parameters following a training process. Historical data (device operational data & environmental conditions) are required towards the extraction of accurate profiling parameters (DER modelling) 2) Following the training process; real time (and short-term forecasting) calculation of demand flexibility potential (at device level and further aggregation at asset or portfolio level).
Post Conditions	• The defined control capabilities of the different energy components will lead to the identification of the optimal control strategy according to specific occupants' flexibility profiles.
Business Impact	Optimization of the energy performance of components through analysis of their flexibility profiles and alternative scenarios utilisation.

EXCESS Use Case 13	
Use Case ID	UC13
Use Case Name	Real-time Building Energy Performance Optimization through Simulation-based control (alternative scenarios) considering flexibility potential
Related Business Scenario(s)	BS1: Construction companies to increase the attractiveness of PEB investments, through enhancing the accuracy of Energy Performance Simulations at the design phase and as a means to reduce the gap between anticipated and actual energy performance of buildings. BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC2, UC4, UC5, UC6, UC7, UC8, UC11, UC12, UC14, UC15
Description	The Model Predictive Control (MPC) component will execute and assess multiple what-if scenarios for the energy performance of a building taking into account the flexibilities of occupants, the capabilities of all involved energy components and real-time sensor data from the intra-building environment in order to identify the optimal energy performance of the building.
Involved Users	Building occupants/ owners/ managers

Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	All energy components that may be involved from each demo site.
Pre-Conditions	• The MPC component is deployed in the buildings.
Use Case Scenario	1) The MPC component collects the flexibility profiles of the occupants defining the control capabilities and boundaries over each device of the building. 2) The MPC component ingests the real-time data coming from the sensors within the building. 3) The MPC component runs multiple executions of energy performance optimization algorithms exploiting the real-time data streams with different combinations of occupants' flexibilities and energy component capabilities. 4) The MPC component defines the optimal energy performance scheme for the building.
Post Conditions	• The building consumes the maximum self-consumption energy while satisfying occupants comfort and allowing positive energy balance creation.
Business Impact	The operation of MPC component leads to optimal energy performance of the building minimizing its dependence from the grid, while it creates a positive energy balance and maintains a comfort ambience for the occupants.

EXCESS Use Case 14	
Use Case ID	UC14
Use Case Name	Monitoring in real-time the energy performance and monetary gains at community level
Related Business Scenario(s)	BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS7: Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions
Related Use Case(s)	UC10, UC11, UC12, UC13, UC15
Description	Through the use of metering devices and actuators, energy metrics for aggregated groups of buildings need to be calculated and visualized (for occupants and building managers) together with respective financial metrics that highlight the impact achieved (in energy and economic terms) out of the deployment of optimization strategies, towards the achievement of the PEB and PED concept. Energy metrics shall also be accompanied by monetary benefits.
Involved Users	Building occupants/ owners/ managers

Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	All available energy components depending on the demo site
Pre-Conditions	• Installation of metering devices for energy consumption and actuators for energy demand at community level. • Provision of a user-friendly application/dashboard with intuitive design for monitoring buildings' operation at community level.
Use Case Scenario	1) Meters and actuators collect information/data about the energy consumption of buildings both in whole but also per individual device flow to a central collection component through the use of appropriate integrated controllers. 2) Information are processed with the use of properly defined methods and functions to provide calculations of Key Energy and Economic performance metrics not only referring to historical data, but also in real-time. 3) Calculated metrics are communicated to building occupants and managers through intuitive visualizations and dashboards that make them clearly understand their cumulative and individual performance and the benefits associated with specific energy performance optimization strategies.
Post Conditions	• Energy optimization resulting in monetary gains through behavioural change upon monitoring and comparing of the real time local energy performance against community
Business Impact	Building occupants to increase their awareness of their self-consumption capabilities through real time monitoring of energy performance at building and community level, leading to behavioural change towards energy savings and monetary gains.

EXCESS Use Case 15	
Use Case ID	UC15
Use Case Name	Optimizing the energy performance of districts through orchestrated control of district-level and building-level assets
Related Business Scenario(s)	BS3: Building owners/ managers to enhance the Self-Consumption capabilities of Buildings by enabling significant energy savings during operation through individual and coordinated flexibility-based control of adaptive facades and energy systems (generation, storage, demand) BS7: Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions
Related Use Case(s)	UC10, UC11, UC12, UC13, UC14
Description	Optimization of the building's energy performance (achieved through maximization of local RES generation and enhance controllability at building-level) can be further extended to district-level by taking advantage of available district-based systems (e.g. storage) ensuring a positive energy equilibrium.

Involved Users	Building occupants/ owners/ managers
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	All energy components that may be involved from each demo site.
Pre-Conditions	• The MPC component is deployed in the buildings of the district. • Interconnectivity between buildings and grid at a district level. • Availability of large volume local RES, storage and smart energy grids/ Integration at district level. • Access on real time data (consumption, generation) from building assets
Use Case Scenario	1) The MPC component collects the flexibility profiles of the occupants at district level defining the control capabilities and boundaries over each device of the available buildings. 2) The MPC component ingests the real-time data coming from the sensors within the building. 3) The MPC component runs multiple executions of energy performance optimization algorithms exploiting the real-time data streams with different combinations of occupants' flexibilities and energy component capabilities, while considering additional flexibility that can be provided by storage systems. 4) The MPC component defines the optimal energy performance scheme for the district by utilizing the flexibility of district-wide systems and a variety of adjunct buildings.
Post Conditions	• Enhancement of district level energy performance
Business Impact	The operation of MPC component leads to optimal energy performance of the district minimizing its dependence from the grid, while it creates a positive energy balance and maintains a comfort ambience for the occupants of the district.

EXCESS Use Case 16	
Use Case ID	UC16
Use Case Name	Non-intrusive monitoring of ambient conditions and load activation in buildings
Related Business Scenario(s)	BS4: Building Occupants to enjoy significant energy savings without sacrificing their comfort preferences and well being
Related Use Case(s)	UC17, UC18, UC19
Description	Towards the identification of the comfort preferences of building occupants, the ambient conditions of the building and the use of controls are continuously monitored in a way that does not intrude, affect or violate the daily routines, schedules and living conditions of occupants.
Involved Users	Building occupants
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium

EXCESS Components Involved	Depending on the demo site, all related energy components will be involved.
Pre-Conditions	• Sensors and actuators should be installed in the buildings that are going to be monitored • All metering devices shall not interfere in the living status of the occupants.
Use Case Scenario	1) Sensors collect information about the temperature and air quality of the building interior. Actuators are collecting information about the switching of controls by the occupants. 2) All information is consolidated in the database of the monitoring system of the building, to facilitate later on the extraction of valuable analytics insights, without annoying building occupants or requiring them to behave in a different manner than they usually do.
Post Conditions	• Collected information is ready for analysis for the extraction of occupants' comfort preferences.
Business Impact	As ambient and control information is collected, the well-being of building occupants can be measured. Combined with energy saving strategies, it will lead to an optimal operation of PEBs where lower energy consumption will not compromise the comfort levels of the occupants.

EXCESS Use Case 17	
Use Case ID	UC17
Use Case Name	Smart correlation of ambient conditions and load control actions for identifying comfort preferences of occupants
Related Business Scenario(s)	BS4: Building Occupants to enjoy significant energy savings without sacrificing their comfort preferences and well being
Related Use Case(s)	UC16, UC18, UC19
Description	Common centrally controlled building devices (e.g. HVAC) operate with predefined operational settings and a set of assumptions without taking into consideration occupants' preferences, resulting in both occupants' discomfort and high energy consumption. Under this context, by integrating the occupants' preferences and comfort profiles (collected through an IoT sensor network) in the devices control system enables fine-tuning of the indoor environment to the extent allowed by the available installations of building amenities.
Involved Users	Building Occupants
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• Availability of wireless sensor network (WSN) and actuators towards identifying comfort zones and occupants' preferences. • Integration of comfort profiles in building's devices control systems
Use Case Scenario	1) WSN collects data of building ambient conditions and actuators provide data of occupants' control actions.

	2) User comfort modelling and profiling based on extracted data streams through analytic algorithms. 3) Integration of generated comfort models into building's devices control systems towards energy savings.
Post Conditions	• Personalized adaptation of the ambient environment according to users' preferences
Business Impact	Better optimisation and management of the building's energy performance resulting in energy savings (thus monetary gains), through the incorporation of occupants' comfort preferences in devices control systems based on comfort-profiling algorithms.

EXCESS Use Case 18	
Use Case ID	UC18
Use Case Name	Building devices automated control for comfort preservation
Related Business Scenario(s)	BS4: Building Occupants to enjoy significant energy savings without sacrificing their comfort preferences and well being
Related Use Case(s)	UC16, UC17, UC19
Description	Upon definition of occupants' comfort models (e.g. Temperature measurements and control actions over HVAC loads), it will be possible through the Model Predictive Control component (MPC) to automate the various building devices performance and operation towards human-centric and comfort preserving energy performance optimization and PEB achievement. As a result, occupants' comfort will not be sacrificed, while the devices automation will enable increased energy savings (flexibility extraction) by setting indoor conditions at less comfortable but, still, acceptable levels (regulated comfort).
Involved Users	Building occupants
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	MPC
Pre-Conditions	• Installation of IoT sensors and actuators in the building's premises and controllers for data acquisition from the sensors and actuators towards identification of the building occupant's comfort preferences/zones.
Use Case Scenario	1) WSN collects data of building ambient conditions and actuators provide data of occupants' control actions 2) MPC component gathers/analyses the above data streams based on the generated comfort models of the occupants 3) Through the above analysis the MPC component orchestrates the operation of the different building devices for the optimisation of the building's energy performance towards energy savings while on the same time preserving occupants' comfort zones
Post Conditions	• Increased energy savings while preserving occupants comfort zones and preferences through automated control of building devices based on user's comfort models.

Business Impact	Automated control of the building's devices can reduce the energy consumption of buildings without sacrificing occupant's comfort and wellbeing, thus increase PEBs energy efficiency and enhance their attractiveness and market uptake in the construction/renovation industry.

EXCESS Use Case 19	
Use Case ID	UC19
Use Case Name	Building devices automated control for Indoor Air Quality requirements satisfaction
Related Business Scenario(s)	BS4: Building Occupants to enjoy significant energy savings without sacrificing their comfort preferences and well being
Related Use Case(s)	UC16, UC17, UC18
Description	Adequate Indoor Air quality within buildings is critical for the occupants' well-being, especially for children and elderly people. Through utilisation of WSN it is possible to identify the real -time indoor pollutant concentrations and provide adjustments when necessary through automated control of the building's devices. Such adjustments can include appropriate control of the building's ventilation to remove indoor generated pollutants, as well as to prevent ingress of outdoor pollutants, while doing all this in an energy efficient manner.
Involved Users	Building Occupants/Owners/Managers
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	MPC
Pre-Conditions	• Installation of real-time IAQ (e.g. T, CO_2, PM, TVOCs) sensors with high sensitivity and long operating life within the building (as well as outdoor sensors for monitoring outdoor pollution and climate (e.g. CO_2, NOx, PM, T, RH, Wind speed) since outdoor conditions can significantly infer the indoor air conditions). • Installation of controllers for the data acquisition from sensors
Use Case Scenario	1) Data regarding IAQ and environmental parameters (with direct impact on IAQ) are collected (from IoT sensors) 2) MPC component gathers/analyses the above data streams based on the building's IAQ standards 3) Through the above analysis the MPC component orchestrates the operation of the different building devices for the optimisation of the building's energy performance towards energy savings while on the same time providing optimal IAQ
Post Conditions	• Automated control of building devices towards meeting adequate IAQ conditions based on thresholds
Business Impact	Improved indoor environment through automated control of the building's devices leading to enhanced occupants' satisfaction while on the same time enjoying energy saving through better device optimisation; thus, increase PEBs energy efficiency and enhance their attractiveness and market uptake in the construction/renovation industry.

EXCESS Use Case 20	
Use Case ID	UC20
Use Case Name	Trading of the excess flexibility not used for self-consumption in the energy markets
Related Business Scenario(s)	BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC21, UC22, UC23, UC24
Description	Flexibility-based optimization of the energy performance of buildings does not necessarily requires the utilization of the maximum available flexibility on the occupants' side. Such flexibility that has not been utilized in any optimization function, can be securely provided to external actors (aggregators) to be traded in upstream energy/ flexibility and in this way generate additional positive externalities to building occupants in monetary terms.
Involved Users	Building occupants (prosumers), Aggregators
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	Depending on the demo site, all related energy components will be involved.
Pre-Conditions	• There are flexibilities from building occupants that are not self-consumed. • Establishment of a marketplace that will facilitate prosumers to make their flexibility available for further exploitation and allowing them to select the best deal. • Availability of standardized contract templates enabling on-the-fly Prosumers-Aggregators negotiations
Use Case Scenario	1) The aggregator utilizes a powerful flexibility analytics toolbox to continuously analyse and the flexibility of the different buildings under its portfolio of customers. 2) Based on network requirements and once signals are triggered for flexibility provision to the network operator, the flexibility analytics component allows the aggregator to configure dynamic VPPs (clusters of flexibility) that can effectively address the operator's requirement. 3) VPPs are verified not only against their flexibility capabilities, but also against the contractual terms between aggregators and buildings reflecting the temporal boundaries, the quantity, the frequency and the duration for flexibility activation on a customer per customer basis. 4) Once an optimal VPP is configured and the flexibility activation event has been completed, the event is settled on the aggregator side and relevant remuneration details are communicated back to the flexibility provider (building occupant/ building manager). 5) The aggregator trades these flexibilities to the energy market.
Post Conditions	• The unconsumed flexibilities are returned as excess energy to the grid.

Business Impact	The trading of not self-consumed flexibilities to the energy market offers an alternative energy source to the grid, while it provides monetary earnings to the building occupants.

EXCESS Use Case 21	
Use Case ID	UC21
Use Case Name	Local Flexibility negotiation over marketplaces between prosumers and aggregators
Related Business Scenario(s)	BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC20, UC22, UC23, UC24
Description	Towards the trading of prosumers' flexibilities in the energy markets by the aggregators, negotiations shall take place between the two involved parties. Through these negotiations, a common agreement about the terms of the flexibility contract (number of activations, frequency, duration, remuneration, loads involved, etc.) needs to be established and recorded in transparent and objective means that will verify the performance of the contract for all sides involved.
Involved Users	Building occupants, Aggregators
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• There are building occupants with unconsumed flexibilities. • Establishment of a marketplace that will facilitate prosumers to make their flexibility available for further exploitation and allowing them to select the best deal. • Availability of standardized contract templates enabling on-the-fly Prosumers-Aggregators negotiations
Use Case Scenario	1) Prosumers disseminate their flexibility available for exploitation 2) The Aggregator searching for prosumers that can provide flexibility with specific criteria 3) Upon identifying the above flexibility, the Aggregator is making an offer to the prosumers for the requested flexibility 4) Prosumer reviews the offer for the requested flexibility and can either accept, decline or negotiate the offer. 5) Upon acceptance the Aggregator validates the contract.
Post Conditions	• The aggregator gathers all the flexibilities from the willing occupants and is ready for trading them in the energy market.
Business Impact	The negotiations between building occupants (prosumers) and aggregators facilitate the identification of the willing occupants and give them the opportunity to define their own prices for their flexibilities. The subsequent trading of their flexibilities after mutual agreement with aggregators will provide them financial profits and also motivate them in further attempts to

	save energy and sell it through the aggregators in the energy markets, thus benefiting their income and the environment.

EXCESS Use Case 22	
Use Case ID	UC22
Use Case Name	On the fly configuration of dynamic VPPs through classification and clustering of individual prosumers flexibilities
Related Business Scenario(s)	BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC12, UC20, UC21, UC23, UC24
Description	Aggregators need to continuously have a clear picture and understanding of their portfolio's performance, in order to constantly devise control strategies over aggregated clusters of customers and hedge against any overrides of control triggers that may lead to penalization by Network Operators. Thus, they need the means to monitor how flexibility events evolve at an individual customer level and modify pre-defined strategies through rapid re-configuration of dynamic VPPs to provide the required flexibility to the grid.
Involved Users	Aggregators, Prosumers (Building Occupants/ Owners), DSOs
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• Prosumers connection with Aggregators and DSOs is required for identification /monitoring of individual prosumers flexibilities. • Predefined bilateral negotiation process that considers real-time contextual information involving Prosumers and Aggregators,
Use Case Scenario	1) Aggregators have access to an analytics application that allows them to evidently create clusters of flexibility to address grid requirements set by DSOs 2) Through the UI of the application they are allowed to constantly monitor the performance of their established clusters/ VPPs (addressing different grid requests for service) and identify potential overrides over flexibility triggers addressed to specific customers. 3) Once such overrides are identified (based on real-time data streams from the customers/ buildings/ flexibility assets), the application immediately performs an optimization function so as to effectively tackle the override by introducing additional flexibility sources into a modified VPP configuration. 4) The process runs continuously until the end of a flexibility event allowing aggregators to avoid being penalized by the grid operator for failing to provide the requested flexibility.
Post Conditions	• Automated reconfiguration of VPPS towards utilizing consumers flexibility consumers

Business Impact	Timely provision of the required flexibility to the grid upon DSOs requests, through continuous analysis of the prosumers' demand/storage flexibility at district/ community level by the Aggregators, along with optimal configuration of demand-based dynamic VPPs, resulting in monetary gains for all involved users

EXCESS Use Case 23	
Use Case ID	UC23
Use Case Name	Involvement of prosumers in Explicit Demand Response schemes (automated control) and transparent/ objective remuneration of utilized flexibility
Related Business Scenario(s)	BS5: Aggregators to analyze occupants' flexibilities on a district/ community level towards increasing monetary benefits for both sides through the provision of ancillary services to network operations BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions
Related Use Case(s)	UC20, UC21, UC22, UC24
Description	The involvement of prosumers/ building occupants or managers in local flexibility markets is mainly intended to the utilization of the offered flexibility for the realization of the business goals of aggregators towards providing services to grid operators in the form of explicit demand response over aggregated clusters of demand assets. To minimize uncertainties and reduce risks, aggregators tend to be more favourable to the deployment of automated demand response strategies (explicit demand response) on the basis of well-established contracts with prosumers/ building occupants/ building managers that define in detail the flexibility to be offered, the loads that will offer it, the duration of each event, the timing of each event and the remuneration provisions.
Involved Users	Building occupants/ managers, Aggregators
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components are involved.
Pre-Conditions	• Establishment of WSN and smart home devices in building • Availability of accurate context-aware demand flexibility profiles (per connection point smart meter) • Availability of building occupants' unconsumed flexibilities, generated from available info about flexibility and response capability. • Availability of energy markets supporting flexibility trading. • Prosumers engagement with the EDR blockchain application.
Use Case Scenario	1) Local prosumers register themselves and the EDRs/ flexibility they wish to offer to aggregators (having first understood through a DR (analytics) app the flexibility of each load they possess and when/ for how long this can be utilized), into the local flexibility market. 2) Following a negotiation phase, a contract is established between the aggregator and the prosumer and recorded in a blockchain infrastructure.

	3) Once a demand response event is expected to be launched, prosumers that are selected and introduced in a VPP configuration are notified via an app about the details of the event and the anticipated automated control actions over specific devices and loads. 4) Prosumers have the opportunity to accept or reject the demand response activation over their loads. If they accept it, they have the opportunity via the app to monitor the evolution of the event and the remuneration to be received at the end of the demand response action. 5) Once the action is over the application informs the prosumer about the settlement of the event and the remuneration about the flexibility offered.
Post Conditions	• The prosumer has profit from the trading of his/her non self-consumed flexibility.
Business Impact	The EDR app enables the trading of building occupants' unconsumed flexibilities to the energy market resulting in proportional monetary gains for the prosumers, giving them extra incentives for energy savings and optimal use of their consumption without compromising their comfort.

EXCESS Use Case 24	
Use Case ID	UC24
Use Case Name	Understanding consumption patterns and flexibility dynamics through visualizations of key energy/ flexibility metrics
Related Business Scenario(s)	BS6: Building occupants/ managers to generate new income by monetizing their flexibility in local flexibility and energy market transactions BS7: Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions
Related Use Case(s)	UC20, UC21, UC22, UC23, UC26
Description	To participate in flexibility trading, prosumers need to perfectly understand the characteristics of their inherent flexibility, such as the amount of flexibility they can trade at each time period, the duration that different flexibility amounts might be available , the frequency that they can offer it, along with how this flexibility can be attributed to each device they operate (along with constraints imposed by device-specific characteristics). This will give them the ability to optimize their market participation and avoid performing non-realistic bids against which they will be penalized by aggregators (due to non-ability to deliver).
Involved Users	Building occupants/ managers
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• Installation of essential monitoring and metering infrastructure (e.g. sensors and meters)

	• Availability of WSN in the building premises to monitor the real time building's operational status, as well as individual user's consumption. • Availability of a user friendly and comprehensive UI for monitoring/visualising energy consumption/flexibility
Use Case Scenario	1) Through an easy to use analytics app prosumers gain access to appropriate dashboards and visualizations that allow them to understand their flexibility characteristics. 2) The app gives them insights by presenting to them analytics over historical data that reveal patterns and insights on the flexibility each of their controllable asset can offer, utilizing about gathered from the WSN and actuators. 3) Gathered data streams are used for processing and profiling flexibility at the level of individual devices and assets, while forecasts are provided for the short and mid-term to support prosumers in their bidding actions.
Post Conditions	• Building occupants get familiar with the flexibility creation and management and the subsequent trading mechanisms.
Business Impact	Building occupants/ managers get a better (personalized) understanding of their consumption and flexibility performance, raising their awareness which in turn can lead to monetary gains by monetizing their flexibility in local flexibility and energy market transactions.

EXCESS Use Case 25	
Use Case ID	UC25
Use Case Name	Proportional sharing of gains achieved at the community level to individual occupants
Related Business Scenario(s)	BS7: Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions
Related Use Case(s)	UC15, UC26
Description	Towards the objective sharing of profits from the use of community level energy components and storage devices, prosumers are incentivized to increase self-consumption through the Objective Benefit Sharing (OBS) application.
Involved Users	Building occupants
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• Active participation of occupants in community level energy savings through use of community level energy components or storage devices. • Generated profits from the energy savings in the community level.
Use Case Scenario	1) Building occupants monitor the energy status at community level (e.g. energy consumption or overproduction) through the OBS app. 2) The OBS app calculates the energy savings and the corresponding total profit based on regular time intervals (e.g. per month). 3) Through the OBS app, building occupants identify their share of participation in community level energy optimizations, which is

	calculated either through the use of common energy components for self-consumption or through the use of common storage device for self-consumption. 4) Building occupants identify their distinct profit (utilising the OBS app) generated from the proportion of their participation in the total energy optimizations and subsequent profits.
Post Conditions	• Each building occupant participating in the community energy optimization earns proportional monetary gains.
Business Impact	The monetary gains from the proportional sharing of profits gives the incentive to the occupants for further attempts to use common energy components and storage devices for self-consumption leading to financial profits and environmental benefits.

EXCESS Use Case 26	
Use Case ID	UC26
Use Case Name	Visualizing flexibility contributions for increasing transparency and behavioural motivation of under-performing occupants to improve their energy performance
Related Business Scenario(s)	BS7: Prosumer engagement enhancement towards increasing self-consumption and energy performance of building blocks and districts through objective sharing of benefits achieved through collective actions
Related Use Case(s)	UC15, UC25
Description	Through the use of visualization options in the Objective Benefit Sharing (OBS) application, building occupants can view their flexibility contribution to the total energy savings and profits of the community and understand the mechanism of the proportional distribution of profits, while under-performing occupants can find the incentive to improve their energy performance to participate in the monetary gains.
Involved Users	Building occupants
Target Demo Site	☒Spain ☒Finland ☒Austria ☒Belgium
EXCESS Components Involved	No energy components involved.
Pre-Conditions	• Active participation of occupants (at community level) in the energy savings through use of community level energy components or storage devices. • There are profits from the energy savings in the community level.
Use Case Scenario	1) The building occupants enter the OBS app and browse to the visualizations page. 2) The occupants view and understand through comprehensive visual diagrams and presentations the total energy consumption of the local community for certain time intervals (e.g. for the previous month) and the participation of themselves in the energy optimization according to their flexibility contributions which are depicted analytically in the OBS app.

Post Conditions	• The building occupants obtain knowledge about the sharing mechanisms and the distribution of profits of local community from energy optimization.
Business Impact	The understanding of the sharing mechanisms of the OBS app motivates the occupants in further attempts for energy optimization at community level, leading to financial profits and environmental benefits.

Annex II: EXCESS End Users Questionnaires Results

The detailed results of the questionnaire analysis are presented in this section according to each demo site. The latest snapshot of the questionnaire responses presented below was taken on the 13th July 2020. The main aim of the questionnaires is to identify the EXCESS s end users' (i.e. Building Occupants, Architects, Building Managers and Aggregators) requirements, addressing their role in the project.

A total number of 42 questionnaires were answered; 21 questionnaires from the Spanish demo, 7 questionnaires from the Belgian demo site, 11 questionnaires from the Austrian demo site and 3 questionnaires from the Finish demo.

Spanish Demo site

Building Occupants

Starting from the building occupants, this actor represents a major end user in the project, by setting context preferences and further defining the operational parameters for building conditions. Within the context of EXCESS project, building occupant is considered as an "active element" of the proposed framework, who will be directly interacting with the EXCESS tools and services. Having this in mind, the building occupants questionnaire is designed to cover the occupant's role in the project and provide them with a tool to express their preferences and needs.

The introductory section of the building occupant's questionnaire aims at defining the generic profile of the building occupants.

Question: Please indicate your gender?

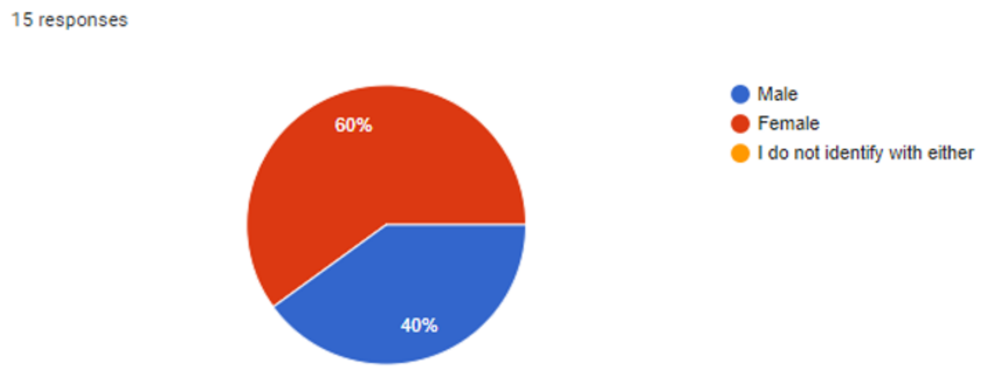

Figure 0-1 Spanish demo - Gender indication

Question: Please indicate your age group?

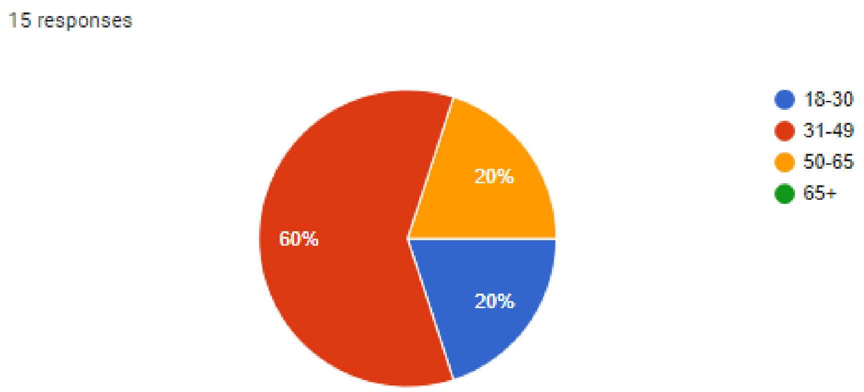

Figure 0-2 Spanish demo - Occupants age group

Question: Please indicate your household composition?

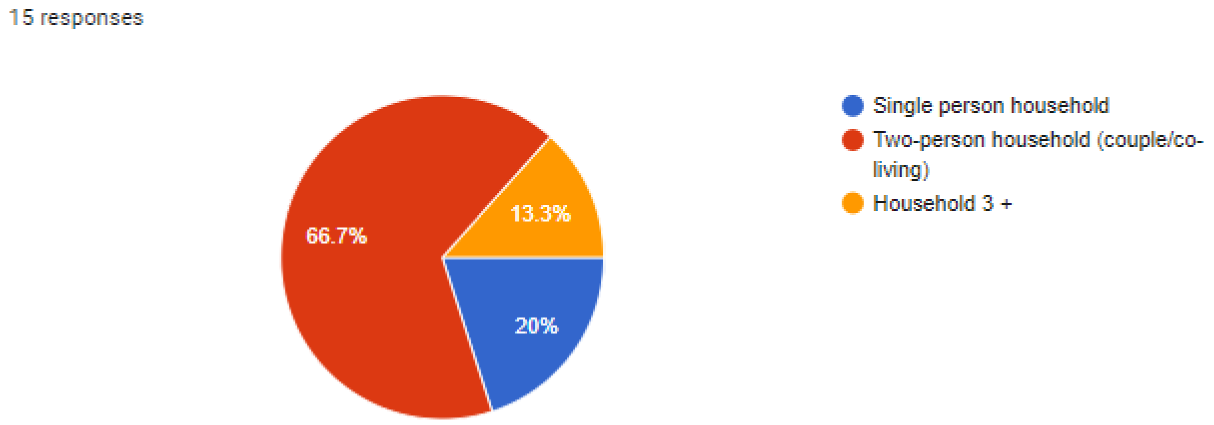

Figure 0-3 Spanish demo - Occupants' household composition

Question: What is your relationship to apartment?

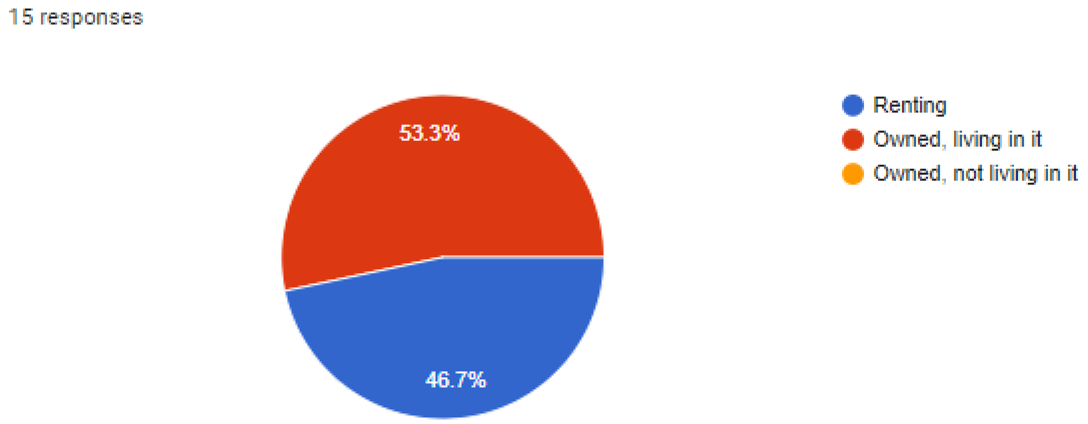

Figure 0-4 Spain demo - Occupants' relationship to apartment

Question: What kind of wireless technology devices do you normally use?

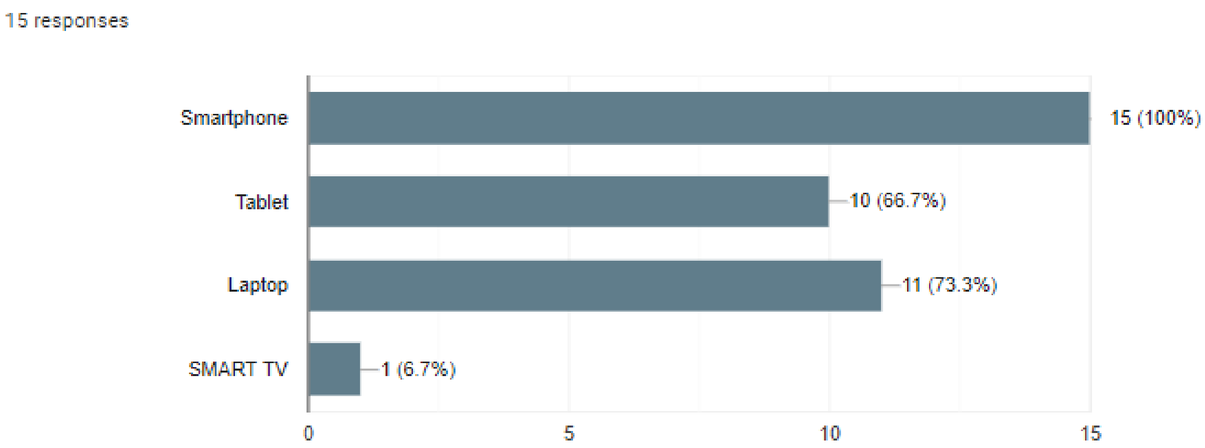

Figure 0-5 Spanish demo - Occupants' usage of wireless technology devices

Question: What kind of internet connectivity is there at your home?

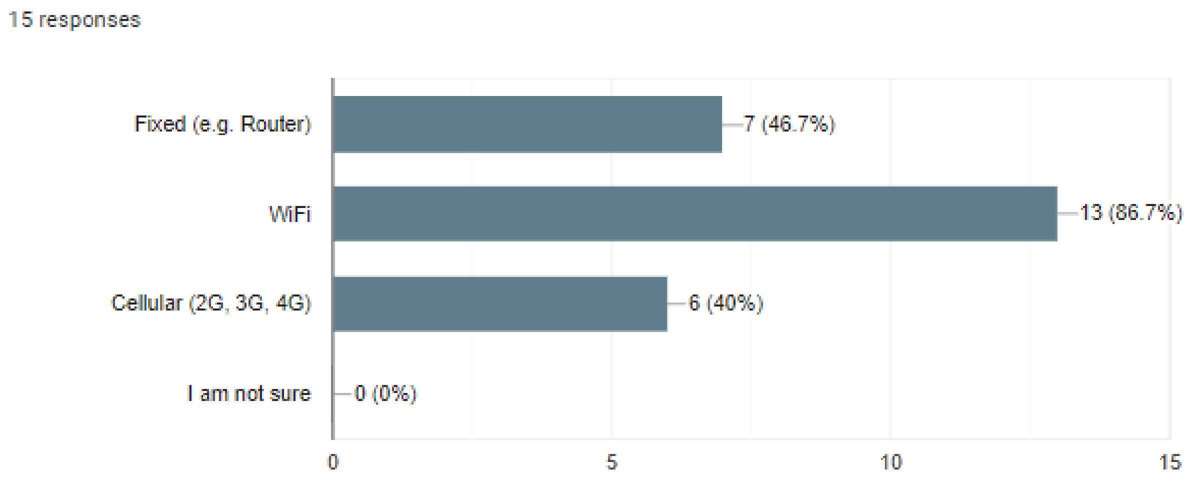

Figure 0-6 Spanish demo - Occupants 'available internet connectivity

Question: Are there any restrictions in your internet connection regarding?

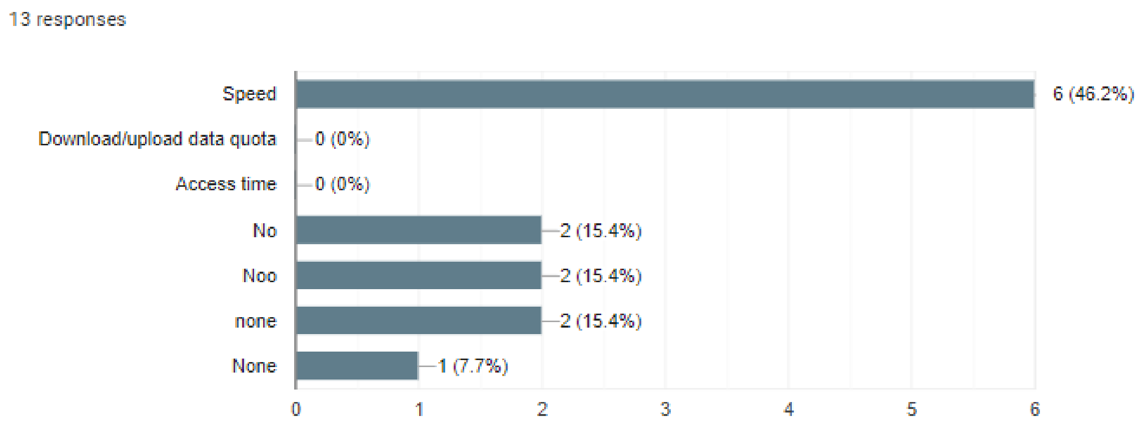

Figure 0-7 Spanish demo - Occupants' Internet connection restrictions

Question: How familiar were you with the concept of Plus Energy Buildings (PEBs) prior to this questionnaire?

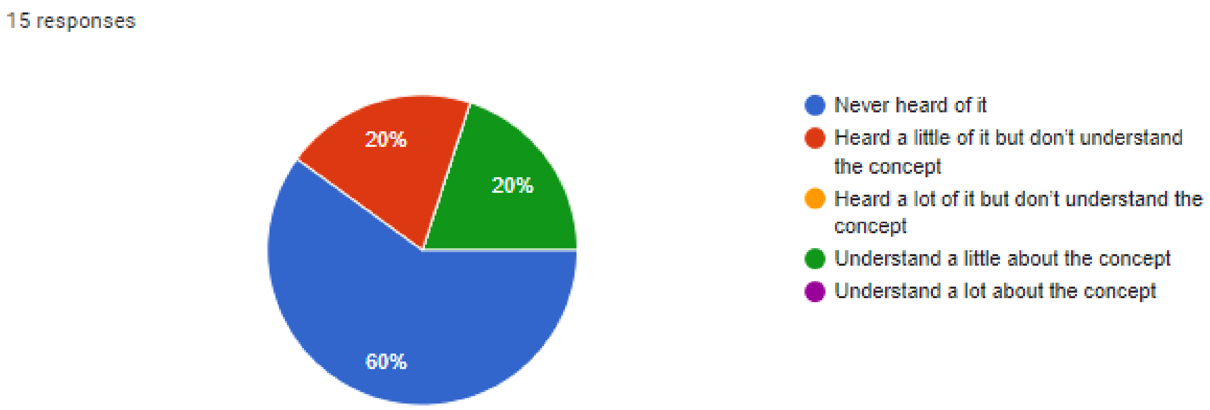

Figure 0-8 Spanish demo - Occupants' familiarization with PEBs concept

Question: How important is it to save energy and use renewable energy sources in your house/building?

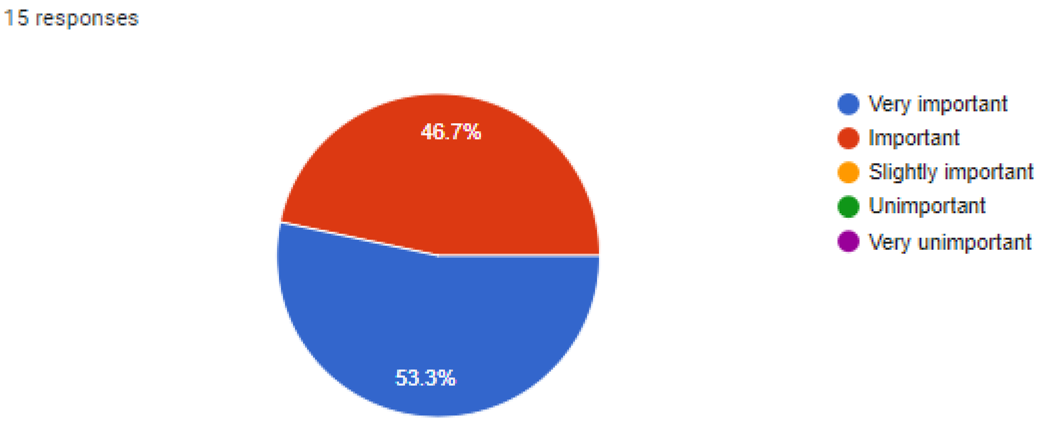

Figure 0-9 Spanish demo – Occupants' opinion on energy savings and renewable energy sources usage

Question: Would you be willing to apply advance control systems for optimizing energy performance?

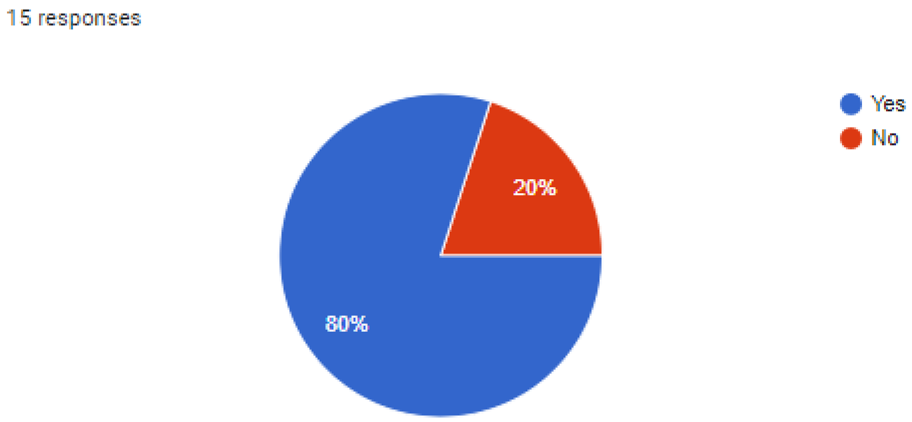

Figure 0-10 Spanish demo - Occupants willingness to apply advance control systems for energy performance optimisation

Question: What type of system would you be willing to accept?

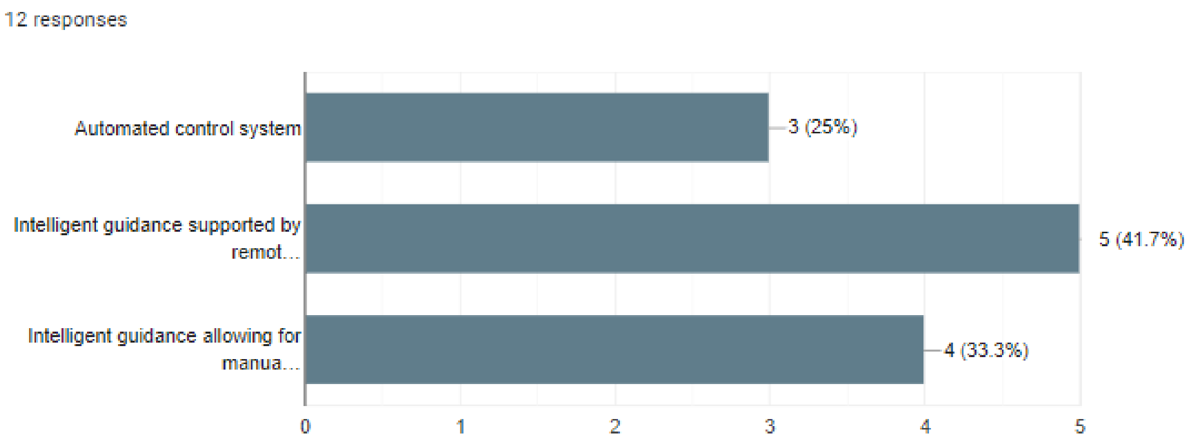

Figure 0-11 Spanish demo - Occupants' preference of advance control systems

Question: What types of devices and assets would you introduce into an advance control framework for self-consumption?

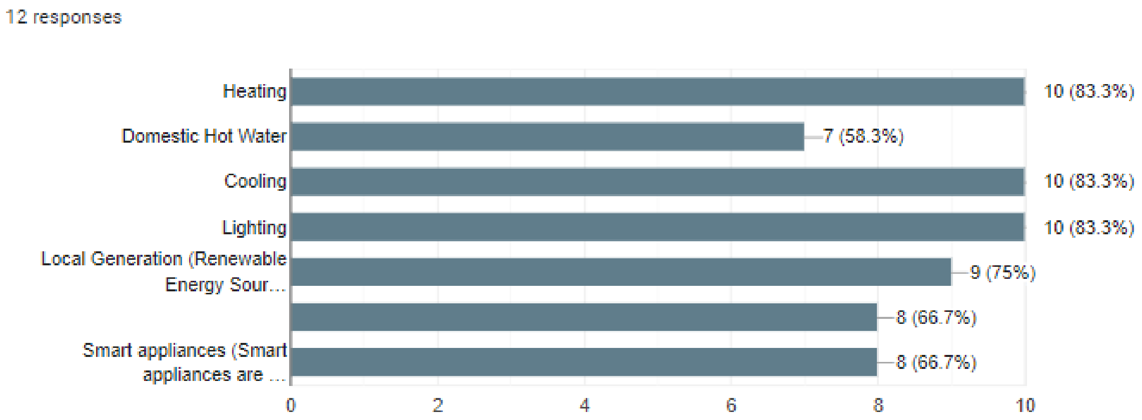

Figure 0-12 Spanish demo - Occupants' preference on devices types and assets for advance control self-consumption

Question: Would you be interested in reducing your energy demand and dependence on grid energy, through the installation of novel smart-ready energy technologies?

Figure 0-13 Spanish demo - Occupants' interest in reducing their energy demand and dependence on grid

Question: Do you have any specific concerns regarding the installation of smart-ready energy technologies in your house/building?

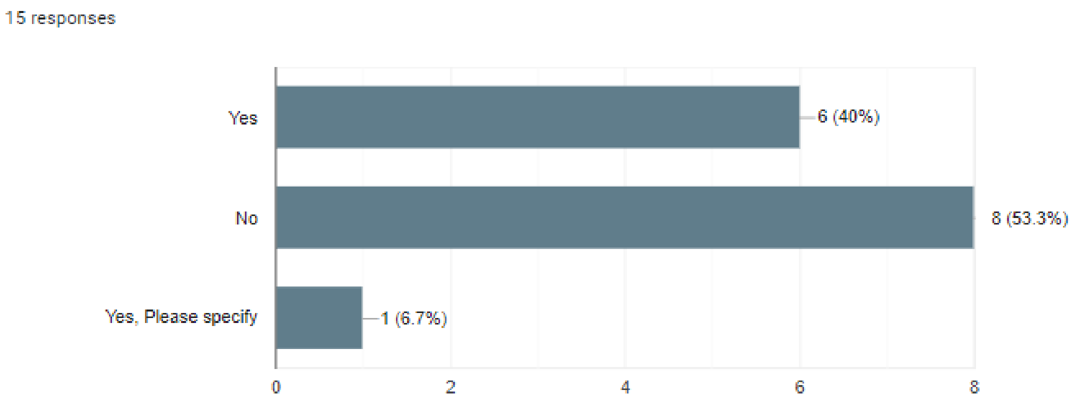

Figure 0-14 Spanish demo – Occupant's concerns on the installation of technologies in their houses/buildings

Question: You decide to improve your house by installing sensors in order to improve the indoor conditions, but you cannot decide what is the best for you and your family. How much are you willing to pay for sensors to be installed inside your house to measure your living preferences (room temperature, light levels, etc.) and finally help you decide on what changes best address your needs?

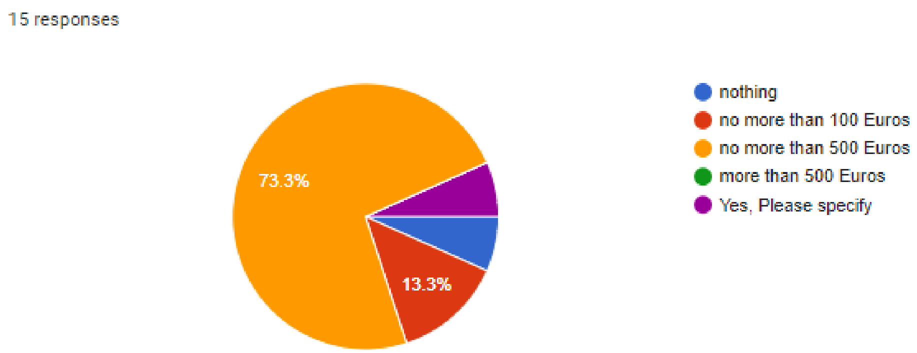

Figure 0-15 Spanish demo - Occupants' willingness to pay for sensors to be installed in their premises

Question: Have you ever been involved in a project that assesses your living comfort and/or indoor air quality?

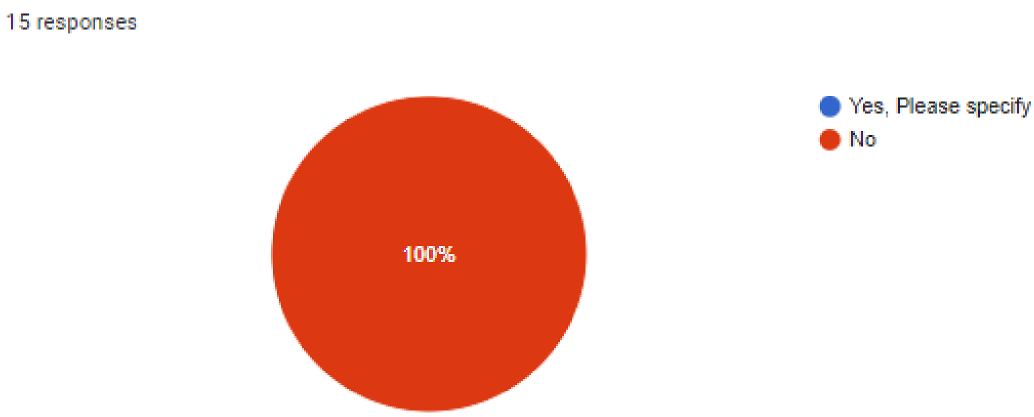

Figure 0-16 Spanish demo - Occupants' involvement in a project assessing living comfort/IAQ

Question: Do you see a value in having a building tailored to your needs in terms of comfort preferences?

15 responses

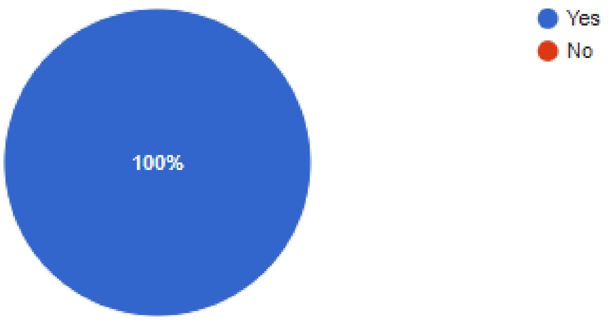

Figure 0-17 Spanish demo - Occupants' indication of seeing value having a building tailored to their needs

Question: Would you object to the installation of low powered Internet of Things devices (such as sensors and actuators) for a period of time to determine your energy consumption, flexibility and comfort preferences, if privacy is respected?

15 responses

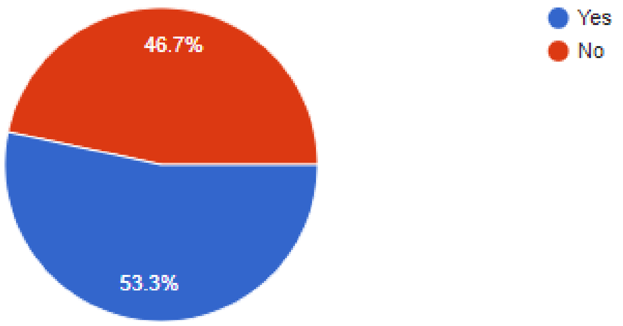

Figure 0-18 Spanish demo – Occupants' objection on the installation of low powered Internet of Things devices (such as sensors and actuators) for a period of time to determine their energy consumption

Question: Would you agree to have data sensors installed at your property for more than a year?

14 responses

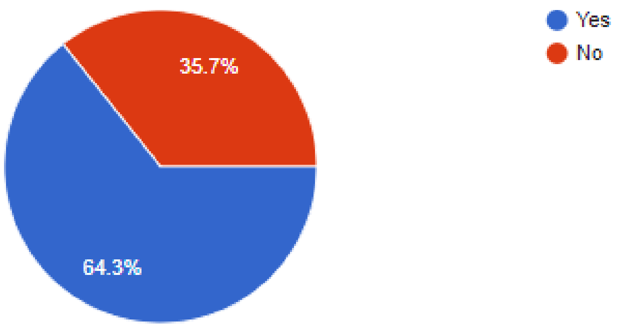

Figure 0-19 Spanish demo – Occupants' agreement with installation of data sensors in their property from more than a year

Question: What is the longest period you are willing to have such monitoring devices installed in your apartment?

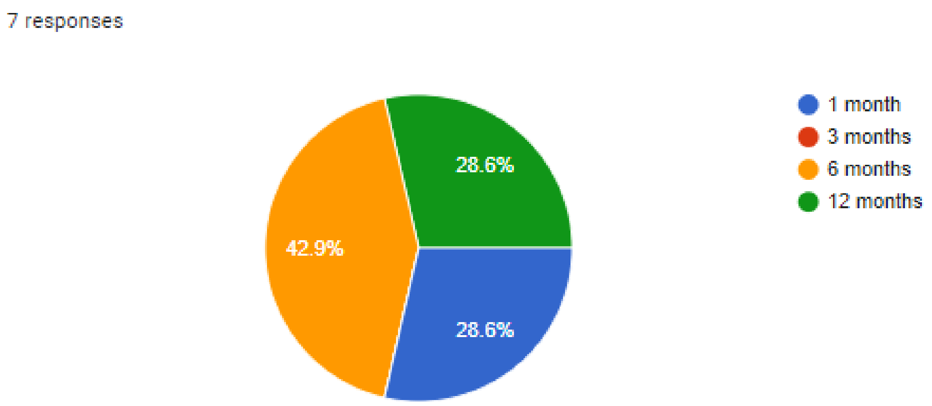

Figure 0-20 Spanish demo – Occupants' willingness to have monitoring devices installed on their apartments

Question: Please indicated how important the following aspects are regarding your living comfort.

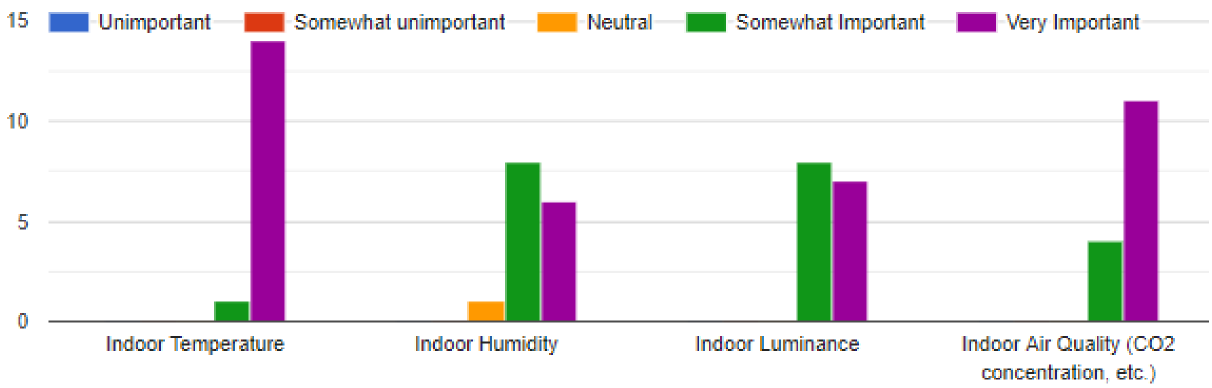

Figure 0-21 Spanish demo – Occupants' indication of aspects important for their living comfort

Question: Are you interested in monitoring your energy consumption and flexibility through visualization applications, i.e. through mobile phones, tablets, laptops?

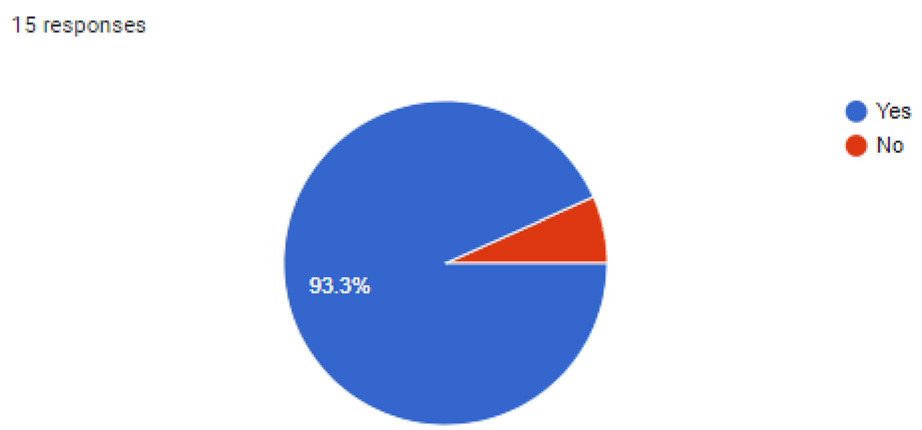

Figure 0-22 Spanish demo – Occupants' interest in monitoring their energy consumption and flexibility through visualization applications

Question: How would you like to monitor your energy consumption and flexibility?

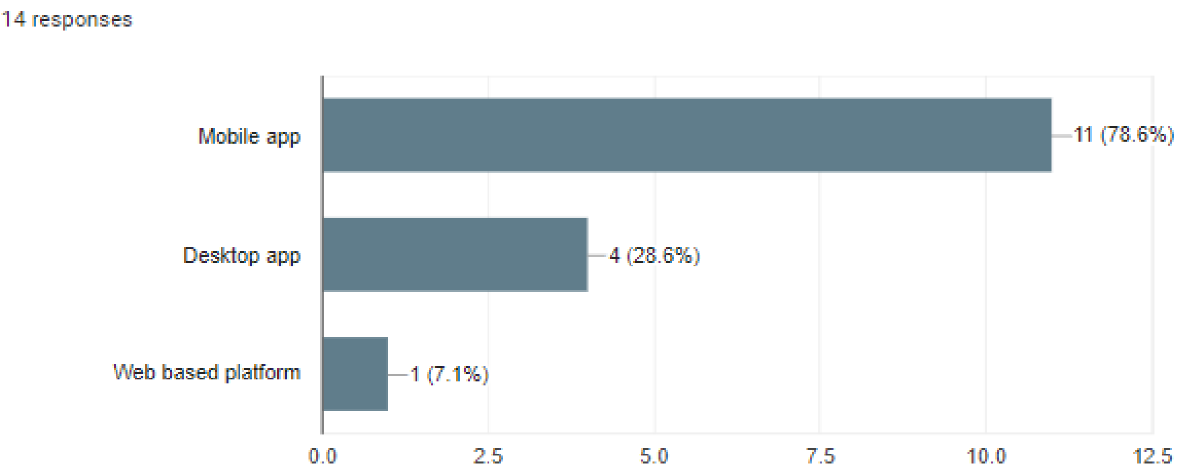

Figure 0-23 Spanish demo – Occupants' preferred devices for monitoring their energy consumption and flexibility

Question: Are you familiar with the concept of electricity self-consumption?

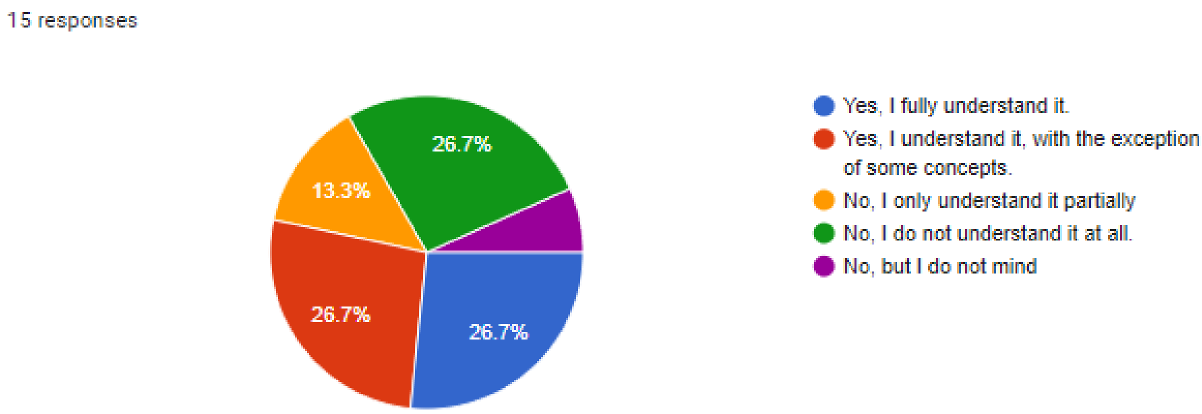

Figure 0-24 Spanish demo – Occupants' familiarity with the concept of electricity self-consumption

Question: Are you interested in monitoring your individual performance in terms of energy consumption and flexibility in comparison with the district/ community level performance (privacy of personal information will be respected)?

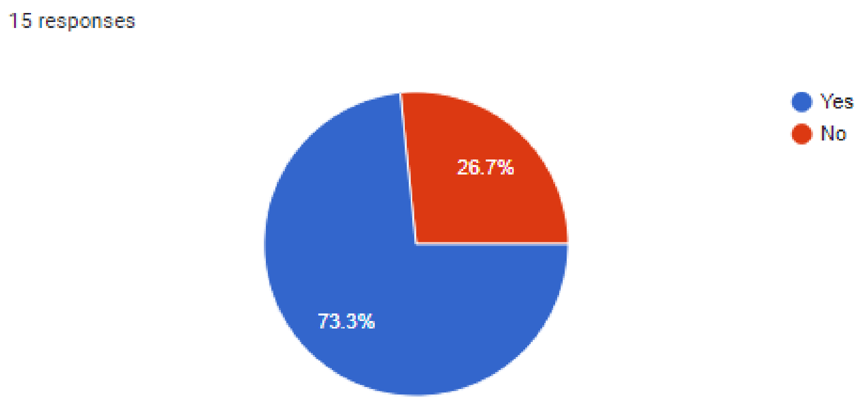

Figure 0-25 Spanish demo – Occupants' interest in monitoring their individual energy performance

Question: Do you agree or disagree with the following statement? "Visualization of my own consumption/energy savings against community level can inspire me towards reducing my energy consumption, leading also to financial profits and environmental benefits"

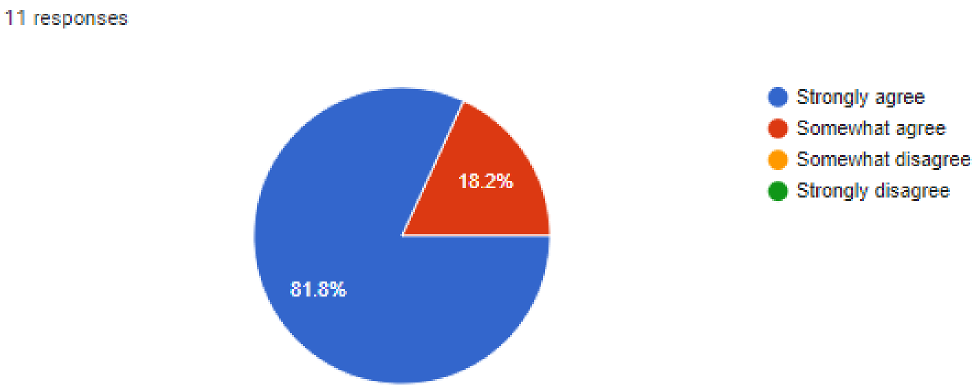

Figure 0-26 Spanish demo – Occupants' agreement with the statement

Question: How would you like to monitor your position against the district/community level energy consumption and flexibility (privacy of personal information will be respected)?

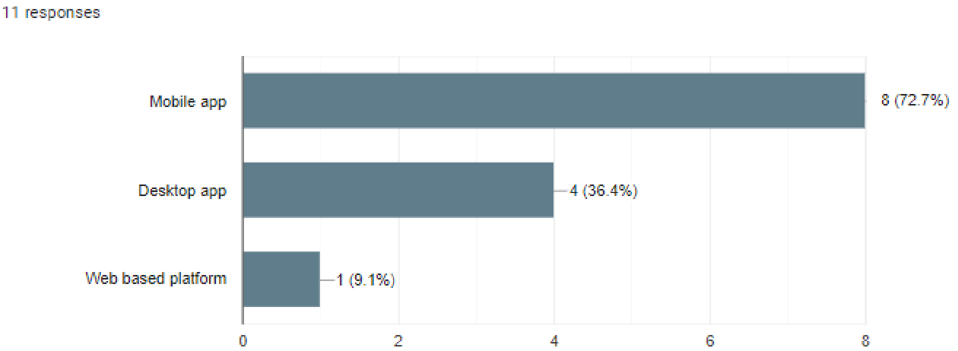

Figure 0-27 Spanish demo – Occupants' preferred means for monitoring their energy consumption and flexibility position against district/community level

Question: Would you object to share your individual flexibility for optimizing the performance of your neighbourhood/ district and maximizing self-consumption (privacy of personal information will be respected)?

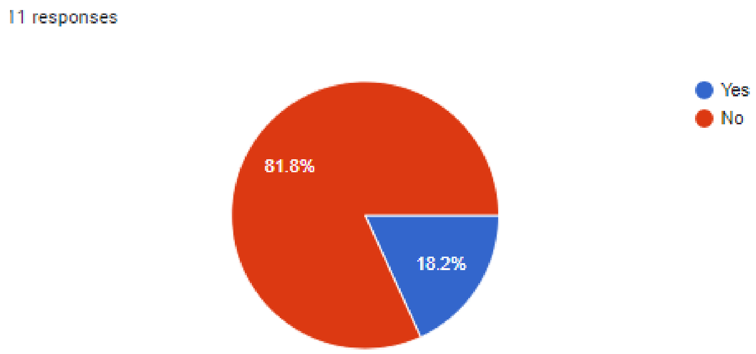

Figure 0-28 Spanish demo – Occupants' objection to share their individual flexibility for optimizing performance of their neighbourhood/district and maximize energy self-consumption

Question: In order for you to participate in collective schemes for self-consumption maximization at community level, please rate (with an "x") the importance of the following aspects:

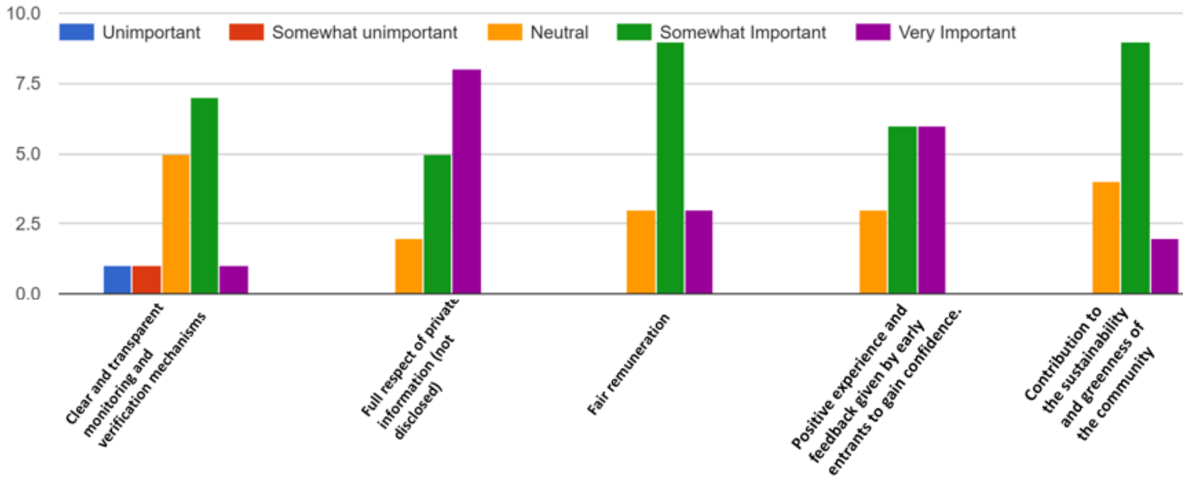

Figure 0-29 Spanish demo – Occupants' rating of important aspects for their participation in collective schemes for self-consumption maximization at community level

Question: Which of the following aspects would make you feel more uneasy to participate in the local self-consumption schemes at community level?

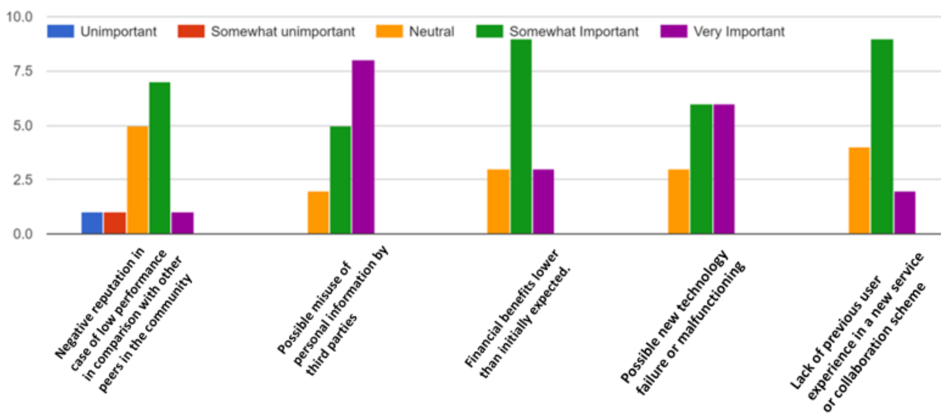

Figure 0-30 Spanish demo – Occupants' rating of aspects considered important for their participation in the local self-consumption schemes

Question: Would you be interested in having an automated control of your building's devices towards reducing energy consumption without sacrificing your comfort preferences?

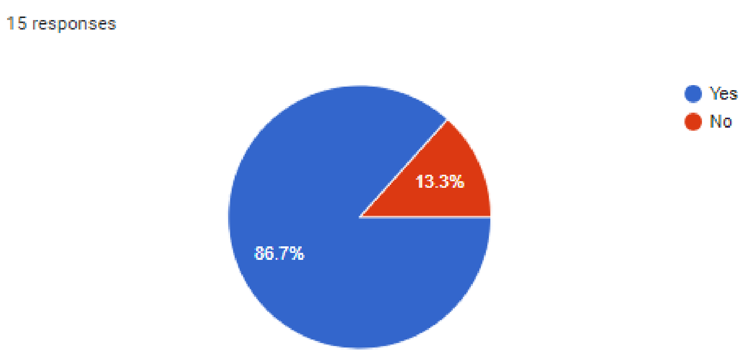

Figure 0-31 Spanish demo – Occupants' interest on having automates control of their building's devices towards reducing energy consumption without sacrificing comfort preferences

Question: Would you be interested in trading your non-self-consumed energy/ flexibility in local flexibility and energy markets towards monetary gains without affecting your comfort?

Figure 0-32 Spanish demo – Occupants' interest in trading their non-self-consumed energy/flexibility in local flexibility and energy markets

Question: How would you like to communicate with Aggregators regarding the exploitation/ trading of your flexibility?

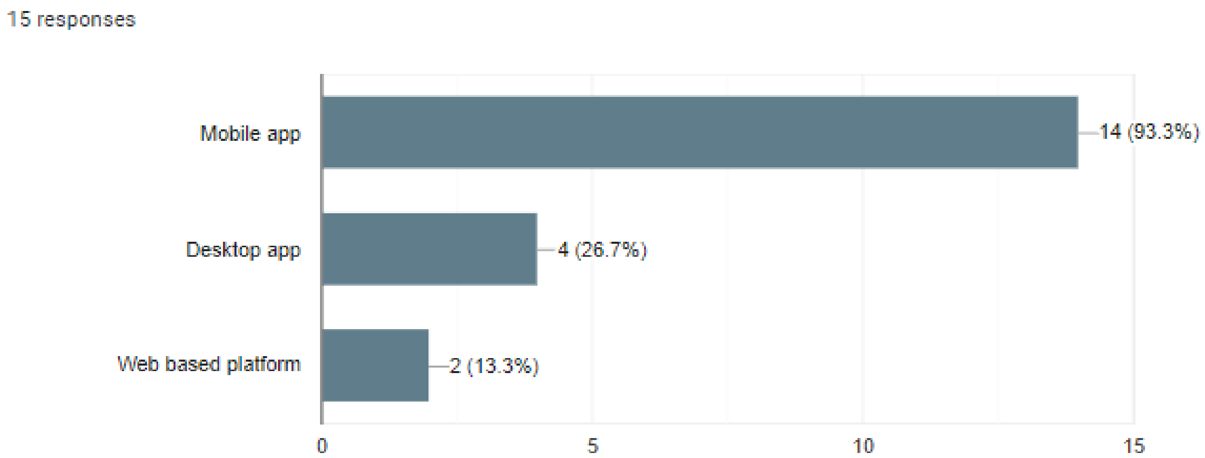

Figure 0-33 Spanish demo – Occupants' preferred devices for communicating with Aggregators regarding their exploitation/trading of their flexibility

Question: Do you like having and using smart devices at home? (Smart Devices are those that can be programmed and controlled remotely with an app or web browser).

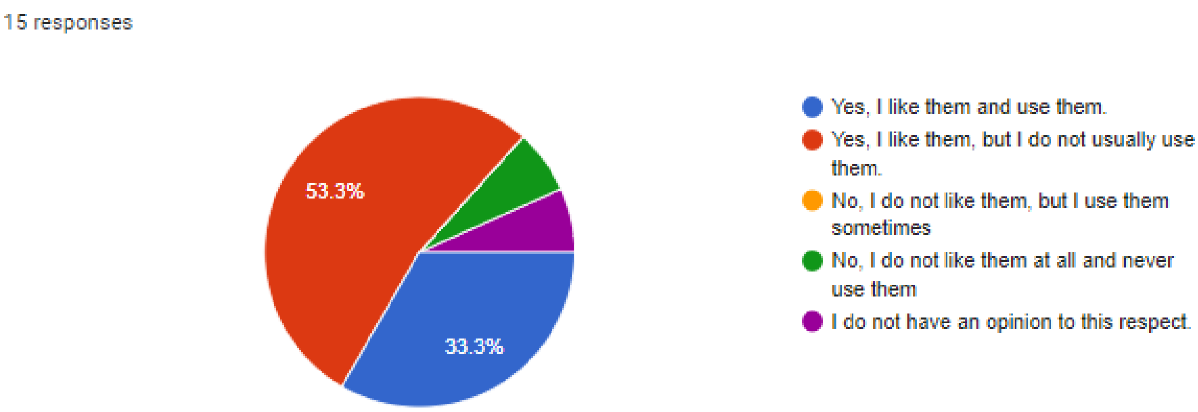

Figure 0-34 Spanish demo – Occupants' preference on having and using smart devices at their home

Question: Would you object in allowing external stakeholders (i.e. aggregators) to control your devices remotely (based on specific agreements) at specific points in time to optimize your participation in energy/ flexibility trading?

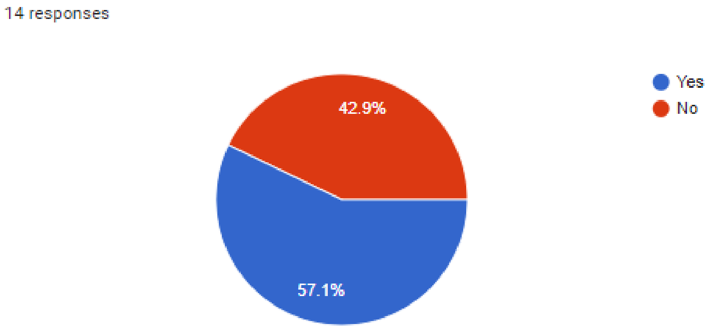

Figure 0-35 Spanish demo – Occupants' objection in allowing external stakeholders to control your devices remotely at specific points in time to optimize their participation in energy/ flexibility trading

Question: Would you agree that an aggregator monitors and operates automatically your devices, without affecting your comfort, so you can provide service to the grid and get a remuneration for it? Please tell us if you would allow it for each of the devices below:

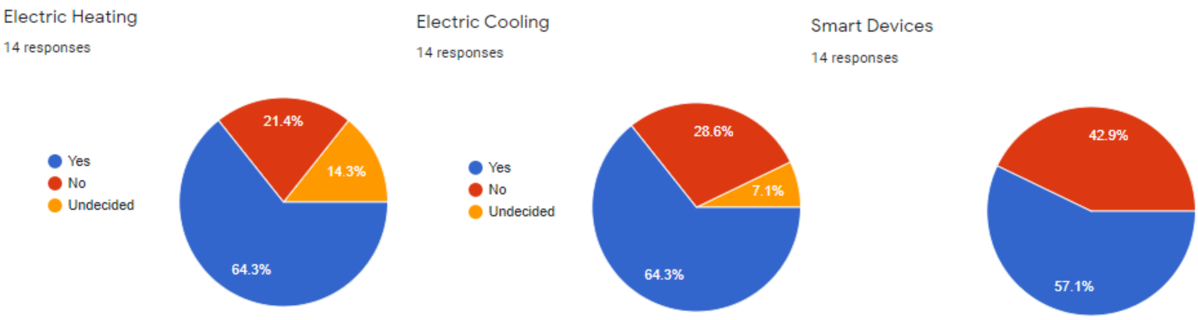

Figure 0-36 Spanish demo - Occupants' preference on allowing aggregators to automatically operate their devices

Question: How often would you like to receive alerts/instructions regarding your unconsumed energy available for trading?

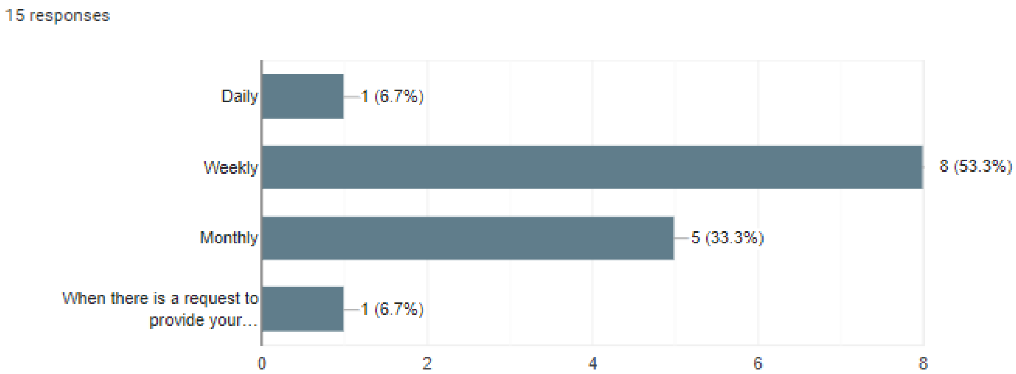

Figure 0-37 Spanish demo – Occupants preference on intervals for receiving alerts/instructions regarding their unconsumed energy available for trading

Question: Would you be interested in monitoring the monetary gains generated from trading your flexibility?

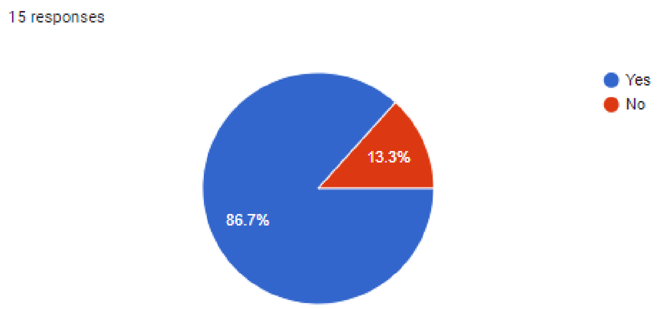

Figure 0-38 Spanish demo – Occupant's interest in monitoring their monetary gains from trading their flexibility

Question: In order for you to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following statements for you?

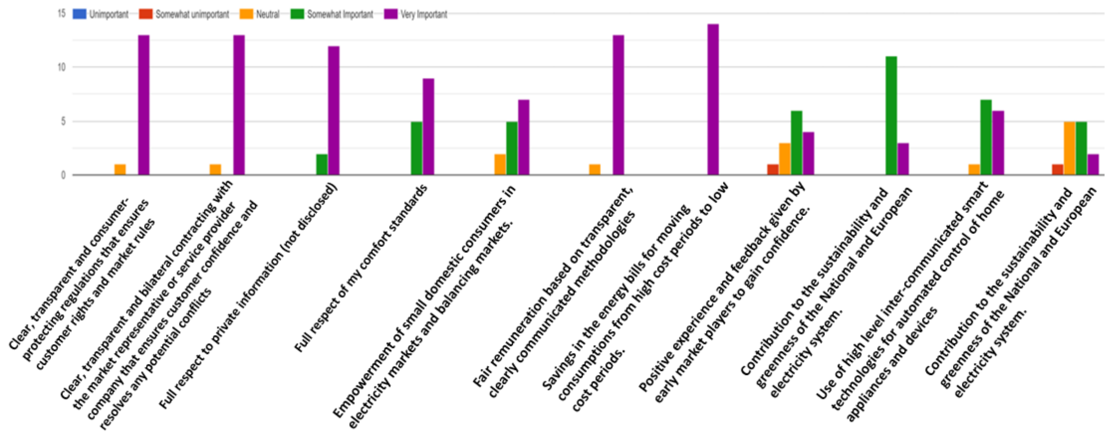

Figure 0-39 Spanish demo – Occupants' opinion on the importance of aspects for participating in demand flexibility renumeration programmes

Question: Which of the following aspects would make you feel more uneasy to participate in the demand flexibility markets described above?

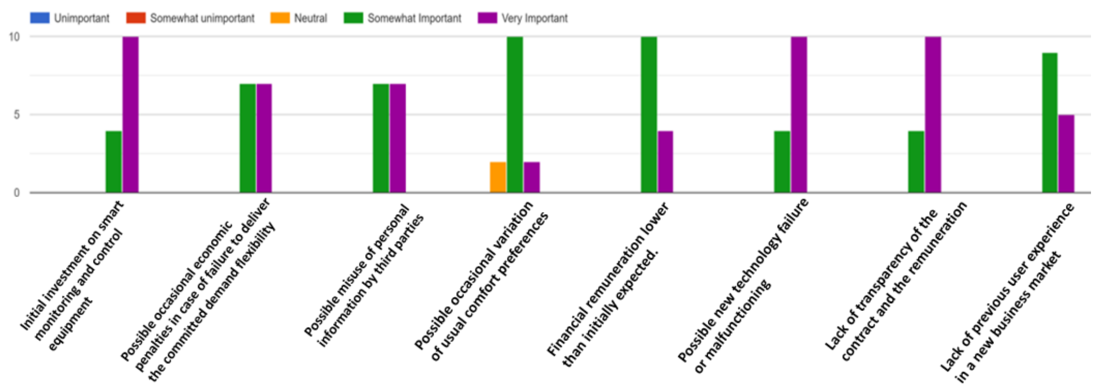

Figure 0-40 Spanish demo – Occupants' preference on aspects that will make it easy for them to participate in the demand flexibility markets

Building Managers

Question: What kind of wireless technology devices do you normally use?

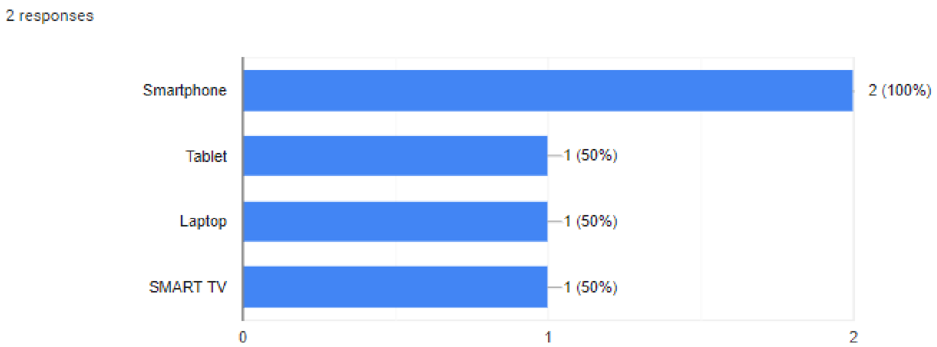

Figure 0-41 Spanish demo – Building Managers' used wireless technology

Question: What kind of internet connectivity is there at your building?

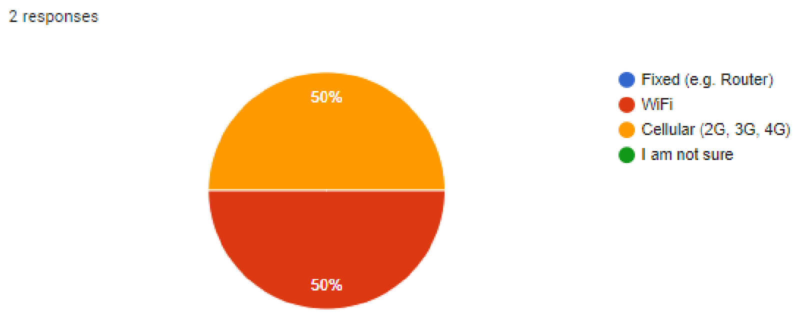

Figure 0-42 Spanish demo – Building Managers' available internet connectivity in their building

Question: Are there any restrictions in your internet connection ?

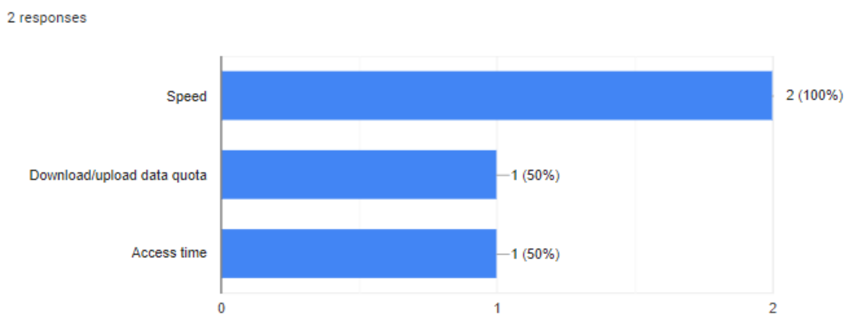

Figure 0-43 Spanish demo – Building Managers' restrictions in their internet connection

Question: How familiar were you with the concept of Plus Energy Buildings (PEBs) prior to this questionnaire?

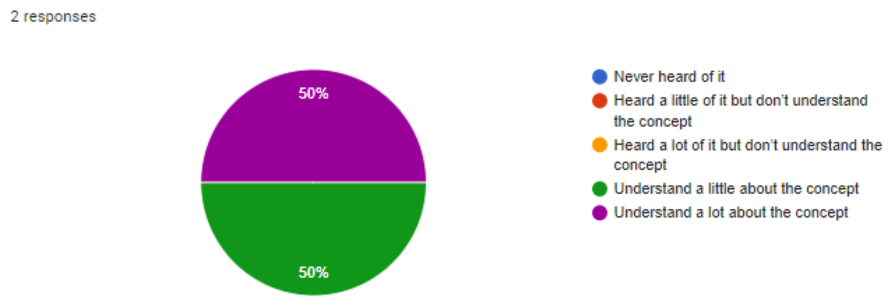

Figure 0-44 Spanish demo – Building Managers' familiarity with PEBs concept

Question: How important is it to save energy and use renewable energy sources in your building?

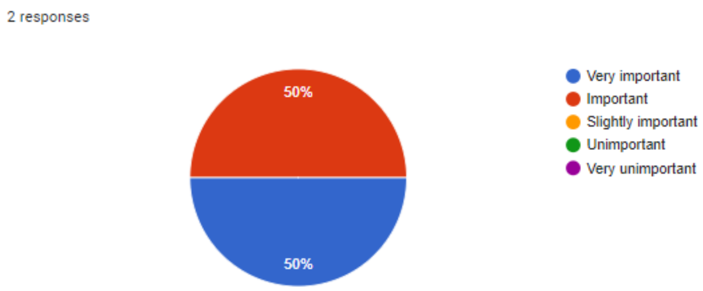

Figure 0-45 Spanish demo – Building Managers' opinion on the importance of saving energy and use of renewable energy sources in their building

Question: Would you be interested in reducing the energy demand and dependence of your building on grid energy, through the installation of novel smart-ready energy technologies?

Figure 0-46 Spanish demo – Building Managers' interest in reducing the energy demand and dependence of their building on grid energy, through the installation of novel smart-ready energy technologies

Question: Do you have any specific concerns regarding the installation of smart-ready energy technologies in your building?

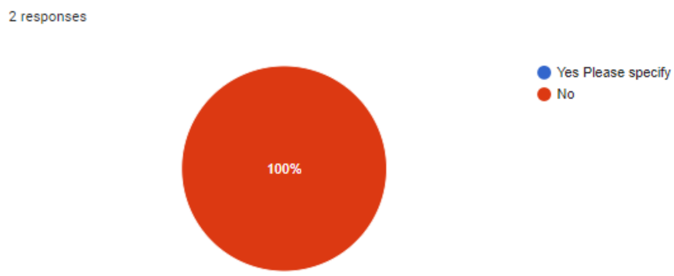

Figure 0-47 Spanish demo – Building Managers' concerns regarding the installation of smart-ready energy technologies in their building

Question: Are you interested in monitoring your building's energy consumption and flexibility through a visualization application (in your mobile, tablet, laptop)?

Figure 0-48 Spanish demo – Building Managers' interest in monitoring their building's energy consumption and flexibility through a visualization application

Question: How would you like to monitor your building's energy consumption and flexibility?

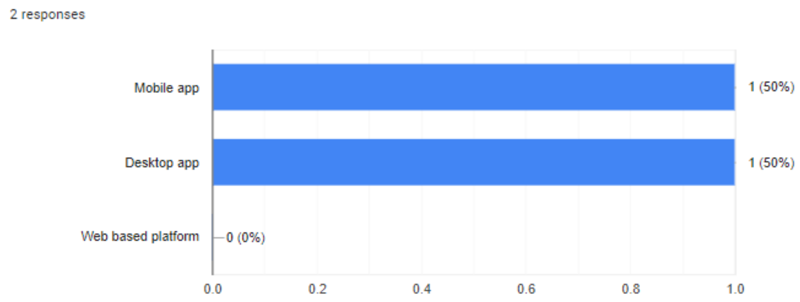

Figure 0-49 Spanish demo – Building Managers' preferred means for monitoring their building's energy consumption and flexibility

Question: Are you familiar with the concept of electricity self-consumption?

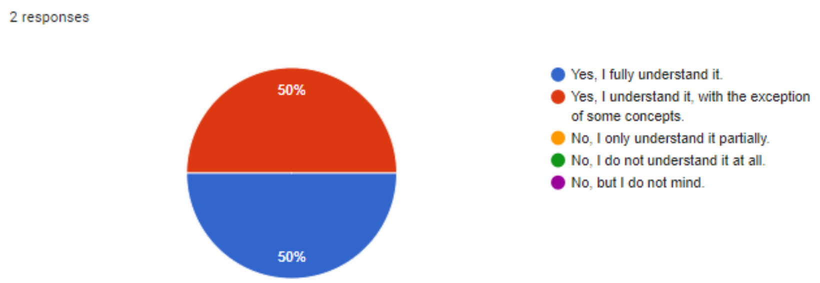

Figure 0-50 Spanish demo – Building Managers' familiarisation with the concept of electricity self-consumption

Question: Would you object to share your building's flexibility for optimizing the performance of your neighbourhood/ district and maximizing self-consumption?

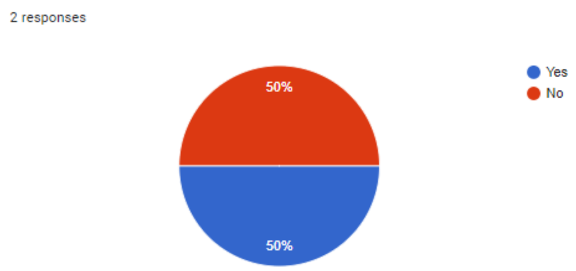

Figure 0-51 Spanish demo – Building Managers' interest in sharing their building's flexibility for optimizing the performance of their neighbourhood/ district and maximizing self-consumption

Question: Are you interested in monitoring your building's performance in terms of energy consumption and flexibility against the district/ community level performance?

Figure 0-52 Spanish demo – Building Managers' interest in monitoring their building's performance in terms of energy consumption and flexibility against the district/ community level performance

Question: How would you like to monitor your building's position against the district/community level energy consumption and flexibility?

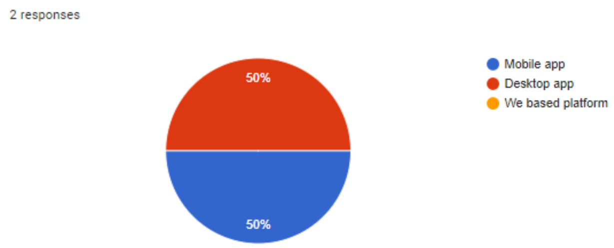

Figure 0-53 Spanish demo – Building Managers' preferred means for monitoring their building's position against the district/community level energy consumption and flexibility

Question: Would you agree in sharing your building's flexibility and energy consumption (real-time data) with Aggregators towards participating in flexibility trading?

Figure 0-54 Spanish demo – Building Managers' agreement in sharing their building's flexibility and energy consumption with Aggregators towards participating in flexibility trading

Question: In order for you to participate in collective schemes for self-consumption maximization at community level, how important are the following aspects for you?

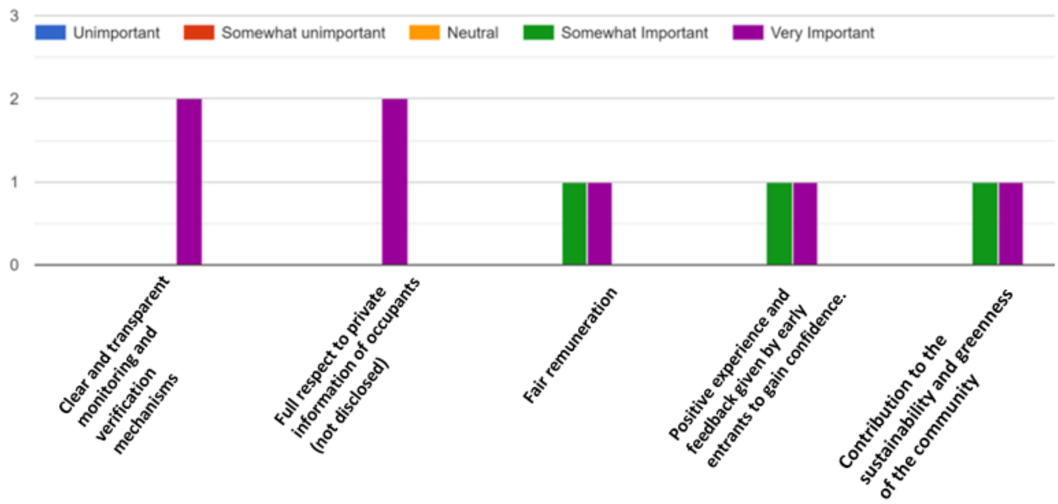

Figure 0-55 Spanish demo – Building Managers' opinion on aspects considered important for their participation in collective schemes for self-consumption maximization at community level

Question: Which of the following statements would make you feel more uneasy to participate in the local self-consumption schemes at community level?

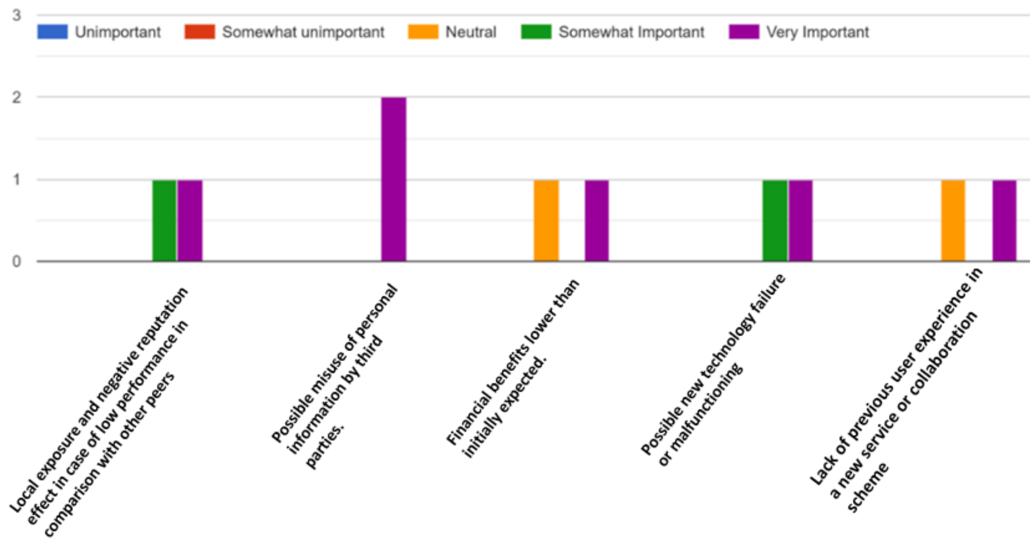

Figure 0-56 Spanish demo – Building Managers' opinion on aspects considered important for making them feel more uneasy to participate in the local self-consumption schemes at community level

Question: Would you be interested in trading your building's non-self-consumed energy in local flexibility and energy markets towards monetary gains?

Figure 0-57 Spanish demo – Building Managers' interest in trading their building's non-self-consumed energy in local flexibility and energy markets towards monetary gains

Question: How would you like to communicate with Aggregators regarding the exploitation/trading of your building's flexibility?

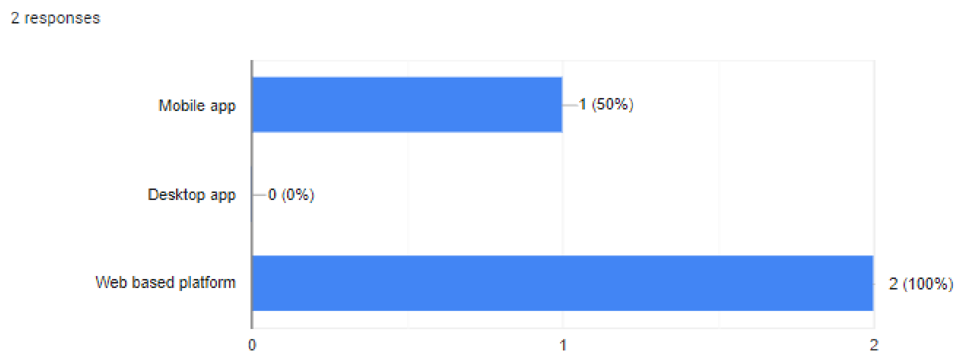

Figure 0-58 Spanish demo – Building Managers' preferred means for communicating with Aggregators regarding the exploitation/trading of their building's flexibility

Question: How often would you like to receive alerts/instructions regarding your building's unconsumed energy available for trading?

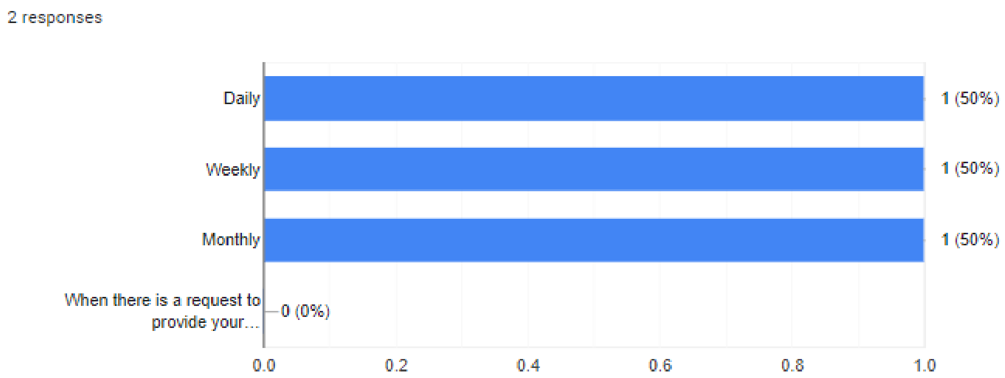

Figure 0-59 Spanish demo – Building Managers' preference on the intervals for receiving alerts/instructions regarding their building's unconsumed energy available for trading

Question: Would you be interested in monitoring the monetary gains generated from trading your building's flexibility?

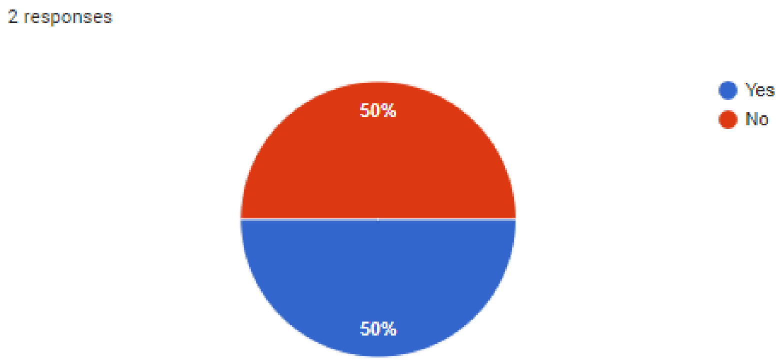

Figure 0-60 Spanish demo – Building Managers' interest in monitoring the monetary gains generated from trading their building's flexibility

Question: Do you agree or disagree with the following statement? "Visualization of my building's consumption/energy savings against community level can inspire the building occupants towards reducing their energy consumption, leading also to financial profits and environmental benefits"

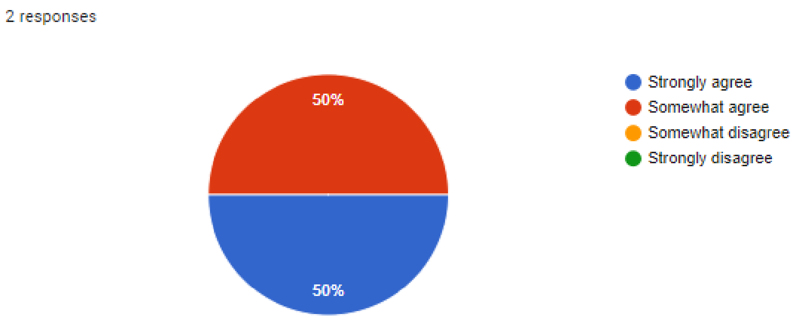

Figure 0-61 Spanish demo – Building Managers' agreement with the statement

Question: Would you object in allowing external stakeholders (i.e. aggregators) to control your devices remotely (based on specific agreements) at specific points in time to optimize your participation in energy/ flexibility trading?

Figure 0-62 Spanish demo – Building Managers' objection in allowing external stakeholders to control their devices remotely at specific points in time to optimize your participation in energy/ flexibility trading

Question: In order for you to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following aspects for you?

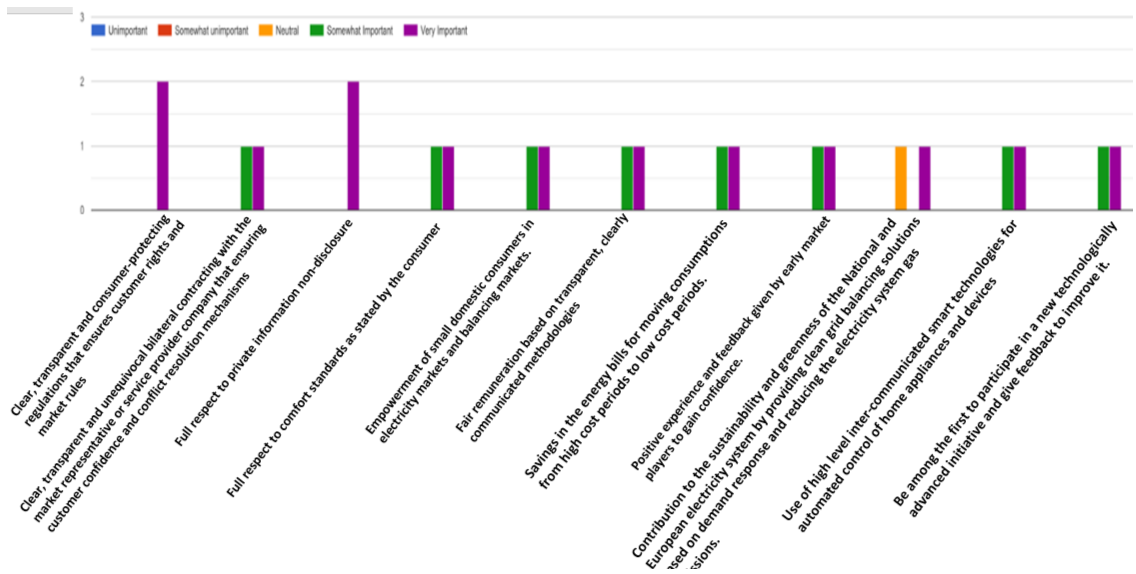

Figure 0-63 Spanish demo – Building Managers' rating of aspects important for them to participate in the demand flexibility remuneration programmes through a demand aggregator

Question: Which of the following aspects would make you feel more uneasy to participate in the demand flexibility markets described above?

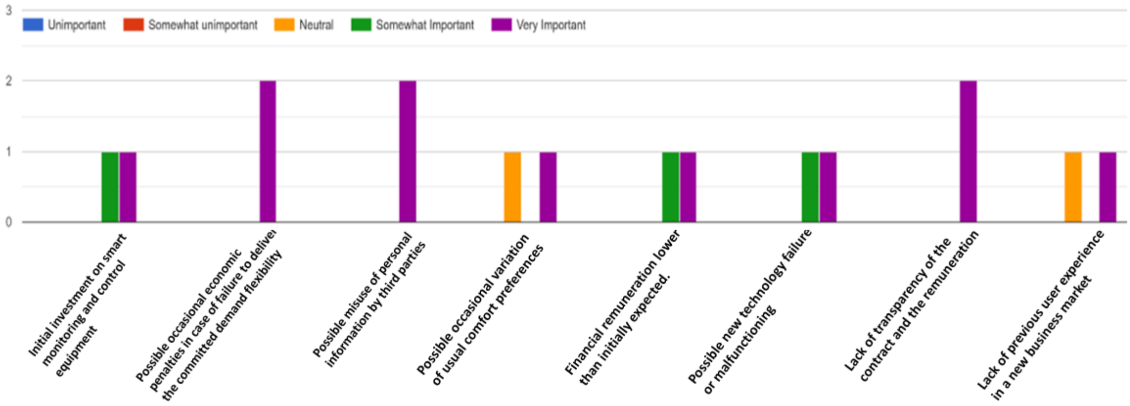

Figure 0-64 Spanish demo – Building Managers' rating of aspects important to make them feel more uneasy to participate in the demand flexibility markets

Architects

Question: What kind of buildings do you usually design?

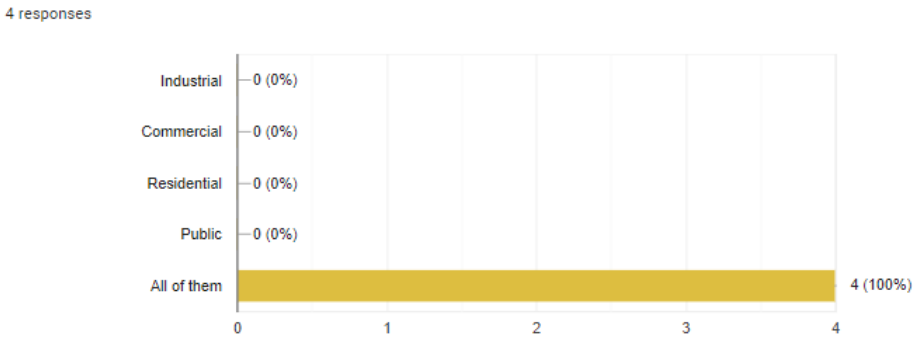

Figure 0-65 Spanish demo – Architects' usual buildings

Question: What type of clients do you usually work with?

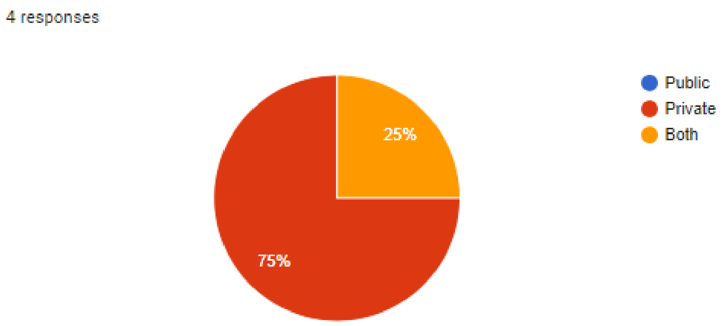

Figure 0-66 Spanish demo – Architects' usual clients

Question: What kind of internet connectivity do you have in your office?

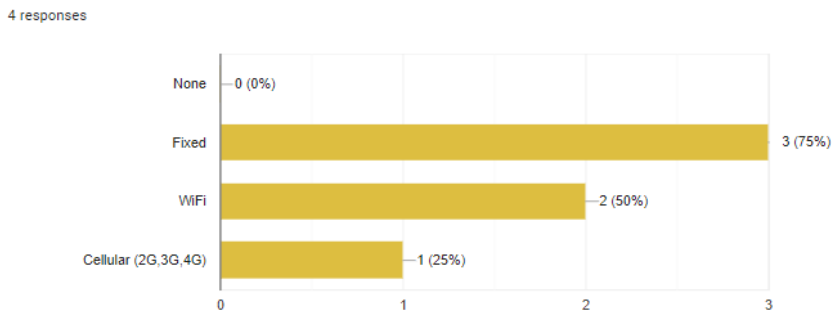

Figure 0-67 Spanish demo – Architects' available internet connectivity at their offices

Question: Which devices do you use for work?

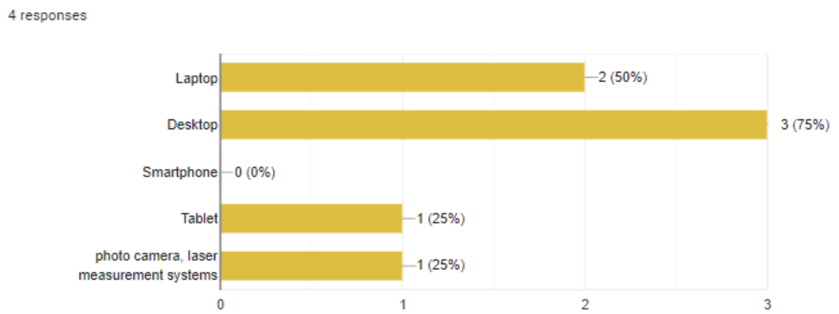

Figure 0-68 Spanish demo – Architects' preferred devices for work

Question: What operating systems do these devices use?

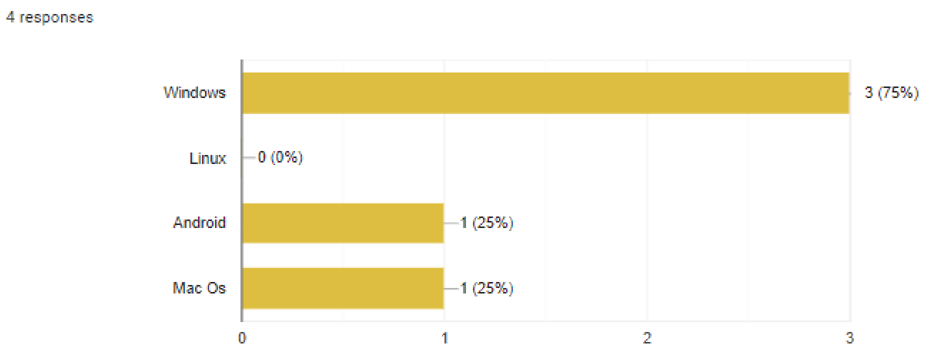

Figure 0-69 Spanish demo – Architects' preferred operating systems

Question: Which applications and information systems do you typically use in your everyday job?

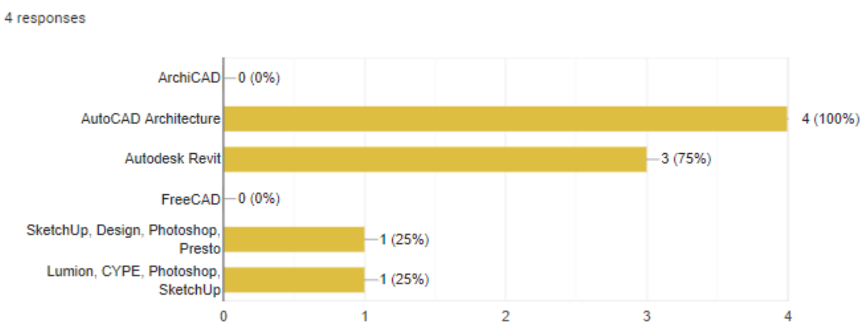

Figure 0-70 Spanish demo – Architects' typical application and information systems used in their job

Question: What export functionality do they support?

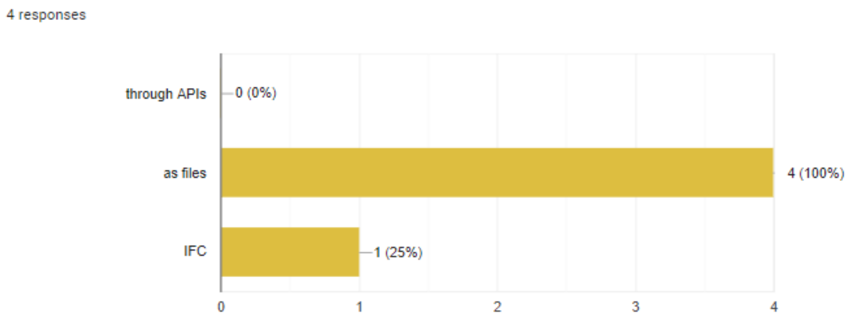

Figure 0-71 Spanish demo – Architects' information systems export functionality

Question: What data formats are supported for exporting data from these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

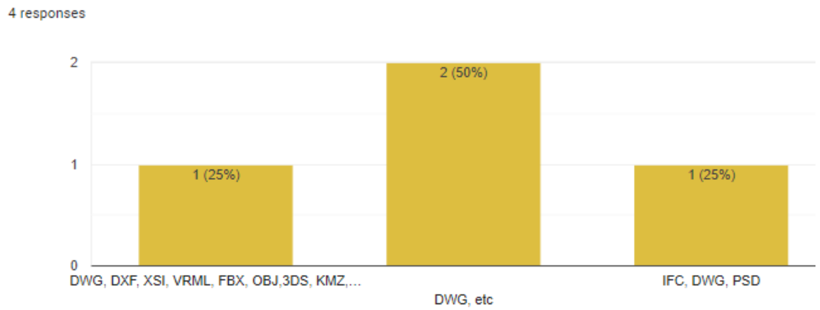

Figure 0-72 Spanish demo – Architects applications' supported data formats

Question: Which tools/systems do you use for handling Building Information Modelling (BIM) models?

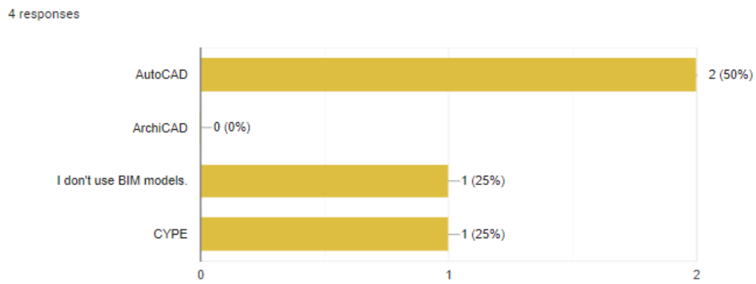

Figure 0-73 Spanish demo – Architects preferred tools/systems for handling BIM models

Question: Which formats do you export to your BIM models, when using these systems? (e.g. IFC, gbXML, etc.)

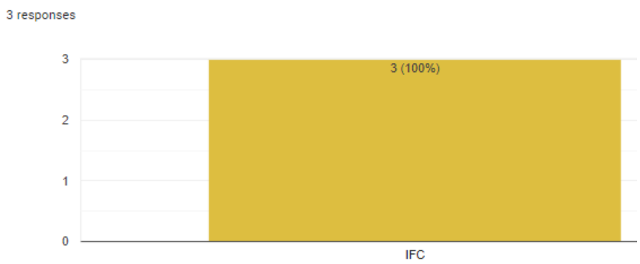

Figure 0-74 Spanish demo – Architects' preferred format for exporting their BIM models

Question: What type of data do you need from other stakeholders in order to properly complete your work?

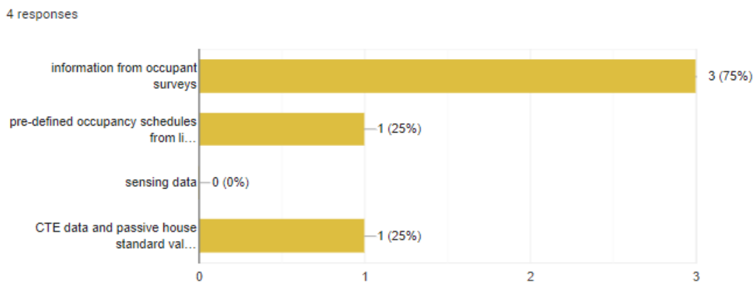

Figure 0-75 Spanish demo – Architects' required data from other stakeholders towards properly completing their work

Question: How do you currently find data you need, but you do not have electronically in your information systems?

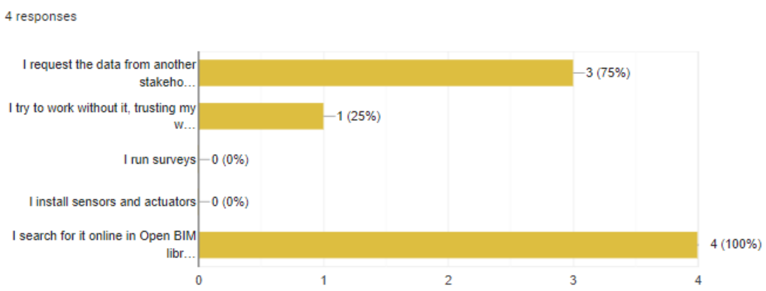

Figure 0-76 Spanish demo – Architects' ways of finding required data that are not electronically in their information systems

Question: What are the security and privacy requirements you have for the building data / information you manage?

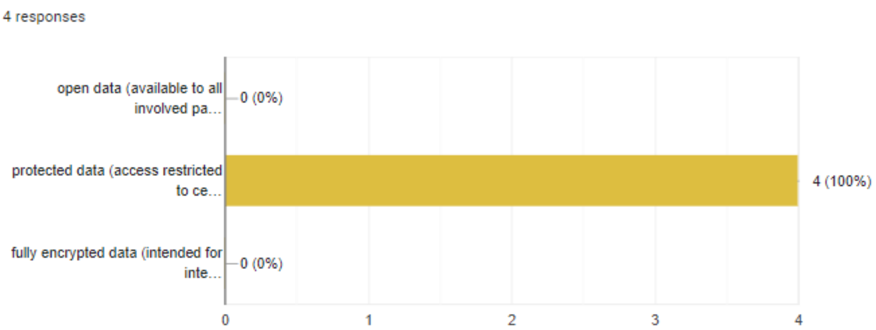

Figure 0-77 Spanish demo – Architects' security and privacy requirements for their building data/information they manage

Question: Which tools are you using to model energy performance?

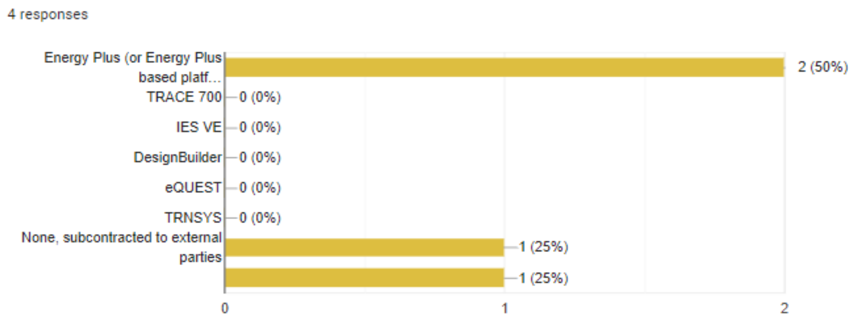

Figure 0-78 Spanish demo – Architects' used tools to model energy performance

Question: What import functionality do they support

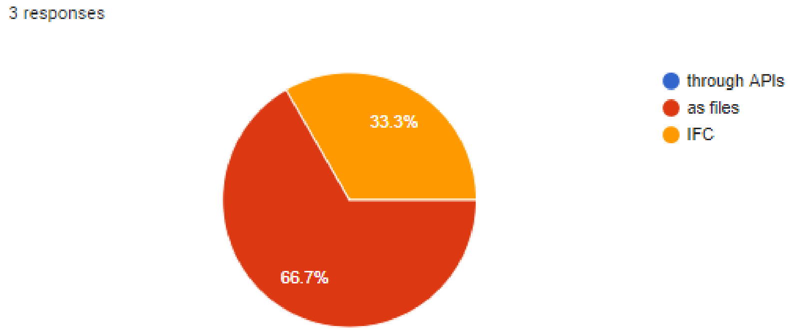

Figure 0-79 Spanish demo – Architects energy performance modelling tools' import functionality

Question: What data formats are supported for importing data to these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

1 response

IFC, DWG, XML

Figure 0-80 Spanish demo – Architects energy performance modelling tools data formats for import

Question: What data do you see as of high interest during the energy performance modelling?

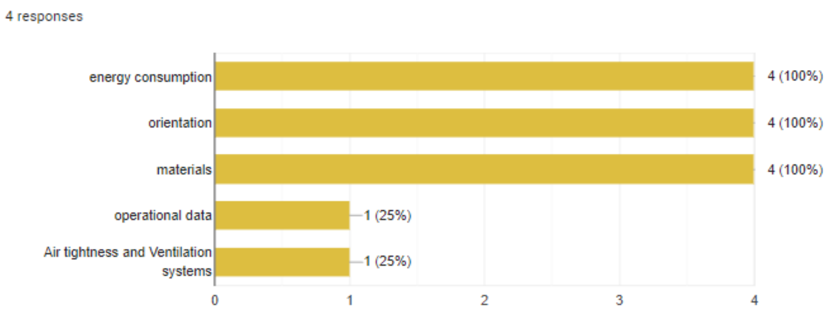

Figure 0-81 Spanish demo – Architects' preferred high interest data for energy performance modelling

Question: If you take into account operational energy data during the design phase, what data do you consider?

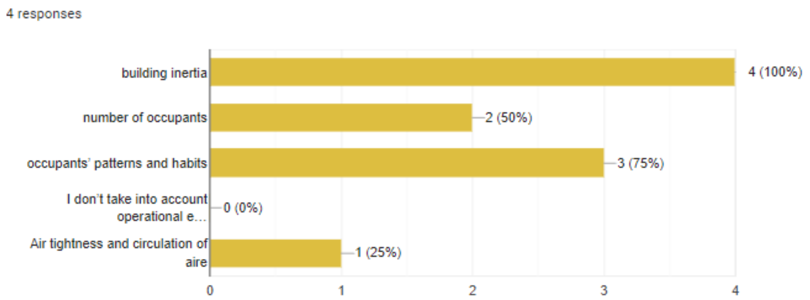

Figure 0-82 Spanish demo – Architects considered data in operational energy modelling

Question: If you consider the occupants' comfort in your calculations, how do you quantify (or measure) occupants' comfort?

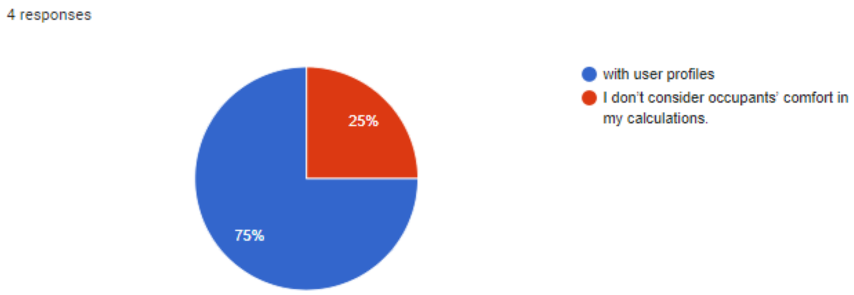

Figure 0-83 Spanish demo – Architects' quantification of occupants' comfort

Question: Do you consider the use of smart Internet of Things solutions to monitor indoor comfort and energy consumption?

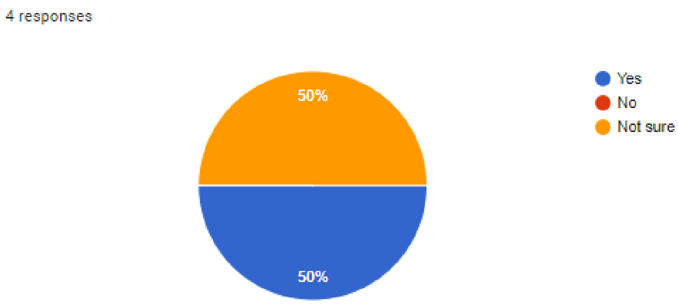

Figure 0-84 Spanish demo – Architects' views on considering use of Smart IoT solution for monitoring indoor comfort and energy consumption

Question: Do you think that this would be beneficial for your work? (e.g. more accurate prediction of energy performance based on realistic occupancy schedules).

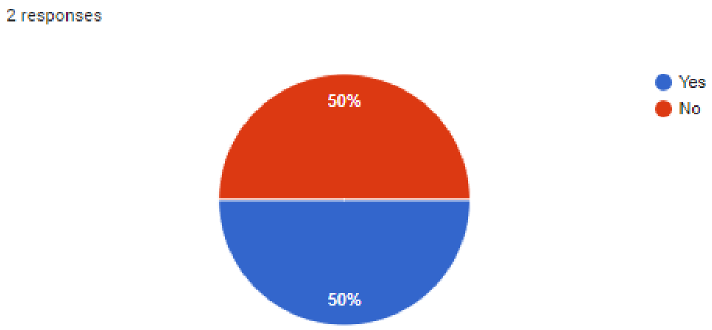

Figure 0-85 Spanish demo – Architects' view on using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: If answered "Yes" in the previous question, please specify why:

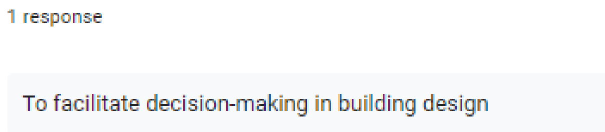

Figure 0-86 Spanish demo – Architects' reasons for using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: In the tools that you use for energy performance modelling and simulation, are you knowledgeable of the building control routines they apply?

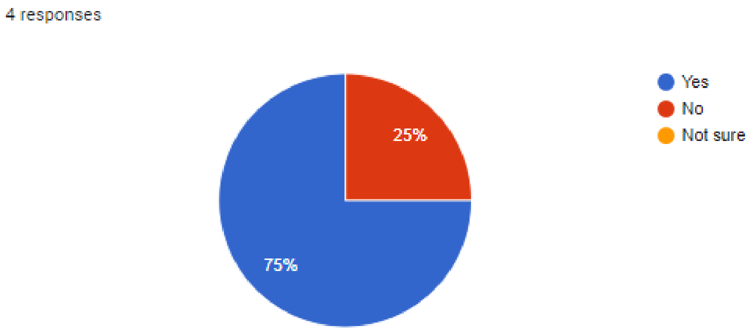

Figure 0-87 Spanish demo – Architects' knowledge of applied building control routines

Question: If you are knowledgeable of the control routines they apply, are you satisfied with the accuracy they achieve?

Figure 0-88 Spanish demo – Architects' satisfaction with the accuracy of building control routines used in energy performance modelling

Question: Would you be open to adopt more advanced building systems control routines in your tools as a means to increase performance prediction accuracy?

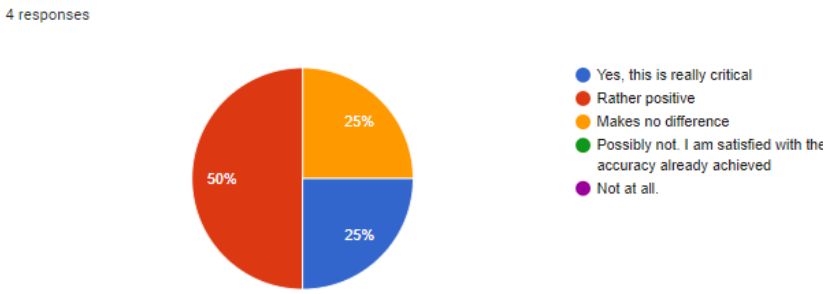

Figure 0-89 Spanish demo – Architects' willingness to adopt more advanced building systems control routines in their tools as a means to increase performance prediction accuracy

Austrian Demo site

Building Occupants

Question: Please indicate your gender?

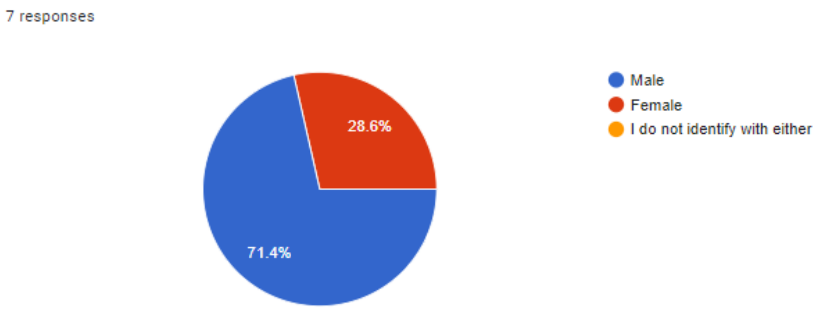

Figure 0-90 Austrian demo – Gender indication

Question: Please indicate your age group?

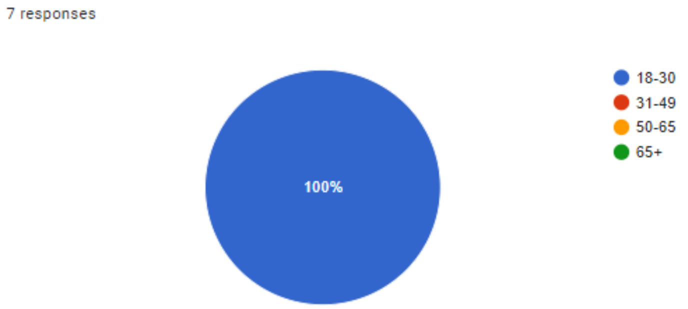

Figure 0-91 Austrian demo – Occupants age group

Question: What type of household do you live in?

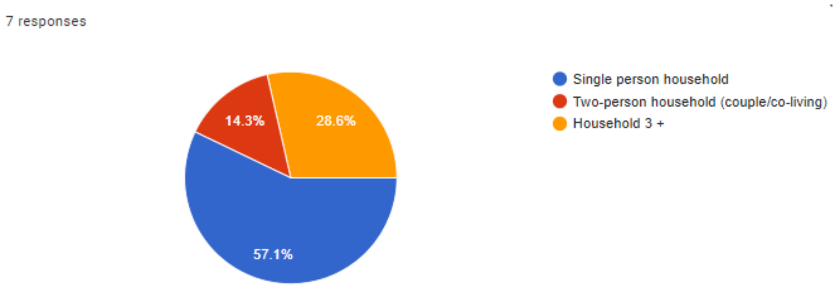

Figure 0-92 Austrian demo – Occupants' household composition

Question: What is your relationship to apartment?

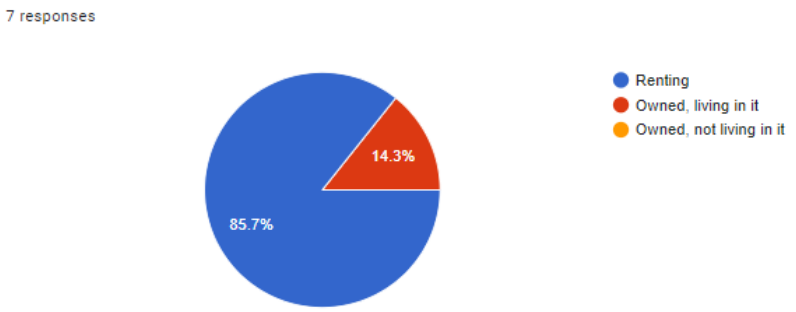

Figure 0-93 Austrian demo – Occupants' relationship to apartment

Question: What kind of wireless technology devices do you normally use?

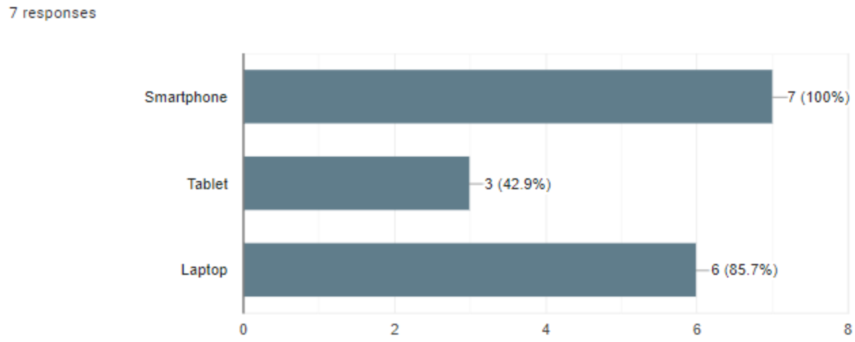

Figure 0-94 Austrian demo – Occupants' usage of wireless technology devices

Question: What kind of internet connectivity is there at your home?

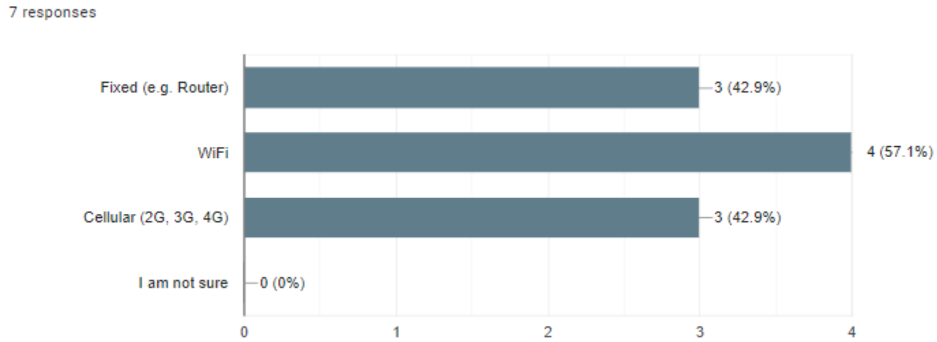

Figure 0-95 Austrian demo – Occupants' available internet connectivity

Question: Are there any restrictions in your internet connection regarding?

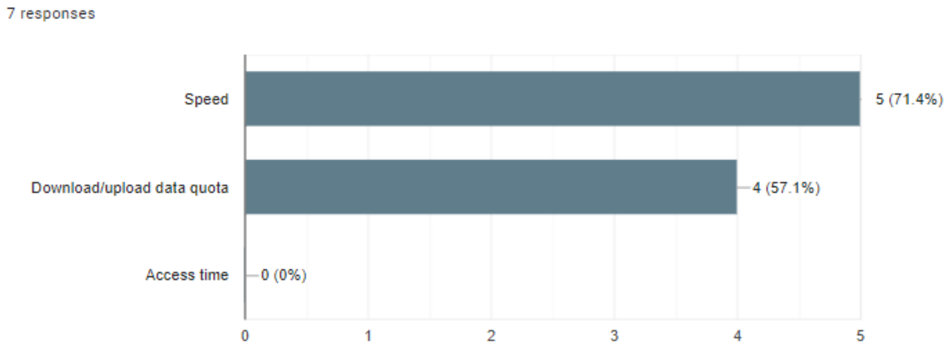

Figure 0-96 Austrian demo –Occupants' Internet connection restrictions

Question: How familiar were you with the concept of Plus Energy Buildings (PEBs) prior to this questionnaire?

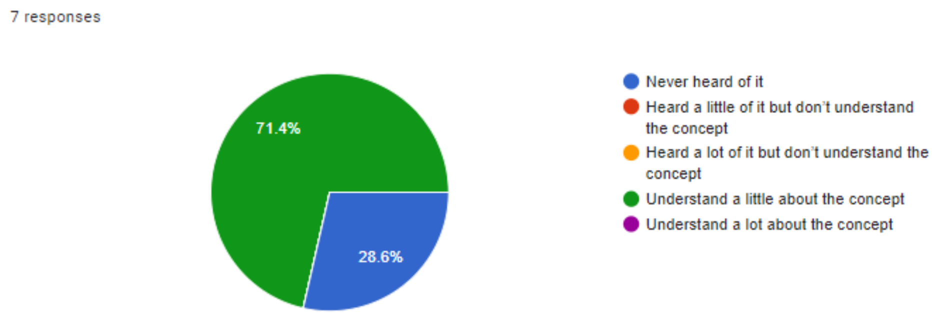

Figure 0-97 Austrian demo – Occupants' familiarization with PEBs concept

Question: How important is it to save energy and use renewable energy sources in your house/building?

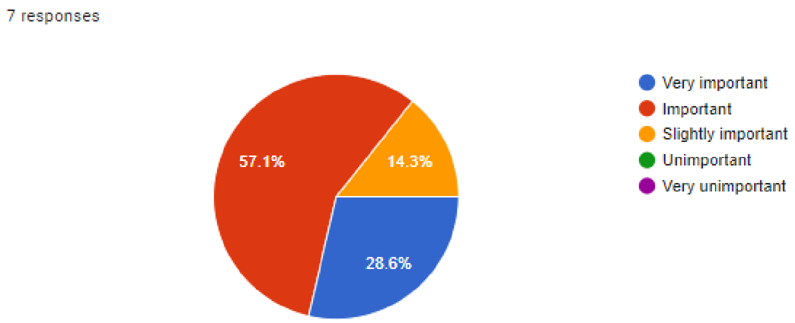

Figure 0-98 Austrian demo – Occupants' opinion on energy savings and renewable energy sources usage

Question: Would you be willing to apply advance control systems for optimizing energy performance?

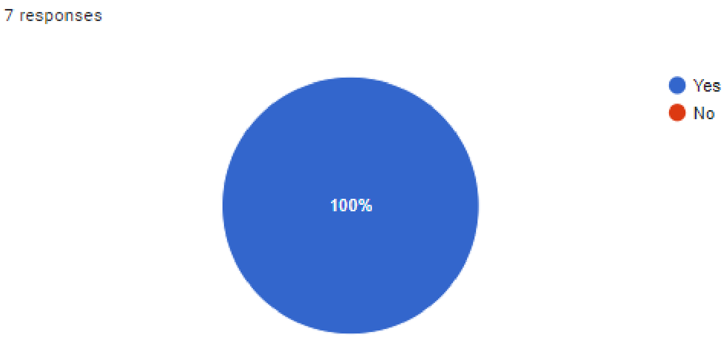

Figure 0-99 Austrian demo – Occupants willingness to apply advance control systems for energy performance optimisation

Question: What type of system would you be willing to accept?

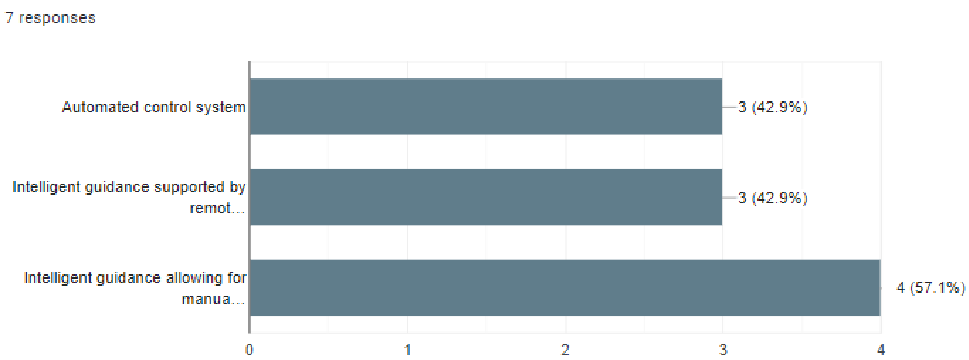

Figure 0-100 Austrian demo – Occupants' preference of advance control systems

Question: What types of devices and assets would you introduce into an advance control framework for self-consumption?

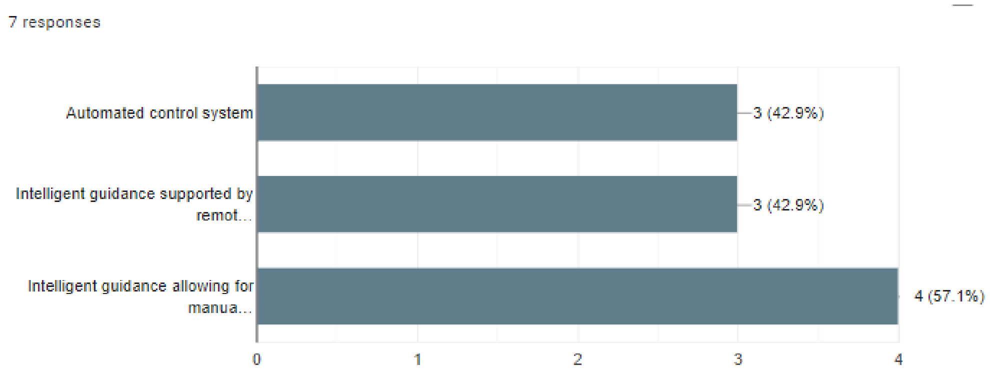

Figure 0-101 Austrian demo – Occupants' preference on devices types and assets for advance control self-consumption

Question: Would you be interested in reducing your energy demand and dependence on grid energy, through the installation of novel smart-ready energy technologies?

Figure 0-102 Austrian demo – Occupants' interest in reducing their energy demand and dependence on grid

Question: Do you have any specific concerns regarding the installation of smart-ready energy technologies in your house/building?

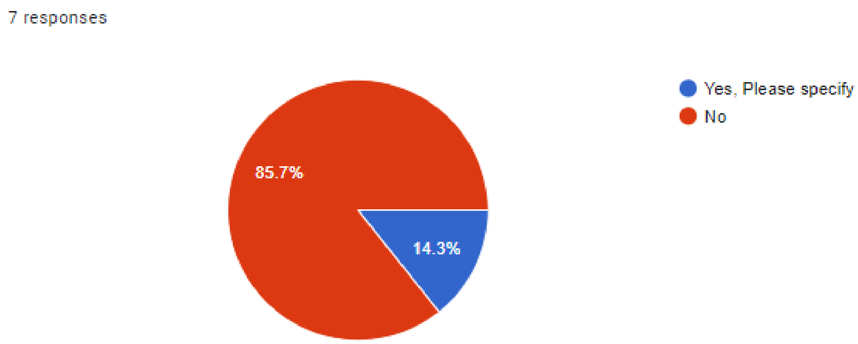

Figure 0-103 Austrian demo – Occupant's concerns on the installation of technologies in their houses/buildings

Question: You decide to improve your house by installing sensors in order to improve the indoor conditions, but you cannot decide what is the best for you and your family. How much are you willing to pay for sensors to be installed inside your house to measure your living preferences (room temperature, light levels, etc.) and finally help you decide on what changes best address your needs?

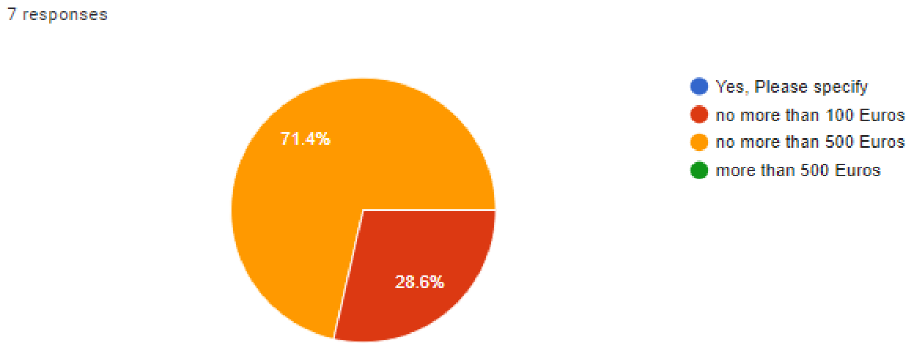

Figure 0-104 Austrian demo – Occupants' willingness to pay for sensors to be installed in their premises

Question: Have you ever been involved in a project that assesses your living comfort and/or indoor air quality?

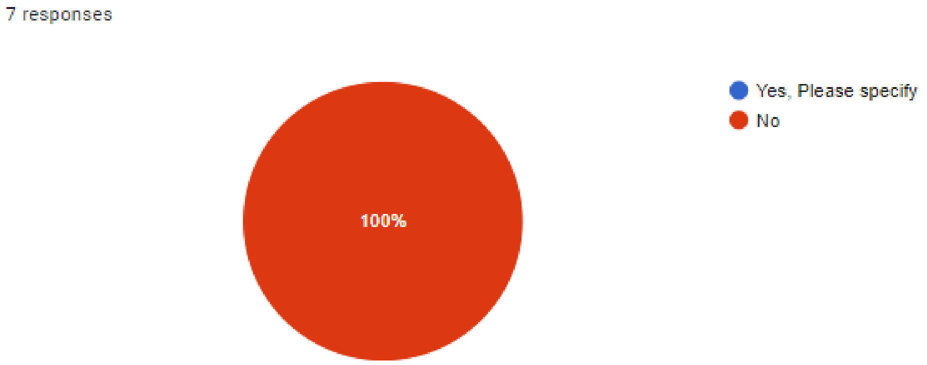

Figure 0-105 Austrian demo – Occupants' involvement in a project assessing living comfort/IAQ

Question: Do you see a value in having a building tailored to your needs in terms of comfort preferences?

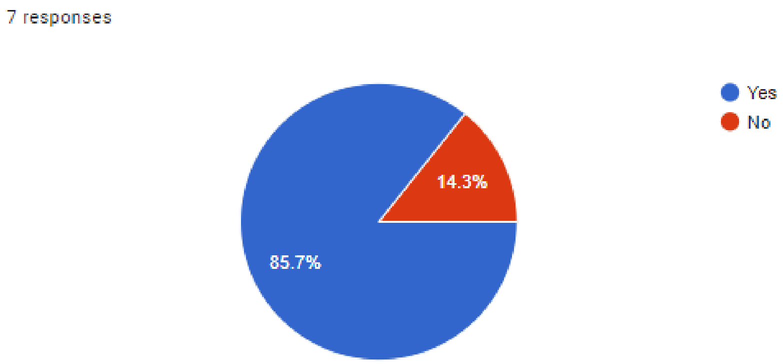

Figure 0-106 Austrian demo – Occupants' indication of seeing value having a building tailored to their needs

Question: Would you object to the installation of low powered Internet of Things devices (such as sensors and actuators) for a period of time to determine your energy consumption, flexibility and comfort preferences, if privacy is respected?

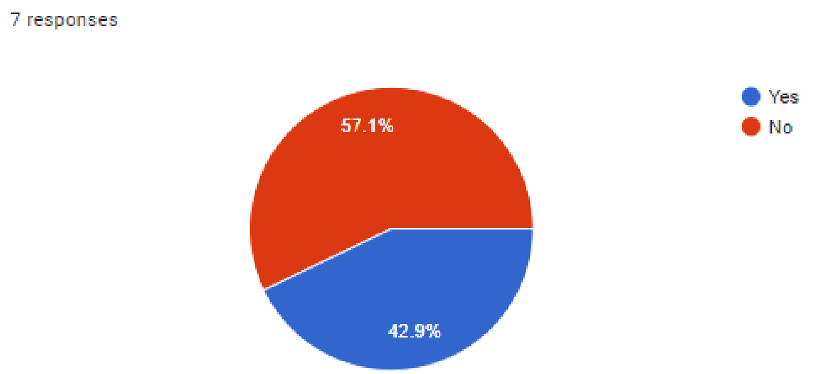

Figure 0-107 Austrian demo – Occupants' objection on the installation of low powered Internet of Things devices (such as sensors and actuators) for a period of time to determine their energy consumption

Question: Would you agree to have data sensors installed at your property for more than a year?

Figure 0-108 Austrian demo – Occupants' agreement with installation of data sensors in their property from more than a year

Question: What is the longest period you are willing to have such monitoring devices installed in your apartment?

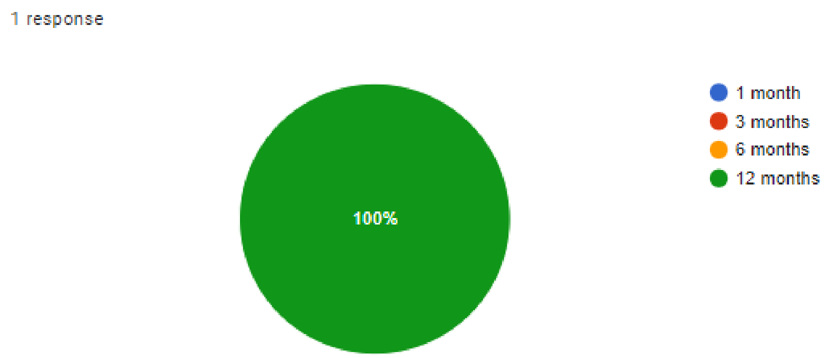

Figure 0-109 Austrian demo – Occupants' willingness to have monitoring devices installed on their apartments

Question: Please indicated how important the following aspects are regarding your living comfort.

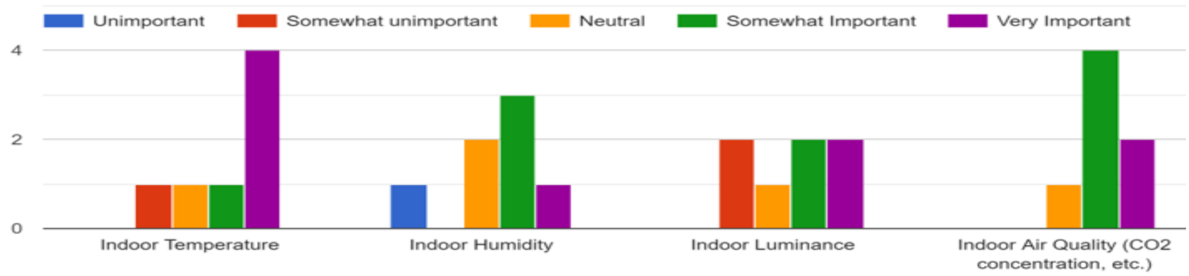

Figure 0-110 Austrian demo – Occupants' indication of aspects considered important for their living comfort

Question: Are you interested in monitoring your energy consumption and flexibility through visualization applications, i.e. through mobile phones, tablets, laptops?

Figure 0-111 Austrian demo – Occupants' interest in monitoring their energy consumption and flexibility through visualization applications

Question: How would you like to monitor your energy consumption and flexibility?

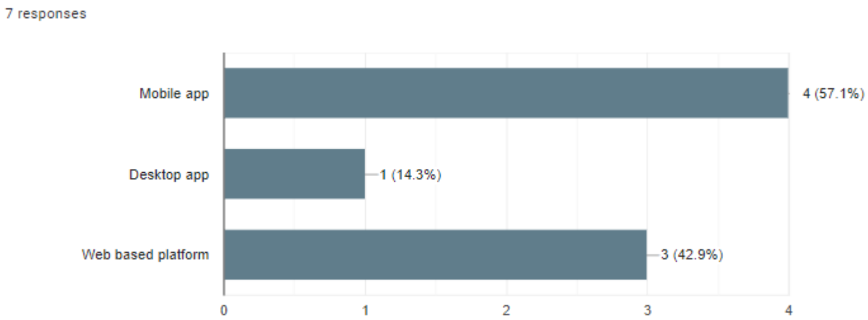

Figure 0-112 Austrian demo – Occupants' preferred devices for monitoring their energy consumption and flexibility

Question: Are you familiar with the concept of electricity self-consumption?

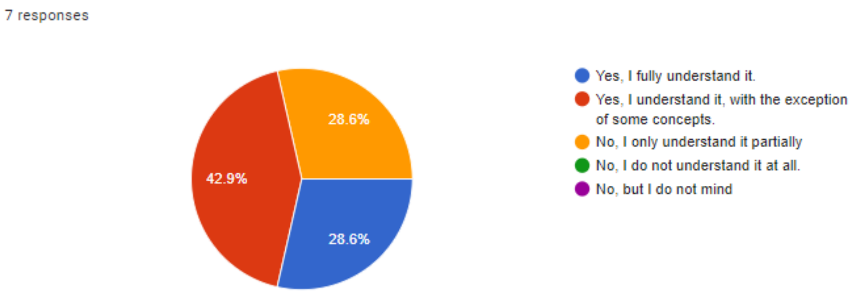

Figure 0-113 Austrian demo – Occupants' familiarity with the concept of electricity self-consumption

Question: Are you interested in monitoring your individual performance in terms of energy consumption and flexibility in comparison with the district/ community level performance (privacy of personal information will be respected)?

Figure 0-114 Austrian demo – Occupants' interest in monitoring their individual energy performance

Question: Do you agree or disagree with the following statement? "Visualization of my own consumption/energy savings against community level can inspire me towards reducing my energy consumption, leading also to financial profits and environmental benefits"

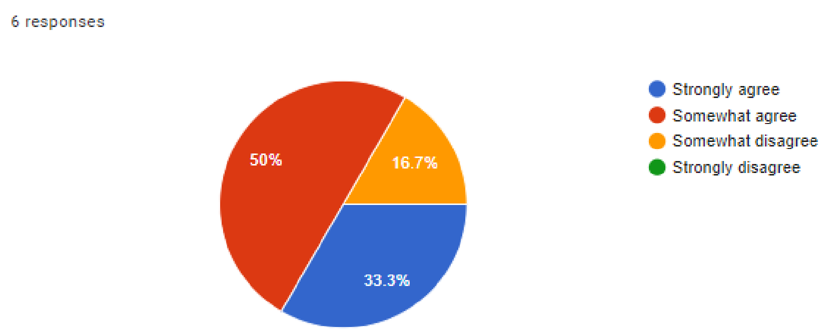

Figure 0-115 Austrian demo – Occupants' agreement with the statement

Question: How would you like to monitor your position against the district/community level energy consumption and flexibility (privacy of personal information will be respected)?

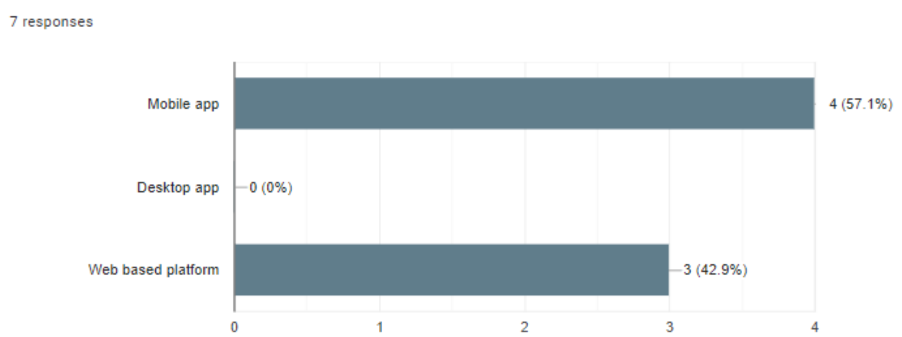

Figure 0-116 Austrian demo – Occupants' preferred means for monitoring their energy consumption and flexibility position against district/community level

Question: Would you object to share your individual flexibility for optimizing the performance of your neighbourhood/ district and maximizing self-consumption (privacy of personal information will be respected)?

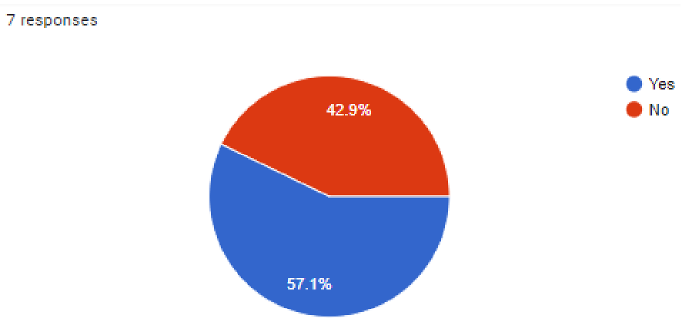

Figure 0-117 Austrian demo – Occupants' objection to share their individual flexibility for optimizing performance of their neighbourhood/district and maximize energy self-consumption

Question: In order for you to participate in collective schemes for self-consumption maximization at community level, please rate (with an "x") the importance of the following aspects:

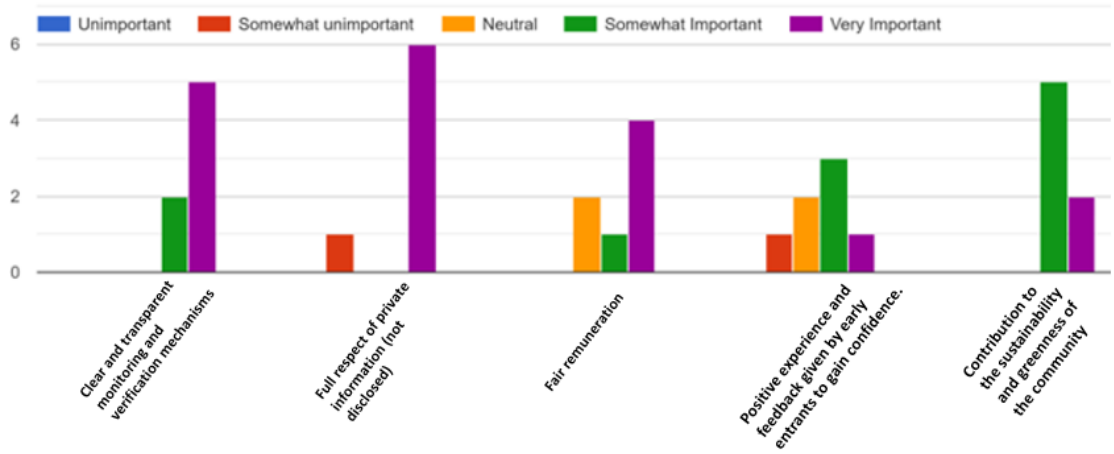

Figure 0-118 Austrian demo – Occupants' rating of important aspects for their participation in collective schemes for self-consumption maximization at community level

Question: Which of the following aspects would make you feel more uneasy to participate in the local self-consumption schemes at community level?

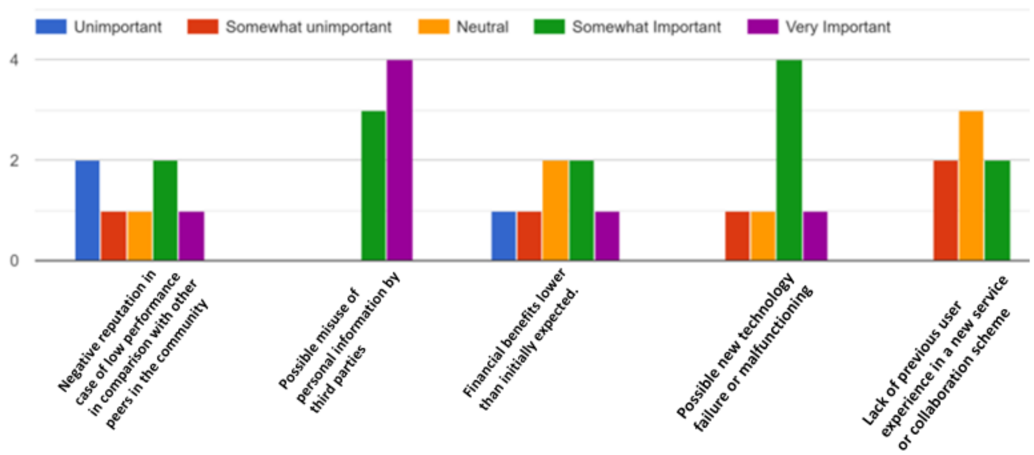

Figure 0-119 Austrian demo – Occupants' rating of aspects considered important for their participation in the local self-consumption schemes

Question: Would you be interested in having an automated control of your building's devices towards reducing energy consumption without sacrificing your comfort preferences?

Figure 0-120 Austrian demo – Occupants' interest on having automates control of their building's devices towards reducing energy consumption without sacrificing comfort preferences

Question: Would you be interested in trading your non-self-consumed energy/ flexibility in local flexibility and energy markets towards monetary gains without affecting your comfort?

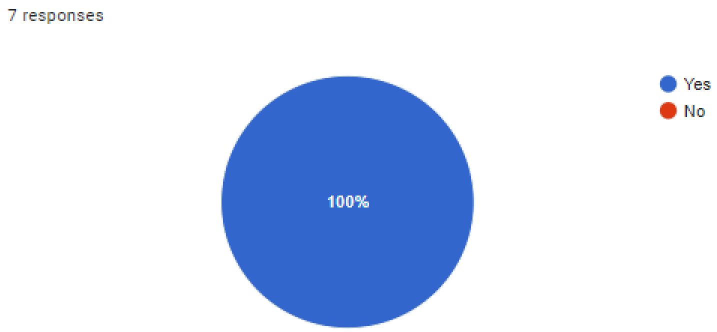

Figure 0-121 Austrian demo – Occupants' interest in trading their non-self-consumed energy/flexibility in local flexibility and energy markets

Question: How would you like to communicate with Aggregators regarding the exploitation/ trading of your flexibility?

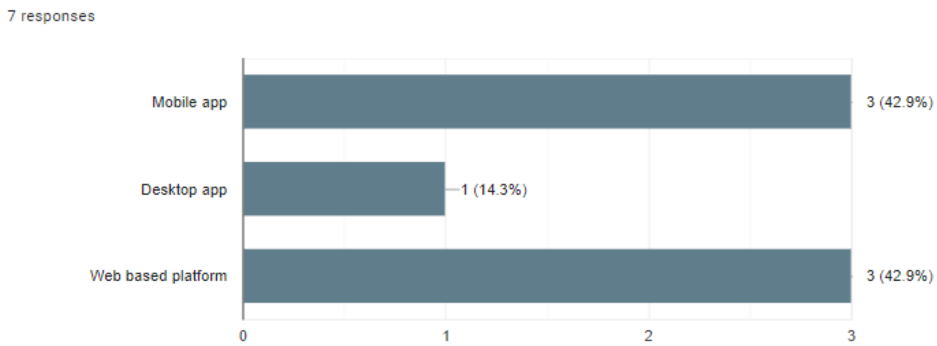

Figure 0-122 Austrian demo – Occupants' preferred devices for communicating with Aggregators regarding their exploitation/trading of their flexibility

Question: Do you like having and using smart devices at home? (Smart Devices are those that can be programmed and controlled remotely with an app or web browser).

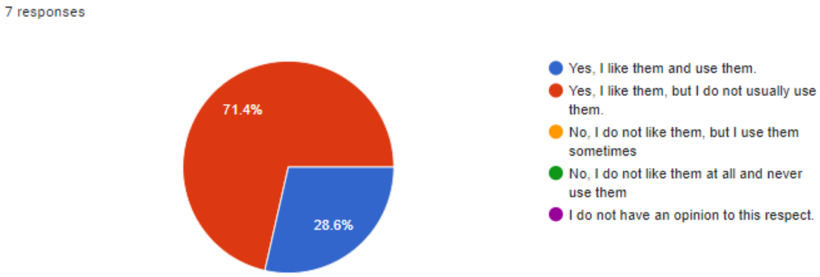

Figure 0-123 Austrian demo – Occupants' preference on having and using smart devices at their home

Question: Would you object in allowing external stakeholders (i.e. aggregators) to control your devices remotely (based on specific agreements) at specific points in time to optimize your participation in energy/ flexibility trading?

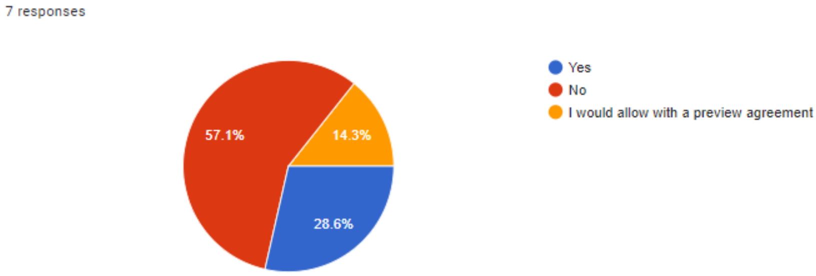

Figure 0-124 Austrian demo – Occupants' objection in allowing external stakeholders to control your devices remotely at specific points in time to optimize their participation in energy/ flexibility trading

Question: Would you agree that an aggregator monitors and operates automatically your devices, without affecting your comfort, so you can provide service to the grid and get a remuneration for it? Please tell us if you would allow it for each of the devices below:

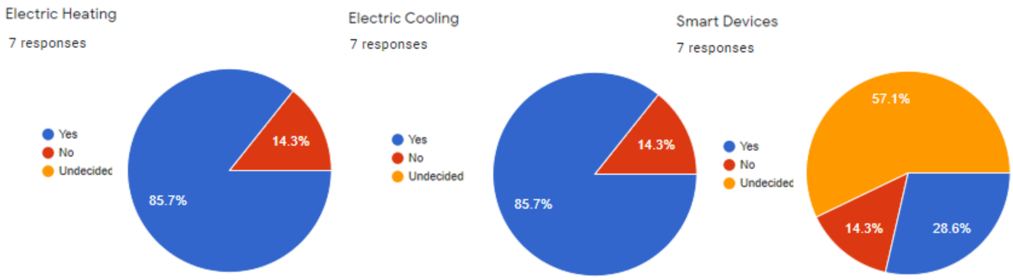

Figure 0-125 Austrian demo - Occupants' preference on allowing aggregators to automatically operate their devices

Question: How often would you like to receive alerts/instructions regarding your unconsumed energy available for trading?

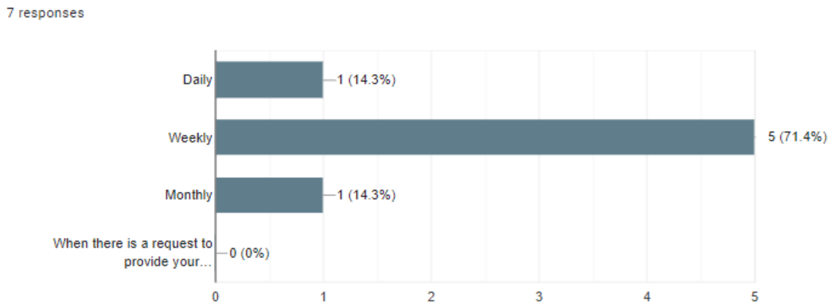

Figure 0-126 Austrian demo – Occupants preference on intervals for receiving alerts/instructions regarding their unconsumed energy available for trading.

Question: Would you be interested in monitoring the monetary gains generated from trading your flexibility?

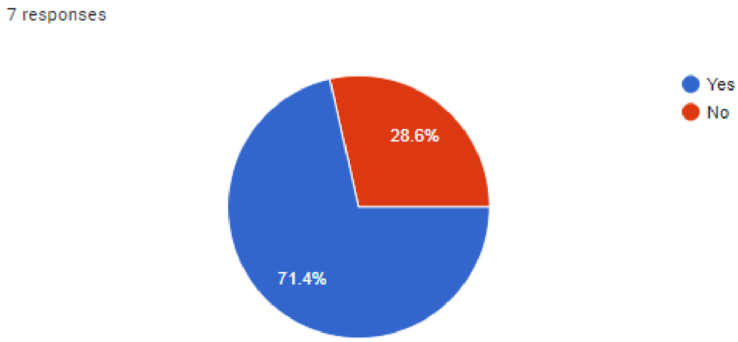

Figure 0-127 Austrian demo – Occupant's interest in monitoring their monetary gains from trading their flexibility

Question: In order for you to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following statements for you?

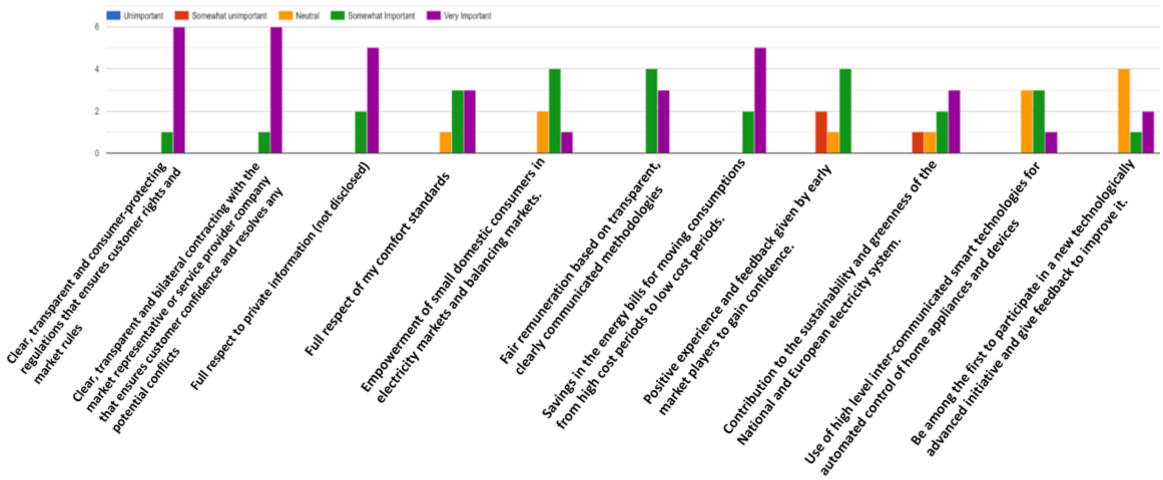

Figure 0-128 Austrian demo – Occupants' opinion on the importance of aspects for participating in demand flexibility renumeration programmes

Question: Which of the following aspects would make you feel more uneasy to participate in the demand flexibility markets described above?

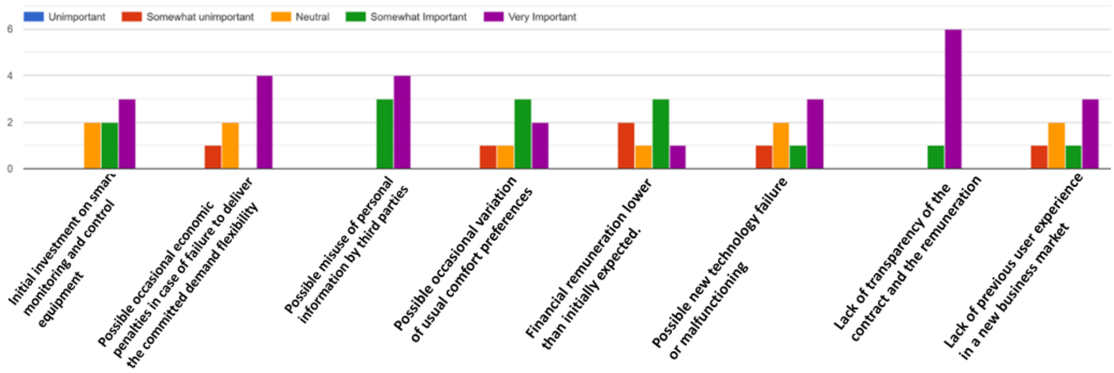

Figure 0-129 Austrian demo – Occupants' preference on aspects that will make it easy for them to participate in the demand flexibility markets.

Building Managers

Question: What kind of wireless technology devices do you normally use?

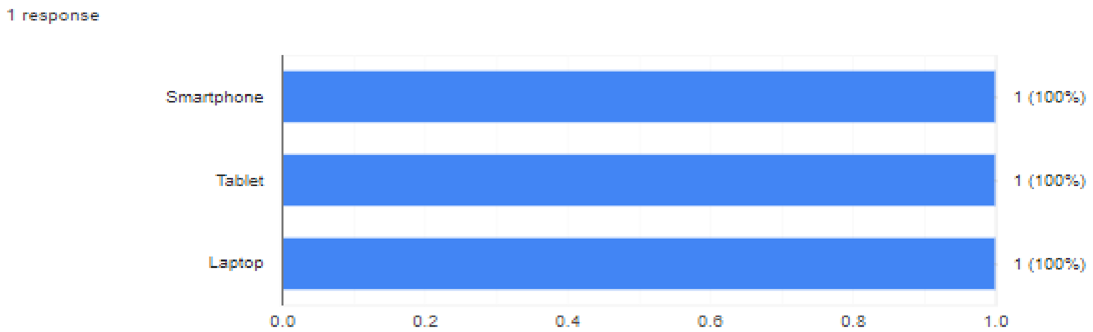

Figure 0-130 Austrian demo – Building Managers' used wireless technology

Question: What kind of internet connectivity is there at your building?

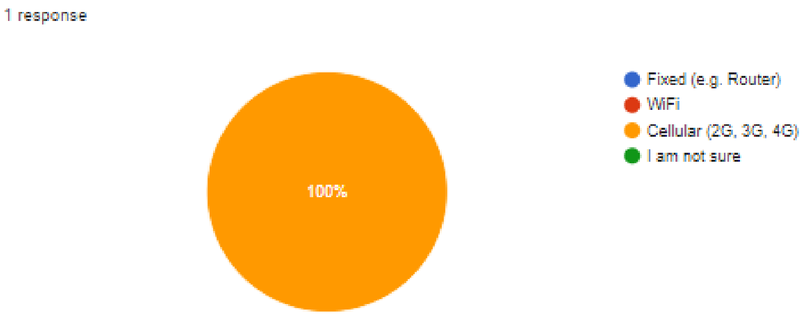

Figure 0-131 Austrian demo – Building Managers' available internet connectivity in their building

Question: Are there any restrictions in your internet connection ?

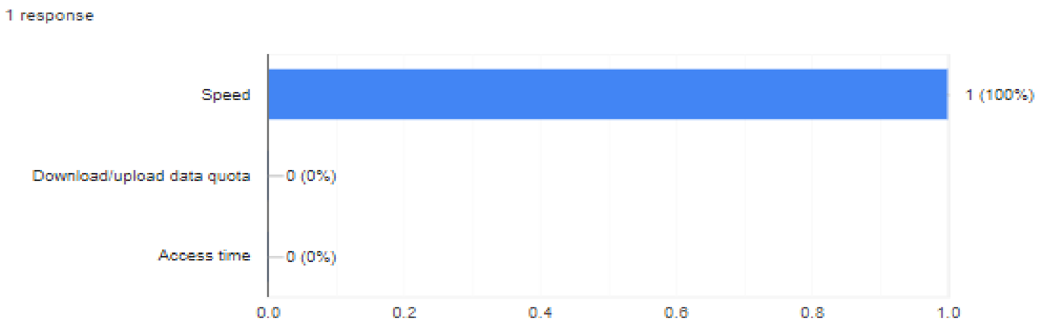

Figure 0-132 Austrian demo – Building Managers' restrictions in their internet connection

Question: How familiar were you with the concept of Plus Energy Buildings (PEBs) prior to this questionnaire?

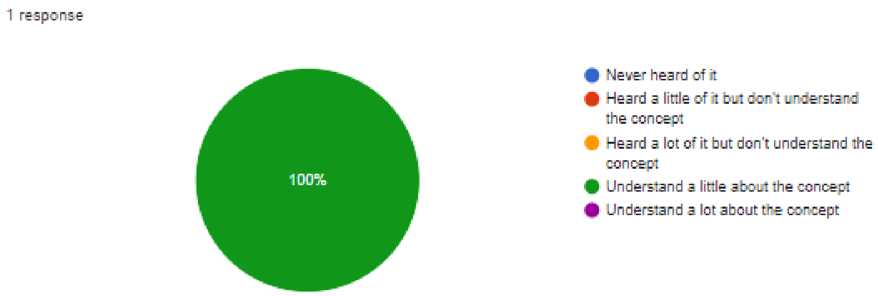

Figure 0-133 Austrian demo – Building Managers' familiarity with PEBs concept

Question: How important is it to save energy and use renewable energy sources in your building?

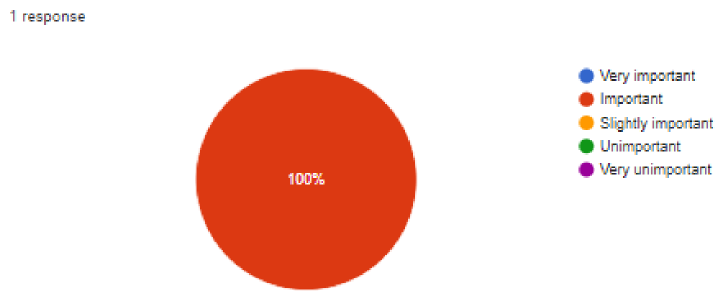

Figure 0-134 Austrian demo – Building Managers' opinion on the importance of saving energy and use of renewable energy sources in their building

Question: Would you be interested in reducing the energy demand and dependence of your building on grid energy, through the installation of novel smart-ready energy technologies?

Figure 0-135 Austrian demo – Building Managers' interest in reducing the energy demand and dependence of their building on grid energy, through the installation of novel smart-ready energy technologies

Question: Do you have any specific concerns regarding the installation of smart-ready energy technologies in your building?

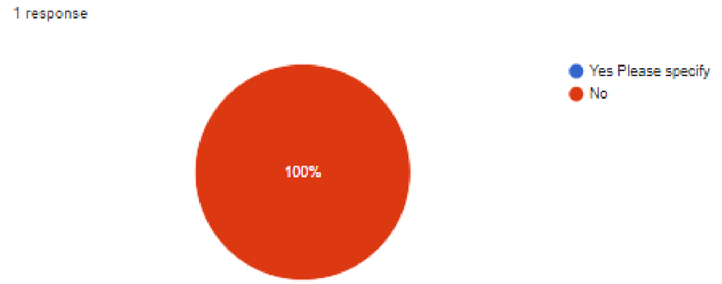

Figure 0-136 Austrian demo – Building Managers' concerns regarding the installation of smart-ready energy technologies in their building

Question: Are you interested in monitoring your building's energy consumption and flexibility through a visualization application (in your mobile, tablet, laptop)?

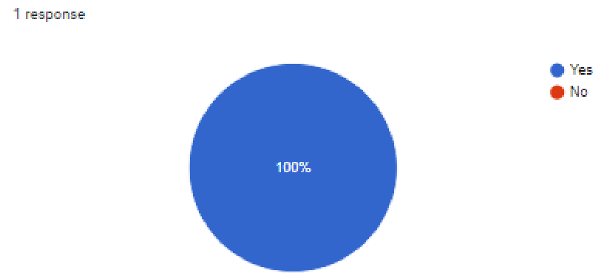

Figure 0-137 Austrian demo – Building Managers' interest in monitoring their building's energy consumption and flexibility through a visualization application

Question: How would you like to monitor your building's energy consumption and flexibility?

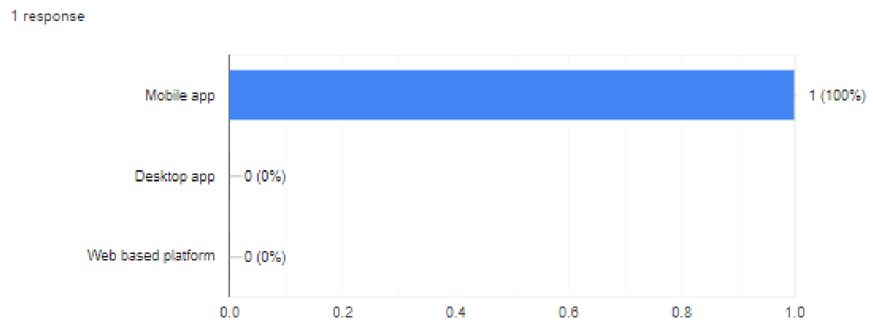

Figure 0-138 Austrian demo – Building Managers' preferred means for monitoring their building's energy consumption and flexibility

Question: Are you familiar with the concept of electricity self-consumption?

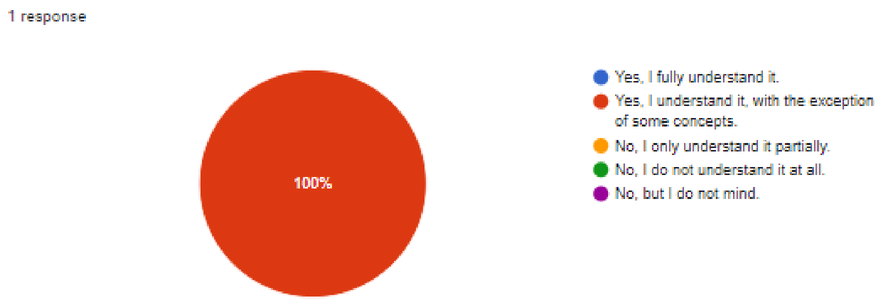

Figure 0-139 Austrian demo – Building Managers' familiarisation with the concept of electricity self-consumption

Question: Would you object to share your building's flexibility for optimizing the performance of your neighbourhood/ district and maximizing self-consumption?

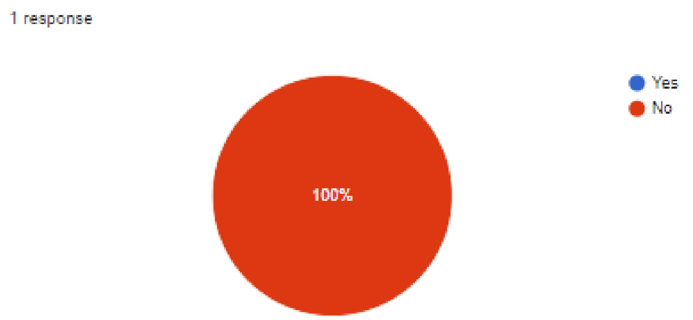

Figure 0-140 Austrian demo – Building Managers' interest in sharing their building's flexibility for optimizing the performance of their neighbourhood/ district and maximizing self-consumption

Question: Are you interested in monitoring your building's performance in terms of energy consumption and flexibility against the district/ community level performance?

Figure 0-141 Austrian demo – Building Managers' interest in monitoring their building's performance in terms of energy consumption and flexibility against the district/ community level performance

Question: How would you like to monitor your building's position against the district/community level energy consumption and flexibility?

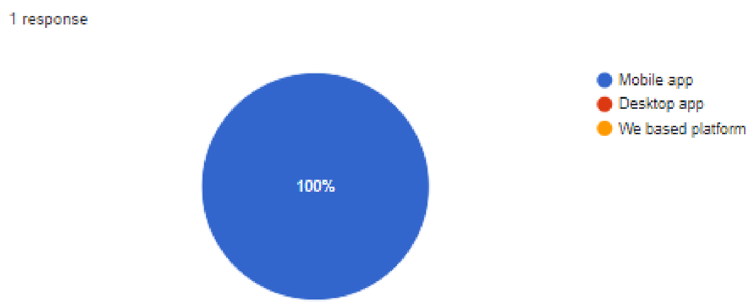

Figure 0-142 Austrian demo – Building Managers' preferred means for monitoring their building's position against the district/community level energy consumption and flexibility.

Question: Would you agree in sharing your building's flexibility and energy consumption (real-time data) with Aggregators towards participating in flexibility trading?

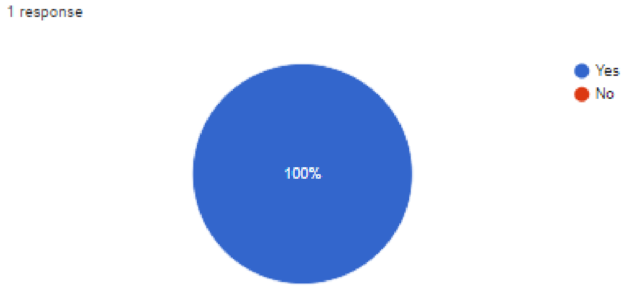

Figure 0-143 Austrian demo – Building Managers' agreement in sharing their building's flexibility and energy consumption with Aggregators towards participating in flexibility trading

Question: In order for you to participate in collective schemes for self-consumption maximization at community level, how important are the following aspects for you?

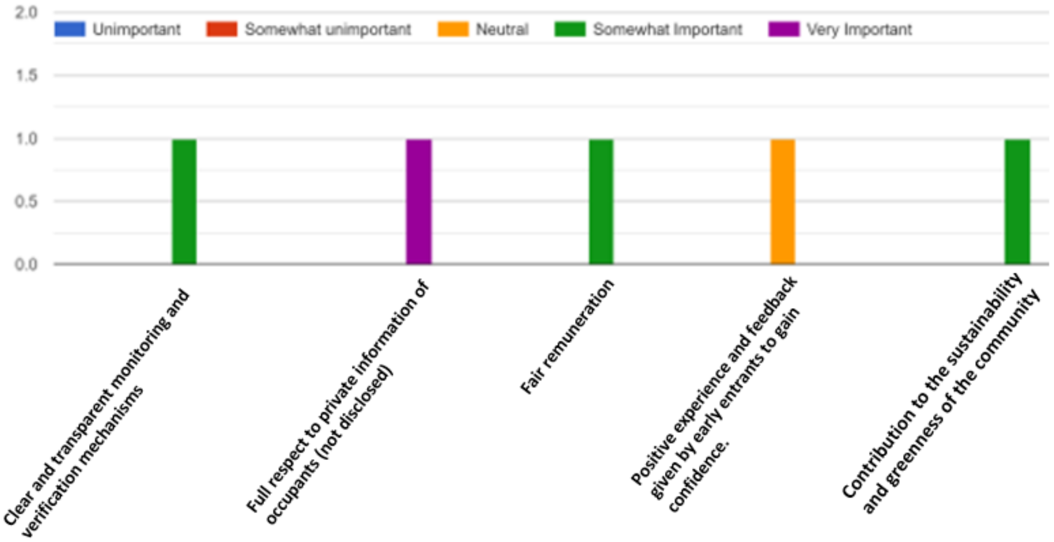

Figure 0-144 Austrian demo – Building Managers' opinion on aspects considered important for their participation in collective schemes for self-consumption maximization at community level

Question: Which of the following statements would make you feel more uneasy to participate in the local self-consumption schemes at community level?

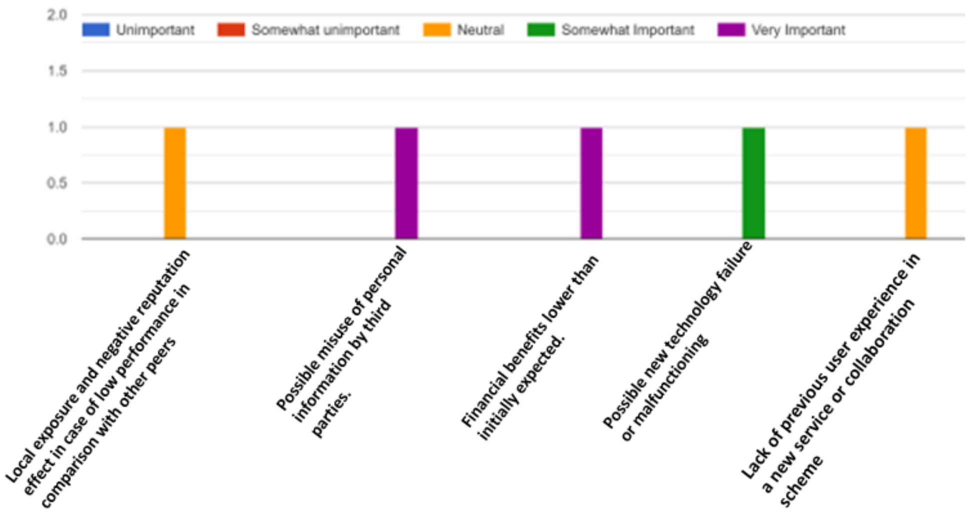

Figure 0-145 Austrian demo – Building Managers' opinion on aspects considered important for making them feel more uneasy to participate in the local self-consumption schemes at community level

Question: Would you be interested in trading your building's non-self-consumed energy in local flexibility and energy markets towards monetary gains?

Figure 0-146 Austrian demo – Building Managers' interest in trading their building's non-self-consumed energy in local flexibility and energy markets towards monetary gains

Question: How would you like to communicate with Aggregators regarding the exploitation/trading of your building's flexibility?

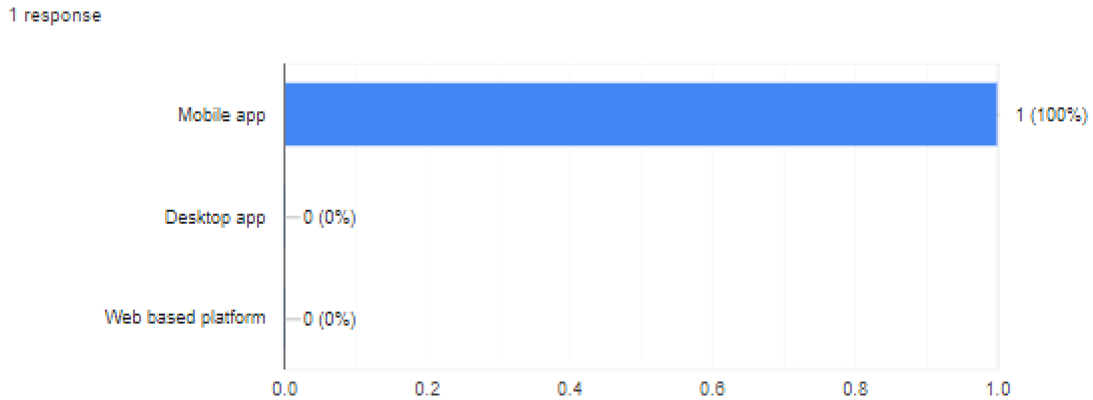

Figure 0-147 Austrian demo – Building Managers' preferred means for communicating with Aggregators regarding the exploitation/trading of their building's flexibility

Question: How often would you like to receive alerts/instructions regarding your building's unconsumed energy available for trading?

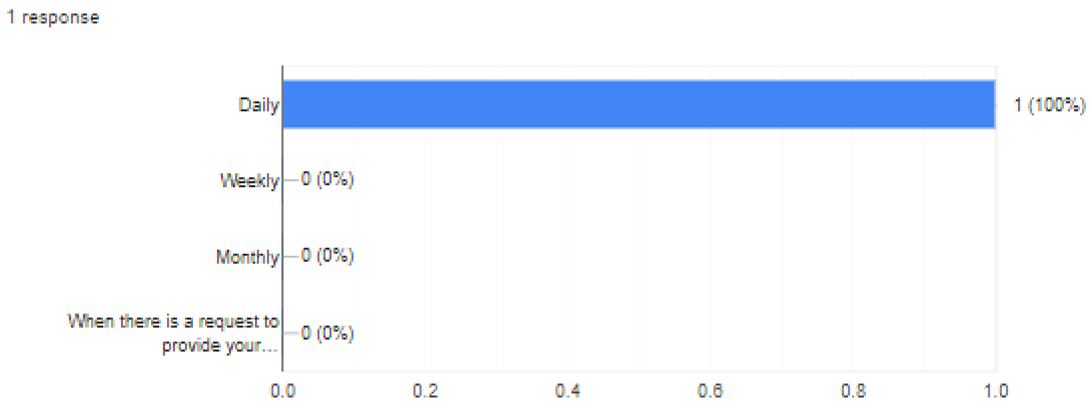

Figure 0-148 Austrian demo – Building Managers' preference on the intervals for receiving alerts/instructions regarding their building's unconsumed energy available for trading

Question: Would you be interested in monitoring the monetary gains generated from trading your building's flexibility?

Figure 0-149 Austrian demo – Building Managers' interest in monitoring the monetary gains generated from trading their building's flexibility

Question: Do you agree or disagree with the following statement? "Visualization of my building's consumption/energy savings against community level can inspire the building occupants towards reducing their energy consumption, leading also to financial profits and environmental benefits"

Figure 0-150 Austrian demo – Building Managers' agreement with the statement

Question: Would you object in allowing external stakeholders (i.e. aggregators) to control your devices remotely (based on specific agreements) at specific points in time to optimize your participation in energy/ flexibility trading?

Figure 0-151 Austrian demo – Building Managers' objection in allowing external stakeholders to control their devices remotely at specific points in time to optimize your participation in energy/ flexibility trading?

Question: In order for you to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following aspects for you?

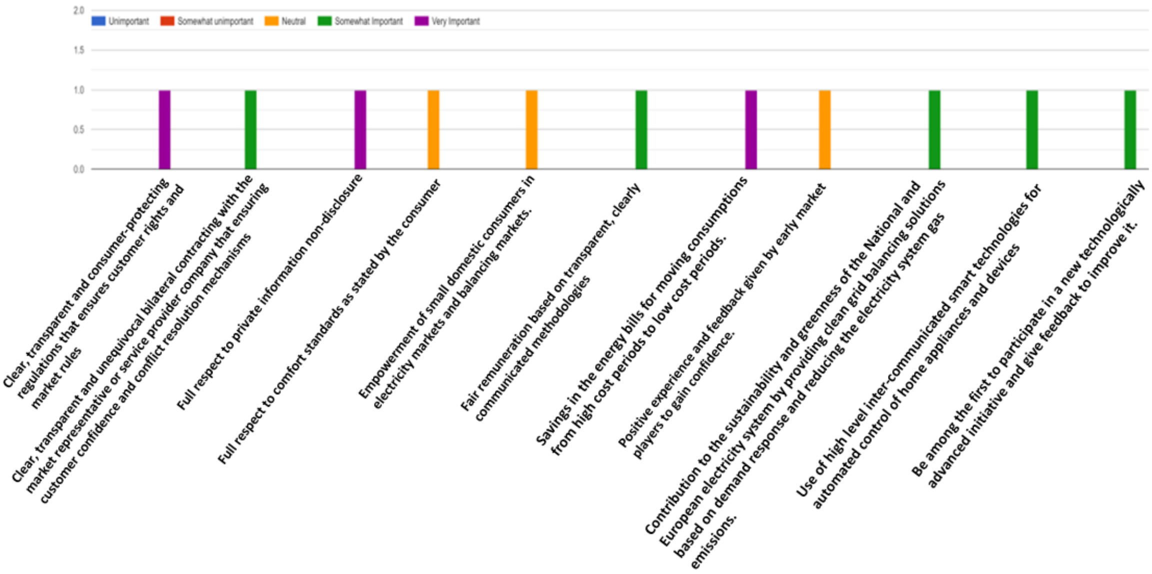

Figure 0-152 Austrian demo – Building Managers' rating of aspects important for them to participate in the demand flexibility remuneration programmes through a demand aggregator

Question: Which of the following aspects would make you feel more uneasy to participate in the demand flexibility markets described above?

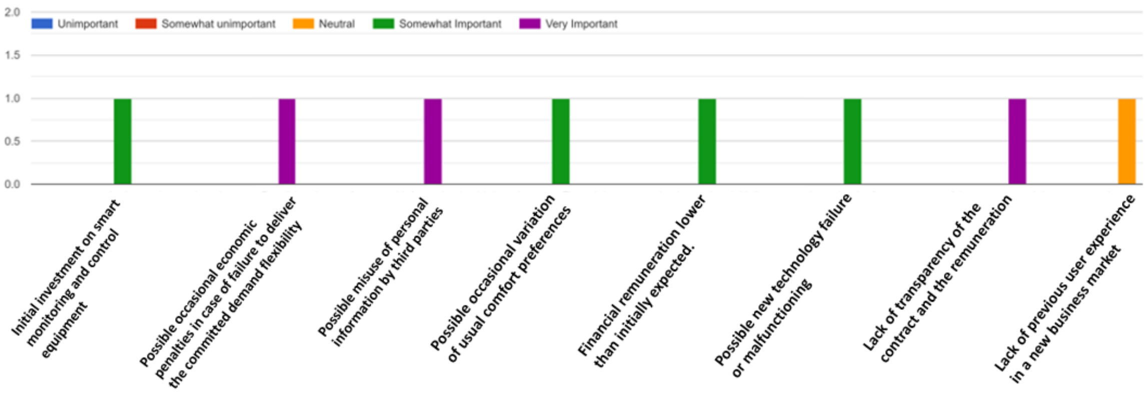

Figure 0-153 Austrian demo – Building Managers' rating of aspects important to make them feel more uneasy to participate in the demand flexibility markets

Architects

Question: What kind of buildings do you usually design?

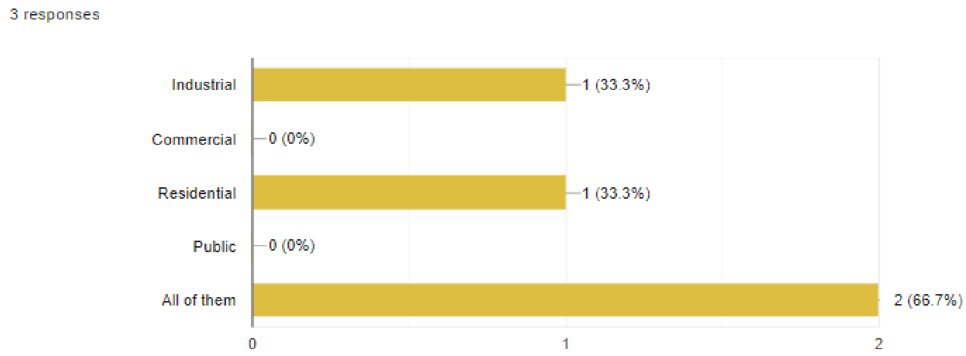

Figure 0-154 Austrian demo – Architects' usual buildings

Question: What type of clients do you usually work with?

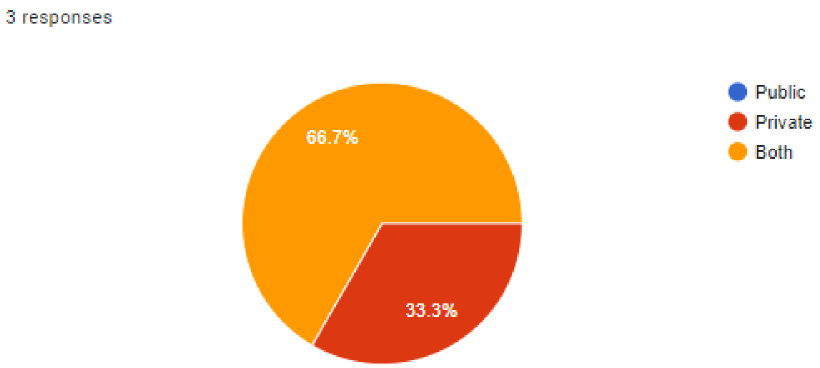

Figure 0-155 Austrian demo – Architects' usual clients

Question: What kind of internet connectivity do you have in your office?

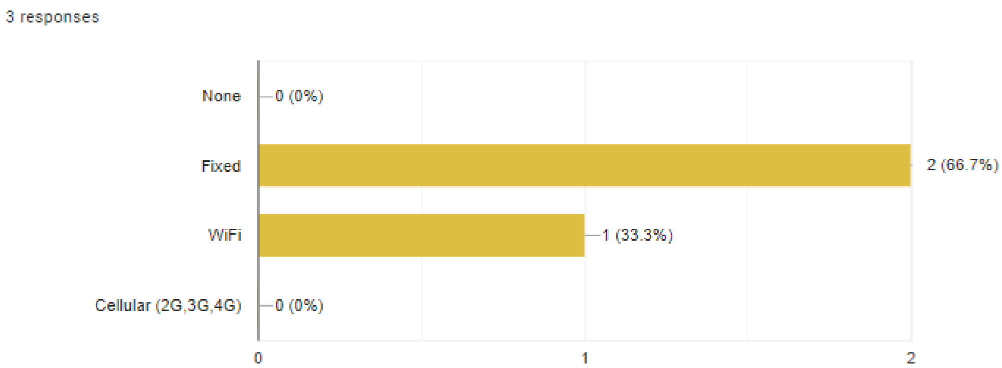

Figure 0-156 Austrian demo – Architects' available internet connectivity at their offices

Question: Which devices do you use for work?

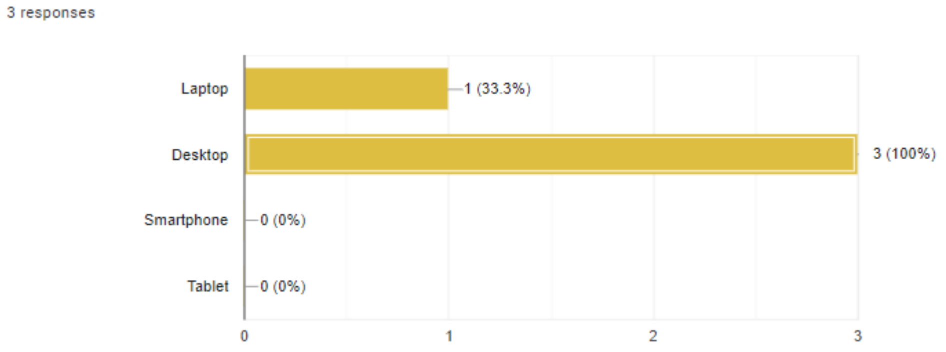

Figure 0-157 Austrian demo – Architects' preferred devices for work

Question: What operating systems do these devices use?

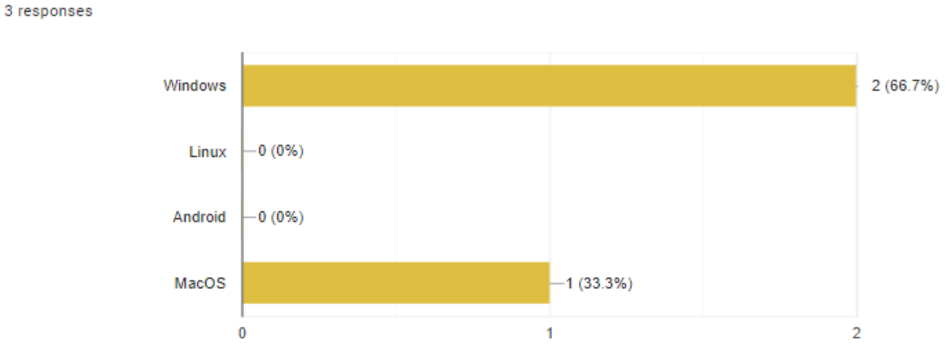

Figure 0-158 Austrian demo – Architects' preferred operating systems

Question: Which applications and information systems do you typically use in your everyday job?

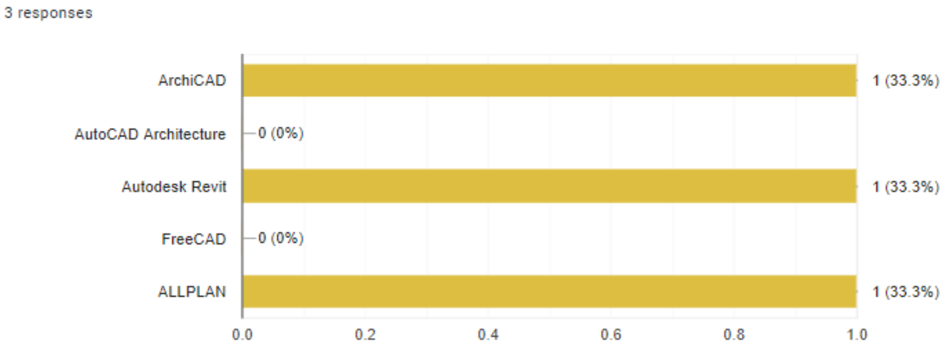

Figure 0-159 Austrian demo – Architects' typical application and information systems used in their job

Question: What export functionality do they support?

3 responses

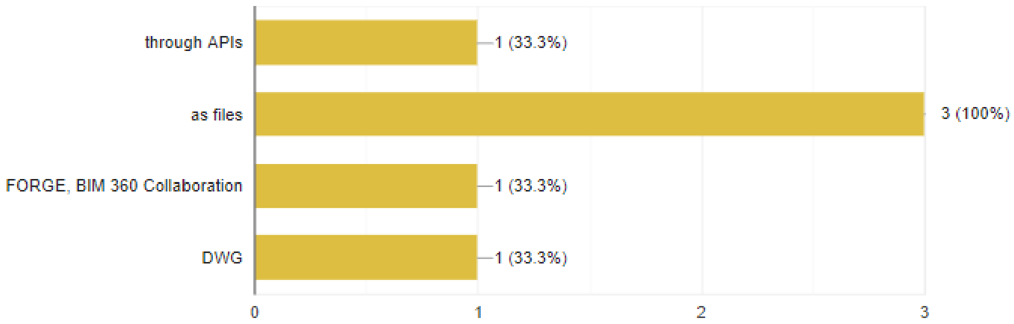

Figure 0-160 Austrian demo – Architects' information systems export functionality

Question: What data formats are supported for exporting data from these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

3 responses

.IFC .IFCXML .IFCZIP .BCF .NWC .SMC .C4D .3DM .3DS .ATL .KML .KMZ .SKP .DAE .EPX .FACT .OBJ .STL .U3D .FBX .TMA .WRL .BIMX

IFC, DWG, DXF, DWF, gbXML,

DWG,IFC,STL

Figure 0-161 Austrian demo – Architects applications' supported data formats

Question: Which tools/systems do you use for handling Building Information Modelling (BIM) models?

3 responses

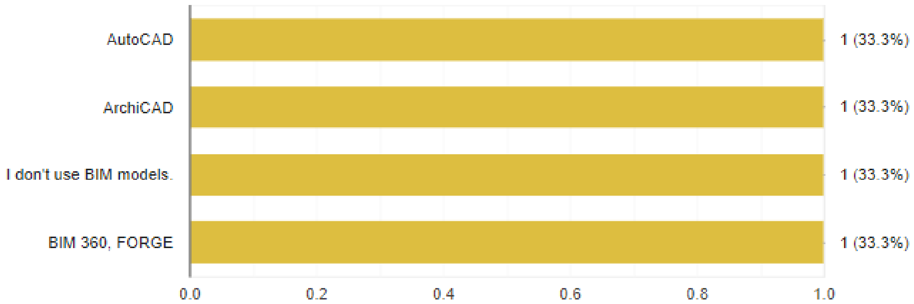

Figure 0-162 Austrian demo – Architects preferred tools/systems for handling BIM models

Question: Which formats do you export to your BIM models, when using these systems? (e.g. IFC, gbXML, etc.)

2 responses

IFC .IFCXML .BIMX

IFC, DWG, DXF, DWF, gbXML

Figure 0-163 Austrian demo – Architects' preferred format for exporting their BIM models

Question: What type of data do you need from other stakeholders in order to properly complete your work?

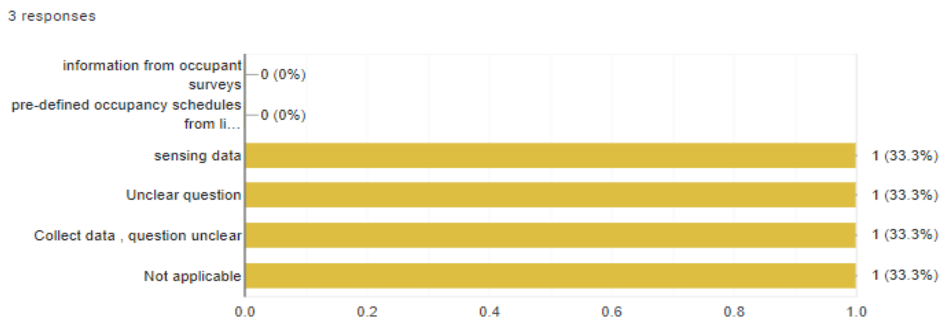

Figure 0-164 Austrian demo – Architects' required data from other stakeholders towards properly completing their work

Question: How do you currently find data you need, but you do not have electronically in your information systems?

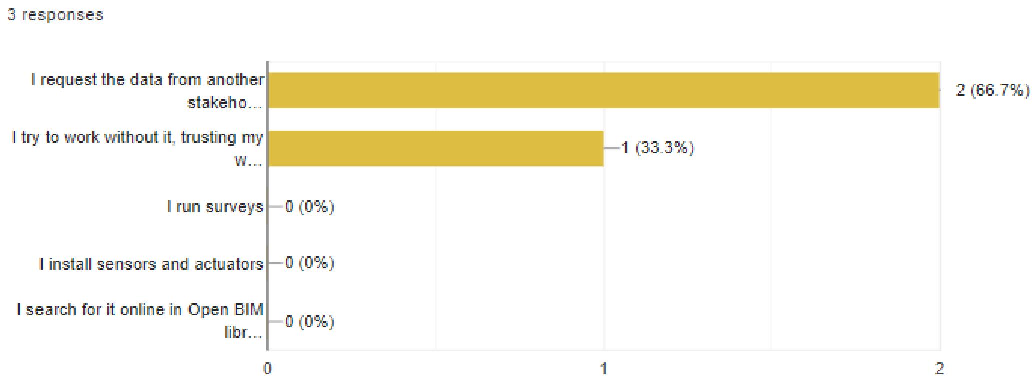

Figure 0-165 Austrian demo – Architects' ways of finding required data that are not electronically in their information systems

Question: What are the security and privacy requirements you have for the building data/ information you manage?

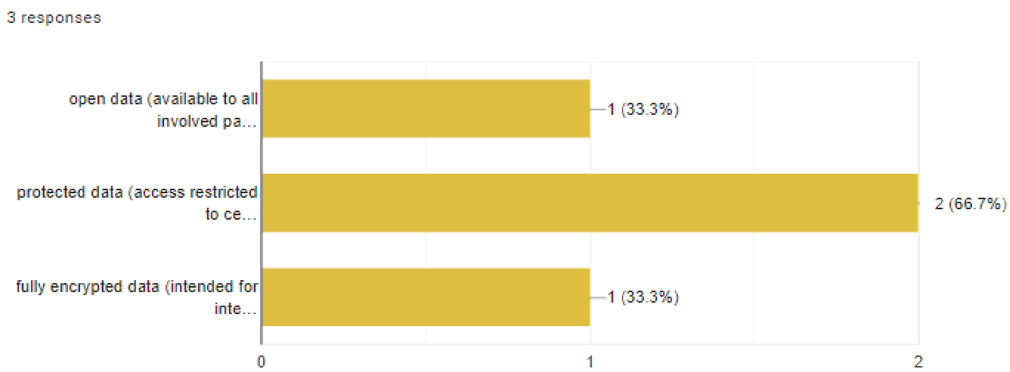

Figure 0-166 Austrian demo – Architects' security and privacy requirements for their building data/information they manage

Question: Which tools are you using to model energy performance?

3 responses

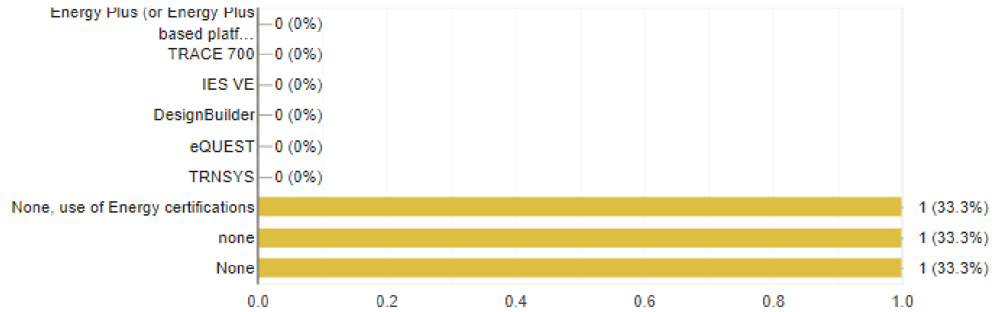

Figure 0-167 Austrian demo – Architects' used tools to model energy performance

Question: What import functionality do they support?

3 responses

Figure 0-168 Austrian demo – Architects energy performance modelling tools' import functionality

Question: What data formats are supported for importing data to these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

3 responses

.IFC .IFCXML .IFCZIP .BCF .NWC .SMC .C4D .3DM .3DS .ATL .KML .KMZ .SKP .DAE .EPX .FACT .OBJ .STL .U3D .FBX .TMA .WRL .BIMX

IFC

DWG, IFC, STC

Figure 0-169 Austrian demo – Architects energy performance modelling tools data formats for import

Question: What data do you see as of high interest during the energy performance modelling?

3 responses

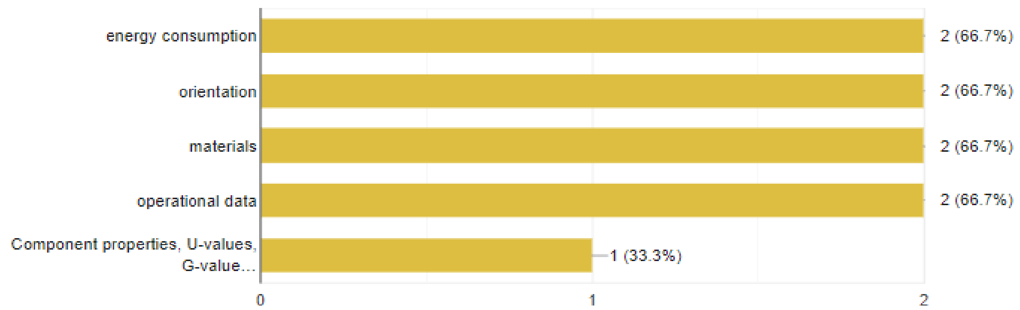

Figure 0-170 Austrian demo – Architects' preferred high interest data for energy performance modelling

Question: If you take into account operational energy data during the design phase, what data do you consider?

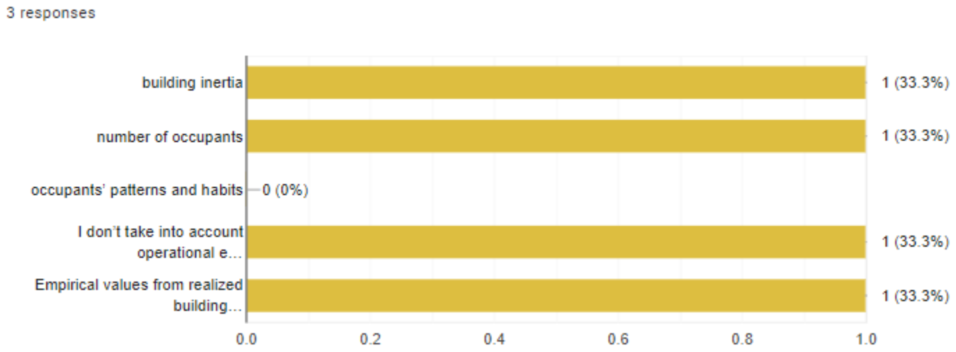

Figure 0-171 Austrian demo – Architects considered data in operational energy modelling

Question: If you consider the occupants' comfort in your calculations, how do you quantify (or measure) occupants' comfort?

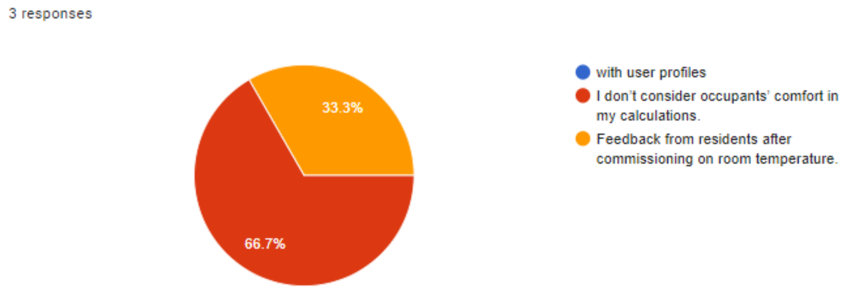

Figure 0-172 Austrian demo – Architects' quantification of occupants' comfort

Question: Do you consider the use of smart Internet of Things solutions to monitor indoor comfort and energy consumption?

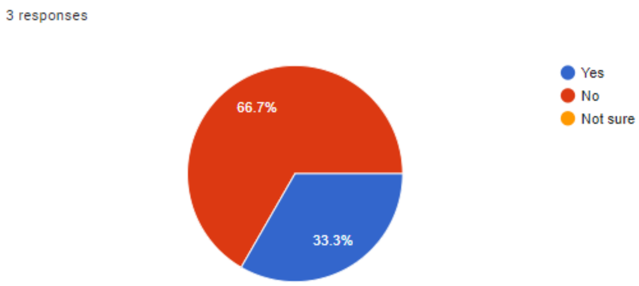

Figure 0-173 Austrian demo – Architects' views on considering use of Smart IoT solution for monitoring indoor comfort and energy consumption

Question: Do you think that this would be beneficial for your work? (e.g. more accurate prediction of energy performance based on realistic occupancy schedules).

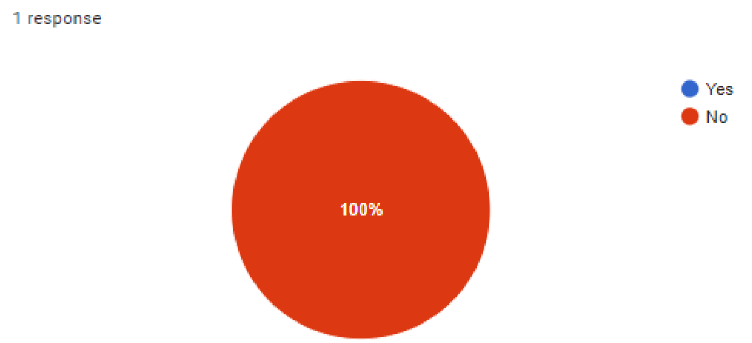

Figure 0-174 Austrian demo – Architects' view on using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: In the tools that you use for energy performance modelling and simulation, are you knowledgeable of the building control routines they apply?

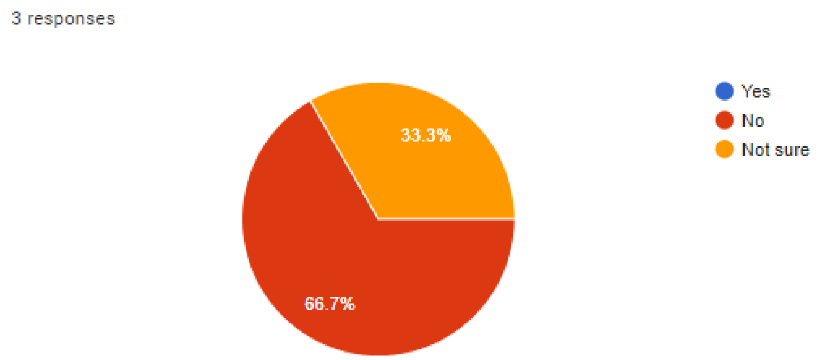

Figure 0-175 Austrian demo – Architects' knowledge of applied building control routines

Question: Would you be open to adopt more advanced building systems control routines in your tools as a means to increase performance prediction accuracy?

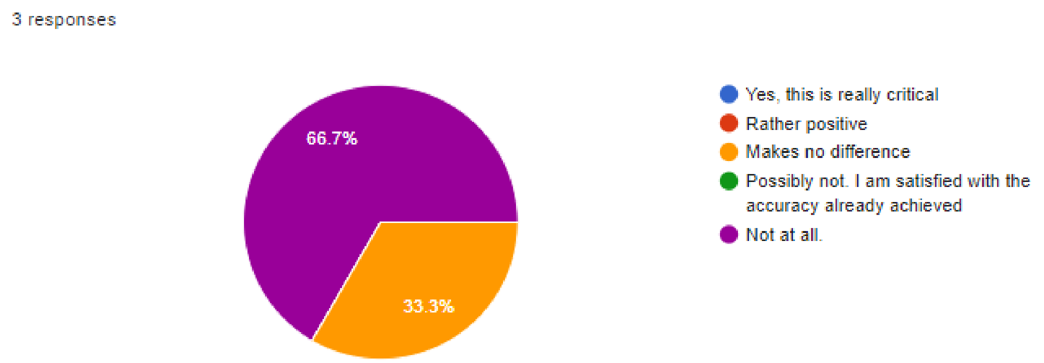

Figure 0-176 Austrian demo – Architects' willingness to adopt more advanced building systems control routines in their tools as a means to increase performance prediction accuracy

Finnish Demo site

Architects

Question: What kind of buildings do you usually design?

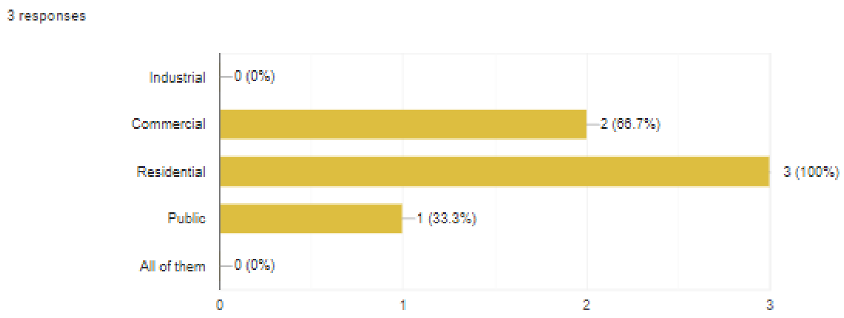

Figure 0-177 Finnish demo – Architects' usual buildings

Question: What type of clients do you usually work with?

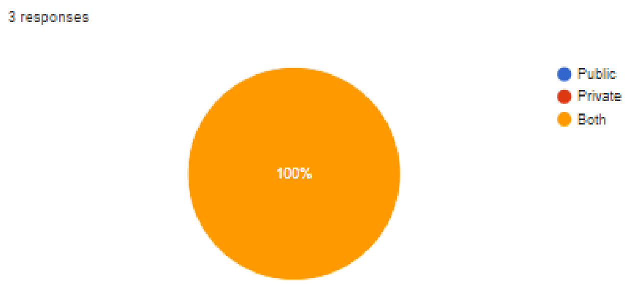

Figure 0-178 Finnish demo – Architects' usual clients

Question: What kind of internet connectivity do you have in your office?

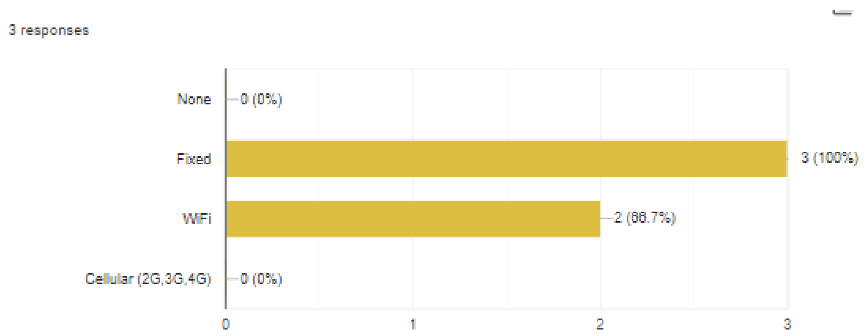

Figure 0-179 Finnish demo – Architects' available internet connectivity at their offices

Question: Which devices do you use for work?

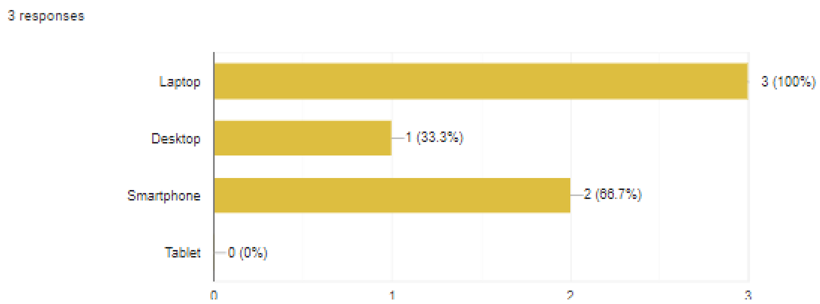

Figure 0-180 Finnish demo – Architects' preferred devices for work

Question: What operating systems do these devices use?

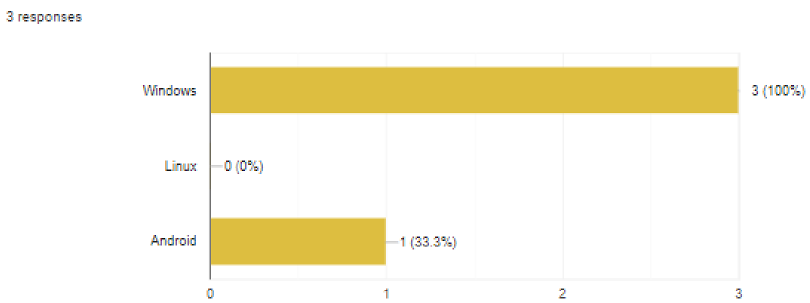

Figure 0-181 Finnish demo – Architects' preferred operating systems

Question: Which applications and information systems do you typically use in your everyday job?

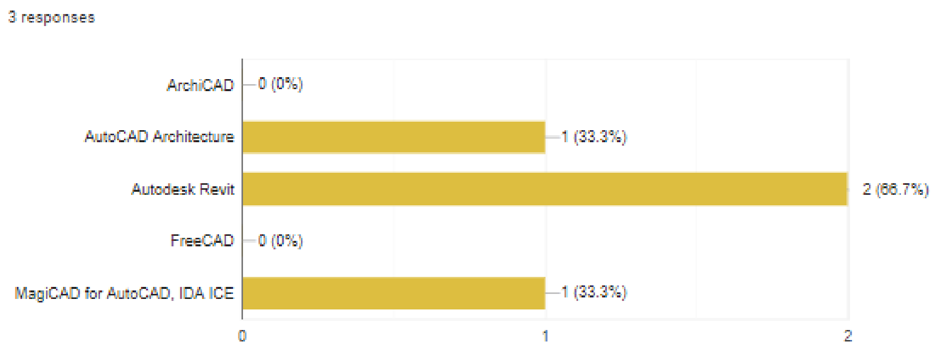

Figure 0-182 Finnish demo – Architects' typical application and information systems used in their job

Question: What export functionality do they support?

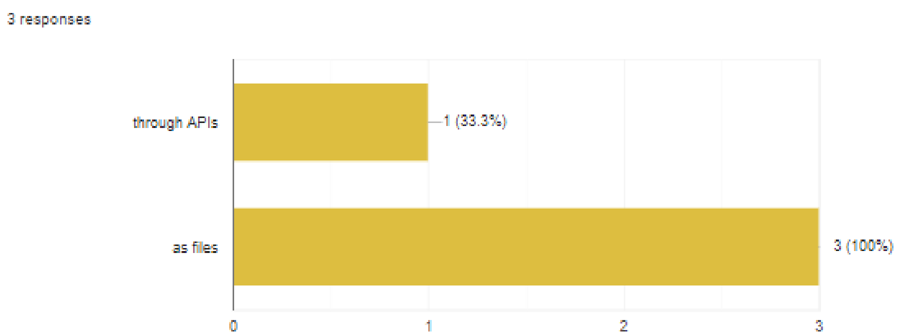

Figure 0-183 Finnish demo – Architects' information systems export functionality

Question: What data formats are supported for exporting data from these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

2 responses

IFC, DWG, FBX

IFC, DWG

Figure 0-184 Finnish demo – Architects applications' supported data formats

Question: Which tools/systems do you use for handling Building Information Modelling (BIM) models?

3 responses

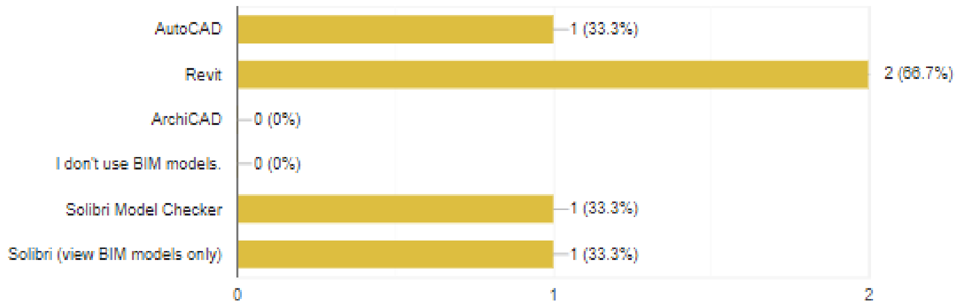

Figure 0-185 Finnish demo – Architects preferred tools/systems for handling BIM models

Question: Which formats do you export to your BIM models, when using these systems? (e.g. IFC, gbXML, etc.)

2 responses

IFC

IFC models.

Figure 0-186 Finnish demo – Architects' preferred format for exporting their BIM models

Question: What type of data do you need from other stakeholders in order to properly complete your work?

2 responses

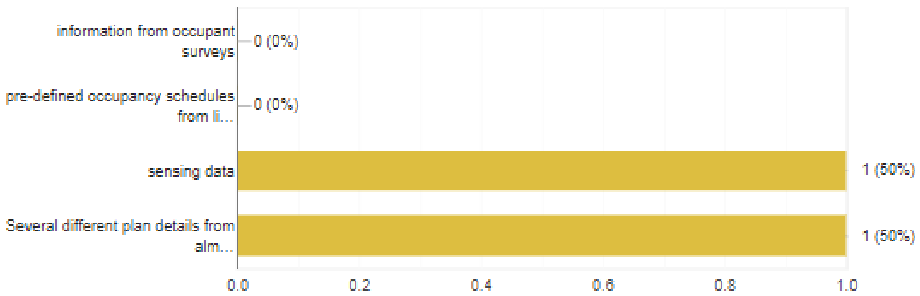

Figure 0-187 Finnish demo – Architects' required data from other stakeholders towards properly completing their work

Question: How do you currently find data you need, but you do not have electronically in your information systems?

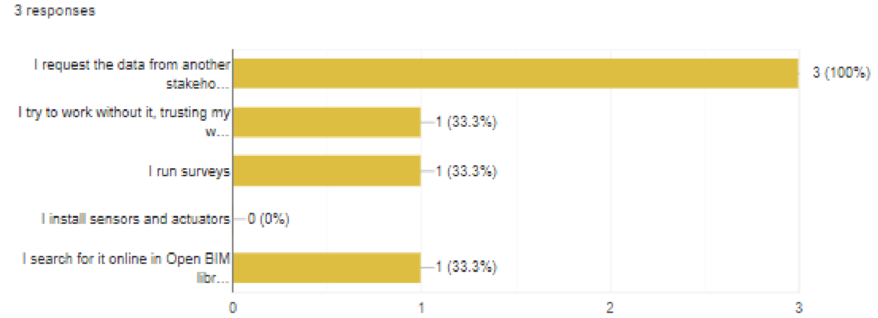

Figure 0-188 Finnish demo – Architects' ways of finding required data that are not electronically in their information systems

Question: What are the security and privacy requirements you have for the building data / information you manage?

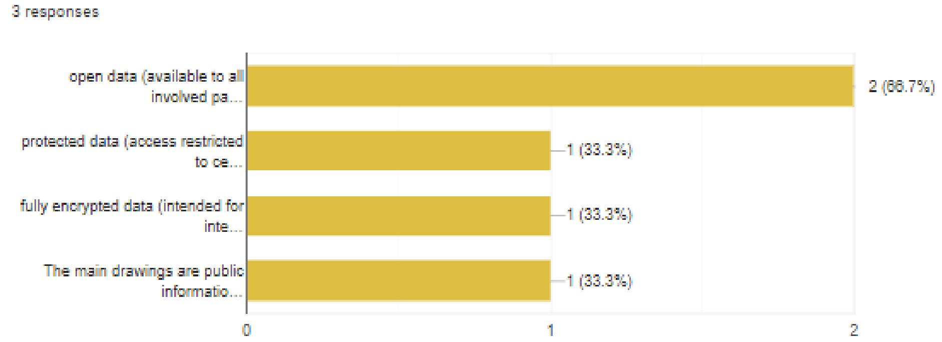

Figure 0-189 Finnish demo – Architects' security and privacy requirements for their building data/information they manage

Question: Which tools are you using to model energy performance?

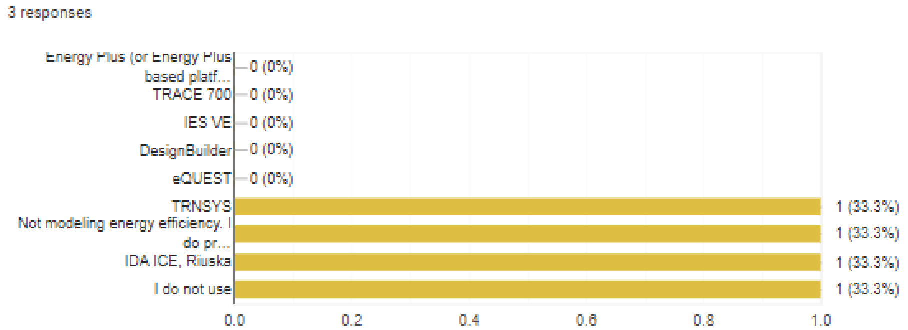

Figure 0-190 Finnish demo – Architects' used tools to model energy performance

Question: What import functionality do they support?

Figure 0-191 Finnish demo – Architects energy performance modelling tools' import functionality

Question: What data formats are supported for importing data to these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

2 responses

most common formats

IFC, DWG, 3DS

Figure 0-192 Finnish demo – Architects energy performance modelling tools data formats for import

Question: What data do you see as of high interest during the energy performance modelling?

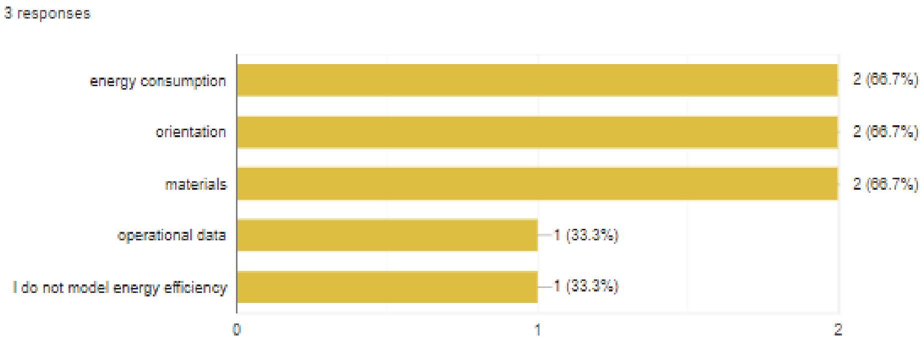

Figure 0-193 Finnish demo – Architects' preferred high interest data for energy performance modelling

Question: If you take into account operational energy data during the design phase, what data do you consider?

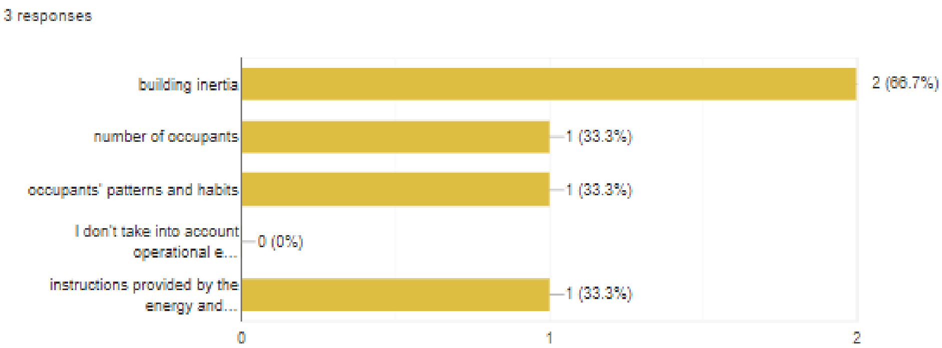

Figure 0-194 Finnish demo – Architects considered data in operational energy modelling

Question: If you consider the occupants' comfort in your calculations, how do you quantify (or measure) occupants' comfort?

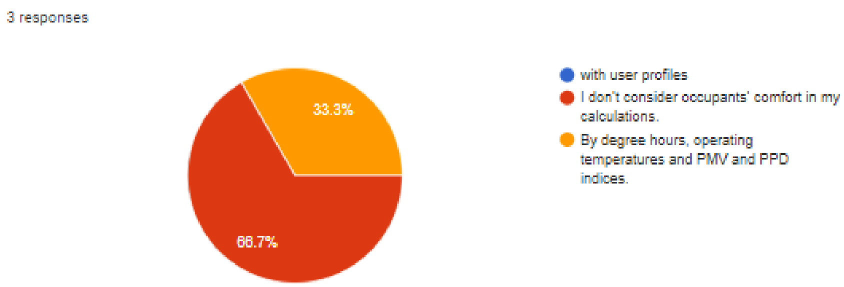

Figure 0-195 Finnish demo – Architects' quantification of occupants' comfort

Question: Do you consider the use of smart Internet of Things solutions to monitor indoor comfort and energy consumption?

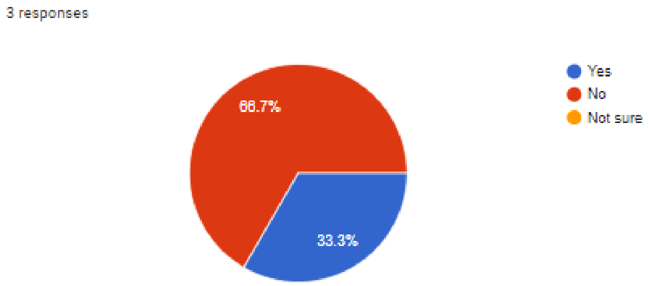

Figure 0-196 Finnish demo – Architects' views on considering use of Smart IoT solution for monitoring indoor comfort and energy consumption

Question: Do you think that this would be beneficial for your work? (e.g. more accurate prediction of energy performance based on realistic occupancy schedules).

Figure 0-197 Finnish demo – Architects' view on using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: If answered "Yes" in the previous question, please specify why:

1 response

IDA ICE or Riuska energy simulation tools do not include energy monitoring or control methods

Figure 0-198 Finnish demo – Architects' reasons for using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: In the tools that you use for energy performance modelling and simulation, are you knowledgeable of the building control routines they apply?

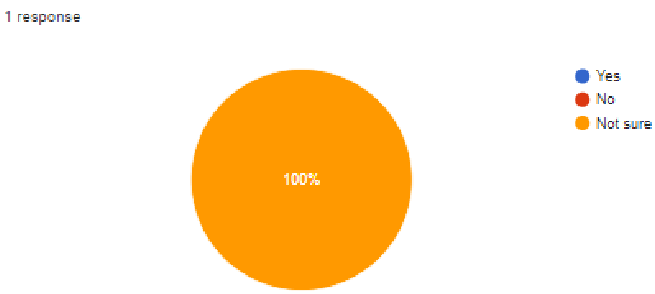

Figure 0-199 Finnish demo – Architects' knowledge of applied building control routines

Question: If you are knowledgeable of the control routines they apply, are you satisfied with the accuracy they achieve?

0 responses

No responses yet for this question.

Figure 0-200 Finnish demo – Architects' satisfaction with the accuracy of building control routines used in energy performance modelling

Question: Would you be open to adopt more advanced building systems control routines in your tools as a means to increase performance prediction accuracy?

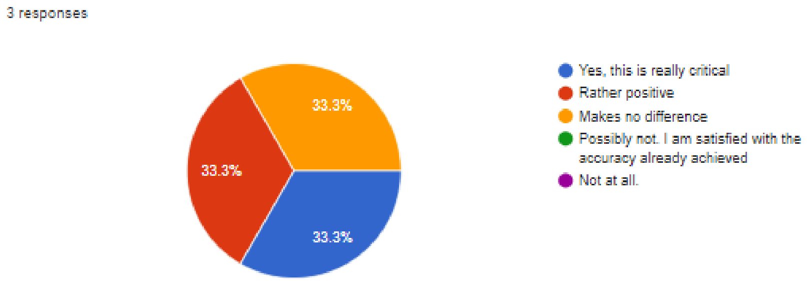

Figure 0-201 Finnish demo – Architects' willingness to adopt more advanced building systems control routines in their tools as a means to increase performance prediction accuracy

Belgian Demo site

Building Occupants

Note: Answers are provided by CORDIUM (social services), responsible for the Belgian demo site.

Question: Please indicate your gender?

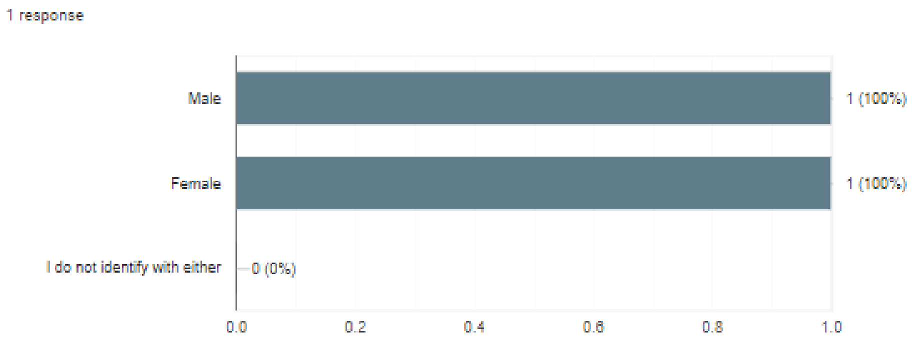

Figure 0-202 Belgian demo – Gender indication

Question: Please indicate your age group?

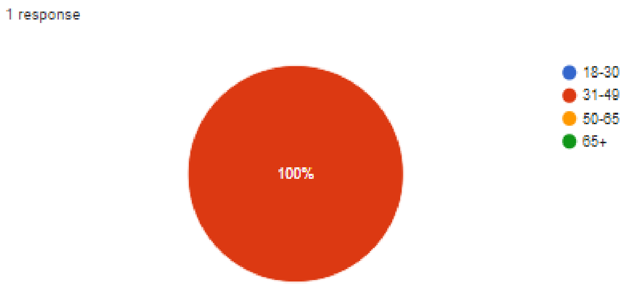

Figure 0-203 Belgian demo – Occupants age group

Question: Please indicate your household composition ?

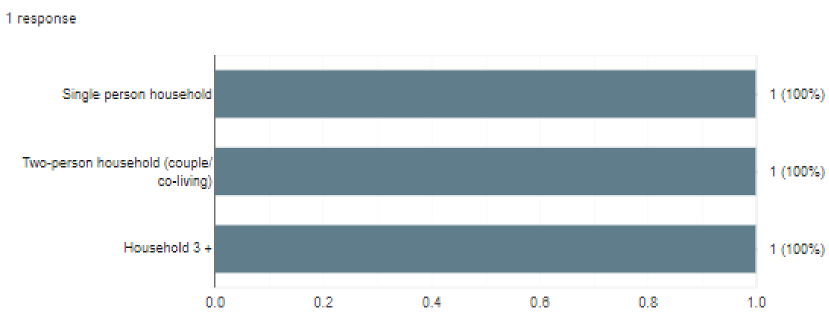

Figure 0-204 Belgian demo – Occupants' household composition

Question: What is your relationship to apartment?

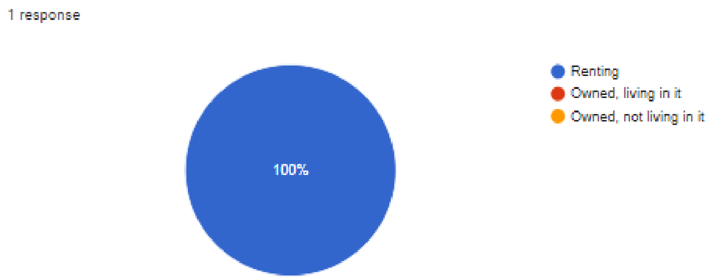

Figure 0-205 Belgian demo – Occupants' relationship to apartment

Question: What kind of wireless technology devices do you normally use?

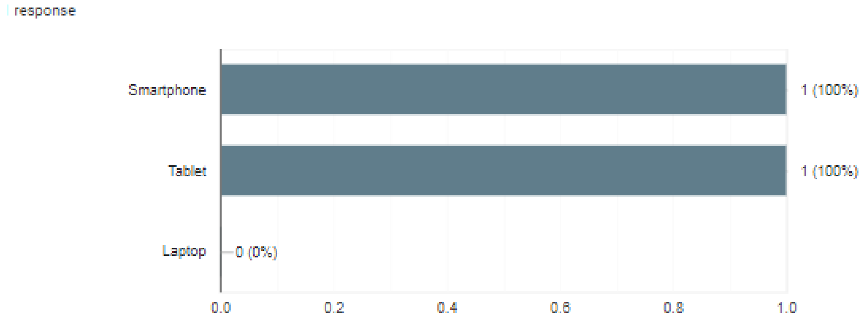

Figure 0-206 Belgian demo – Occupants' usage of wireless technology devices

Question: What kind of internet connectivity is there at your home?

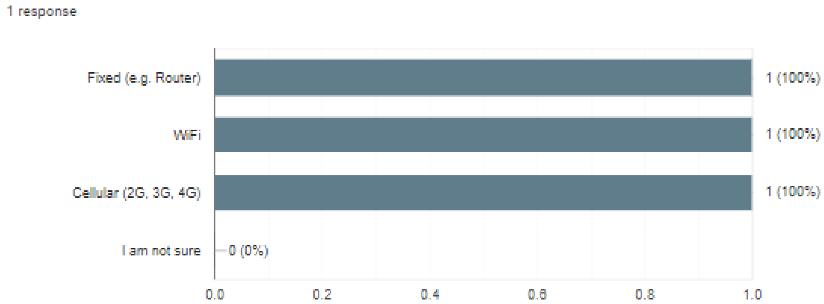

Figure 0-207 Belgian demo – Occupants' available internet connectivity

Question: Are there any restrictions in your internet connection regarding?

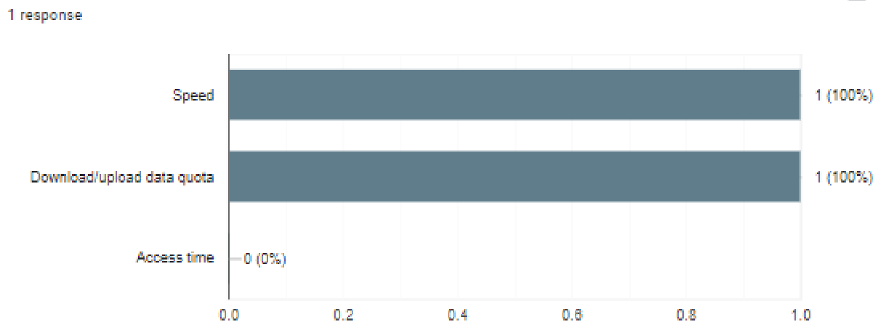

Figure 0-208 Belgian demo –Occupants' Internet connection restrictions

Question: How familiar were you with the concept of Plus Energy Buildings (PEBs) prior to this questionnaire?

0 responses

No responses yet for this question.

Figure 0-209 Belgian demo – Occupants' familiarization with PEBs concept

Question: How important is it to save energy and use renewable energy sources in your house/building?

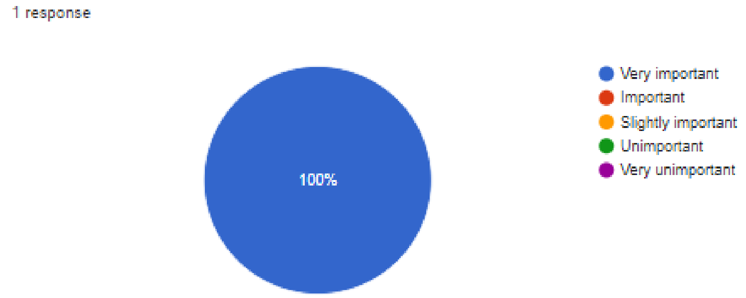

Figure 0-210 Belgian demo – Occupants' opinion on energy savings and renewable energy sources usage

Question: Would you be willing to apply advance control systems for optimizing energy performance?

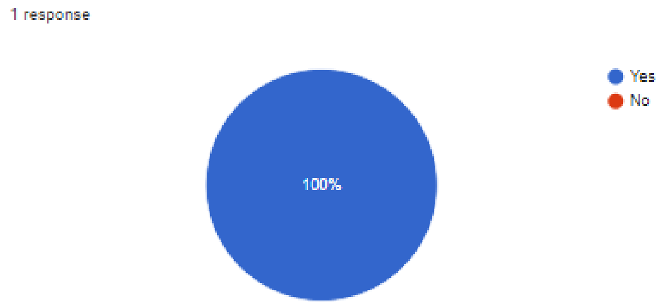

Figure 0-211 Belgian demo – Occupants willingness to apply advance control systems for energy performance optimisation

Question: What type of system would you be willing to accept?

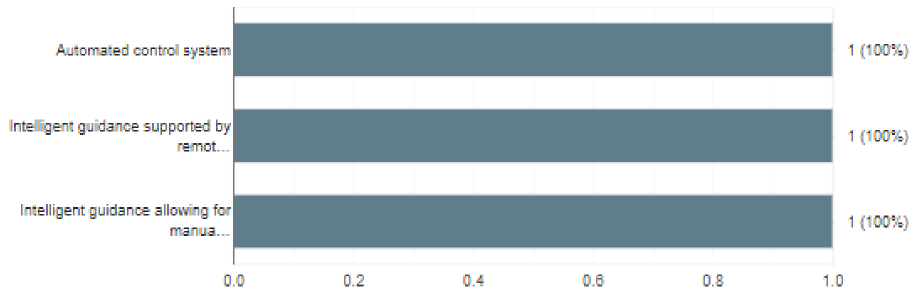

Figure 0-212 Belgian demo – Occupants' preference of advance control systems

Question: What types of devices and assets would you introduce into an advance control framework for self-consumption?

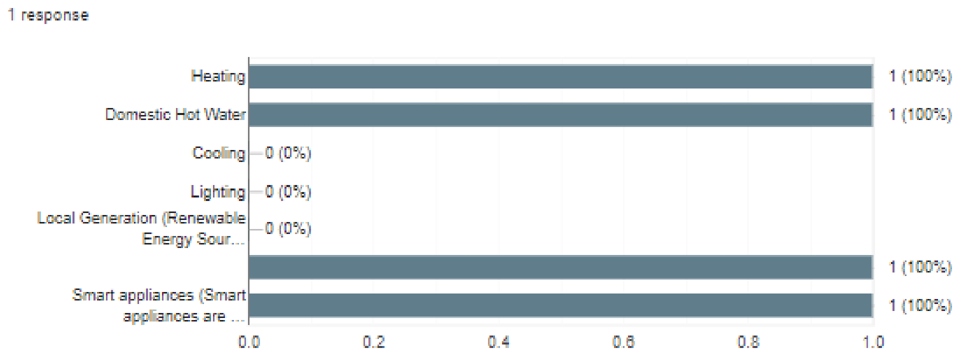

Figure 0-213 Belgian demo – Occupants' preference on devices types and assets for advance control self-consumption

Question: Would you be interested in reducing your energy demand and dependence on grid energy, through the installation of novel smart-ready energy technologies?

Figure 0-214 Belgian demo – Occupants' interest in reducing their energy demand and dependence on grid energy, through the installation of novel smart-ready energy technologies?

Question: Do you have any specific concerns regarding the installation of smart-ready energy technologies in your house/building?

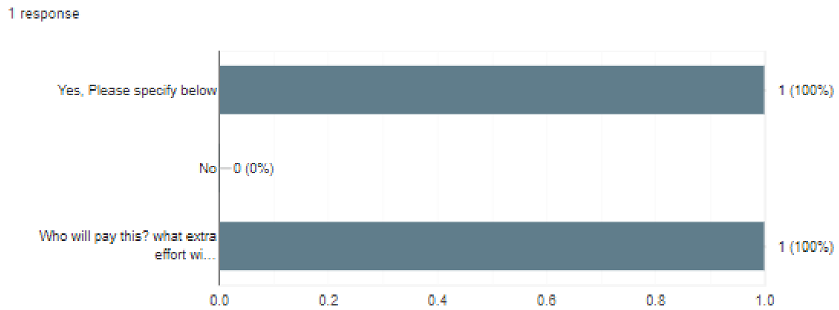

Figure 0-215 Belgian demo – Occupant's concerns on the installation of technologies in their houses/buildings

Question: You decide to improve your house by installing sensors in order to improve the indoor conditions, but you cannot decide what is the best for you and your family. How much are you willing to pay for sensors to be installed inside your house to measure your living preferences (room temperature, light levels, etc.) and finally help you decide on what changes best address your needs?

Figure 0-216 Belgian demo – Occupants' willingness to pay for sensors to be installed in their premises

Question: Have you ever been involved in a project that assesses your living comfort and/or indoor air quality?

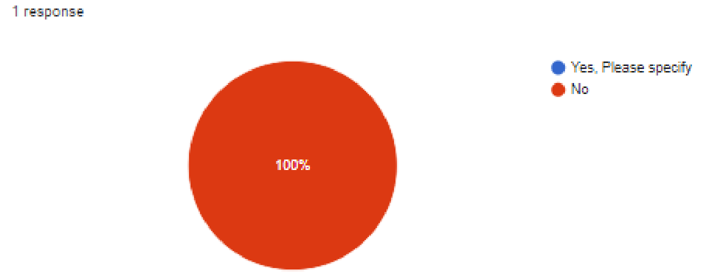

Figure 0-217 Belgian demo – Occupants' involvement in a project assessing living comfort/IAQ

Question: Do you see a value in having a building tailored to your needs in terms of comfort preferences?

Figure 0-218 Belgian demo – Occupants' indication of seeing value having a building tailored to their needs

Question: Would you object to the installation of low powered Internet of Things devices (such as sensors and actuators) for a period of time to determine your energy consumption, flexibility and comfort preferences, if privacy were respected?

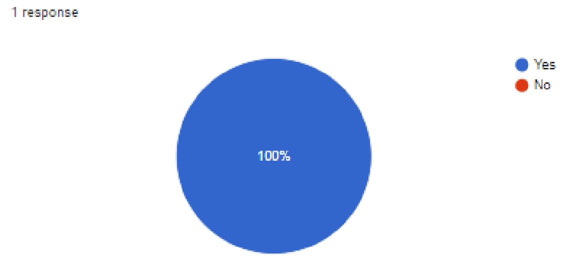

Figure 0-219 Belgian demo – Occupants' objection on the installation of low powered Internet of Things devices (such as sensors and actuators) for a period of time to determine their energy consumption

Question: Would you agree to have data sensors installed at your property for more than a year?

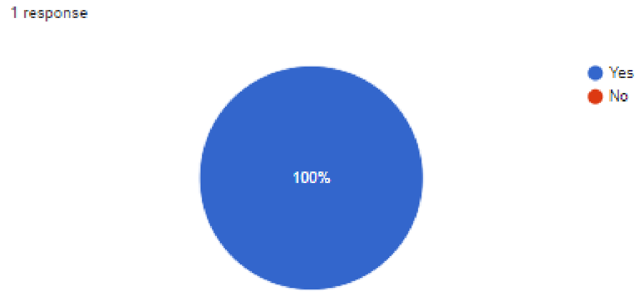

Figure 0-220 Belgian demo – Occupants' agreement with installation of data sensors in their property from more than a year

Question: What is the longest period you are willing to have such monitoring devices installed in your apartment?

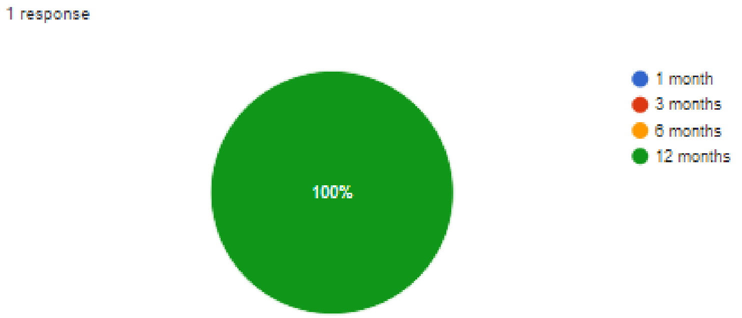

Figure 0-221 Belgian demo – Occupants' willingness to have monitoring devices installed on their apartments.

Question: Please indicated how important the following aspects are regarding your living comfort.

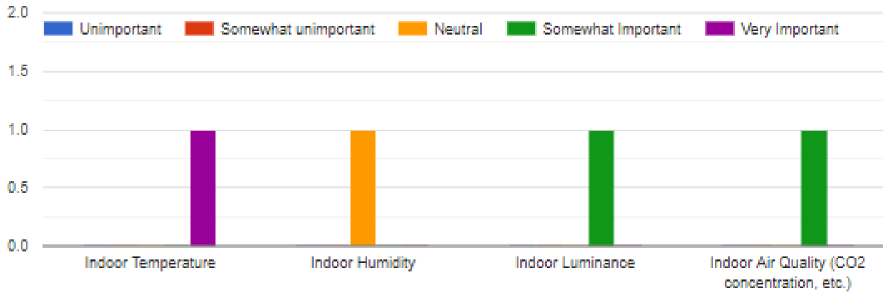

Figure 0-222 Belgian demo – Occupants' indication of aspects important for their living comfort

Question: Are you interested in monitoring your energy consumption and flexibility through visualization applications, i.e. through mobile phones, tablets, laptops?

Figure 0-223 Belgian demo – Occupants' interest in monitoring their energy consumption and flexibility through visualization applications

Question: How would you like to monitor your energy consumption and flexibility?

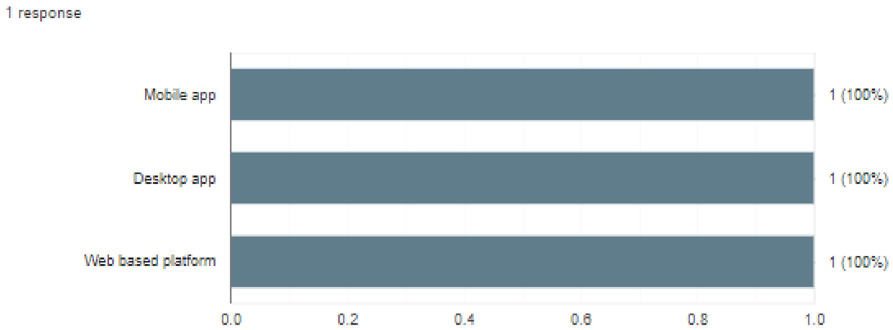

Figure 0-224 Belgian demo – Occupants' preferred devices for monitoring their energy consumption and flexibility

Question: Are you familiar with the concept of electricity self-consumption?

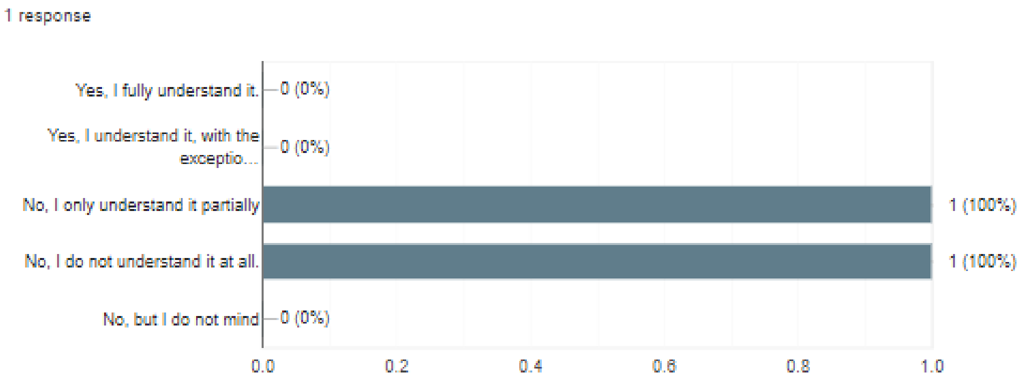

Figure 0-225 Belgian demo – Occupants' familiarity with the concept of electricity self-consumption

Question: Are you interested in monitoring your individual performance in terms of energy consumption and flexibility in comparison with the district/ community level performance (privacy of personal information will be respected)?

Figure 0-226 Belgian demo – Occupants' interest in monitoring their individual energy performance

Question: Do you agree or disagree with the following statement? "Visualization of my own consumption/energy savings against community level can inspire me towards reducing my energy consumption, leading also to financial profits and environmental benefits"

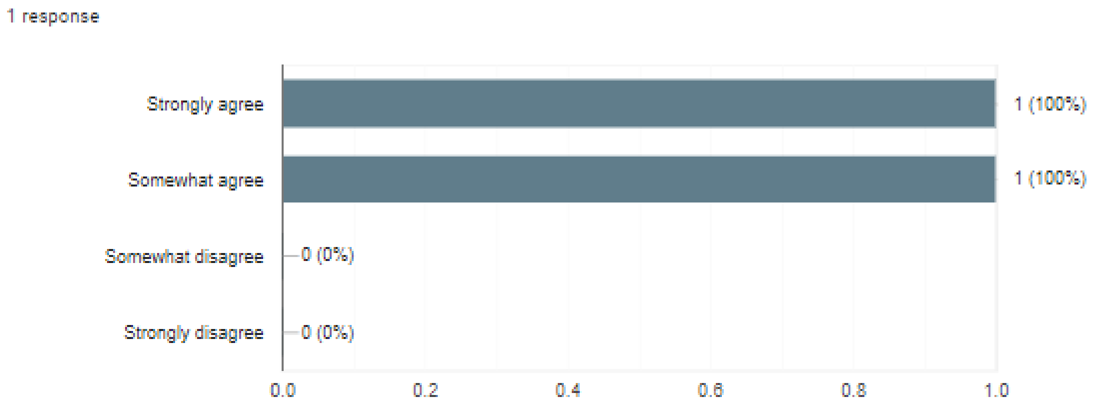

Figure 0-227 Belgian demo – Occupants' agreement with the statement

Question: How would you like to monitor your position against the district/community level energy consumption and flexibility (privacy of personal information will be respected)?

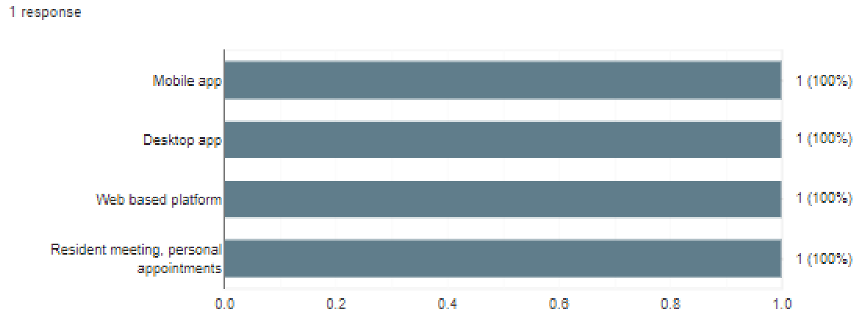

Figure 0-228 Belgian demo – Occupants' preferred means for monitoring their energy consumption and flexibility position against district/community level.

Question: Would you object to share your individual flexibility for optimizing the performance of your neighbourhood/ district and maximizing self-consumption (privacy of personal information will be respected)?

Figure 0-229 Belgian demo – Occupants' objection to share their individual flexibility for optimizing performance of their neighbourhood/district and maximize energy self-consumption

Question: In order for you to participate in collective schemes for self-consumption maximization at community level, please rate (with an "x") the importance of the following aspects:

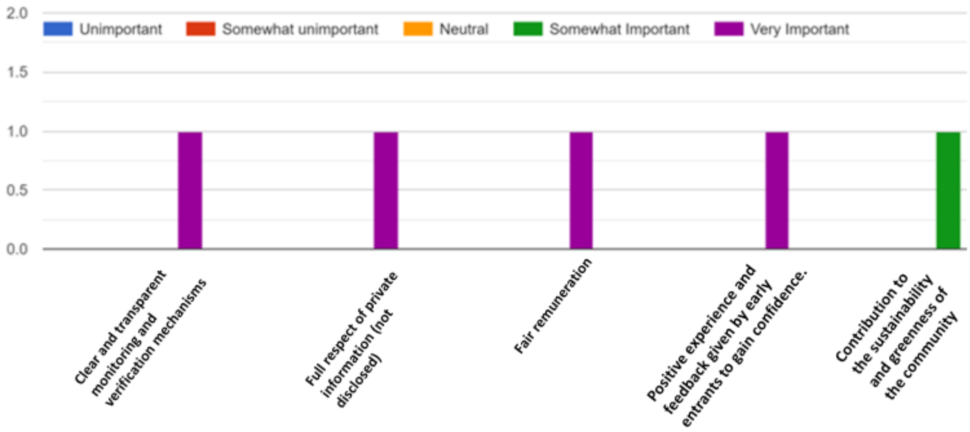

Figure 0-230 Belgian demo – Occupants' rating of important aspects for their participation in collective schemes for self-consumption maximization at community level.

Question: Which of the following aspects would make you feel more uneasy to participate in the local self-consumption schemes at community level?

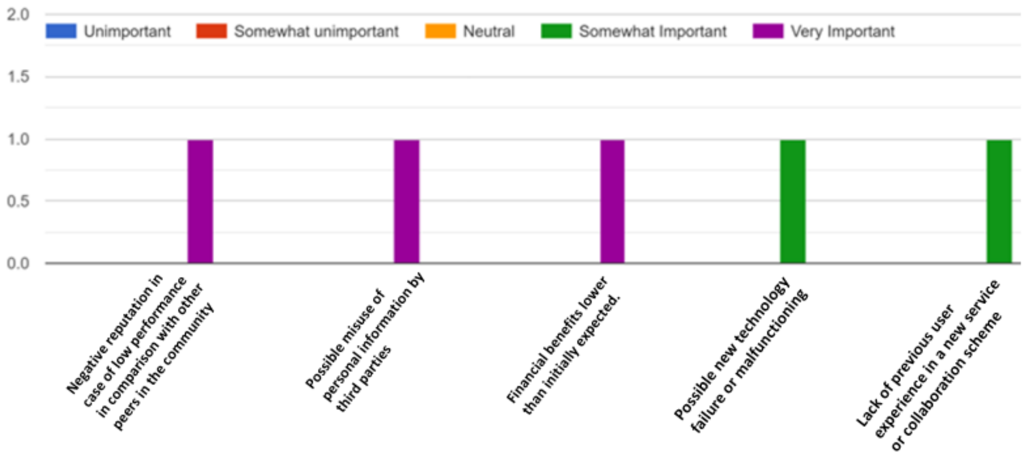

Figure 0-231 Belgian demo – Occupants' rating of aspects considered important for their participation in the local self-consumption schemes

Question: Would you be interested in having an automated control of your building's devices towards reducing energy consumption without sacrificing your comfort preferences?

Figure 0-232 Belgian demo – Occupants' interest on having automates control of their building's devices towards reducing energy consumption without sacrificing comfort preferences

Question: Would you be interested in trading your non-self-consumed energy/ flexibility in local flexibility and energy markets towards monetary gains without affecting your comfort?

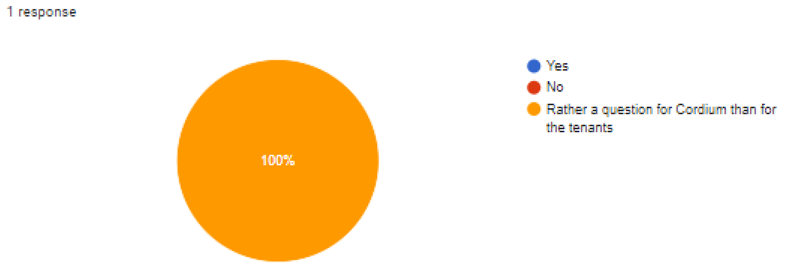

Figure 0-233 Belgian demo – Occupants' interest in trading their non-self-consumed energy/flexibility in local flexibility and energy markets

Question: How would you like to communicate with Aggregators regarding the exploitation/ trading of your flexibility?

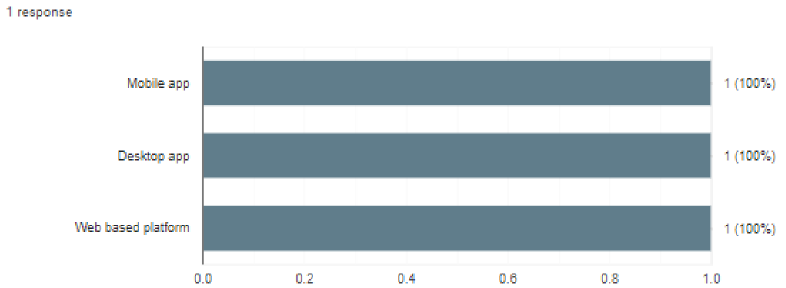

Figure 0-234 Belgian demo – Occupants' preferred devices for communicating with Aggregators regarding their exploitation/trading of their flexibility

Question: Do you like having and using smart devices at home? (Smart Devices are those that can be programmed and controlled remotely with an app or web browser).

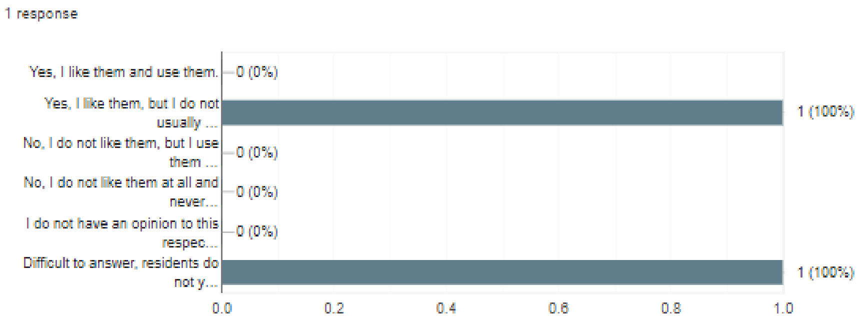

Figure 0-235 Belgian demo – Occupants' preference on having and using smart devices at their home

Question: Would you object in allowing external stakeholders (i.e. aggregators) to control your devices remotely (based on specific agreements) at specific points in time to optimize your participation in energy/ flexibility trading?

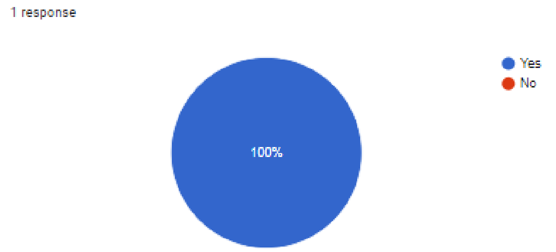

Figure 0-236 Belgian demo – Occupants' objection in allowing external stakeholders to control your devices remotely at specific points in time to optimize their participation in energy/ flexibility trading

Question: Would you agree that an aggregator monitors and operates automatically your devices, without affecting your comfort, so you can provide service to the grid and get a remuneration for it? Please tell us if you would allow it for each of the devices below:

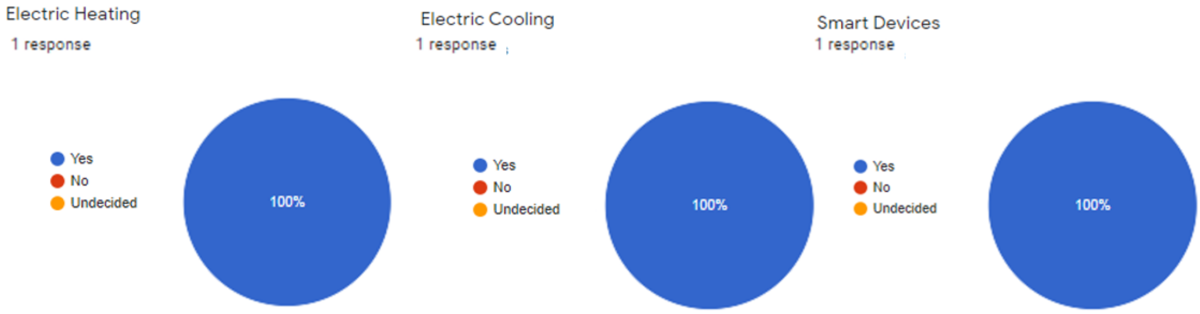

Figure 0-237 Belgian demo - Occupants' preference on allowing aggregators to automatically operate their devices

Question: How often would you like to receive alerts/instructions regarding your unconsumed energy available for trading?

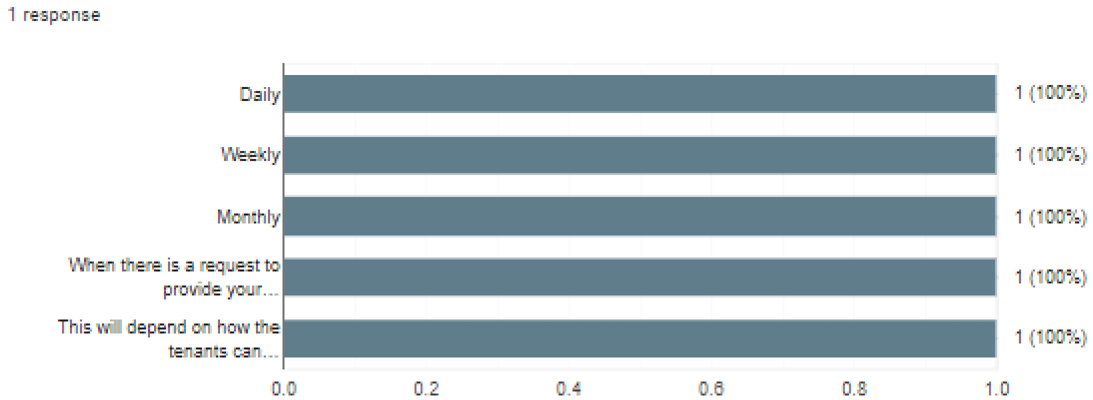

Figure 0-238 Belgian demo – Occupants preference on intervals for receiving alerts/instructions regarding their unconsumed energy available for trading.

Question: Would you be interested in monitoring the monetary gains generated from trading your flexibility?

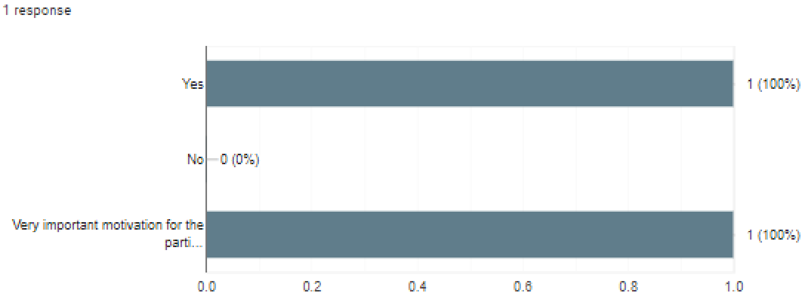

Figure 0-239 Belgian demo – Occupant's interest in monitoring their monetary gains from trading their flexibility

Question: In order for you to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following statements for you?

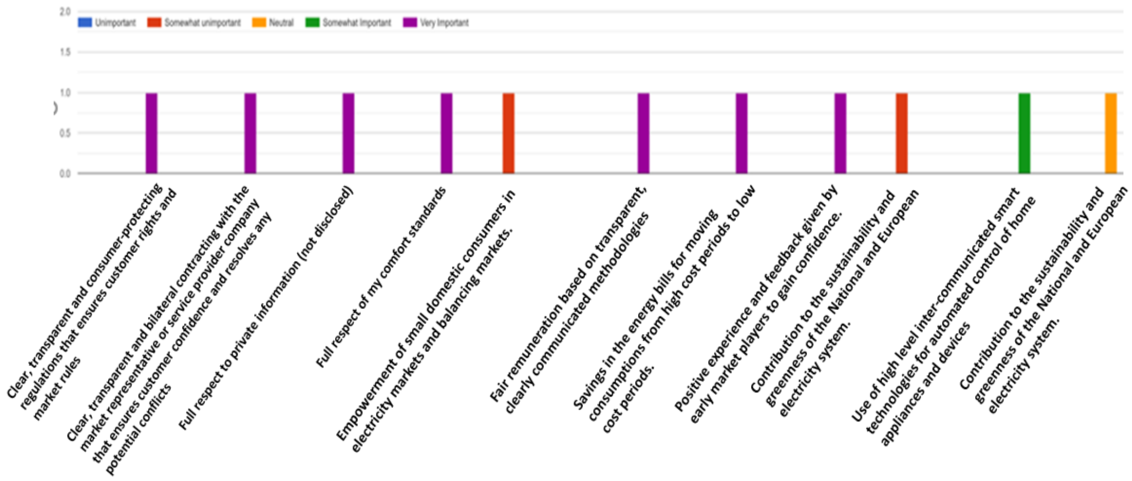

Figure 0-240 Belgian demo – Occupants' opinion on the importance of aspects for participating in demand flexibility renumeration programmes

Question: Which of the following aspects would make you feel more uneasy to participate in the demand flexibility markets described above?

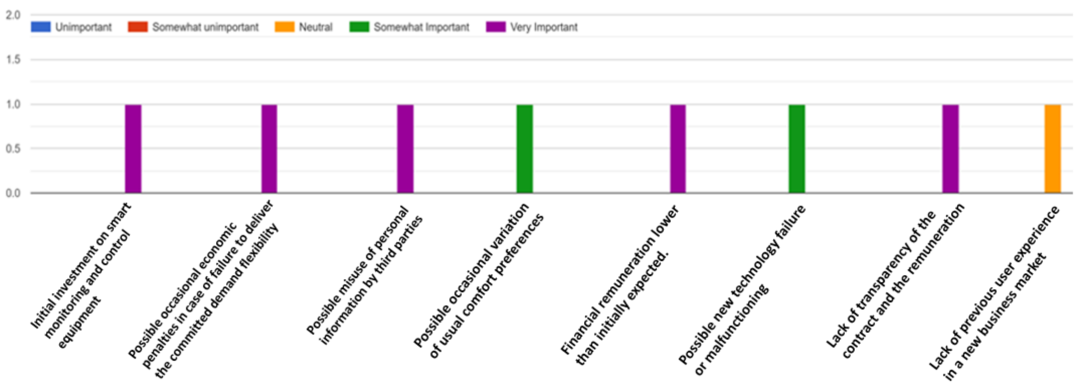

Figure 0-241 Belgian demo – Occupants' preference on aspects that will make it easy for them to participate in the demand flexibility markets

Building Managers

Question: What kind of wireless technology devices do you normally use?

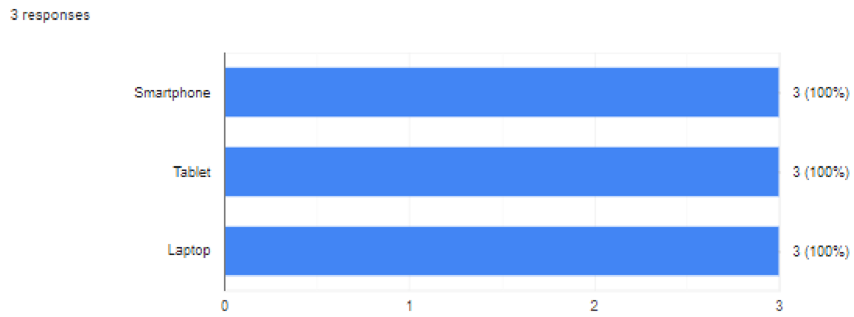

Figure 0-242 Belgian demo – Building Managers' used wireless technology

Question: What kind of internet connectivity is there at your building?

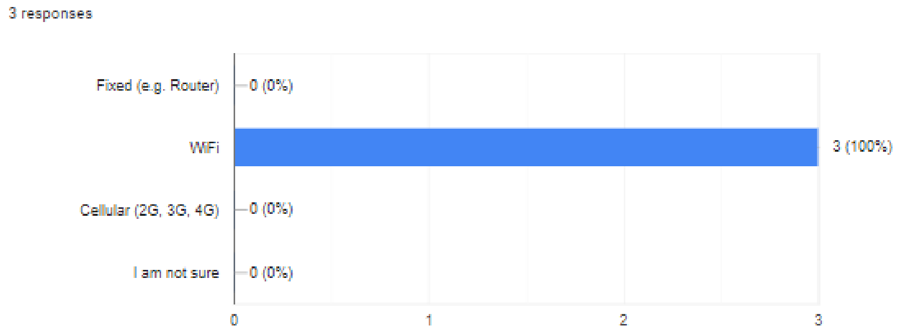

Figure 0-243 Belgian demo – Building Managers' available internet connectivity in their building

Question: Are there any restrictions in your internet connection ?

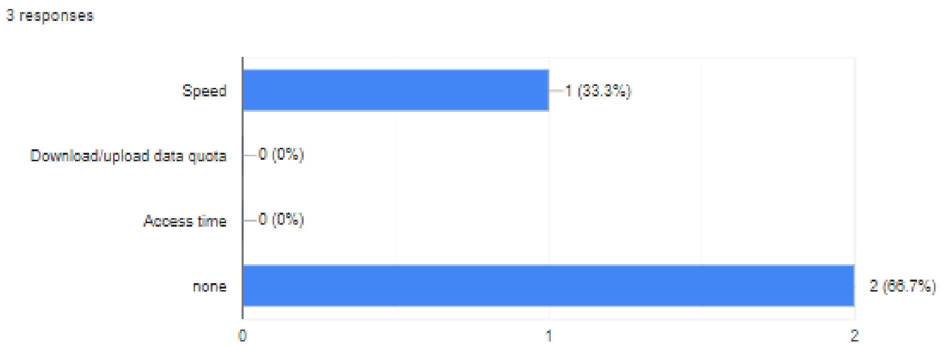

Figure 0-244 Belgian demo – Building Managers' restrictions in their internet connection

Question: How familiar were you with the concept of Plus Energy Buildings (PEBs) prior to this questionnaire?

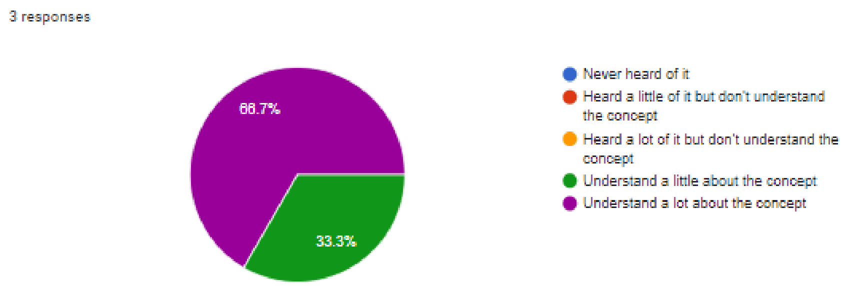

Figure 0-245 Belgian demo – Building Managers' familiarity with PEBs concept

Question: How important is it to save energy and use renewable energy sources in your building?

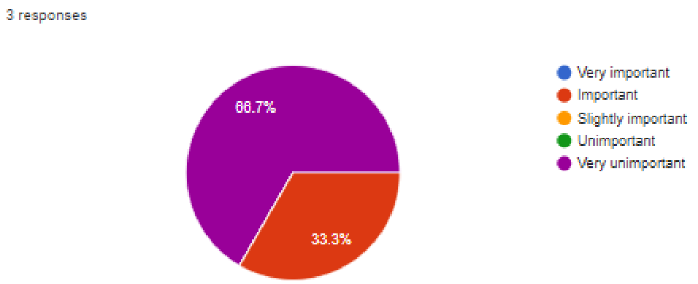

Figure 0-246 Belgian demo – Building Managers' opinion on the importance of saving energy and use of renewable energy sources in their building

Question: Would you be interested in reducing the energy demand and dependence of your building on grid energy, through the installation of novel smart-ready energy technologies?

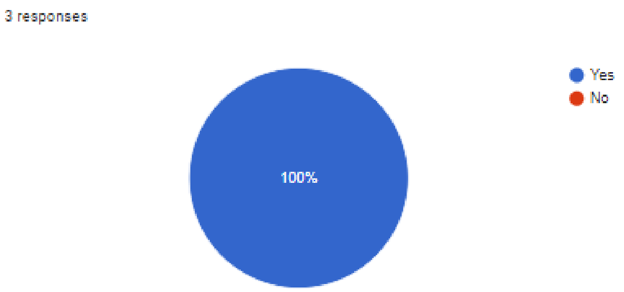

Figure 0-247 Belgian demo – Building Managers' interest in reducing the energy demand and dependence of their building on grid energy, through the installation of novel smart-ready energy technologies

Question: Do you have any specific concerns regarding the installation of smart-ready energy technologies in your building?

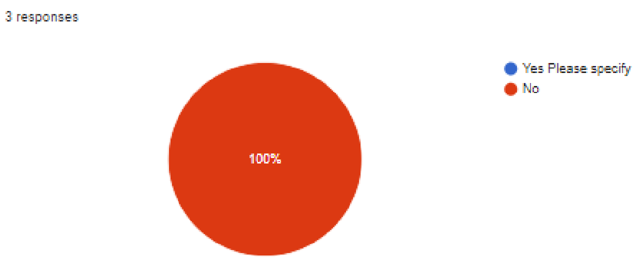

Figure 0-248 Belgian demo – Building Managers' concerns regarding the installation of smart-ready energy technologies in their building

Question: Are you interested in monitoring your building's energy consumption and flexibility through a visualization application (in your mobile, tablet, laptop)?

Figure 0-249 Belgian demo – Building Managers' interest in monitoring their building's energy consumption and flexibility through a visualization application

Question: How would you like to monitor your building's energy consumption and flexibility?

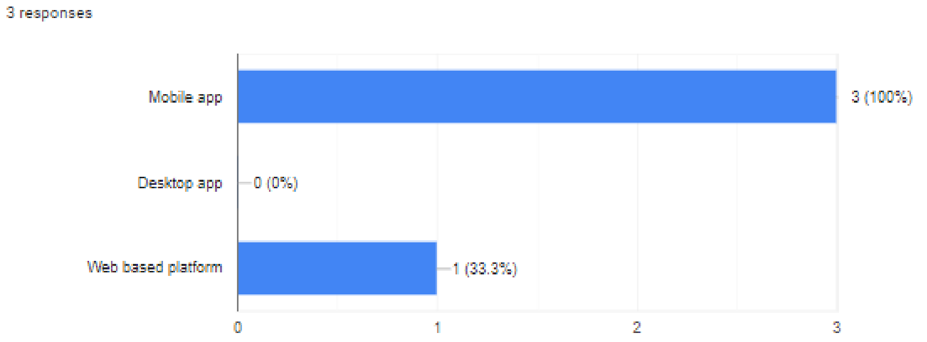

Figure 0-250 Belgian demo – Building Managers' preferred means for monitoring their building's energy consumption and flexibility

Question: Are you familiar with the concept of electricity self-consumption?

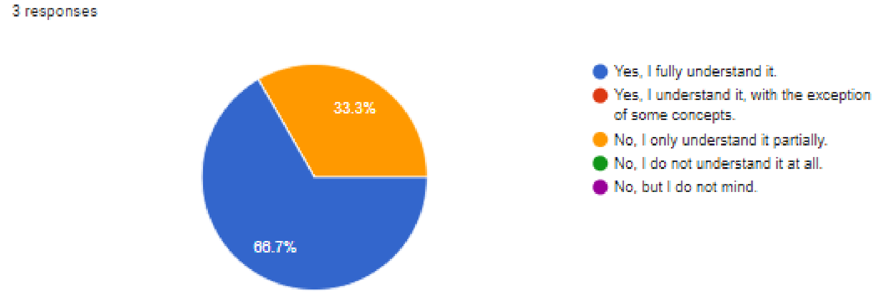

Figure 0-251 Belgian demo – Building Managers' familiarisation with the concept of electricity self-consumption

Question: Would you object to share your building's flexibility for optimizing the performance of your neighbourhood/ district and maximizing self-consumption?

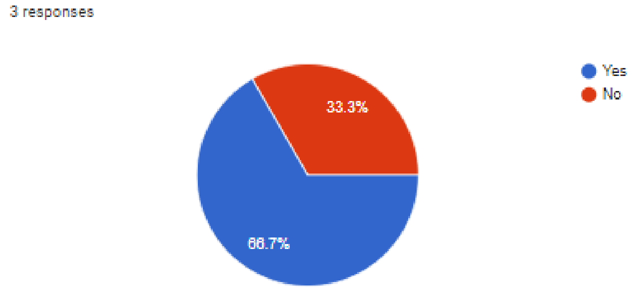

Figure 0-252 Belgian demo – Building Managers' interest in sharing their building's flexibility for optimizing the performance of their neighbourhood/ district and maximizing self-consumption

Question: Are you interested in monitoring your building's performance in terms of energy consumption and flexibility against the district/ community level performance?

Figure 0-253 Belgian demo – Building Managers' interest in monitoring their building's performance in terms of energy consumption and flexibility against the district/ community level performance

Question: How would you like to monitor your building's position against the district/community level energy consumption and flexibility?

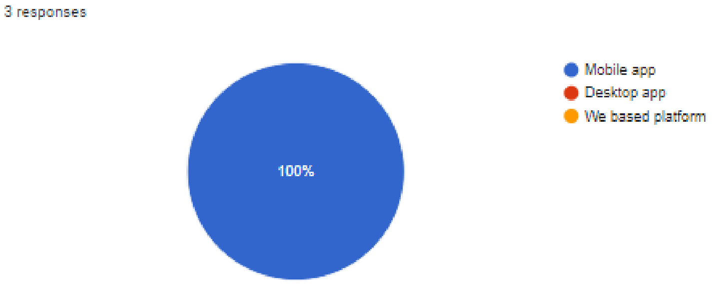

Figure 0-254 Belgian demo – Building Managers' preferred means for monitoring their building's position against the district/community level energy consumption and flexibility.

Question: Would you agree in sharing your building's flexibility and energy consumption (real-time data) with Aggregators towards participating in flexibility trading?

Figure 0-255 Belgian demo – Building Managers' agreement in sharing their building's flexibility and energy consumption with Aggregators towards participating in flexibility trading

Question: In order for you to participate in collective schemes for self-consumption maximization at community level, how important are the following aspects for you?

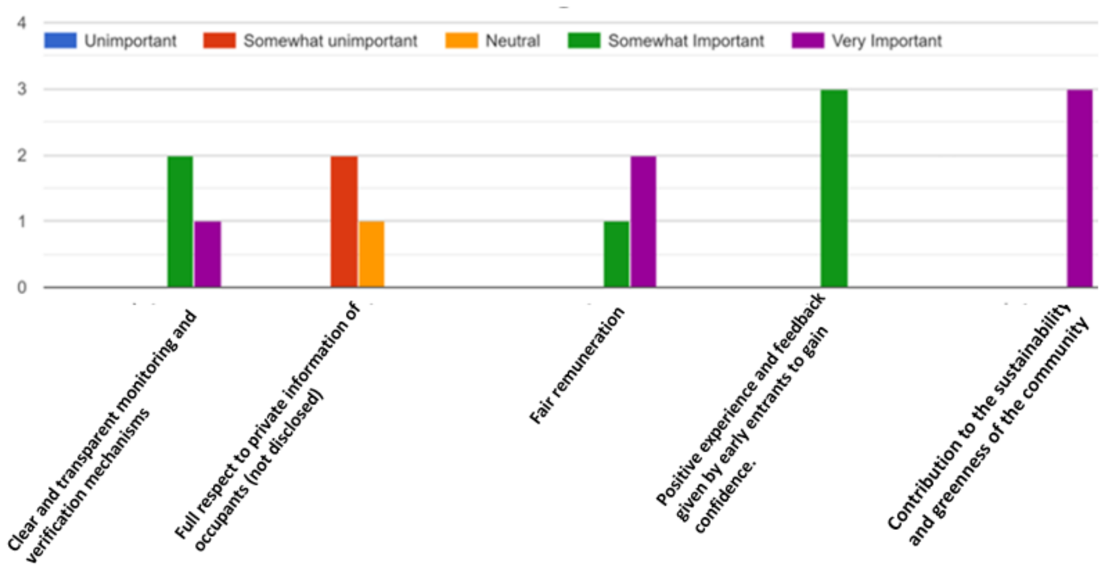

Figure 0-256 Belgian demo – Building Managers' opinion on aspects considered important for their participation in collective schemes for self-consumption maximization at community level

Question: Which of the following statements would make you feel more uneasy to participate in the local self-consumption schemes at community level?

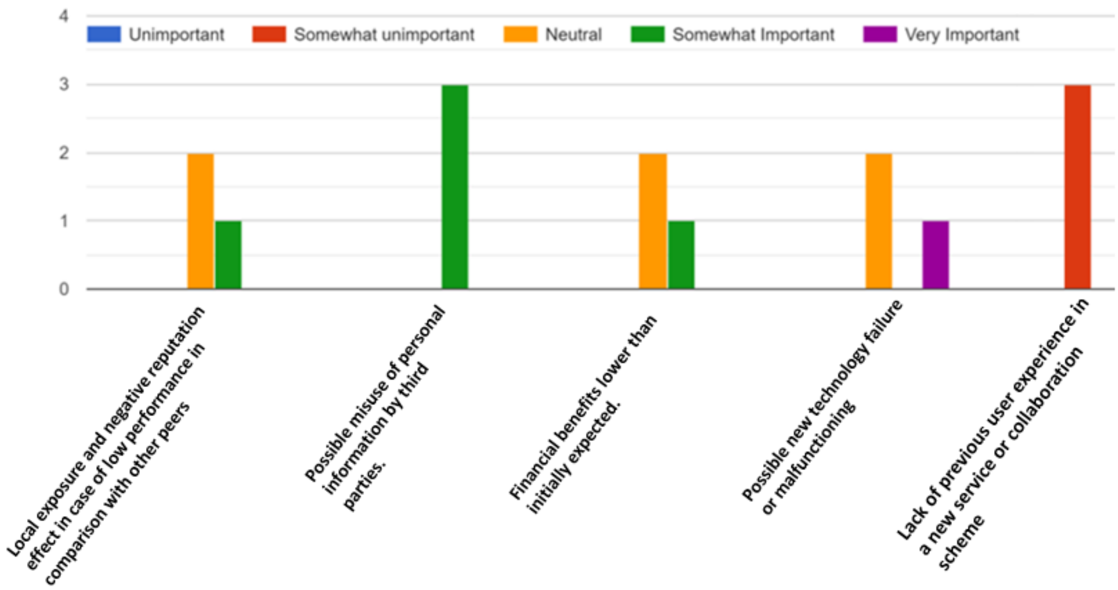

Figure 0-257 Belgian demo – Building Managers' opinion on aspects considered important for making them feel more uneasy to participate in the local self-consumption schemes at community level.

Question: Would you be interested in trading your building's non-self-consumed energy in local flexibility and energy markets towards monetary gains?

Figure 0-258 Belgian demo – Building Managers' interest in trading their building's non-self-consumed energy in local flexibility and energy markets towards monetary gains

Question: How would you like to communicate with Aggregators regarding the exploitation/trading of your building's flexibility?

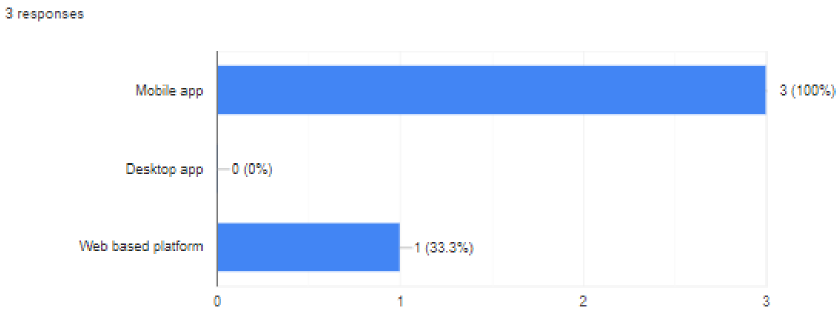

Figure 0-259 Belgian demo – Building Managers' preferred means for communicating with Aggregators regarding the exploitation/trading of their building's flexibility

Question: How often would you like to receive alerts/instructions regarding your building's unconsumed energy available for trading?

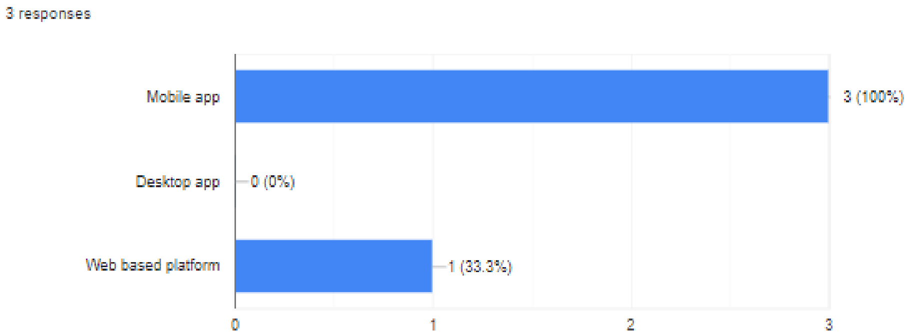

Figure 0-260 Belgian demo – Building Managers' preference on the intervals for receiving alerts/instructions regarding their building's unconsumed energy available for trading

Question: Would you be interested in monitoring the monetary gains generated from trading your building's flexibility?

Figure 0-261 Belgian demo – Building Managers' interest in monitoring the monetary gains generated from trading their building's flexibility

Question: Do you agree or disagree with the following statement? "Visualization of my building's consumption/energy savings against community level can inspire the building occupants towards reducing their energy consumption, leading also to financial profits and environmental benefits"

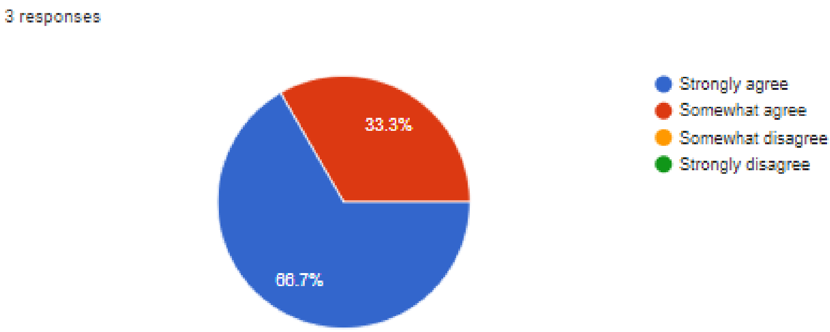

Figure 0-262 Belgian demo – Building Managers' agreement with the statement

Question: Would you object in allowing external stakeholders (i.e. aggregators) to control your devices remotely (based on specific agreements) at specific points in time to optimize your participation in energy/ flexibility trading?

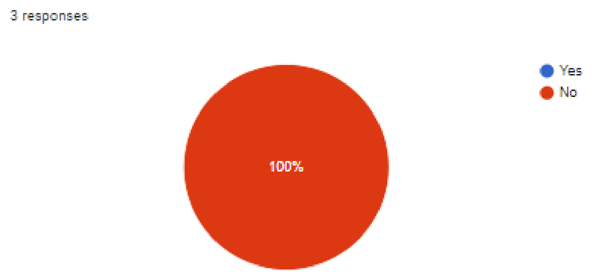

Figure 0-263 Belgian demo – Building Managers' objection in allowing external stakeholders to control their devices remotely at specific points in time to optimize your participation in energy/ flexibility trading

Question: In order for you to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following aspects for you?

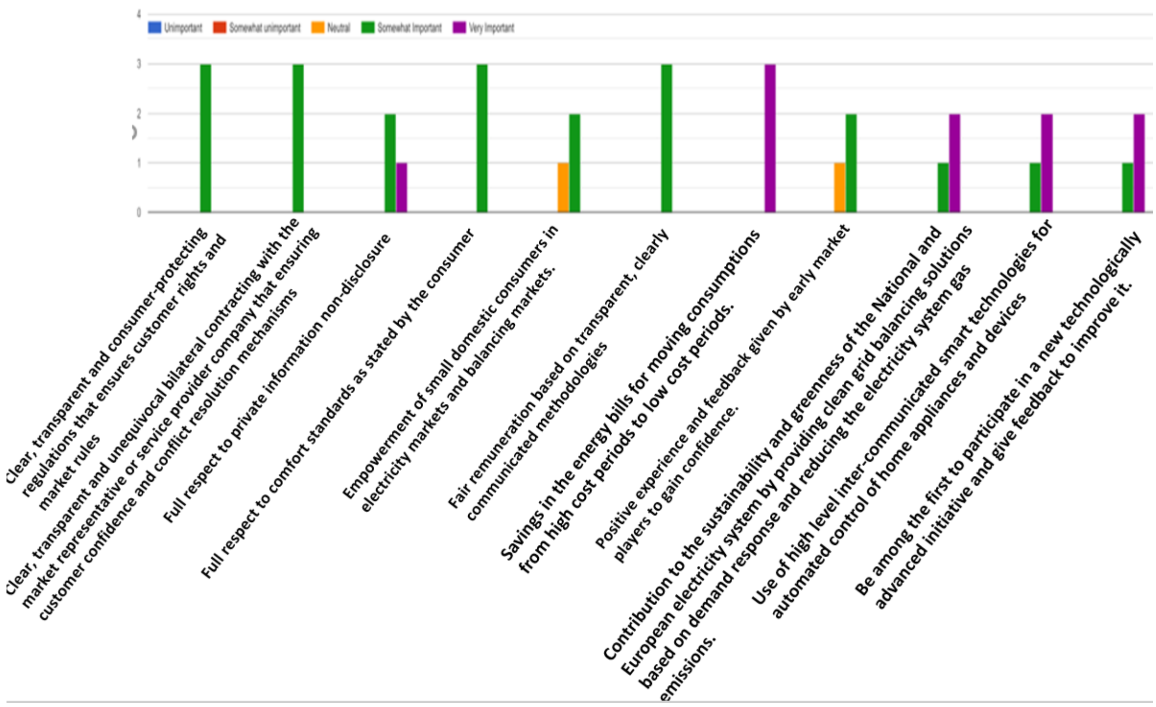

Figure 0-264 Belgian demo – Building Managers' rating of aspects important for them to participate in the demand flexibility remuneration programmes through a demand aggregator

Question: Which of the following aspects would make you feel more uneasy to participate in the demand flexibility markets described above?

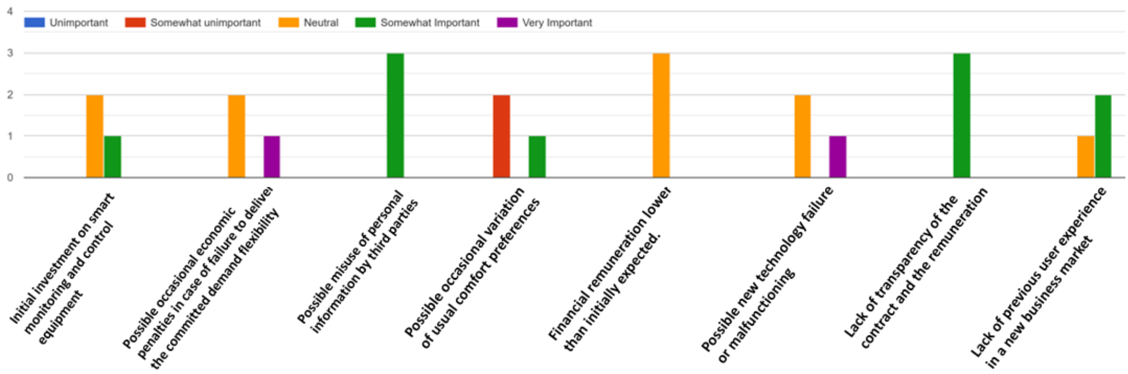

Figure 0-265 Belgian demo – Building Managers' rating of aspects important to make them feel more uneasy to participate in the demand flexibility markets

Architects

Question: What kind of buildings do you usually design?

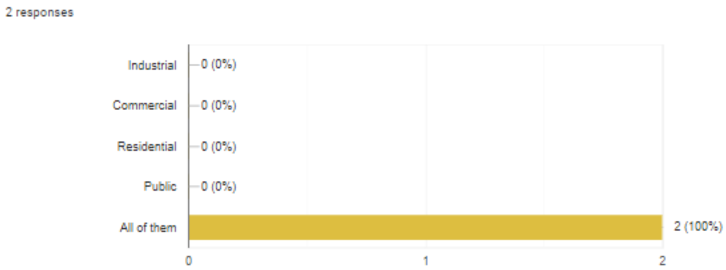

Figure 0-266 Belgian demo –Usual bbuildings designed by the Architects

Question: What type of clients do you usually work with?

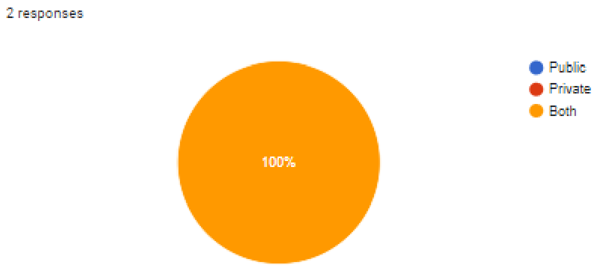

Figure 0-267 Belgian demo – Architects' usual clients

Question: What kind of internet connectivity do you have in your office?

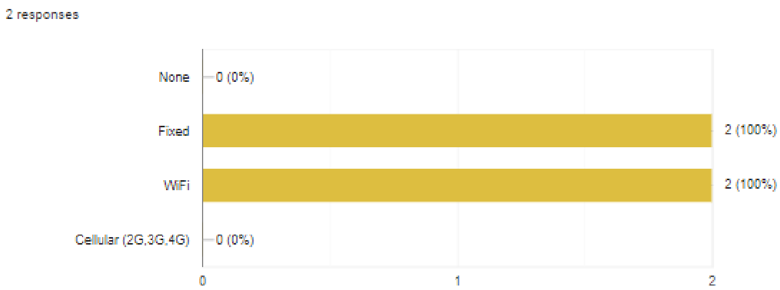

Figure 0-268 Belgian demo – Architects' available internet connectivity at their offices

Question: Which devices do you use for work?

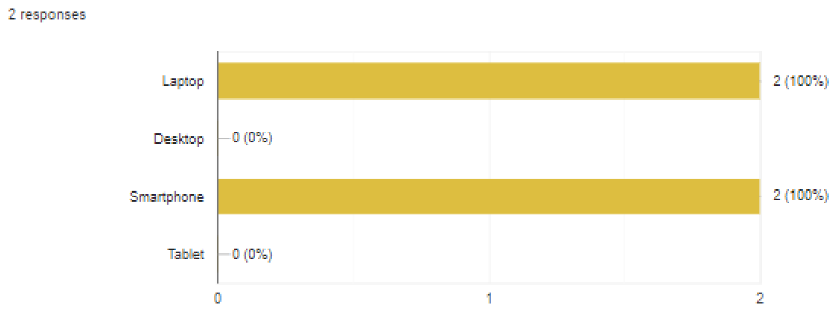

Figure 0-269 Belgian demo – Architects' preferred devices for work

Question: What operating systems do these devices use?

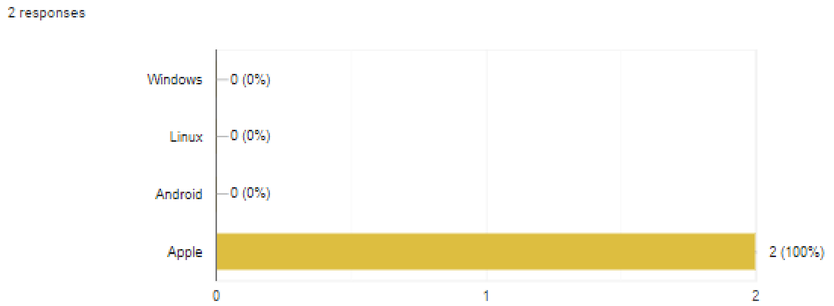

Figure 0-270 Belgian demo – Architects' preferred operating systems

Question: Which applications and information systems do you typically use in your everyday job?

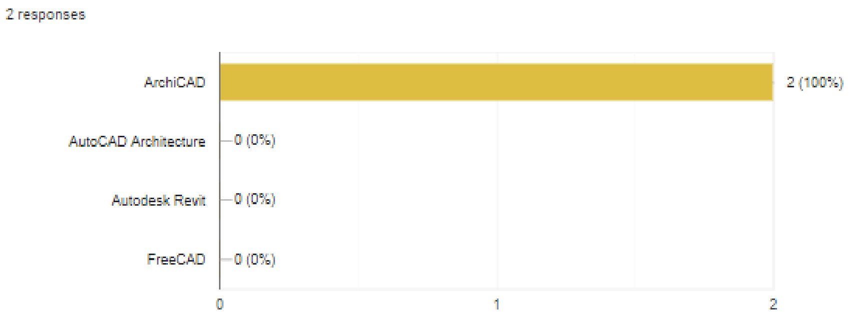

Figure 0-271 Belgian demo – Architects' typical application and information systems used in their job

Question: What export functionality do they support?

Figure 0-272 Belgian demo – Architects' information systems export functionality

Question: What data formats are supported for exporting data from these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

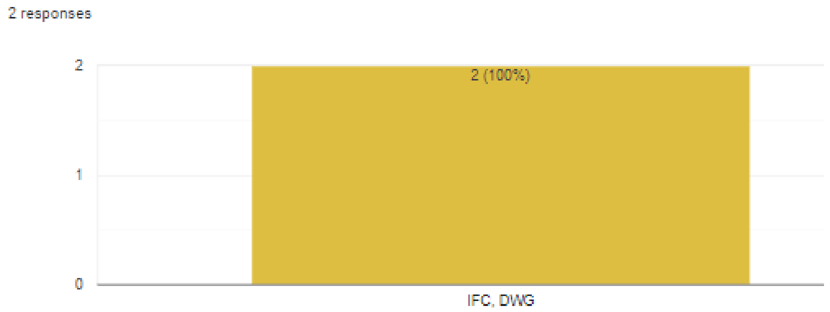

Figure 0-273 Belgian demo – Architects applications' supported data formats

Question: Which tools/systems do you use for handling Building Information Modelling (BIM) models?

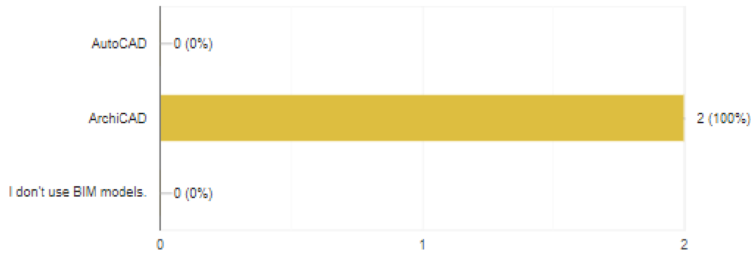

Figure 0-274 Belgian demo – Architects' preferred tools/systems for handling BIM models

Question: Which formats do you export to your BIM models, when using these systems? (e.g. IFC, gbXML, etc.)

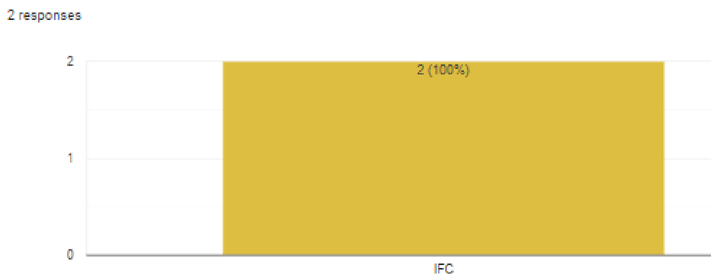

Figure 0-275 Belgian demo – Architects' preferred format for exporting their BIM models

Question: What type of data do you need from other stakeholders in order to properly complete your work?

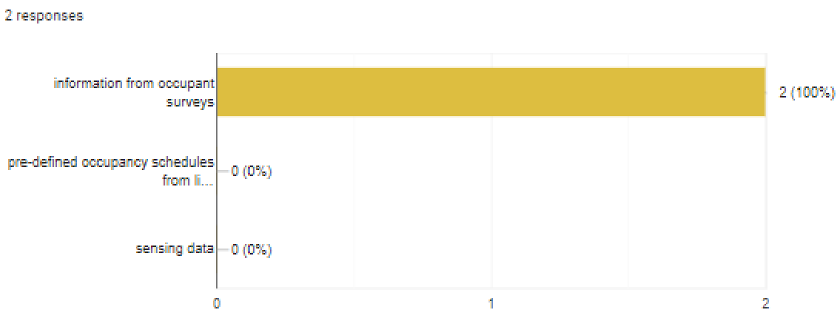

Figure 0-276 Belgian demo – Architects' required data from other stakeholders towards properly completing their work

Question: How do you currently find data you need, but you do not have electronically in your information systems?

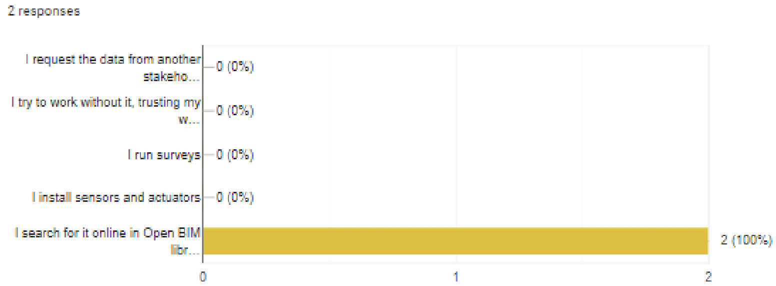

Figure 0-277 Belgian demo – Architects' ways of finding required data that are not electronically in their information systems

Question: What are the security and privacy requirements you have for the building data / information you manage?

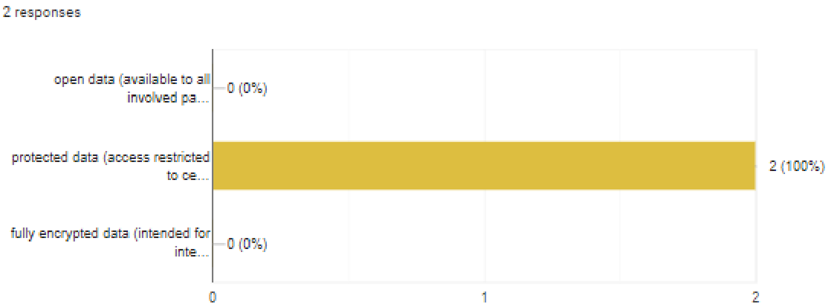

Figure 0-278 Belgian demo – Architects' security and privacy requirements for their building data/information they manage

Question: Which tools are you using to model energy performance?

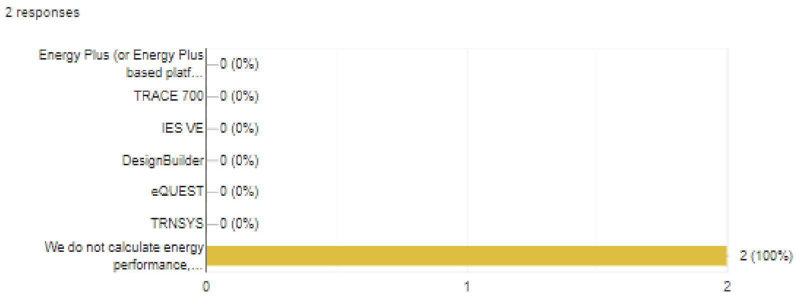

Figure 0-279 Belgian demo – Architects' used tools to model energy performance

Question: What import functionality do they support?

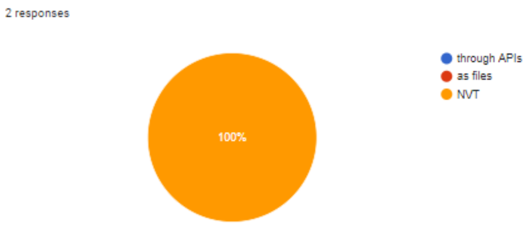

Figure 0-280 Belgian demo – Architects energy performance modelling tools' import functionality

Question: What data formats are supported for importing data to these applications? (e.g. IFC, DGN, DWX, XML, JSON, CSV, ASCII, GML)

0 responses

No responses yet for this question.

Figure 0-281 Belgian demo – Architects energy performance modelling tools data formats for import.

Question: What data do you see as of high interest during the energy performance modelling?

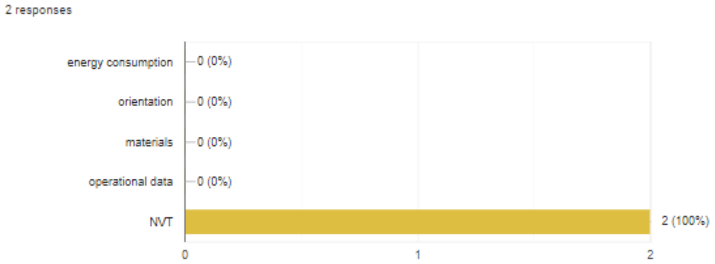

Figure 0-282 Belgian demo – Architects' preferred high interest data for energy performance modelling

Question: If you take into account operational energy data during the design phase, what data do you consider?

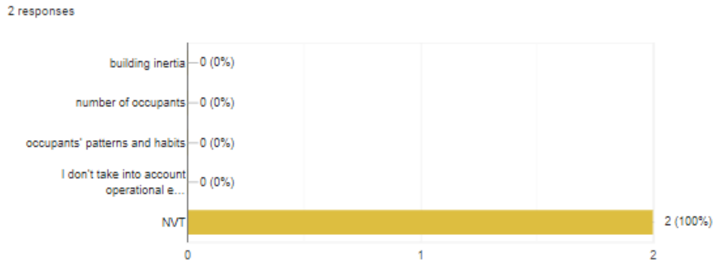

Figure 0-283 Belgian demo – Architects considered data in operational energy modelling

Question: If you consider the occupants' comfort in your calculations, how do you quantify (or measure) occupants' comfort?

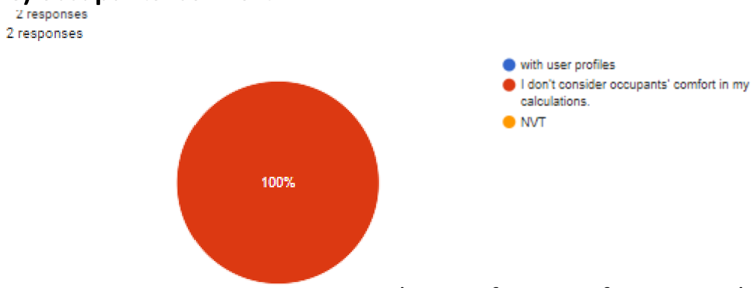

Figure 0-284 Belgian demo – Architects' quantification of occupants' comfort

Question: Do you consider the use of smart Internet of Things solutions to monitor indoor comfort and energy consumption?

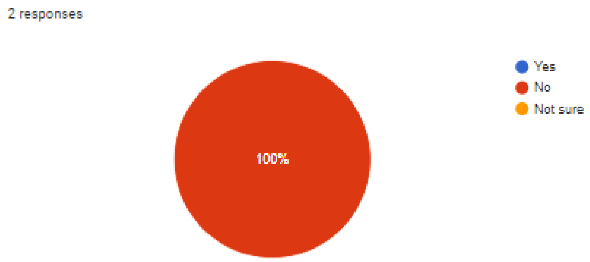

Figure 0-285 Belgian demo – Architects' views on considering use of Smart IoT solution for monitoring indoor comfort and energy consumption

Question: Do you think that this would be beneficial for your work? (e.g. more accurate prediction of energy performance based on realistic occupancy schedules).

0 responses

No responses yet for this question.

Figure 0-286 Belgian demo – Architects' view on using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: If answered "Yes" in the previous question, please specify why:

0 responses

No responses yet for this question.

Figure 0-287 Belgian demo – Architects' reasons for using smart Internet of Things solutions to monitor indoor comfort and energy consumption

Question: In the tools that you use for energy performance modelling and simulation, are you knowledgeable of the building control routines they apply?

0 responses

No responses yet for this question.

Figure 0-288 Belgian demo – Architects' knowledge of applied building control routines

Question: If you are knowledgeable of the control routines they apply, are you satisfied with the accuracy they achieve?

0 responses

No responses yet for this question.

Figure 0-289 Belgian demo – Architects' satisfaction with the accuracy of building control routines used in energy performance modelling

Question: Would you be open to adopt more advanced building systems control routines in your tools as a means to increase performance prediction accuracy?

0 responses

No responses yet for this question.

Figure 0-290 Belgian demo – Architects' willingness to adopt more advanced building systems control routines in their tools as a means to increase performance prediction accuracy

Aggregators

Question: What wireless devices do you use?

Figure 0-291 Belgian demo – Aggregator's preferred wireless devices

Question: What operating systems do these devices use?

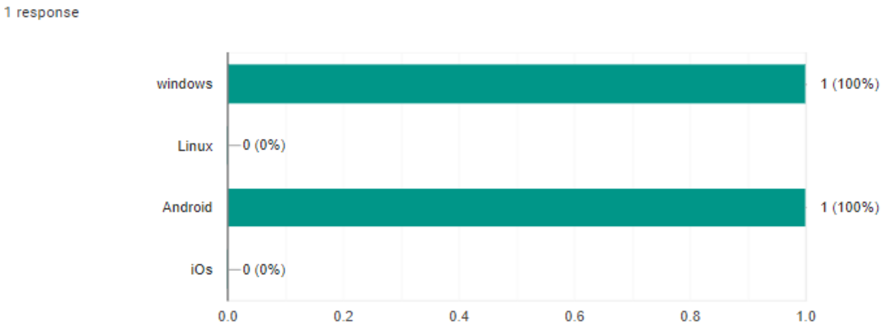

Figure 0-292 Belgian demo - Aggregator's preferred operating systems

Question: Currently, do you monitor your members/clients' electricity consumption?

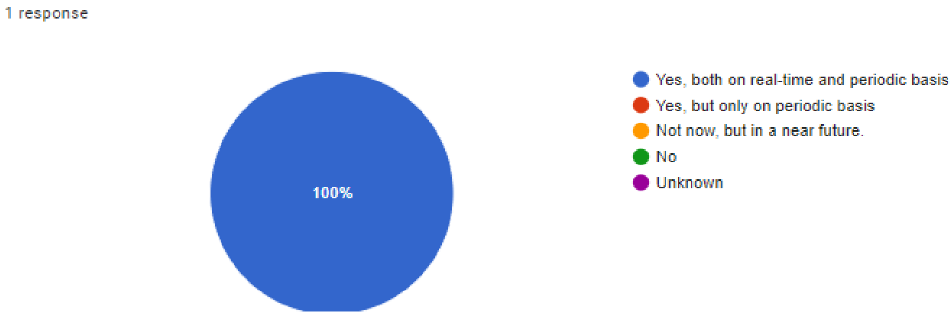

Figure 0-293 Belgian demo - Aggregator's information on their members/clients' electricity consumption

Question: Do you have access to the electricity meters of your clients?

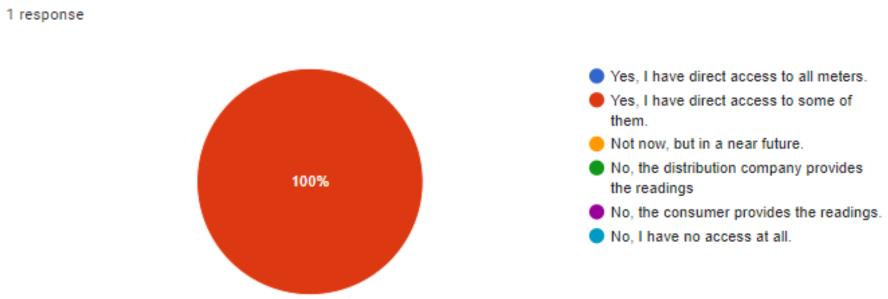

Figure 0-294 Belgian demo – Aggregator's access to the electricity meters of his clients

Question: In your database, do you have available information about your members and clients?

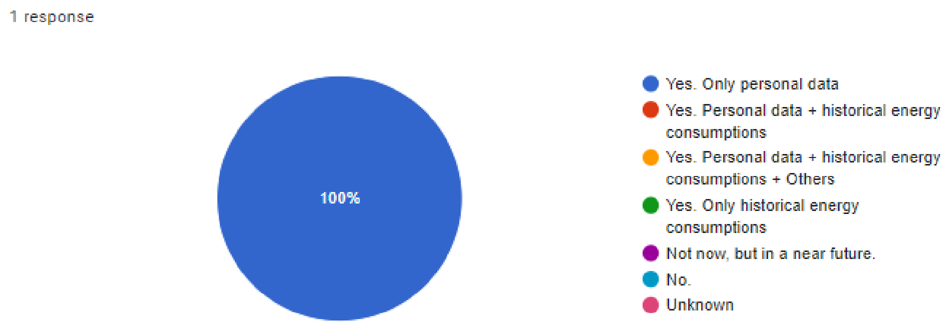

Figure 0-295 Belgian demo – Aggregator's available information in his database about his members and clients

Question: What information do you have about your clients' electrical devices and equipment at home?

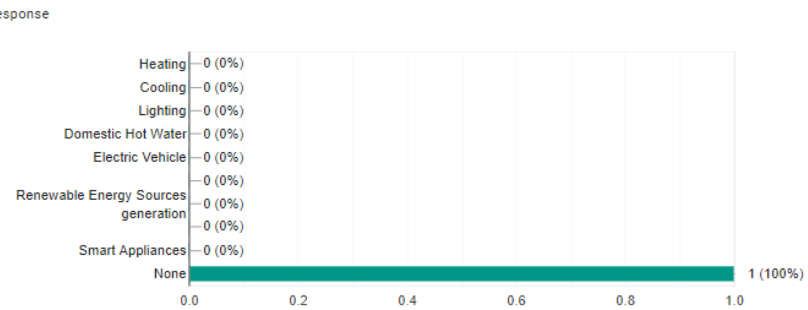

Figure 0-296 Belgian demo - Aggregator's available information about his clients' electrical devices and equipment at home

Question: How do you identify the flexibility that each client can provide?

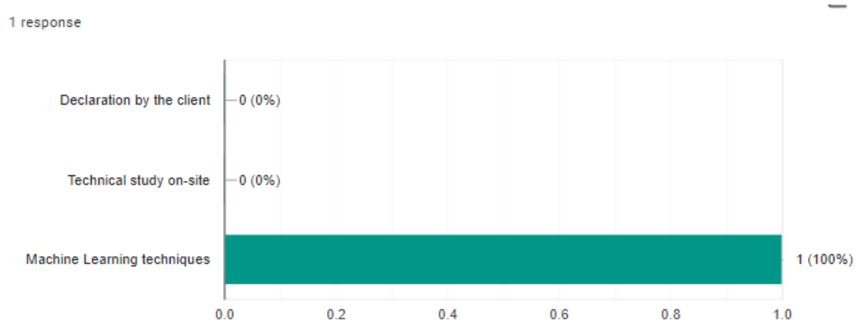

Figure 0-297 Belgian demo - Aggregator's ways for identifying the flexibility that each client can provide?

Question: Do you consider human comfort aspects when quantifying flexibility?

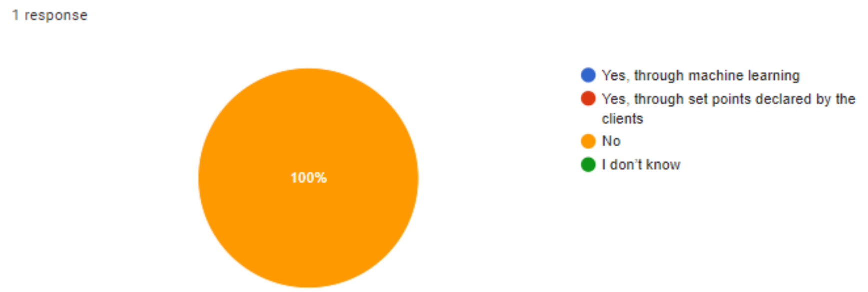

Figure 0-298 Belgian demo - Aggregator's consideration of human comfort aspects when quantifying flexibility?

Question: What tool/software are you using now for the exploration and analysis of the flexibilities of your portfolio of clients? Please specify………………

0 responses

No responses yet for this question.

Figure 0-299 Belgian demo – Aggregator's tool/software used for the exploration and analysis of the flexibilities of their portfolio of clients

Question: What types of Demand Response offerings do you provide to your clients?

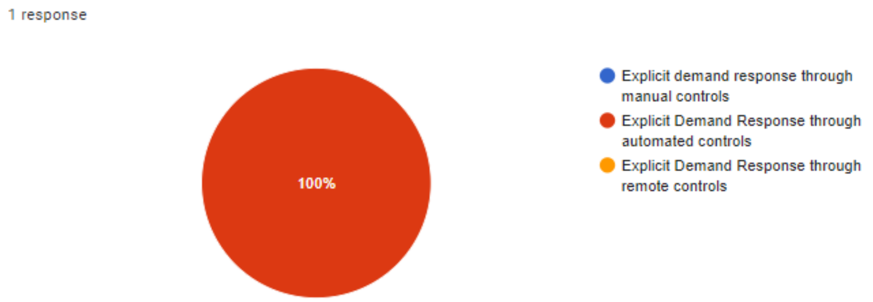

Figure 0-300 Belgian demo - Aggregator's provided types of Demand Response to his clients

Question: Do your service offerings respect human well-being in the built environment?

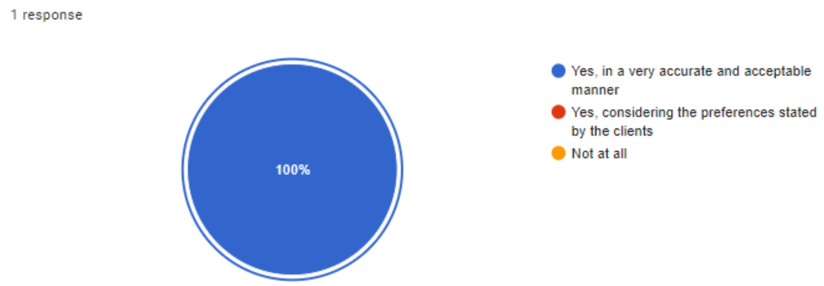

Figure 0-301 Belgian demo - Aggregator's perception of his offering service in regard to respecting human well-being in the built environment?

Question: How do your clients declare their interest to get involved in DR/ flexibility provision services?

0 responses

No responses yet for this question.

Figure 0-302 Belgian demo – Aggregator's means for enabling clients to declare their interest to get involved in DR/ flexibility provision services

What are the terms included in the contracts between you and the building occupants?

0 responses

No responses yet for this question.

Figure 0-303 Belgian demo - Aggregator's terms included in the contracts between him and the building occupants

Question: What types of flexibility sources do you usually contract?

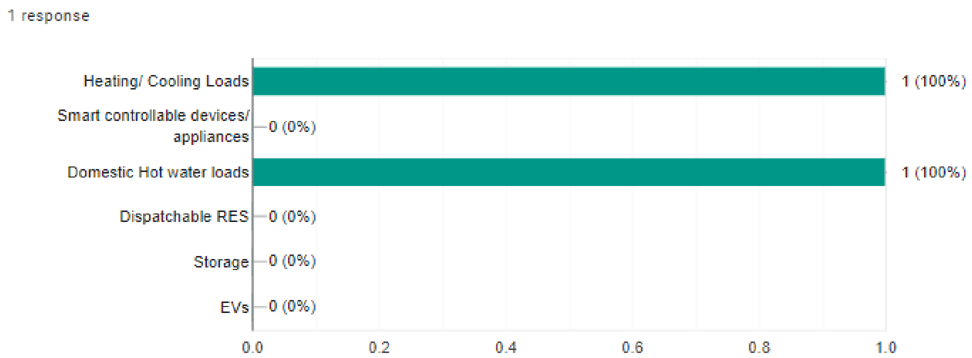

Figure 0-304 Belgian demo - Aggregator's usual contracted flexibility sources

Question: Through what means are the remuneration details communicated to the building occupants?

0 responses

No responses yet for this question.

Figure 0-305 - Belgian demo - Aggregator's means to communicate the remuneration details communicated to the building occupants

Question: What kind of visualizations do you use for monitoring the performance of their established clusters/ Virtual Power Plants (addressing different grid requests for service) and identify potential overrides over flexibility triggers addressed to specific customers? Please specify…………………

0 responses

No responses yet for this question.

Figure 0-306 Belgian demo - Aggregator's types of visualizations used for monitoring the performance of their established clusters/ VPPs

Question: Please rate how important the following aspects are for you as an aggregator regarding demand flexibility for domestic users:

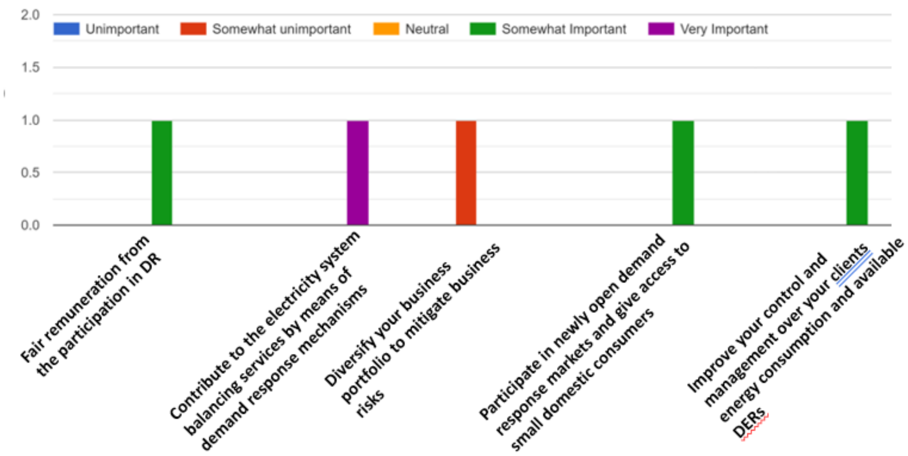

Figure 0-307 Belgian demo - Aggregator's rating of aspects important for an aggregator regarding demand flexibility for domestic users

Question: Please rate how important the following aspects are for you as an aggregator of demand flexibility for domestic users:

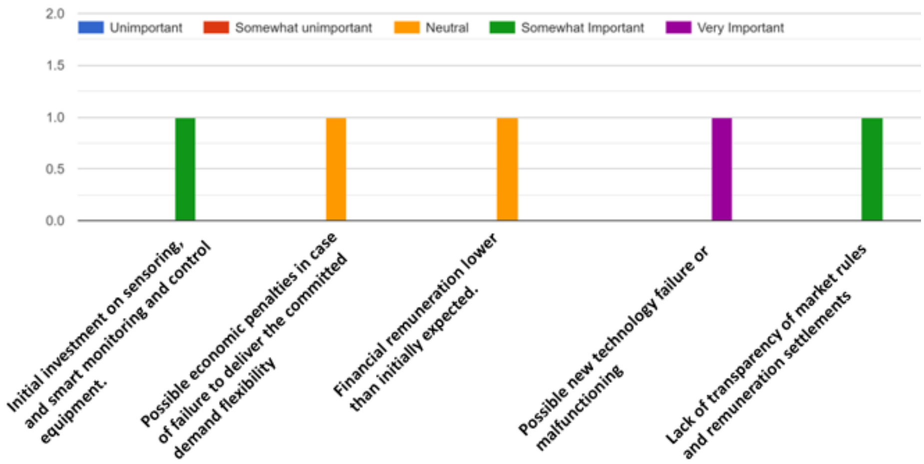

Figure 0-308 Belgian demo - Aggregator's rating of aspects important for an aggregator of demand flexibility for domestic users

Question: Would you be willing to participate in demand response markets as an aggregator of domestic end users' demand flexibility?

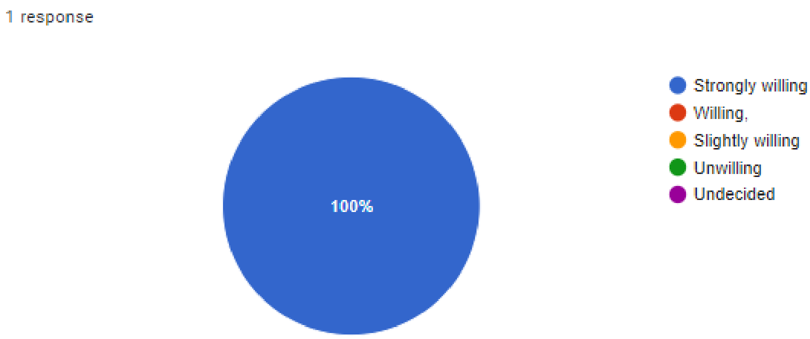

Figure 0-309 Belgian demo - Aggregator's willingness to participate in demand response markets as an aggregator of domestic end users' demand flexibility

Question: Please rate each of the following capabilities that a tool for aggregators should integrate:

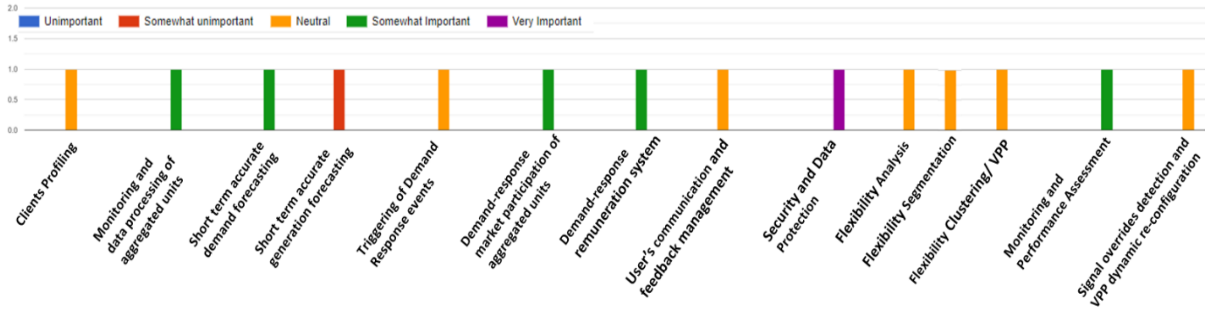

Figure 0-310 Belgian demo - Aggregator's rating of capabilities that a tool for aggregators should integrate