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D7.5 Pre-pilot deployment and validation

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1 Executive summary

This deliverable presents the results of the first pilot phase (pre-pilot) for all three pilot sites. It describes the current achievements and status of the deployment of iFLEX in the pilots as well as the initial validation results covering both end-user validation, technical validation and business validation aspects.
For this first pilot phase, only a very small number of end-users are actively involved. Therefore, the end-user validation activities have focused on a usability test of the initial iFLEX Assistant user interface and a public survey investigating the user acceptance of the iFLEX concept.

In the first pre-pilot phase, the iFLEX Assistant graphics mobile application were designed. The application is not yet complete in terms of all functionalities, however a usability test was performed on a sample of 11 users (users from Slovenian and Greek cluster). The usability test of iFLEX applications was performed individually with each end user. First a short demo video of the iFLEX application is played to everyone. Then each user was gained remote access to iFLEX application and usability was tested in form of performing basic tasks. Upon completion of the iFLEX application usability testing, an anonymous survey form was provided to everyone with questions (in digital web form) related to the user experience. Based on skills, comments, visual insight into the application and completed survey questionnaires of individual users, useful information was obtained, which is extremely important for the further development of the iFLEX application.

The public survey took the form of an online questionnaire which was distributed in the three pilot countries. A total of 1.280 completed questionnaires were collected. The primary focus was to assess consumers/prosumers' key motivations for offering their energy flexibility, what they would prefer to do and how. The results were quite similar for all three countries (or pilot sites) which is interesting as the characteristics of the data subjects differed notably across the three pilot sites with regards to age, household composition (i.e. with/without children) and dwelling type, size and tenure-ship.

Overall the concept of iFLEX was positively received as was the idea of offering energy flexibility. There was a very small difference between how Finnish respondents would engage in flexibility and how the Slovenian and Greek respondents would. Thus, while most respondents in Slovenia answered "*I could invest in technology that would allow my energy devices (e.g. electric water heater) to automatically adjust consumption when needed by the grid*" (69%), which was the Greek respondents' 2nd choice with 67%), this was the option which least of the Finnish respondents chose (52%). We can only speculate as to the reason for this, but it is interesting to note that the Finnish respondents represented a much older age group (47% were +61 years old) compared to the Greek (2% were +61 years old) and Slovenian respondents (22% were +61 years old). Therefore, we may speculate if the older age group is less interested in investing in (new) technology.

The motivational drivers were divided into three categories: i) Save the world, ii) Save money, and iii) Told to do it. Not surprisingly, "save money" was the dominant motivator and applied to nearly all respondents as did "save the world". In fact, there was only an insignificant difference between these two drivers. This result demonstrates that when designing incentives both aspects should be considered; people may be motivated by a variety of drivers and depending on the context one driver may be stronger in some situations than others. The results were also quite similar for all three pilot sites with one expected difference with regards to what respondents would do to offer their flexibility. Thus, whereas respondents from Finland and Slovenia prefer to change their daily habit rather than turn the heating down, respondents from Greece would prefer the turn the heating down. Given the climatic differences this result was expected as heating issues affects the Greek respondents to a much lesser degree than the Finnish and Slovenian respondents.

Finally, it was evident that all respondents prefer a solution that combines manual and automated functionalities indicating that while respondents were positive towards offering energy flexibility and an automated and/or smart solution, they ultimately want to remain in control, suggesting that the balance between comfort and convenience versus saving money and contributing to a clean energy transition (save the world) is essential and subjective.

During this phase-1 the work on technical validation focused mainly on internal verification activities which involved component and integration tests. In accordance to the fine-grained documentation of functionalities to be tested for each iFA component interfacing during the pre-pilot (i.e. in JIRA), different tests took place to validate the operation of these components as well as their interaction. On the other hand, validation of specific iFA instances (MVPs) was of reduced scope given the different maturity levels in the prototype components of iFA for the Greece, Slovenian and Finnish pilots.

The document also defines Business validation based on known cost data for each pilot cluster. A breakdown of costs is presented separately for equipment and separately for support and maintenance of the entire system. As each pilot is involved in the data collecting, processing and control of different consumers, it is difficult to estimate in the first pilot phase how much this cost will be on the final number of users in separate pilot cluster. The cost is expected to be slightly higher in the first pilot phase, because it took a lot of development hours to develop new communication drivers and to experimentally validate existing equipment and upgrade/rework them for the purpose of this project.

2 Introduction

2.1 Purpose, context and scope

The purpose of this document is to review the validation status of the first pilot phase. With the help of validation mechanisms an end user validation, technical validation and business validation were performed as well as deployment view of each pilot cluster were presented. The basic mechanisms for the implementation of end user validation relate to the use of questionnaires of the public and usability tests with the first pre-pilot users. Based on the cost of installed equipment at the first pre-pilot users, business validation was performed for each pilot cluster. In the business validation, it was tried to include all incurred direct (labour, installed equipment and data processing and storing) and indirect (maintenance) costs and from this to give business guidelines. There are also work on technical validation which was focused on internal activities which involve component and integration tests. In scope of technical validation different test took place to validate iFA components as vell as their interaction. On the other hand, validation of specific iFA instances (MVPs) was of reduced scope given the different maturity levels in the prototype components of iFA for the different pilots.

2.2 Content and structure

Document D7.5 is structured into six main chapters. The chapters cover aspects:

- pre-pilot deployment in phase 1, which describes the progress of the iFLEX Framework integration for end-users,
- validation plan for phase 1, this chapter describes used validation procedures,
- end user validation, the chapter covers the used methodology and results of public surveys for individual pilot areas (Greek, Slovenian and Finnish public survey) in statistical / graphical form, as well as the results and methods of usability test of iFLEX graphical user mobile application,
- technical validation, a chapter focused on the validation of iFLEX assistance blocks at the level of each pilot region,
- business validation, the chapter describes the cost aspect of an individual pilot, as costs in a disaggregated form (costs, maintenance, purchase of equipment, development costs, etc.),
- validation progress monitoring, the chapter covers the KPI table of the achieved objectives in the first pilot phase.

3 Pilot deployment phase 1 (pre-pilot)

The iFLEX pilot will be deployed in three separate phases. The transition from one phase to the next will be seamless as pilots run continuously rather than having a period of inactivity between pilot phases. The end/start of a pilot phase will indicate a scaling up of the number of end-users involved (recruited) and a technological development of the solution that will be implemented, tested and validated in the pilot phase. For the phase 1, a very small number of end-users have been involved and the focus has been on testing and validating the minimal viable product. In the following, the actual phase 1 deployment in each of the three pilot settings is described.

3.1 Greek pre-pilot deployment

3.1.1 Greek pre-pilot user selection and activities with them (HERON)

In the first pre-pilot phase, HERON has identified a pool of participants through targeting initially HERON and TERNA ENERGY (both companies are members of the GEK-TERNA group in Greece) employees. The informational campaign has identified residents from around 100 households willing to join the pilot with 80 of them committing on the installation of electricity smart meters. It is expected that they will be operational, once iFlex consent form is translated from Greek to English.

3.1.2 Acquisition of the first pre-pilot users

Group and unit leaders were given a presentation of HERON's smart metering platform and iFlex objectives, in addition a series of posts were made in intranet channels and by emails. The effort was repeated every 2-3 months to cover new hired colleagues. The number of households that have committed to join HERON's platform and consequently iFlex, contributes towards HERON's total objectives but however are not yet available for the pre-pilot. In order to demonstrate and validate the technical aspects of HERON's platform, (which acts as the backend for HERON's Smart Energy App) and its integration with iFlex assistant, one smart meter was installed at an employee's 4-member household. Access to the platform was given to the household member that followed the specified for this purpose consent process developed by HERON (see below), before signing the specific iFlex consent form.

During the drafting of the consent forms, unforeseen critical legal complexities were identified which significantly delayed the whole process, ultimately reducing the number of smart meter installations to one in order to meet the deadlines set by the installer. After giving the consent form to a pool of keen prospective pilot participants it was revealed that some of them where not the same person as bill payer; that is, the electricity supply was not registered on their name. This is a common feature in Greece in cases, for example, where parents may own the property in which the grown-up children live, or between couples were utility bills are divided based on the services (e.g. electricity, water, internet/phone etc). This realisation required an overhaul of the process following the advice of the DPO and through the combined effort of HERON's legal and R&D teams.

3.1.3 Installation of equipment

The Shelly 3EM 3-Phase Energy meter was installed on the user's 3-phase electrical system (Figure 1). The smart meter is connected via the user's Wi-Fi Network and provides API access for integration with HERON's platform and iFlex Architecture. The meter can provide 30sec measurements for each phase individually and for the installation's aggregated consumption. During the technician's visit it was decided that the installation's first phase (Phase-0 in HERON's platform) will be used for kitchen appliances and the second phase (Phase-1) for the washing machine. Using this as a guideline in future installations will allow iFlex to perform some "low tech" load disaggregation for at least the heavy loads.

Figure 1: The Shelly Smart Meter and the installation in the user's electrical board

3.1.4 HERON's Energy Metering Platform

Potential users are given a link to register in HERON's platform following a three-step process:

1. Register in the platform as the legal owner of the electricity supply (HERON Energy Metering Platform user is the bill payer) (Figure 2),
2. Read and accept the terms and conditions regarding access to the platform and participation in European Projects (Figure 3),
3. Give consent for access to personal data regarding consumption (total and disaggregated), generation and billing (Figure 3).

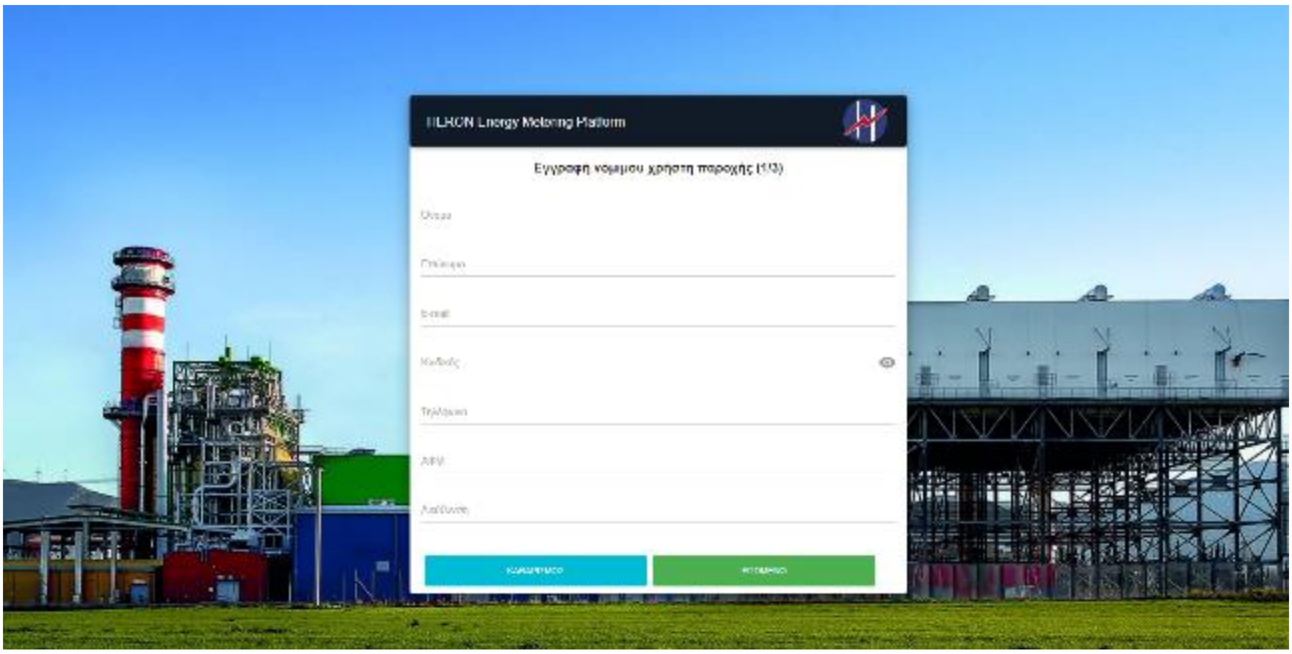


Figure 2: HERON home user registration page

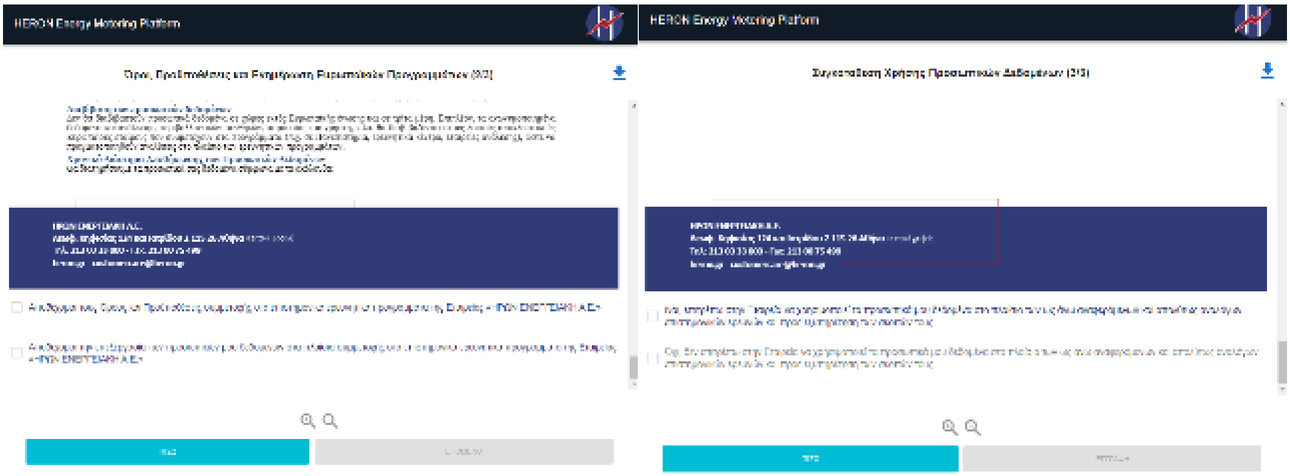


Figure 3: Screenshots where end-user accepts terms and condition and give consent for access to personal data (related to energy consumption)

The users accessing the platform will be able to review their energy consumption (kWh), the power their connected devices demand (W) and the voltage of their installation. All data can be given for three phases is the installation supports it, with the user able to set the period they want to review and the time interval.

Figure 4: Metrics for the past 2 days for iFlex selected user

3.2 Slovenian pre-pilot deployment

In the first pre-pilot phase, so-called friendly users (employees of ECE and ELE) were selected who met the basic age and location requirements. An interview was carried out with the selected pre-pilot users in the form of a workshop in which all Slovenian partners of the iFLEX project participated. In the interview, they acquainted the pilot users with the basic form of informed consent (collection and processing of personal data and informed them with all rights they have as participants in the iFLEX project) at the same time, technical information was obtained from the first pre-pilot users about built-in consumers / generators within household.

After the interview, a technical inspection of the existing installed equipment was performed on an individual pre-pilot user. All installation lines, built-in devices that use/generate electricity for their operation were inspected. Basically, the review checked the possibility of installing the Home Energy Management System (HEMS) (installation location and methods of connecting the HEMS system), defined consumers / generators that will be monitored and controlled with the help of iFA, primary focus was on consumers / generators, which represent the majority of produced and consumed electricity.

After reviewing the current situation of pre-pilot users, two HEMS systems from different manufacturers were installed at house of two different pre-pilot users. Detailed installation of the HEMS system and the validation of both systems can be found in the chapter technical validation.

3.2.1 Selection and recruitment of the first pre-pilot users

The first step that was took in the iFLEX project on Slovenian pilot is to invite employees of Slovenian partners (mainly ECE and ELE employees) to participate by determining the set of household consumers and generators of electricity that they are willing to put under iFLEX Assistant management. The focus was on household users who already have built-in electricity consumers and generators (e.g. solar power plant, heat pump, electric boiler, car charging station, etc.), consume electricity provided from ECE and are in the Kozjansko and Savinjska regions (see Figure 5).

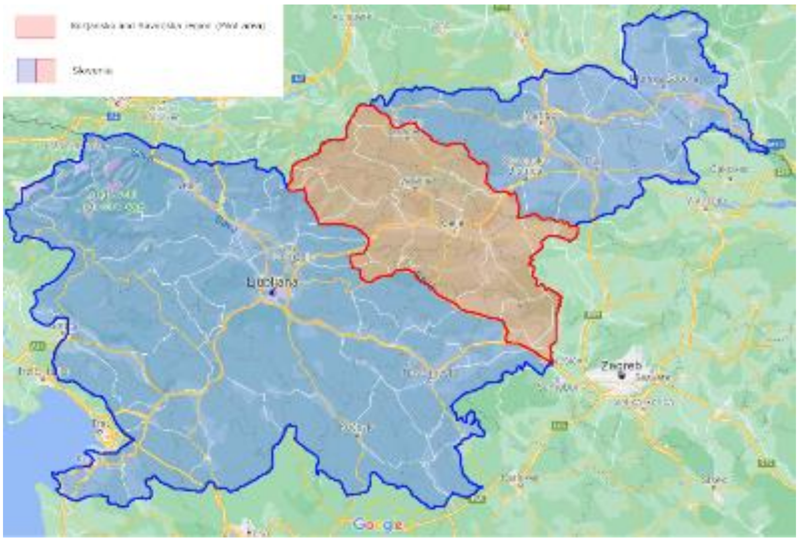


Figure 5: The area of Slovenia with the Kozjansko and Savinska region

3.2.2 Workshop with pre-pilot users

After recruiting the first 5. pre-pilot friendly users a workshop was held in order to get to know users better, the main guidelines of the iFLEX project were presented and obtained key information regarding to individual users build-in household equipment. On workshop the important data was provided and collected in terms of currently used energy consumption and energy generation devices. The description and type of energy devices used by pre-pilot users means a lot, because HEMS integration together with other external electronic will be faster. During the workshop a presentation of initial iFLEX Assistant end user interface mock-up has been given by ICOM. Main comments from the end users were that the EUI is too complex and should be simplified. The first simplification should be based on profiling the user first, and then prepare on this profile user preferences. The second simplification should be in a direction of providing a smart interface for flexibility market participation. Too many controls of devices should be omitted and replaced by GUI utilizing the features of the iFLEX Assistant like digital twin and automation, to achieve the goals set in user preferences in an automated way. More details about the workshop can be found in D6.5 Initial application-specific iFLEX Assistant prototype.

3.2.3 Technical inspections of pre-pilot users

Based on data collected in workshop with first 5. pre-pilot user a technical inspection of installed devices was performed. Inspection was mainly focus on large consumers and generators of electricity such as e.g., heat pump, solar power plant, e-bikes and car chargers. During the inspection, an inventory of the material that will need to be installed for each individual user were carried out and electrical schematic for each pilot users were drawn (Annex 1 Slovenian pre-pilot user electrical schematic). The capacity of the existing electrical cabinets (number of free spaces) and the connecting length between the main house cabinet and potential consumers that will be controlled via the HEMS were checked out and recorded. Also, a detailed inspection of the installed devices in terms of connection and further safe control of the device was performed. A brief pictorial summary of the electrical cabinets and installed user specific equipment can be found in Figure 6 below.

Figure 6: Build-in equipment in houses of first pre-pilot users

3.2.4 Home Energy Management System test and selection

As briefly described above in 3.2.1, two different HEMS systems were installed in the first pre-pilot phase to test the technical monitoring and controlling capabilities on the existing equipment installed at the pre-pilot users. Based on the tests, the manufacturer of HEMS systems is selected, which enables easy installation in the existing environment (use of existing pre build digital measuring devices and communication interfaces), enables advanced solutions for connecting to existing devices (connecting HEMS system to user devices via already built-in serial or parallel communication protocols), encourages the development of new drivers and extension communication protocols (HEMS manufacturer offers the development of software solutions that allow reading and writing to and from the control and status registers of pre-embedded user devices), and allows easy connection and communication of multiple HEMS systems integration into the iFA sub system.

3.2.4.1 Testing and verification the usability of the HEMS system (first manufacturer)

The first manufacturer's HEMS system was installed at the pre-pilot user environment, with the following specifications:

- living area of the building 250 m^2,
- connected power of the building 3x25 A (17 kW of power),
- built-in Landis + Gry E450 electricity distribution meter,
- a self-sufficient solar power plant with a rated power of 10,8 kW and Solar Edge ES17k inverter,
- boiler with a rated power of 3 kW.

HEMS was installed in a wall cabinet near the main installation wiring at the Solar Edge inverter from the solar power plant. As can be seen from Figure 7, the main unit of the HEMS system was connected to the existing home Internet via an Ethernet cable connection, and via the RS485 communication protocol on the external peripheral unit for measuring electrical current and voltage (indirect measurement of electrical power). Two external peripheral units for measuring electrical power have been installed, the first peripheral unit is intended for measuring the generated electric power on the solar power plant site, while the second peripheral unit is used to measure the consumption of the entire house.

1. Protective fuses (3x20 A for solar power plant and 1x5 A for HEMS),
2. Main HEMS unit,
3. Power meter for measuring power plant production (connected to HEMS),
4. Power meter for measuring house power consumption (connected to HEMS),
5. 230 V/ 50 Hz HEMS power supply,
6. RS485 serial connection for communication with electric power meters,
7. Ethernet physical connection to home internet.

Figure 7: End-user HEMS integration

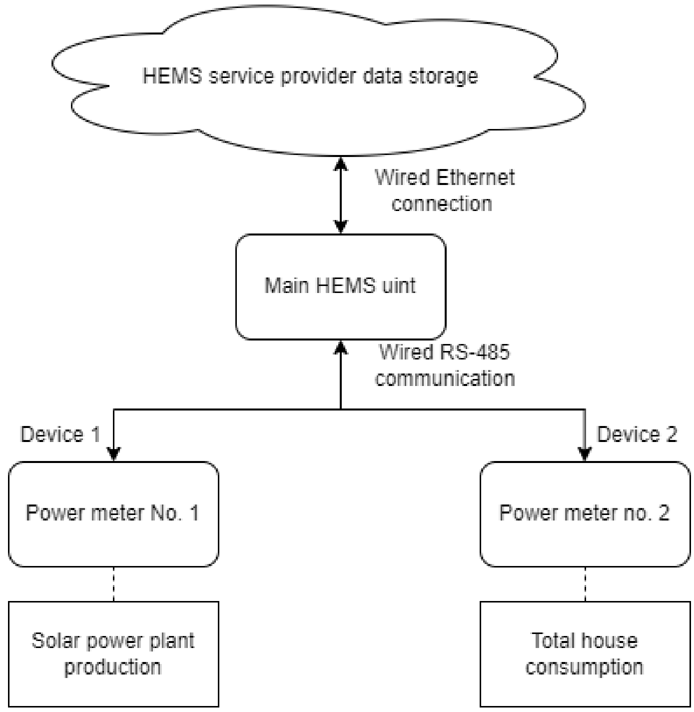


Figure 8: Flowchart of the installed devices (first manufacturer)

The manufacturer of the HEMS system provided an insight into the online graphic display to view the consumed and produced electricity within the building (Figure 9).

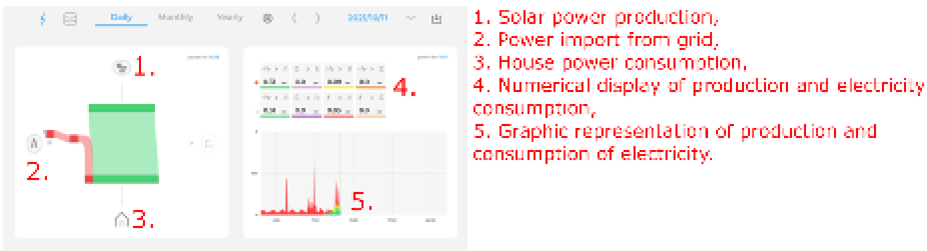


Figure 9: Graphical user interface

Based on the built-in HEMS system (first manufacturer), the following conclusion were identified:

- the first manufacturer's HEMS system proved to be very inflexible from the point of view of installation,
- poor protocol support of drivers (software drivers for protocols used by heat pump, solar power plant, power distribution meter, etc.),
- poor support of wireless communication between individual peripherals and the HEMS main unit,
- poor technical support of the staff responsible for the development of HEMS services,
- high final costs of the entire HEMS system,
- unknown communication protocol between iFA an HEMS cloud service.

3.2.4.2 Testing and verification the usability of the HEMS system (second manufacturer)

The second manufacturer's HEMS system was installed at the pre-pilot user environment, with the following specifications:

- living area of the building 220 m^2,
- connected power of the building 3x25 A (17 kW of power),
- built-in Landis + Gry E450 electricity distribution meter,
- a self-sufficient solar power plant with a rated power of 15,58 kW and Solar Edge ES17k inverter,
- heat pump BOSCH Compress 6000.

The second manufacturer HEMS system is experimentally installed in a surface-mounted iron cabinet (Figure 10) next to the Solar Edge inverter of the solar power plant and near the main distribution power meter for measured electricity consumption. The HEMS system consists of a main control unit and three external units. External peripherals or gateways are intended for communication conversion of various protocols, such as:

- RS485 (MODBUS RTU) to Ethernet,
- Meter bus (M-bus) to Ethernet,
- Energy management system (EMS) to Ethernet.

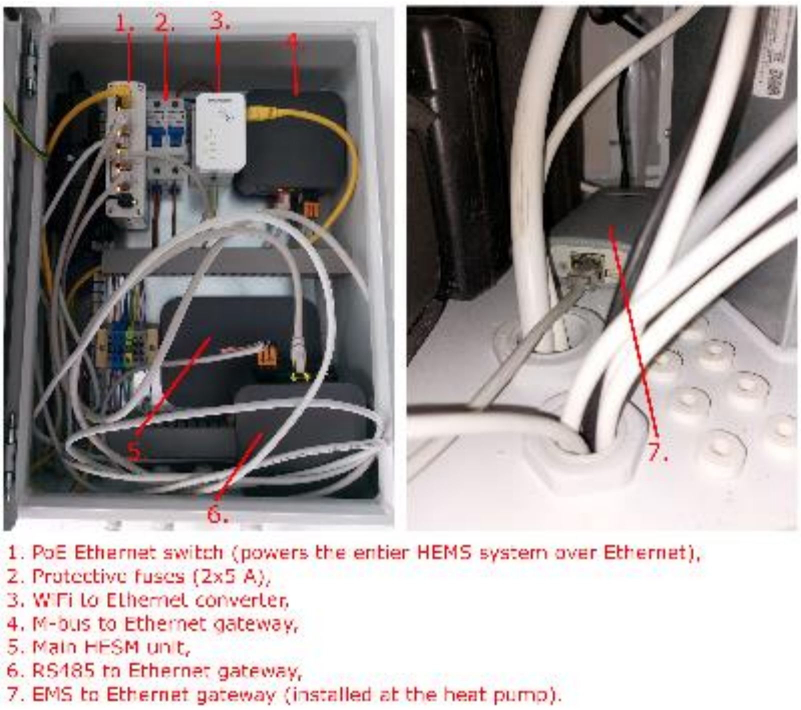


Figure 10: End-user HEMS integration

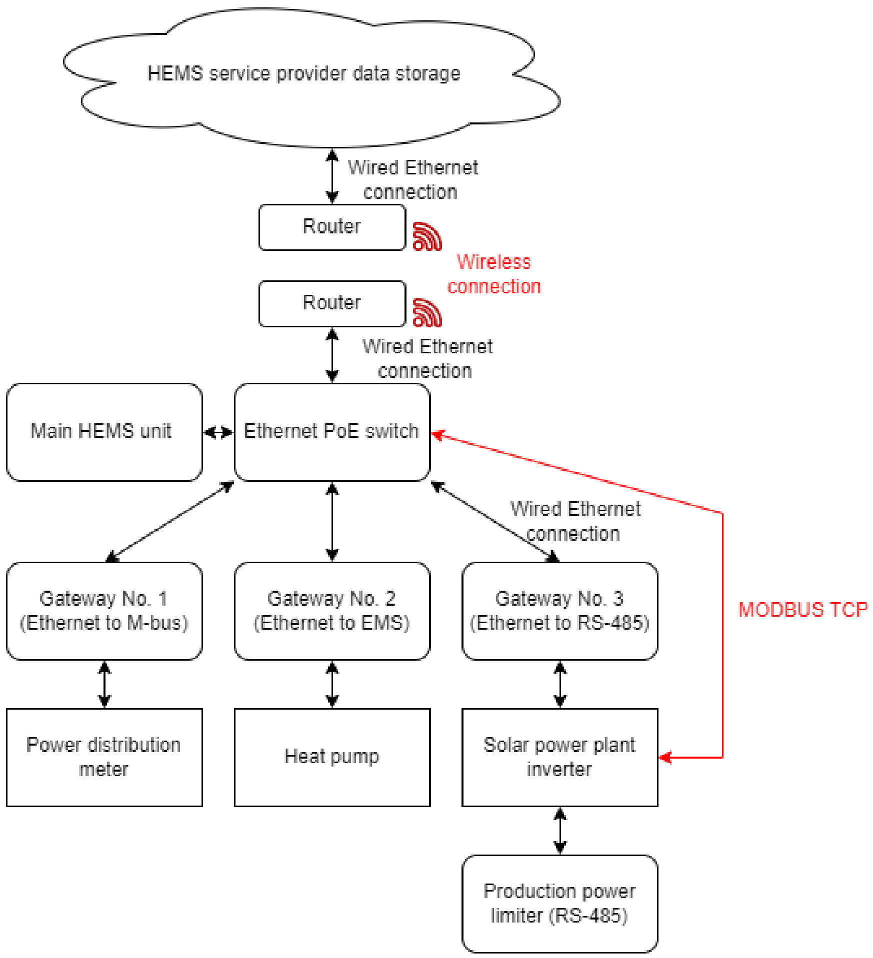


Figure 11: Flowchart of the installed devices (second manufacturer)

The gateway, which converts the serial RS485 to Ethernet communication protocol, is used for communication between the main HEMS control unit and the Solar Edge inverter from which data on produced energy, electric power and electric current and voltage (by phase) are collected (Figure 12).

Figure 12: Graphical user interface for solar power plant data representation

A gateway that converts M-bus (Meter bus) serial signal into an Ethernet signal was used for communication with distribution power meter from which data on voltage and current (by individual phase), consumed and produced energy and power are obtained (Figure 13).

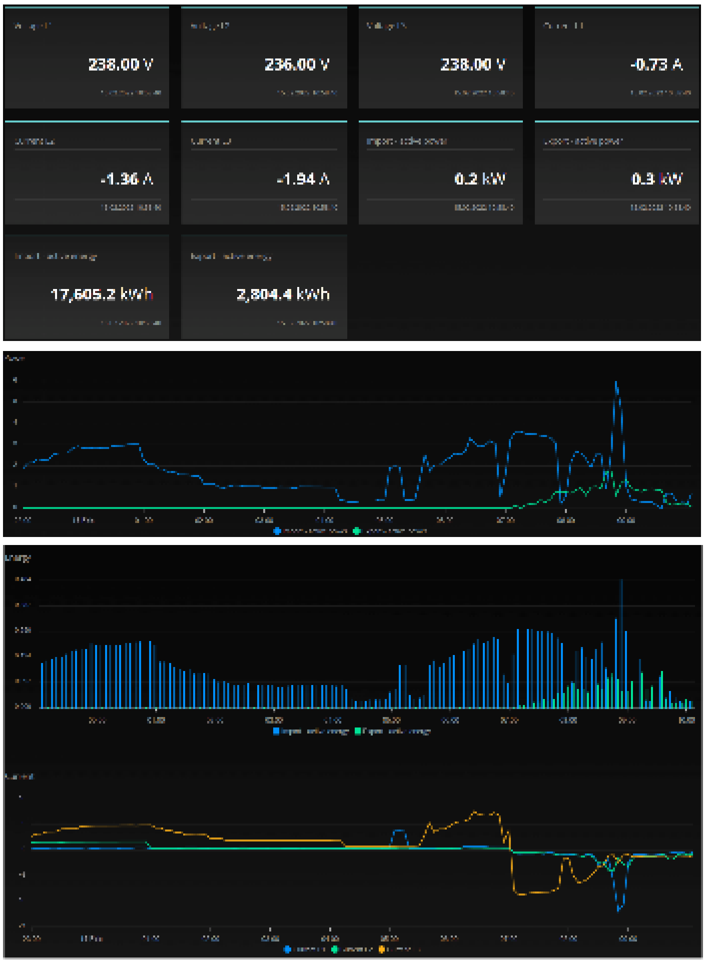


Figure 13: Graphical user interface for distribution power meter data representation

The last gateway used by the end user is the gateway to convert EMS signals to Ethernet. The mentioned gateway is installed inside the heat pump and is connected to the main HEMS controller via a wired Ethernet connection (the gateway also enables wireless WiFi connection). With the help of EMS to Ethernet gateway it is possible to read and set the parameters of devices that communicate via EMS data bus, these devices are (Figure 14):

- main heat pump controller,
- room thermostats,
- mixing valves.

Figure 14: Active and inactive devices on the EMS bus

Measurement and control parameters can be obtained for all active devices connected to the EMS bus. The measuring parameters can only be read from the EMS bus, while the control parameters can be read and written into device. For example, 77 measurement parameters (read-only) and 22 control parameters (read and write) can be obtained from the heat pump main controller (Figure 15 and Figure 16)

Boiler Data	
heating active	off
warm water active	off
selected flow temperature	32,0 °C
burner selected max power	0 %
heating pump modulation	0 %
heating pump 2 modulation	0 %
outside temperature	10,6 °C
current flow temperature	41,4 °C
return temperature	38,1 °C
system pressure	0 bar
exhaust temperature	0,0 °C
gas	off
flame current	0 uA
heating pump	on
fan	off
ignition	off
heating activated	on
heating temperature	85,0 °C
burner min period	10 minutes
burner min power	20 %
burner max power	100 %
hysteresis on temperature	-6,0 °C
hysteresis off temperature	6,0 °C
burner current power	0 %
burner starts	0 times
total burner operating time	0 minutes
total heat operating time	0 minutes
total UBA operating time	101 days 17 hours 40 minutes
last error code	/7760 start: 2021.11.05 18:15, end: none
service code	0H
service code number	203
operating time total heat	71 days 10 hours 58 minutes
operating time compressor heating	71 days 10 hours 58 minutes
operating time compressor cooling	0 minutes
operating time compressor warm water	0 minutes
operating time compressor pool	0 minutes
total compressor control starts	197 times
heating control starts	197 times
cooling control starts	0 times
warm water control starts	0 times
pool control starts	0 times
total energy consumption	4.037 kWh
energy consumption compressor total	3.831 kWh
energy consumption compressor heating	3.831 kWh
energy consumption compressor warm water	0 kWh
energy consumption compressor cooling	0 kWh
energy consumption compressor pool	0 kWh
auxiliary electrical heater energy consumption total	206 kWh
auxiliary electrical heater energy consumption heating	206 kWh
auxiliary electrical heater energy consumption warm water	0 kWh
auxiliary electrical heater energy consumption pool	0 kWh
total energy supplied	10.541 kWh
total energy supplied heating	10.541 kWh
total energy warm supplied warm water	0 kWh
total energy supplied cooling	0 kWh
total energy supplied pool	0 kWh
Compressor power output	0 kW
HP Compressor	off

Figure 15: The first set of measuring and control parameters collected from heat pump

Compressor Activity	none
HP Heating	off
HP Cooling	off
HP Warm water	off
HP Pool	off
Brine Pump Speed	0 %
Switch Valve	off
Compressor Speed	0 %
Circulation pump Speed	10 %
Brine in/Evaporator	0,0 °C
Brine out/Condenser	0,0 °C
Suction gas	32,2 °C
Hot gas/Compressed	44,9 °C
Heat carrier return (TC0)	38,2 °C
Heat carrier forward (TC1)	41,8 °C
condenser temperature (TC3)	41,0 °C
refrigerant temperature liquid side (condenser output) (TR3)	31,2 °C
evaporator inlet temperature (TR4)	26,6 °C
compressor inlet temperature (TR5)	32,2 °C
compressor outlet temperature (TR6)	44,9 °C
air inlet temperature (TL2)	8,6 °C
low pressure side temperature (PL1)	7,7 °C
high pressure side temperature (PH1)	8,0 °C
pool set temperature	28,0 °C
ww selected temperature	48,0 °C
ww set temperature	0,0 °C
ww selected lower temperature	42,0 °C
ww single charge temperature	65,0 °C
ww circulation pump available	off
ww hysteresis on temperature	-2,0 °C
ww hysteresis off temperature	0,0 °C
ww disinfection temperature	65,0 °C
ww circulation pump frequency	3x3min
ww circulation active	off
ww activated	on
ww one time charging	off
ww disinfection	off
ww charging	off
ww recharging	off
ww temperature ok	off
ww heating	off
ww starts	0 times
ww active time	0 minutes

Figure 16: The second set of measuring and control parameters collected from heat pump

It is also possible to obtain 2 measuring and 2 control parameters from each mixing valve (Figure 17) and 9 measuring and 26 controller parameters from each room thermostat (Figure 18).

Mixer Data	
hc1 flow temperature in assigned hc (TC1)	33,7 °C
hc1 mixing valve actuator in assigned hc (VC1)	24 %
hc1 setpoint flow temperature	32,0 °C
hc1 pump status in assigned hc (PC1)	on

Figure 17: Measuring and control parameters collected from mixing valve

Thermostat Data	
date/time	11:28:29 15/02/2022
floor drying	off
damped outdoor temperature	6,8 °C
floor drying temperature	0,0 °C
building	medium
minimal external temperature	-13,0 °C
ww mode	low
ww circulation pump frequency	own_prog
ww charge duration	1 hour
ww charge	off
ww disinfection	off
ww disinfection day	tu
ww disinfection time	2 hours
hc1 selected room temperature	21,5 °C
hc1 current room temperature	21,7 °C
hc1 mode	manual
hc1 mode type	comfort
hc1 eco temperature	15,0 °C
hc1 manual temperature	21,5 °C
hc1 comfort temperature	21,0 °C
hc1 summer temperature	17,0 °C
hc1 design temperature	45,0 °C
hc1 offset temperature	0,0 °C
hc1 min flow temperature	25,0 °C
hc1 max flow temperature	58,0 °C
hc1 room influence	5,0 °C
hc1 current room influence	0,0 °C
hc1 nofrost temperature	5,0 °C
hc1 target flow temperature	32,0 °C
hc1 heating type	radiator
hc1 set summer mode	auto
hc1 summer mode	off
hc1 control mode	optimized
hc1 program	prog_1
hc1 fast heatup	0 %

Figure 18: Measuring and control parameters collected from room thermostat

Based on the built-in HEMS system (second manufacturer), the following conclusion were identified:

- the second manufacturer's HEMS system has proven to be a very useful and elegant solution for the end user,
- external peripherals can be connected to the HEMS system both wired and wireless,
- the manufacturer of the HEMS system is flexible to implement new drivers for connection to the existing end-user equipment (software drivers for connection to major electric generators and consumers such as heat pumps, solar power plants, distribution meters, etc.),
- with the help of the HEMS system and external peripherals (gateways), we obtained a number of control and measurement parameters that are crucial for the iFLEX project.

3.3 Finnish pre-pilot deployment

In the Finnish pilot an iFLEX Assistant is deployed into an apartment building to demonstrate how the iFLEX Assistant provides flexibility management for the whole building community. The iFA is responsible for forecasting the buildings baseline consumption and flexibility both for electricity and district heating (DH). The flexibility in the apartment building comes from the buildings heating system and thermal mass of the building which can be used for shifting the DH and electricity (heat pump) consumption.

From use case point of view, Finnish pilot focuses mainly on the HLUC-3: *Manage flexibility at building community level* (see D2.1 for description of the use cases). In the first phase, the pilot demonstrated and validated technical functionalities providing explicit DR at the apartment building level. The following list the objectives planned for the phase 1:

1. To validate the technical functionality related to data collection (online and historical) and control of flexible resources.
2. To provide forecast on the buildings' electricity and district heating consumption (baseline consumption without demand response events) and evaluate the initial accuracy of the forecasts against measurement data.
3. To demonstrate and evaluate the how building's thermal mass can be used as a source for flexibility by controlling HVAC the building. Indoor air temperature and relative humidity values will be monitored for ensuring occupants' thermal comfort.
4. To evaluate how accurately the initial iFLEX Assistant is able to estimate the building's flexibility and response to flexibility activations.
5. To demonstrate visualization features at building (electricity and district heating consumption, CO_2 footprint, average thermal comfort) and apartment level (thermal comfort).
6. To evaluate the end-user feedback features, including feedback on thermal comfort and general feedback on the end-user interface and the features desired by the user.

The Finnish pilot building is depicted in Figure 19. The building is owned by HOAS and it provides rental flats for students. It consists of 93 apartments and has over 140 residents. The pilot was advertised to all the residents of the building. Every resident has access to the User Interface that provides visualizations about the buildings' energy consumption, CO2 emissions, thermal comfort measurements (registration required), as well as, the possibility give feedback about the thermal comfort. During the 1st phase four residents registered to the pilot and sensors (temperature, humidity and CO2) were deployed into their premises.


Figure 19: The apartment building for the Finnish pilot

The building is equipped with a Building Management System (BMS) that enables monitoring and controlling the building's assets, including district heating substation, radiator-based heating network, heating of domestic hot water, exhaust air heat pump and related ventilation solution. A monitoring view of the BMS is presented in Figure 20.

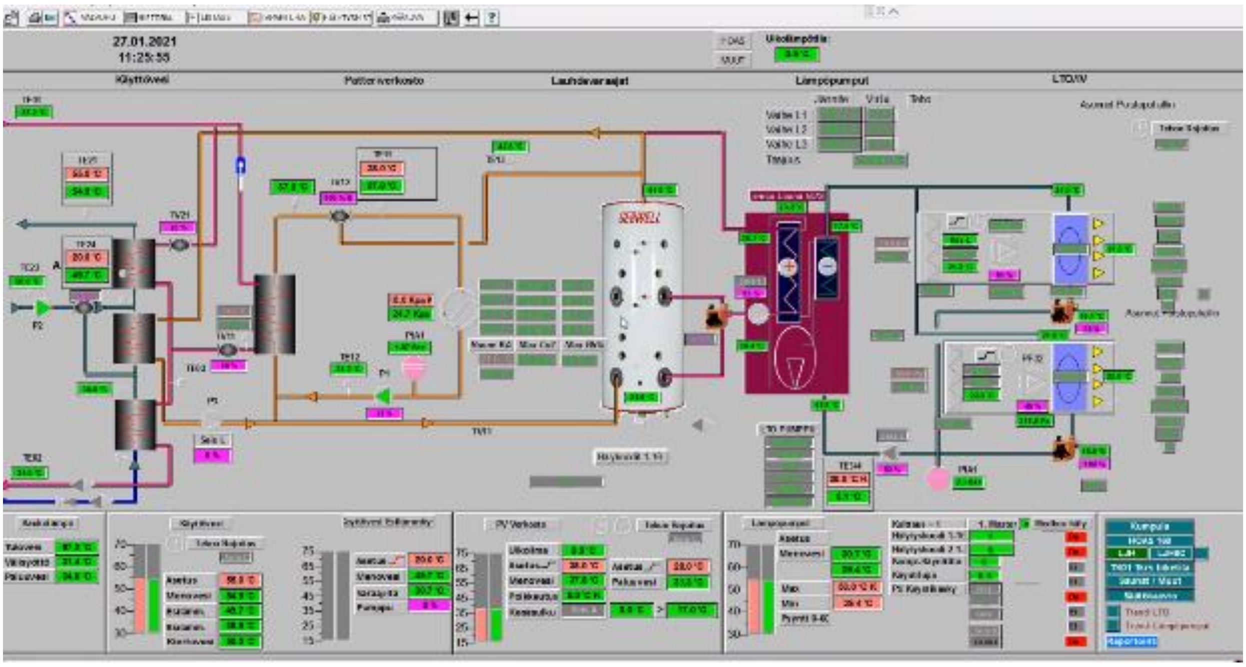


Figure 20: Monitoring view of the building management system

There were some limitations in the buildings BMS that were fixed during the piloting phase. First limitation was that the building did not have an open connection for the iFLEX Assistant to access the measurements and send control commands. To overcome this problem a JACE gateway was deployed to the pilot building. How the iFLEX Assistant interfaces with the building automation system via the JACE gateway is described in more detail in D4.1. A second limitation was that the district heating measurements were only available at 60-minute sampling rate, which is too low for our purposes. A new interface (card) was added to the DH meter to allow reading the cumulative energy and power measurements at higher frequencies. The following lists the measurements that are being collected to the RAI of the iFLEX Assistant:

1. Weather forecast data.
2. Building level electricity consumption at five second resolution.
3. District heating power and energy in 20 second time resolution.
4. Ventilation units' return air temperature and optionally return air relative humidity and CO_2.
5. Average indoor air temperature, relative humidity, and CO_2 of the apartments.

6. District heating, heating network, domestic hot water and exhaust air heat pump supply and return water temperature and related setpoint values.
7. Status information (percentage or on/off) on water pumps', fans', control valves' and heat pump compressor status.
8. Extract air temperature of the exhaust air heat pump.

In addition to the measurements, an interface for controlling the water temperature of the space heating was implemented to the BMS. Additionally, a restriction program that monitors thermal comfort of the building was developed to ensure residents comfort also in situations where the iFLEX Assistant's connection to the building is compromised e.g. by network issues.
The data collected from the buildings is used by the End-user Interface (EUI) and the Automated Flexibility Management components. The EUI deployed for the Finnish pilot provides users with:

- Building's district heating and electricity consumptions.
- CO2 footprint of the apartment building
- Feedback mechanisms (thermal comfort and common feedback)
- Apartment specific thermal comfort measurements (only for registered users)
- Apartment specific thermal comfort feedback (only for registered users).

Screenshots of the EUI adapted for the Finnish pilot are represented in Figure 21. The EUI is described in more detail in D3.4 – Initial Natural User Interfaces.

Figure 21: Screenshots from the End-user Interface tailored for the Finnish pilot

The AFM and the associated Digital Twin of the building utilize the measurement data collected from the pilot building to learn the consumer behaviour and dynamics of the building's heating system. This is needed to forecast the baseline load profile and flexibilities at the building level. The AFM module is also responsible for sending the control commands to the BEMS via RAI when flexibilities are activated by the Aggregator. In the 1st phase, the iFA is not yet connected to an aggregation platform. Instead, a demonstration interface, presented in Figure 22 and Figure 23, is used for representing the forecasts and activating the flexibilities. The demonstrator interface visualizes the flexibility forecast and provides means for sending flexibility signals to the iFA.

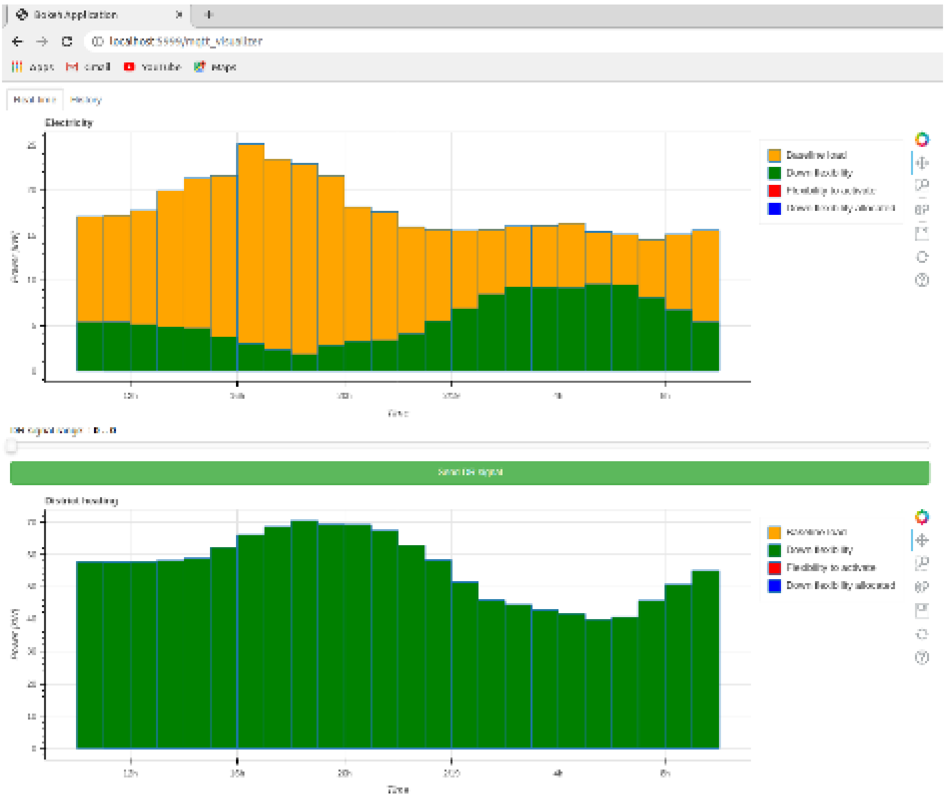


Figure 22: Demonstration interface visualizing the baseline and flexibility forecasts for electricity and district heating in the Finnish pilot building

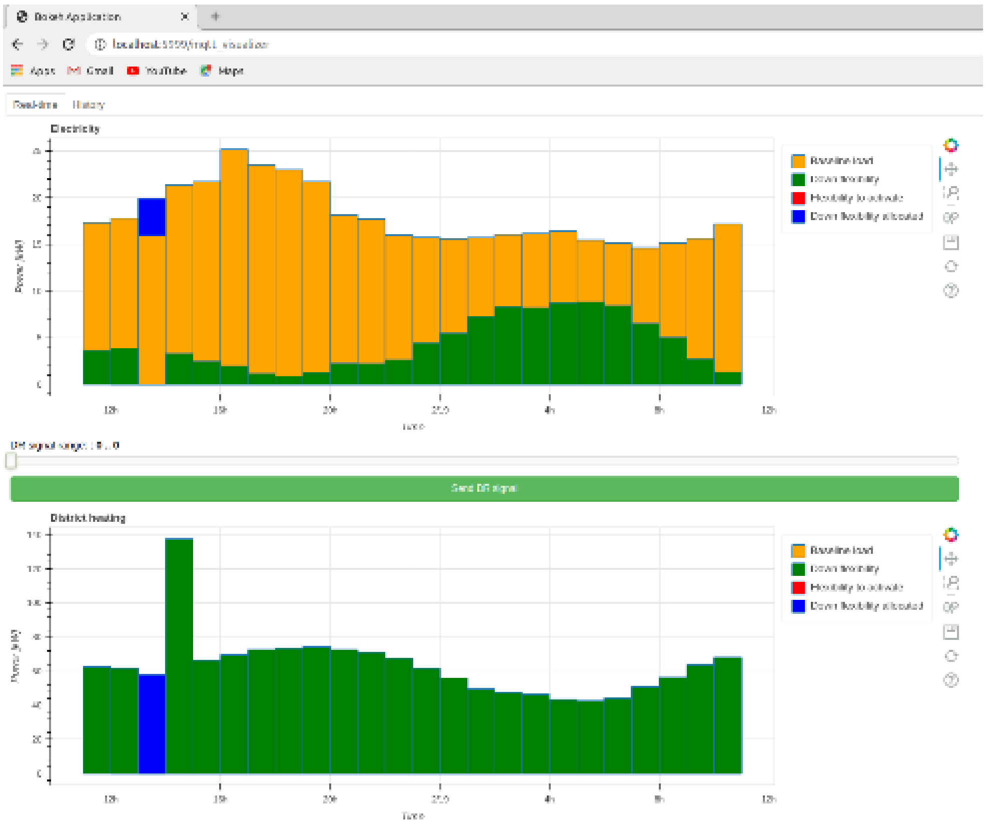


Figure 23: Demonstration interface visualizing the baseline and flexibility forecasts for electricity and district heating in the Finnish pilot building. The flexibility for period from 13:00 to 14:00 ECT was activated for both electricity and district heating vectors

In addition to the validating the functional requirements the objective was to evaluate the accuracy of the initial building models developed in WP3. In the first phase, state-of-the-art machine learning methods were tailored for forecasting the baseline loads (electricity and district heating) of the building. The lead time of the forecast was zero (i.e., the forecast period started from the current time onwards) and the length of the forecast was 24h. 60-minute sampling rate was used. The root-mean-square error (RMSE) for district heating and electricity baseline forecasting were 14.4 kW and 2.1 kW, respectively. When normalized with respect to minimum and maximum values, the NRMSE for DH and electricity were 7.8% and 7.6%, respectively. These are quite good results

To summarize, the 1st phase pilot was successful, and we were able to meet all six objectives set in the pilot specification (D7.1). All the functionality planned for the phase 1 was successfully demonstrated and validated.

4 Validation plan for phase 1

The project's validation framework and plan were defined in D7.4 in the beginning of the project. The validation plan allows for minor adjustments to ensure that the validation activities suit the actual stage and context of the project. The following sections briefly describe the key objectives and the validation activities that have been carried out for the different aspects of the validation of the pre-pilot phase.

4.1 End user validation plan

In the project context, it is possible to distinguish between two types of end-users:

- iFLEX Assistant (iFA) end-users or pilot end-user: consumers/prosumers (also referred to as pilot participants) who are recruited by the pilot owner (or hosts) to participate in their pilot cluster
- Pilot owners: market participants (e.g. Aggregator) who are partners in the project and who make up the pilot cluster.

However, for the purpose of the end-user validation, we focus on the pilot end-users with the aim to assess and validate the iFLEX solution (which includes the iFA) as a tool for making participation in demand response easy and attractive. End user experience here encompasses user acceptance, satisfaction and usability, which are considered as being intrinsically linked.

In D7.4 Validation frameworks and plans, two overall validation items, or activities, were identified:

- Usability focusing on prototype user interface (UI) of the iFLEX Assistant App (efficiency and effectiveness)
- User acceptance of the iFLEX concept, focusing on acceptance of the use cases as well as the main functionalities and user interface (of the iFLEX Assistant).

Usability testing with pilot end-users focused on the prototype user interface (UI) of the iFLEX Assistant App and the primary objective was to get initial feedback from end-users on their experience in using basic functions of the application and the concepts of the solution (e.g. demand response event, iFA suggestions, notifications). Through this feedback suggestions for changes and improvements that can be implemented for the 2nd phase of the pilots were identified. The usability tests of the UI overlaps to some extend with the technical validation activities, since access to the prototype application was provided to the end-users and a series of tasks was requested.

User acceptance of the iFLEX concept was first investigated from a wider perspective by distributing a public survey in the three pilot countries. The overall objective was to collect data from the general public on their overall opinions, attitudes and perceptions related to demand response and the concept of iFLEX. In particular, we wanted to find out what it would take for the general consumer/prosumer to participate in energy flexibility and how they would like to manage this flexibility, notably with regards to automation, user control and notifications (in the iFLEX Assistant).

In chapter 5, we will first present the methodology used and the feedback received from end-users, followed by the key results from both the usability tests and public survey.

4.2 Technical validation plan

As presented in D7.4 the technical validation has different focus areas/activities:

- Requirements validation (analyse use cases and requirements)
- Perform internal verification activities
- Pilot validation of iFLEX Framework and the application-specific iFLEX Assistants (iFA).

The actions taken for the realisation of these validation activities are presented below, whilst their results are presented in chapter 6.

4.2.1 Requirements validation

For the management of the requirements process, the JIRA tool has been installed and configured with the iFLEX requirement template. The tool allows to model and monitor the full lifecycle of requirement from definition to resolution (see D7.4 for more details), as well as to edit and comment the specification of a requirement. Towards this, different views (aka groups) of requirements were modelled in JIRA on the basis of component and pilot, to facilitate monitoring.

The requirements modeled during the initial requirement definition phase (M7) were updated during this period leveraging discussions among project partners, workshops with the pre-pilots' users and maturing of design activities. In the context of these work, any needed updated in requirement definition/scope was introduced, duplicate requirements were removed, whilst the timeline for deployment per pilot was also updated.

4.2.2 Perform internal verification activities

The realisation of verification activities involved a limited scope component/unit tests and integration tests with the focus on testing of core functionality. For testing, a fine-grained documentation of functionalities to be tested for each interfaces the pre-pilot was available in JIRA.

4.2.3 Validation of iFLEX Framework and application-specific iFLEX Assistants

For this phase the validation focused on functional testing of specific iFA instances (Minimum Viable Products) of the different pilots. The functionalities offered by iFA were validated in contract to the Use Cases of the project (D2.1). This validation was of reduced scope since different maturity levels exist in the prototype component of iFA for the different pilots.

4.3 Business validation plan

According to D4.7 and towards the calculation of ROI (BV1), feasibility of BUCs (BV5), business sustainability of BUCs (BV6), business feasibility of enhanced DR services (BV7) and business sustainability of enhanced DR services (BV8), the business validation has currently been focused on:

- The aggregation of cost parameters for the pilot deployments in the 3 countries, namely Finland, Slovenian and Greece, in order to calculate realistic capital expenditures involved in the provision of the iFlex services in the various BUCs.
- The estimation of operational cost parameters for the various BUCs, according to the pilot operation in the 3 countries, namely Finland, Slovenian and Greece.

4.4 DoA KPIs validation plan

Table 1 list the project KPIs that will be monitored after each piloting phase. The final list of KPIs will be validated only at the final validation phase. The target value refers to the final target at the end of the project.

Table 1: A list of project KPIs validated after each pilot phase.

ID	Validation item (description)	Success / Acceptance criteria		Validation method	Validation input (data to be collected, documents, ...)
		Target	Validation measures		
VDOA10	KPI5a - Technology readiness of the iFLEX Framework and iFLEX Assistant prototypes	TRL 7	The iFLEX Framework and application-specific iFLEX Assistants, developed with the framework, have been demonstrated in operational environment.	Validate TRL 7 measures for pilot solution with stakeholders and pilot users. Questionnaire results confirming TRL7	Measures for TRL 7, Pilot solutions, Framework, Business model
VDOA11	KPI5b - Number of innovative demand response and holistic energy management services	5	Total number of new demand response and energy services, including holistic energy management services combining energy with non-energy benefits.	Count innovative DR services – DR services not available among project partners and in pilot sites when the project started.	Baseline DR services, List of new DR services, D2.1 Use cases and requirements, D5.4 Final iFLEX consumer engagement and incentive mechanisms,
VDOA12	KPI6a - Number of consumers in the pilots	>600	Total number of consumers/prosumers in the iFLEX pilots.	Count customers involved into each pilot. Final count of all consumers involved in all pilots.	List of all consumers, prosumers and their consumer group (type)

VDOA13	KPI6b - Number of consumer groups targeted with novel demand response services	3	Total number of different consumer segments that have been engaged with demand response through the pilots.	Count customer groups involved into each pilot. Final count of all consumer groups involved in all pilots.	List of all consumers, prosumers and their consumer group (type)

5 End user validation

As mentioned above, the end-user validation activities for the phase 1 pilot consisted of i) usability tests and ii) a public survey.

5.1 Usability test

5.1.1 Methodology for usability testing

Usability is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." (Stone, D., Jarrett, C., Woodroffe, M., & Minocha, S., 2005). After completing the development of 1st prototype applications providing the Graphical User Interface (GUI) of iFA, their usability was tested in the form of performing basic tasks. The aim of these test was to gather feedback in order to improve their user-friendliness as well as validate their main concepts, based on users' comments. Towards this, a questionnaire was formulated to guide the objectives of the test and feedback collection (see Annex 3: iFLEX Assistant Usability Questionnaire).

Since the iFA is not fully deployed, the target audience was asked to use parts of the solution (the rest was mocked) or was presented a demo video of the application in order to evaluate design's effectiveness as well as basic concepts communicated. In more detail, the two different methods used for the realisation of the usability tests were the following:

1. Online interviews were conducted during which participants:
    - Were provided remote access to the application and followed instructions to complete the tasks;
    - Responded to questions for their experience asked by interviewers
    - Were asked to fill out the questionnaire after the session so better feedback can be provided
2. A video presenting the tasks was shared with participants along with the questionnaire. This method was used only for some of the participants of the Greek Pilot.

5.1.1.1 Participants

The participants were people of all ages with different background, who had no previous experience with the applications. Some of the participants were related to the project and some were not. For the Greek pilot, 6 people took part in the online interviews and 5 people watched the demo video that was created. All 11 participants were asked to fill out the questionnaire. In the Slovenian pilot, 5 participants have participated in the usability test with online interviews who then were asked to fill out the questionnaire.

5.1.1.2 Procedure

For the online interviews the participants' responsibilities were to attempt to complete a set of representative task scenarios presented to them in as efficient and timely a manner as possible, and to provide feedback regarding the usability of the user interface. The participants were directed to provide honest opinions regarding the usability of the application, and to participate in post-session subjective questionnaires.

Participants took part in the usability test via remote screen-sharing technology. The participants were seated at their workstation in their work environment. An application (e.g. Teams, WebEx) for the online meeting was used.

During the meetings, participants were given instructions in order to complete different tasks (see 5.1.1.3) while using the actual app (moderated usability test) whilst were asked questions on their experience. The participant's interaction with the application was monitored by the facilitator. The facilitator briefed the participants on the application and informed the participant that they are evaluating the application and that there is no right or wrong answer. For participant with no prior relation to the project and/or demand response concept a brief introduction was made. At the start of each task, the facilitator read aloud the task description and asked the participant to begin the task. After all tasks had been attempted, the participant completed a post-test satisfaction questionnaire.

5.1.1.3 Tasks

The usability tasks were derived as test scenarios developed from the use cases and requirement implemented for the 1st phase, relevant to iFA's GUI. Due to the range and extent of functionality provided in the application, and the short time for which each participant was available, the tasks were the most common and relatively complex of available functions. The concerns, questions and goals for usability test were identified. These items also drove the tasks chosen for the usability test.

The tasks were identical for all participants on a pilot basis. 12 tasks were created for the Greek and 13 for the Slovenian pilot testing the following screens: Schedules, DR Events, Notifications, Objectives, Profile, Notifications Settings and Energy Monitoring (see D3.4 Initial Natural User Interfaces).

The tasks are presented in the following table:

Table 2: Usability Test: Tasks Definition

Task ID	Task Description	Screen
1	Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.	Schedules
2	In Preferences add a new Schedule Operation Mode for your boiler with the title "Schedule for the boiler" from Monday to Wednesday for the hours 12:00 - 16:00. Make it flexible so that its operation complies with certain time limits (Duration 1hr and 15mins) instead of a fixed time period.	Schedules Form
3	You want to set the Objectives with which the iFLEX Assistant will make decisions to help you achieve them. Activate your optimization policy to be ONLY the "Energy Cost Minimization".	Objectives
4	You get notified about a new DR Event. After checking the details about the time and the date, agree to participate in the DR Event.	Notifications
5	You get notified by iFLEX Assistant of a suggested action in order to participate in the DR Event. Accept the suggested action.	Notifications
6	You changed your mind, find the DR Event you have agreed to participate in and it has not yet taken place and cancel your participation.	DR Events
7	Check out the DR Event you rejected to participate in on 29 of May 2021	DR Events
8	Check out the DR Event in which you participated on January 14th 2021. Check out the suggested schedule for your boiler and tell me the points you gained from it.	DR Events
9	So, in order to check if the boiler really operated at that time because of the DR Event, you have to monitor your energy for the same day. Find your energy data from January 14th 2021 and then check the total consumption of your boiler and its operation time. **Note**: This task was used only in the Slovenian Pilot.	Monitor my Energy
10	Change your Profile from Manual Mode (manual accept/reject your notifications) to Auto Mode (leave it up to iFLEX Assistant to decide if and how you will participate in the upcoming DR Events).	Profile
11	Check the notification you just received from iFLEX Assistant informing you of the decision taken automatically in order to participate in a DR Event.	Notifications
12	For the next period of time, you don't want to receive any push notifications on your mobile phone. Mute all push notifications for the next two hours.	Temporary Silence
13	You work between 9:00-17:00 every day so you don't want to get distracted by push notifications from iFLEX Assistant. Create a rule that will prevent the iFLEX Assistant from bothering you with push notifications during those hours.	Silence Rule

5.1.1.4 Usability Metrics and Goals

During the online interviews, the facilitator recorded participant's actions and comments and based on these, data were generated. For each participant, the problems encountered during the completion of a task, actions and comments (both positive and negative) were recorded. Then the usability metrics were evaluated against the pre-approved goals, subjective evaluations, and specific usability problems and recommendations for resolution. An example of how each participant's progress was captured is presented in the next figure.

USER ID	SCREEN	TASK	COMPLETED	Efficient Way	PROBLEMS
1	Schedules	1	YES	NO	cant see heat pump
1	Schedules Form	2	YES	YES	-
1	Objectives	3	NO	-	Didn't deactivate the other option
1	Notifications	4	YES	YES	-
1	Notifications	5	YES	YES	-
1	DR Events	6	YES	YES	-
1	DR Events	7	YES	YES	-

Figure 24: Usability Test: Interview Assessment example

Usability metrics refer to user performance measured against specific performance goals necessary to satisfy usability requirements. Some common metrics utilized for usability tests' assessment are scenario completion success rate, error rate, efficiency rate and error-free rate (see Nielsen, J. (2012). Usability 101: Introduction to usability). The metrics are defined in the table below.

Table 3: Usability Test: Metrics

Metric	Target
Success rate: The percentage of users in the testing group who ultimately completed the assigned task without critical errors.	A success rate of 75% was the goal for each task in this usability test.
Critical Errors: Critical errors are deviations at completion from the targets of the scenario. Obtaining or otherwise reporting of the wrong data value due to participant workflow is a critical error. Participants may or may not be aware that the task goal is incorrect or incomplete. A critical error is defined as an error that results in an incorrect or incomplete outcome. **Non-critical Errors:** Non-critical errors are errors that are recovered from by the participant or, if not detected, do not result in processing problems or unexpected results. Although non-critical errors can be undetected by the participant, when they are detected they are generally frustrating to the participant. These errors may be procedural, in which the participant does not complete a scenario in the most optimal means (e.g., excessive steps and keystrokes). These errors may also be errors of confusion. A non-critical error is an error that would not have an impact on the final output of the task but would result in the task being completed less efficiently.	Any task in which a critical error was made will be recorded
Efficiency Rate: The percentage of the users who completed the tasks in the best possible way. It shows the amount of cognitive resources it takes for a user to complete tasks. How long does it take a user to complete a task? Do users have to expend a lot of mental energy when completing a task?	An efficiency rate of 75% was the goal for each task in this usability test.
Error-Free Rate: The percentage of test participants who complete the task without any errors (critical or non-critical errors).	An error-free rate of 60% was the goal for each task in this usability test.

5.1.2 Results of usability tests

5.1.2.1 Interviews' Evaluation

The data generated by the test conducted during the online interviews are presented in this section. The focus is on tasks with lower than the goals rates in the various usability metrics are listed below. Possible causes of problems were identified that prevented participants from performing the task correctly, in order to perceive the pain points of the design that confused the users. The analysis of these problems and the answers in the questionnaire revealed future features and changes that can be made to the applications and/or its concepts in order to be more user friendly.

<u>Tasks with success rate < 70%</u>

Pilot	Task	Possible causes
Slovenian	In order to check if the boiler really operated at that time because of the DR Event, you have to monitor your energy for the same day. Find your energy data from January 14th 2021 and then check the total consumption of your boiler and its operation time.	Not clear time alignment in line type graph
Greek	Change your Profile from Manual Mode (manual accept/reject your notifications) to Auto Mode (leave it up to iFLEX Assistant to decide if and how you will participate in the upcoming DR Events). (100% in mobile)	Toggle button status not clear (**fixed**: added text in toggle)

<u>Tasks with efficiency rate < 75%:</u>

Pilot	Task	Possible causes
Slovenian	Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.	The details in the schedules are not visible
	In order to check if the boiler really operated at that time because of the DR Event, you have to monitor your energy for the same day. Find your energy data from January 14th 2021 and then check the total consumption of your boiler and its operation time.	Not clear time alignment in line type graph
	For the next period of time, you don't want to receive any push notifications on your mobile phone. Mute all push notifications for the next two hours.	Temporary silence concept/ term not clear
Greek	Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.	The details in the schedules are not visible
	In Preferences add a new Schedule Operation Mode for your boiler with the title "Schedule for the boiler" from Monday to Wednesday for the hours 12:00 - 16:00. Make it flexible so that its operation complies with certain time limits (Duration 1hr and 15mins) instead of a fixed time period.	Pop up message was confusing (fixed
	You changed your mind, find the DR Event you have agreed to participate in and it has not yet taken place and cancel your participation.	Second tab not easily visible
	Change your Profile from Manual Mode (manual accept/reject your notifications) to Auto Mode (leave it up to iFLEX Assistant to decide if and how you will participate in the upcoming DR Events).	Couldn't understand in which mode they were (fixed
	For the next period of time, you don't want to receive any push notifications on your mobile phone. Mute all push notifications for the next two hours.	Temporary silence concept/ term not clear

Tasks with Critical Errors:

Pilot	Task	Possible causes
Slovenian	You want to set the Objectives with which the iFLEX Assistant will make decisions to help you achieve them. Activate your optimization policy to be ONLY the “Energy Cost Minimization”.	Visibility of options - scrolling
	Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.	Expected to be activated upon save, not clearly visible that schedule was still inactive upon save
Greek	Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.	The details in the schedules are not visible
	Change your Profile from Manual Mode (manual accept/reject your notifications) to Auto Mode (leave it up to iFLEX Assistant to decide if and how you will participate in the upcoming DR Events). X2	Pop up message was confusing (fixed)

Tasks with Error-Free Rate < 60%

UI for the Slovenian Pilot	UI for the Greek Pilot
Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.	Check out your Schedules in Preferences. Activate the Schedule Operation Mode for the days from Monday to Sunday 6:30 -7:00 for the boiler and 18:00-23:00 for the heat pump.
In order to check if the boiler really operated at that time because of the DR Event, you have to monitor your energy for the same day. Find your energy data from January 14th 2021 and then check the total consumption of your boiler and its operation time.	In Preferences add a new Schedule Operation Mode for your boiler with the title “Schedule for the boiler” from Monday to Wednesday for the hours 12:00 - 16:00. Make it flexible so that its operation complies with certain time limits (Duration 1hr and 15mins) instead of a fixed time period.
Change your Profile from Manual Mode (manual accept/reject your notifications) to Auto Mode (leave it up to iFLEX Assistant to decide if and how you will participate in the upcoming DR Events).	
For the next period of time, you don’t want to receive any push notifications on your mobile phone. Mute all push notifications for the next two hours.	
Possible causes of Problems	**Possible causes of Problems**
• **the details in the schedules are not visible** • **The line graph** • **temporary silence concept/ term not clear** • **The option for auto mode profile is hidden when first used**	• Toggle not visible • “Make it flexible” concept not clear

A summary of the tests’ metrics are presented in the following figure.

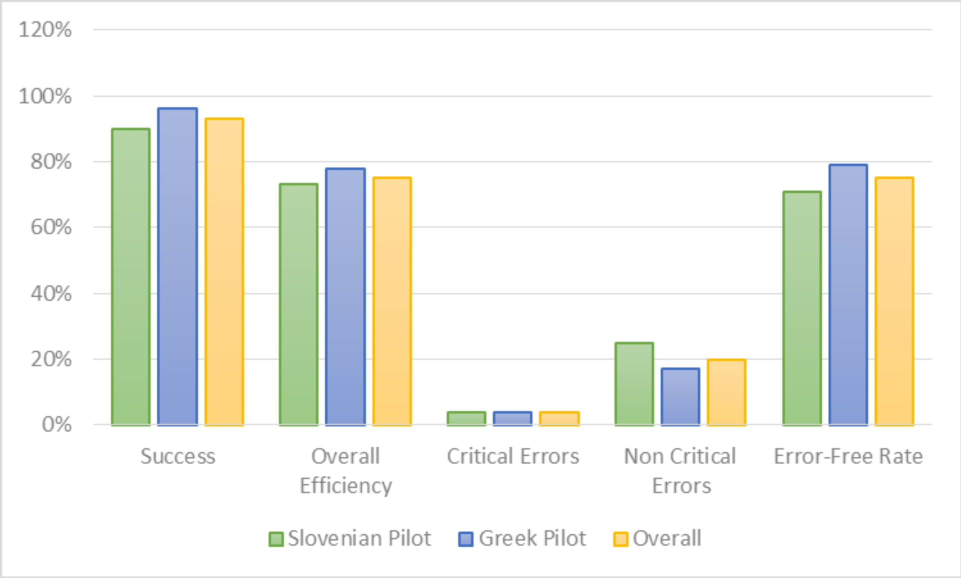


Figure 25: Usability Test: Metrics Summary

5.1.2.2 Questionnaire Evaluations

Subjective evaluations regarding ease of use and user experience were collected via questionnaires and during debriefing at the conclusion of the session. The questionnaires utilized free-form responses, rating scales and multiple choices. The analysis of the answers to the questionnaires revealed some general statistics (ratings) for the applications as well as the attitude of the participants towards the future features of the applications in order to become clear whether these functions will be useful to the users. Some interesting results generated by the analysis of responses of the questionnaires are presented below.

Figure 26: Usability Test: User Rating

Note: The ratings presented in the figures relate to the questionnaire (see Annex 3: iFLEX Assistant Usability Questionnaire) as follows:

- Overall experience relates to question 1.
- Ease of use relate to questions 2, 3, 5, 9 and 12.
- Easy of navigation relate to question 4.

Based on the questionnaire (questions 14, 17, 21, 29, 31, 3), the overall percentage of participants who found the existing features and functionalities important, interesting and not complicated was:

- 94.5% for the Slovenian Pilot
- 94% for the Greek Pilot

Moreover, based on the user answers (question 23) some preference to alternative implementation for selecting optimization policy was highlighted. More specifically, 71.4% of participants prefer to be able to select many policies at the same time and prioritize them based on what is more important to them. Finally, the answers to two more questions (27, 28) raised concerns about Silence Rules' function really is, since 57% of the participants answered that they don't already know the hours of the week/ month that they may not want to be bothered with push notifications. In addition to this, 36% of the participants answered that they don't want to be able to create silence rules. However, since push notification were not part of the actual test, this should be re-assessed in the 2nd phase.

The attitude of the participants towards the future features of the applications is presented in the following pie charts.

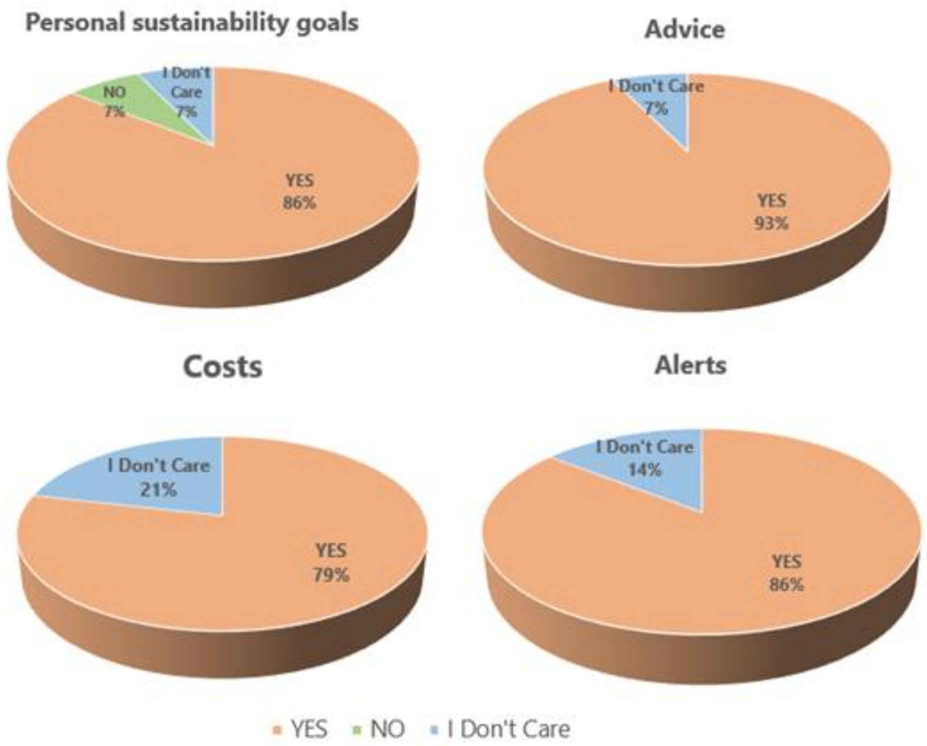


Figure 27: Usability Test: Interest in future features

5.1.2.3 General Feedback

Finally, the most common problems encountered on each screen are presented in the figure below. This canvas presents the feedback received from both interviews and questionnaires and will be the guide on the basis of which the applications will be redesigned in order to be error free, confusion free and intuitive. The goal is for the interfaces to be designed in a way that users find easy to use and pleasurable, so they can have a great experience while using the application.

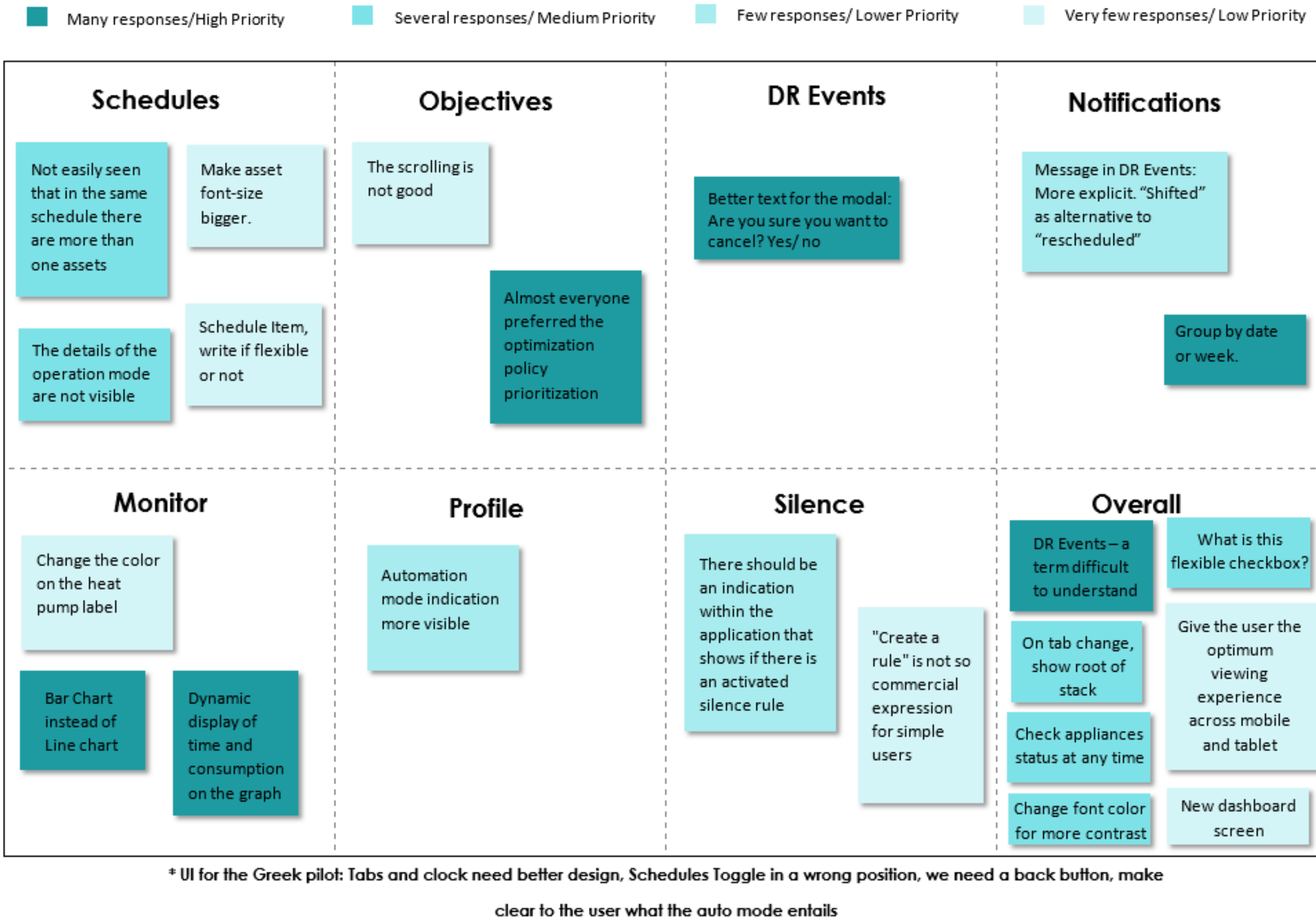


Figure 28: Usability Test: General Feedback Canvas

5.2 Public survey

For the validation in phase 1, the primary objective of the public survey was to validate the iFLEX concept and to find out what the key motivational drivers were for offering energy flexibility. In other words, we wanted find out if and how respondents were willing to participate and what they were willing to do and what would motivate them.

The survey collected a lot of data and covered other themes as well to allow us to use the data in other connections. For example, data on motivations and user characteristics will be used in WP5 for the work on incentives.

5.2.1 Methodology and design of the public survey

The survey consists of an online questionnaire using the SurveyMonkey platform. Several partners, including pilot cluster partners, collaborated in constructing the questionnaire. The questions were separated into three sections:

a) Household and personal characteristics

b) Motivation, behaviour intentions and flexibility

c) The concept of managing flexibility.

In each section, related questions were grouped which also helped to condense the apparent length (number of questions) of the questionnaire. All questions were made obligatory to avoid ended up with incomplete data sets. Of course, there is always a risk of a higher drop-out rate when respondents realise that they cannot skip some questions. However, this risk was acceptable as incomplete data sets would not be useful. Also, respondents were informed in the short introduction to the questionnaire that all questions were required and that the estimated time to complete it was 10 minutes.[1] Respondents were also informed that they could go back and change their answer if necessary; it was possible to edit answers until the questionnaire was submitted.

Only one questionnaire could be filled in per respondent, or more precisely per IP address. Although we did not collect IP addresses, the SurveyMonkey platform does so for their own functionality purposes, e.g. ensuring that respondents could only take the survey once (see below).

The pilots distributed a link to the questionnaire in the pilot local language to their contacts accompanied by a brief introductory email to encourage people to complete the questionnaire. The questionnaires were anonymous; we did not collect IP addresses or other personal identifiable data. The Finnish questionnaire included a voluntary option to input email address for the purpose of entering the prize draw offered by the Finnish pilot (see details related to the privacy issues below).

The survey was open for between three and five weeks with the majority of answers received in the first few days when the questionnaire was distributed:

- Greece: 3 weeks (22/12/21-12/1/22)
- Slovenia: 1 month (19/11/21-20/12/21)[2]
- Finland: 5½ weeks (2/12/21-9/1/22)

As mentioned above, the questions in the survey were split into three categories. Within each categories some specific analytical considerations were made and specific questions were grouped to analyse correlations and/or test certain hypothesises.

5.2.1.1 Household and personal characteristics

This type of data included gender, age, education level, children, number of household members, type and size of housing, information on heating/water heating, green appliances (solar panel, electric car, battery), technology usage, and energy monitoring habits. Additionally, one set of questions were related to user personality in relation to user motivations.[3]

The first two questions in the survey were aimed to determine if respondents represented our target group. The target group being individuals who would be potential end-users of the iFLEX Assistant, i.e. they are responsible for the household's energy consumption as paying users and/or decision-makers (of issues related electricity consumption).

Data on whether or not respondents have children (under the age of 18) living at home is interesting because the general long existing hypothesis that having children influence pro-environmental awareness, values and behaviours because parents have a stronger focus on the future and thus on environmental concerns.[4] Not surprisingly though, it is possible to find both support and rejection of this hypothesis in existing literature.[5] A literature review of this hypothesis is out of scope here, however we consider this as an interesting variable which will be considered for future analysis. Similarly, several studies have looked at the relationship between general education and pro-environmental knowledge and values; these variables will also be analysed at a later stage. For our current purposes, the overall basic results will be presented for each pilot site.

The data on household characteristics, including the presence of (green) appliances, is a useful variable to determine the "potential for participating in demand response" based on respondents' (assumed) energy consumption which would make their household a good candidate for participating in demand response

[1] The typical time spent completing the questionnaire was 10 minutes for Slovenian version, and 11 minutes for the Finnish and Greek version.
[2] The final response received 13/12/21.
[3] These questions were inspired by the HEXAD user type survey (Marczewski, A. 2015). The HEXAD user type survey is far more comprehensive and our results are therefore only interpreted as limited indication of what user type a respondent may be characterised as. A full user type survey was unfortunately out of scope here, as well as not being a primary objective.
[4] Environmental values and knowledge are considered to be positively correlated with energy saving in households (e.g. see Pothitou et al. 2016).
[5] For example, existing research has shown that a focus on the future is associated with greater consideration of environmental protection (see Thomas et al. 2018), that parenthood is often associated with higher level of climate worry (Ekholm & Olofsson 2016), and that parents are more positive towards energy saving when it is framed as part of educating their children (Fell et al. 2013). On the other hand, Thomas et al. (2018) cited several studies that did not support the hypothesis adding their own study to this argument

(DR)and for using the iFLEX Assistant. The analysis looks specifically at the correlations between the potential for DR participation and motivation and behavioural intentions (see 5.2.1.2).

Finally, the use of technology in general and the use of technology to monitor energy consumption in particular are interesting variable related to the potential interest in energy monitoring and energy savings, which may also be used to provide an indication of respondents' interest/acceptance of the iFLEX concept and demand response.

5.2.1.2 Motivation, behaviour intentions and flexibility

Section two in the questionnaire contains questions that aimed at revealing information about what could possibly motivate respondents to participate in DR. This included both information about values, personal norms and perceptions related to environmental and energy issues as well as asking respondents to consider what they would be willing to do to be able to offer energy flexibility.

The ways in which respondents would consider to plan and/or change their energy consumption (their energy behaviours) focused both on specific behavioural changes (e.g. doing washing at certain hours), on their requirements for participating in demand response/flexibility events, and on whether respondents were willing to invest and engage in technological solutions and services to control energy consumption. While all the options are related to energy flexibility and DR actions, the latter also helped to examine respondents' initial opinion and perception of the iFLEX Assistant. The questions in this section of the survey will be analysed in more detail for our current purpose, namely to validate the iFLEX concept.

5.2.1.3 The concept of managing flexibility

The final section of the questionnaire was directly linked to possible functionalities in the iFLEX Assistant. The aim was to let respondents to prioritise these key functionalities (user requirements) which could be used to feed into the requirement engineering and development work of the iFLEX Assistant.

5.2.2 Data protection and privacy

We did not collect any personal identifiable data in the questionnaire (see the Finnish exception below). As mentioned above, SurveyMonkey collects IP addresses for basic functionality and the questionnaire therefore contains a link to SurveyMonkey's privacy policy at the bottom of each page (screen).

While all three pilot questionnaires were anonymous, the Finnish pilot decided to offer a prize draw for an Apple iPhone 13. The prize draw was described in the introduction to the questionnaire, also informing respondents that entering the prize draw would require them to provide their email address. At the end of the questionnaire, respondents were presented with the heading "Your contact details for the prize draw" followed by details of the prize and the question "would you like to enter the prize draw?". If a respondent answered "no" they were presented with the thank you page ("Thank you for completing our survey"). If a respondent answered "yes", they were directed to a page informing them how/what for their contact information would be used with a link to the details of the privacy policy. Only upon accepting the terms and conditions as laid out in the privacy policy, were respondents presented with a field to enter their name and email address.

The Slovenian pilot also offered respondents a prize for having completed the questionnaire. In this case, upon submitting the completed questionnaire, respondents were informed that if they would like to request a copy of the newsletter they had to click on the provided link. This link took them to an external website (www.zps.si) where they could make the request directly. No personal data were therefore collected via the questionnaire.[6]

5.2.3 Public survey results - Greece

The Greek survey was distributed amongst the contacts of the Greek iFLEX partners. 94 responses were received with an 84% completion rate resulting in 86 complete responses.

5.2.3.1 Basic respondent and household characteristics

Nearly all of the respondents (N=73, 85%) were both (one of) the person paying the electricity bill for the household and making decisions related to electricity (e.g. switching supplier, buying energy saving appliances). Three respondents who pay the bill do not make decisions. Of the 13 respondents who do not pay the electricity bill, four do also not make decisions related to electricity (e.g. switching supplier, buying

[6] The ZPS website informed visitors (respondents) on their data privacy policy.

energy saving appliances) whereas six respondents do make decisions related to electricity (e.g. switching supplier, buying energy saving appliances). Of 73 who both pay the bill and make decisions regarding electricity, N=17 (23%) live alone.

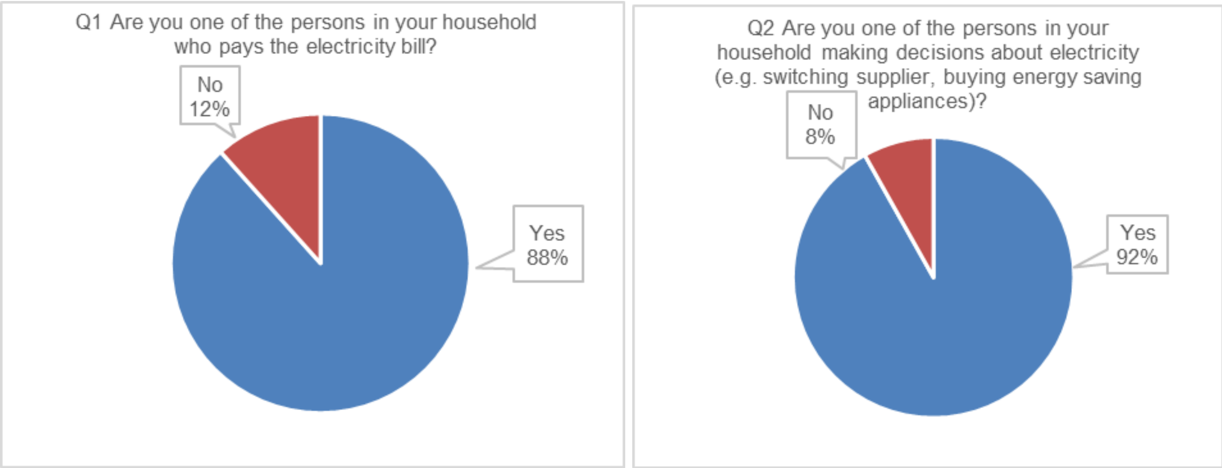


Figure 29: Percentage of respondents who bill the electricity bill (Q1) (left) and who make decisions about electricity (Q2) (right)

Overall, the data from Q1 and Q2 indicate that the respondents represent the relevant and appropriate population for the purposes of the survey.

In order to get a better idea and understanding of who the respondents were and their life situation, data on educational level, household characteristics, type and size of their dwelling was collected.

The majority of respondents were male (66%) and the most dominant age group was 31-40 years old (36%) (female N=7, male N=17) followed closely by 41-50 years old (33%) (female N=11, male=17). The age and gender division of the people who completed the survey are illustrated below (Figure 30).

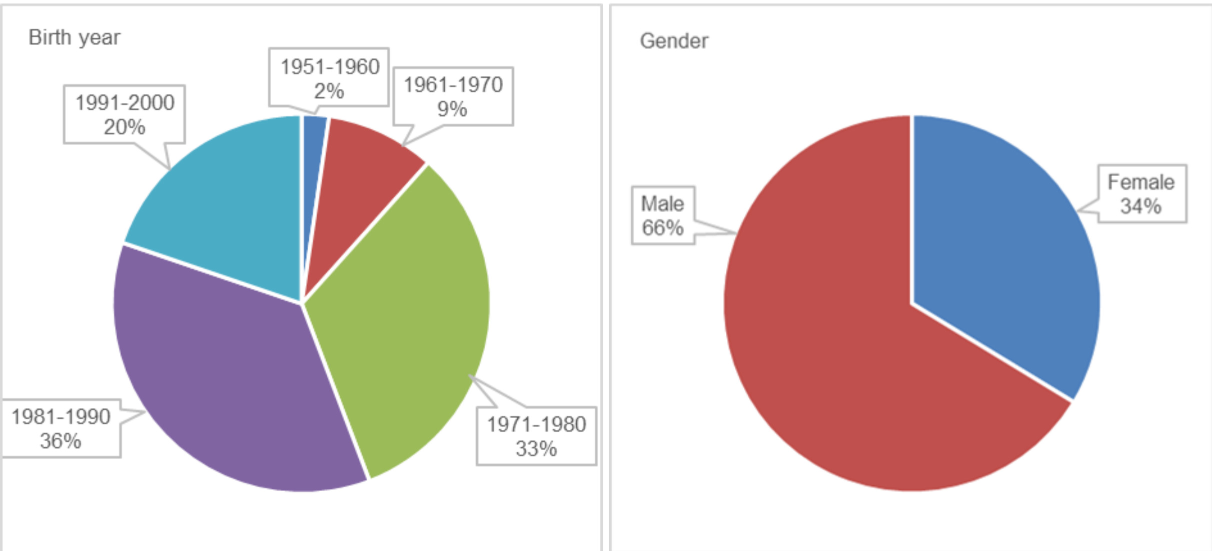


Figure 30: Age division (Q5) (left) and gender division (Q6) (right)

Respondents could be split almost equally into two groups when it came to whether or not they had children (under the age of 18) living at home, with the group with no children slightly larger. A total of N=47 (55%) respondents do not have any children at home and within this group, there are N=18 single households, N=22 households of two adults, N=2 households consist of 3 or 4 adults, and N=1 household consist of 5 or 6 adults. One respondent had answered “everybody” and was therefore excluded.[7]

More than half of the respondents (N=52, 60%) live with one other adult. Within this group, 58% have children living at home: 43% have one child, 40% have two children, and 17% have three children.

[7] This could have been avoided if respondents would have had to choose from a drop-down list (instead of writing a number).

Three respondents inserted the number “0” for Q7 (Figure 31) which presumably mean that they interpreted the question as meaning “in addition to themselves” (see footnote 7).

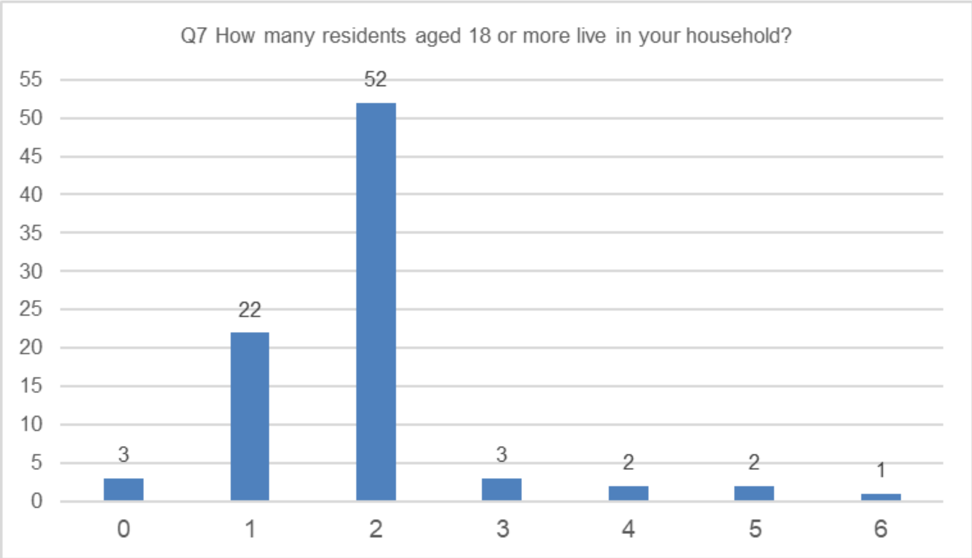


Figure 31: Number of residents over the age of 18 in the household (Q7)

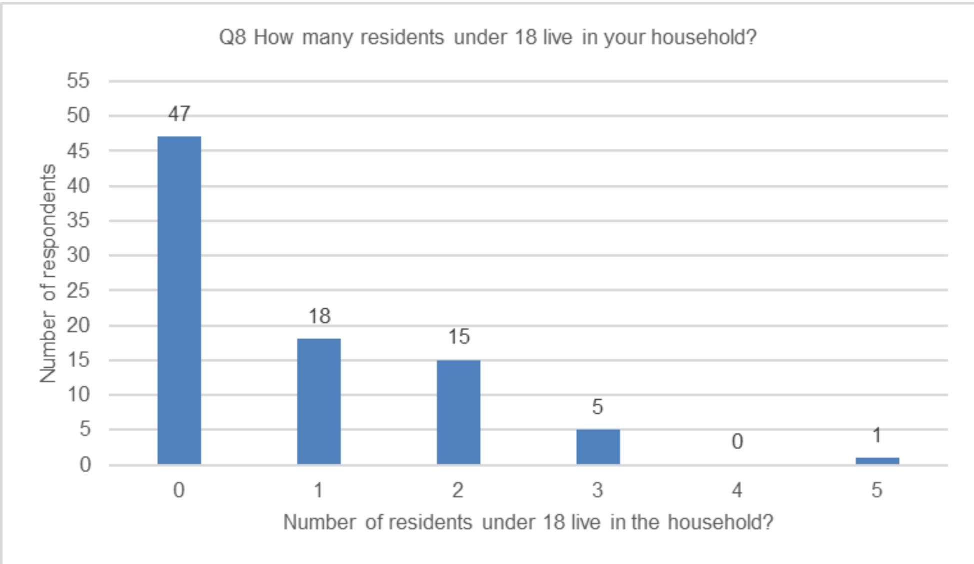


Figure 32: Number of residents under 18 in the household (Q8)

With regards to educational level (Figure 33), the vast majority of respondents have a higher education: 38% hold a Master’s degree, 22% hold a Bachelor’s degree and 21% hold a Doctoral.

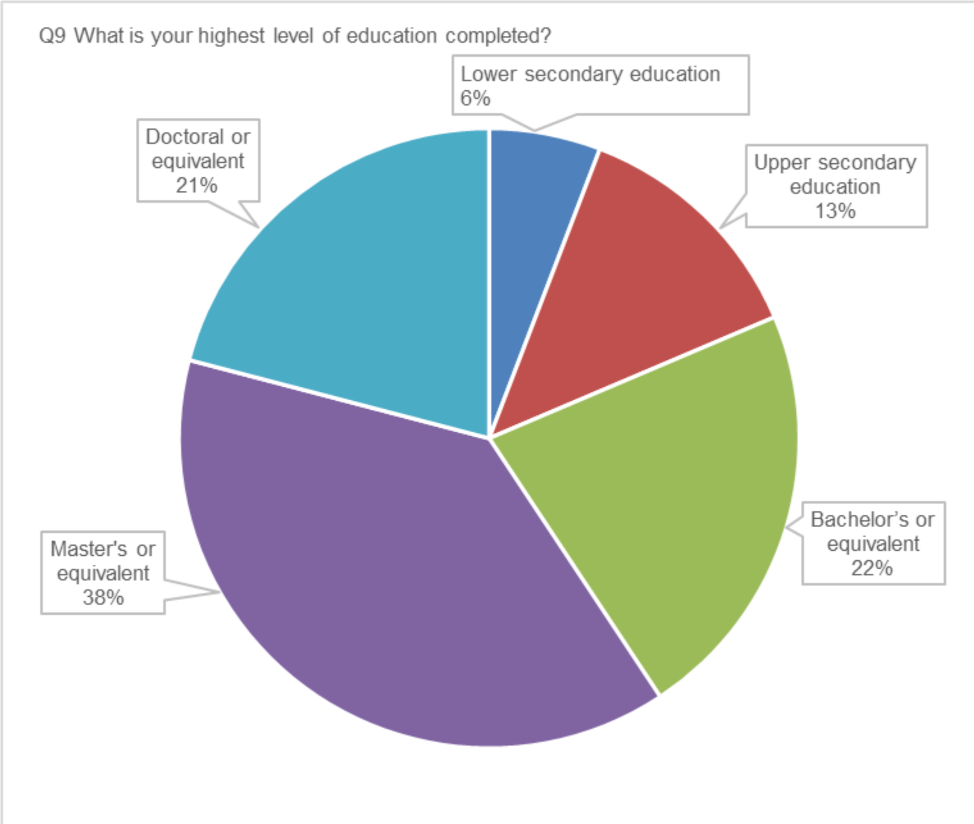


Figure 33: Educational level (Q9)

Basic knowledge on respondents' housing characteristics, i.e. type of home and its size (Figure 34 and Figure 35) and key appliances e.g. heating/cooling system, electric vehicles etc. (Figure 36), is illustrated below.

As Figure 34 shows nearly all respondents live in an apartment and most own their home. Figure 35 illustrates that a little more than one-third of the homes are between 71-100 m^2 (all but four are apartments), 25% are between 101-130 m^2 (17 apartments, 2 single family detached houses, 1 semi-detached house and 1 other [apartment in duplex]) and 21% are between 40-70 m^2. For the N=13 homes that are 131 m^2 or more, N=7 are single family detached houses, N=5 are apartments and N=1 is a semi-detached house.

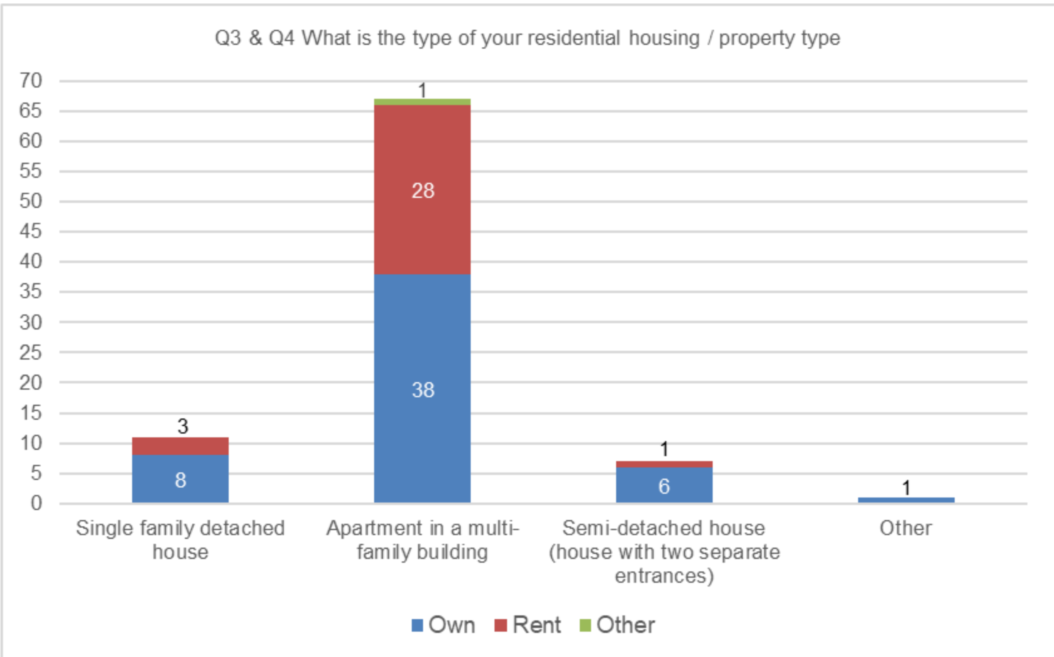


Figure 34: Type of residence (Q3 & Q4)

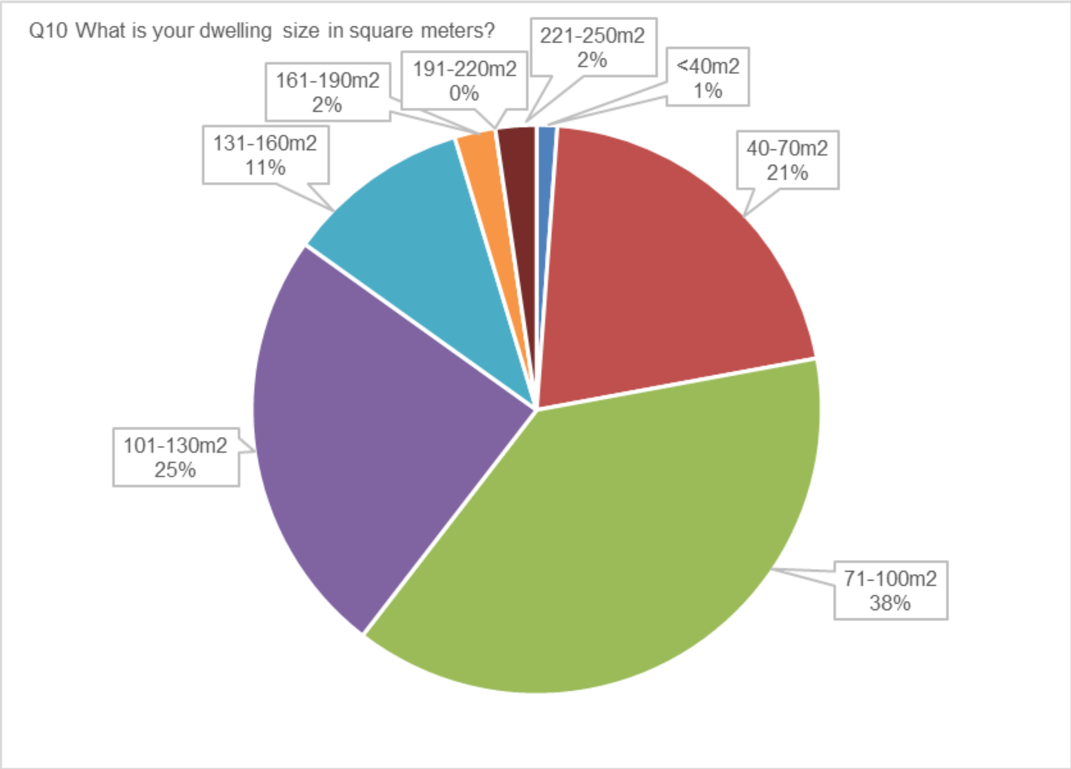


Figure 35: Size of dwelling (Q10)

The following figure illustrate the key household appliances/devices that respondents have.

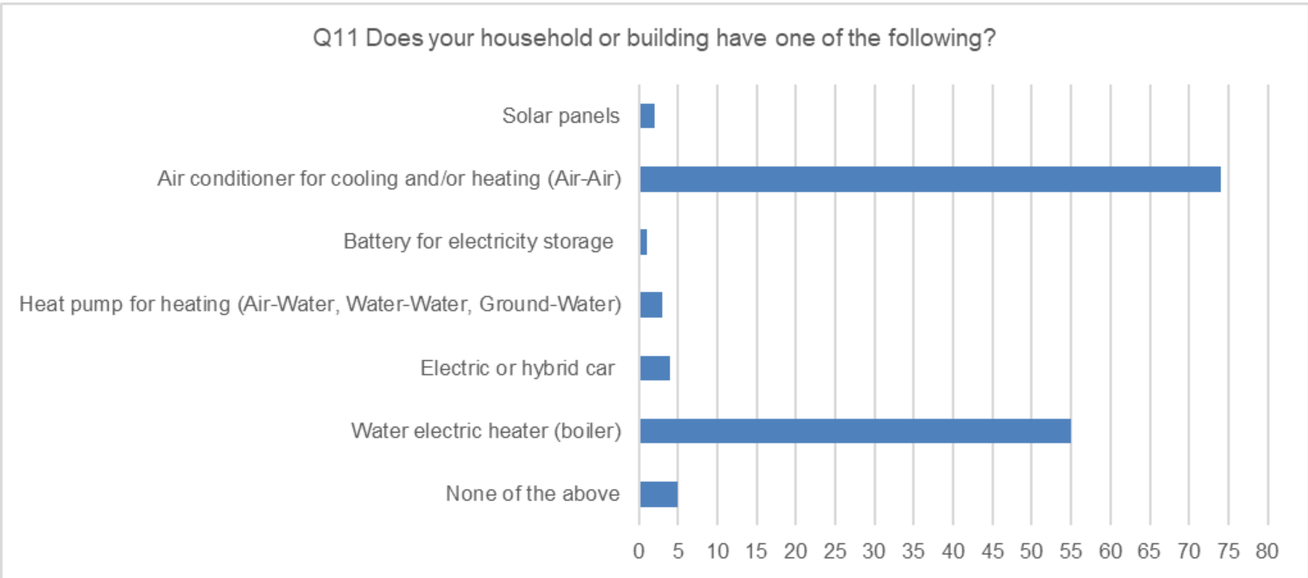


Figure 36: Key household appliances (Q11)

Only two households have solar panels, one of which also have a battery for electricity storage. This is not surprising as most residents live in apartments. All except two of the respondents who have a water electric boiler also have an air conditioner (N=53).

Figure 37 below illustrates how often respondents use the listed technologies and services. The number inside the bar indicates the number of respondents who use the appliance with the indicated frequency.

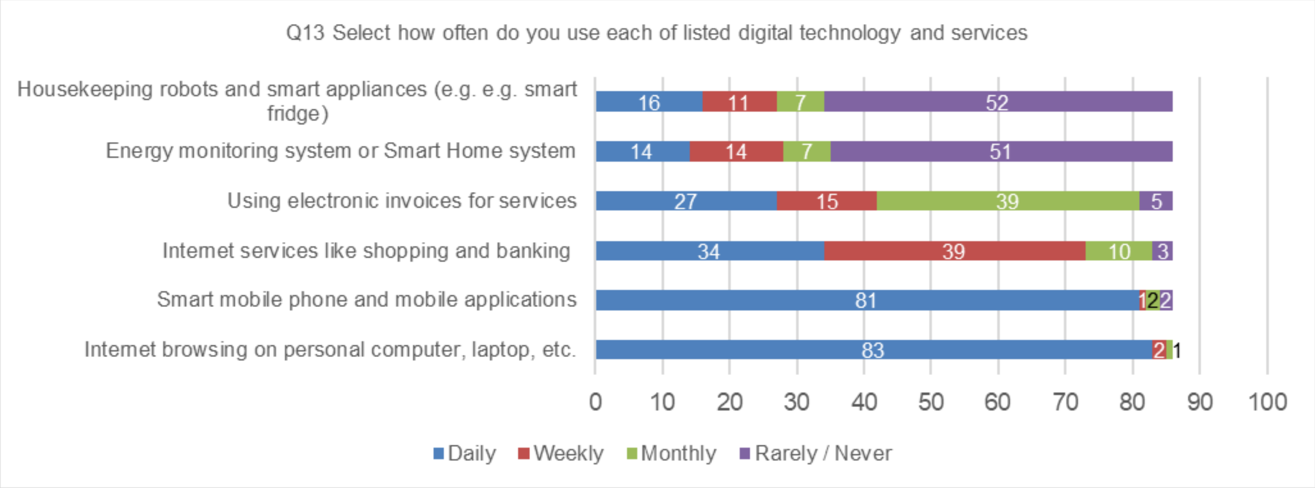


Figure 37: Frequency of use of different technologies and services (Q13)

All but a few use the internet and smart phone/mobile applications on a daily basis. One-third of respondents use an energy monitoring or smart home system on a daily and/or monthly basis. In Figure 38 below, we see that 50% monitor their energy consumption/production using their bill (paper or electronic); 36% of all respondents *only* use their bill. N=30 (35%) do not use any of the listed means. The remaining respondents use either website or mobile application. N=3 respondents use both their bill, website and mobile application to monitor their energy consumption. The number inside the data callout indicates the number of respondents who use the technology for the purpose in question.

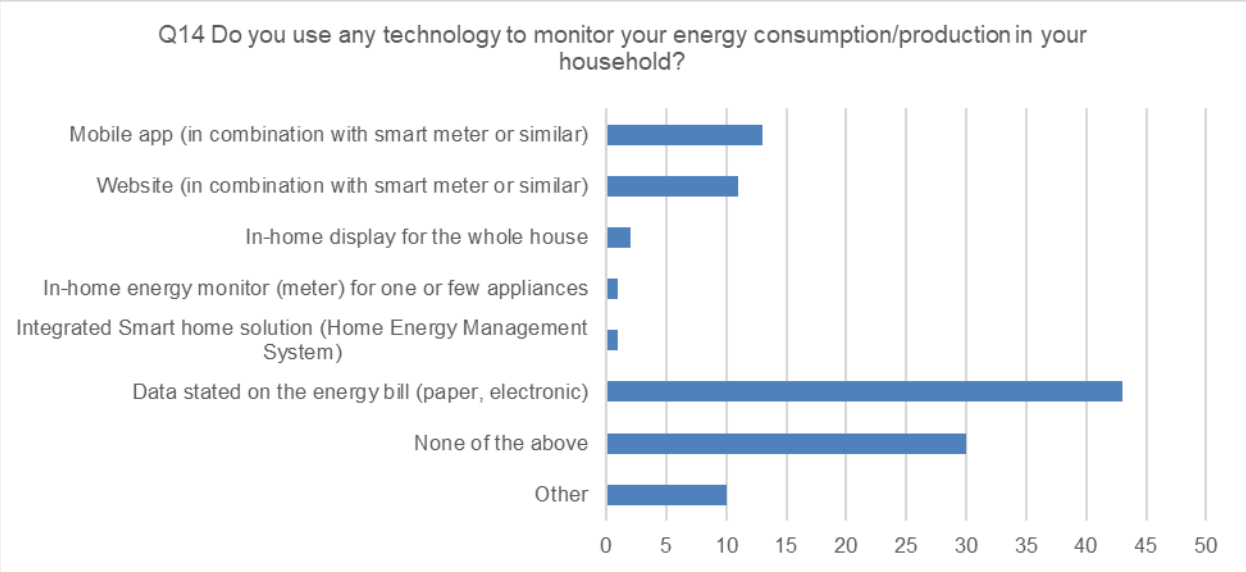
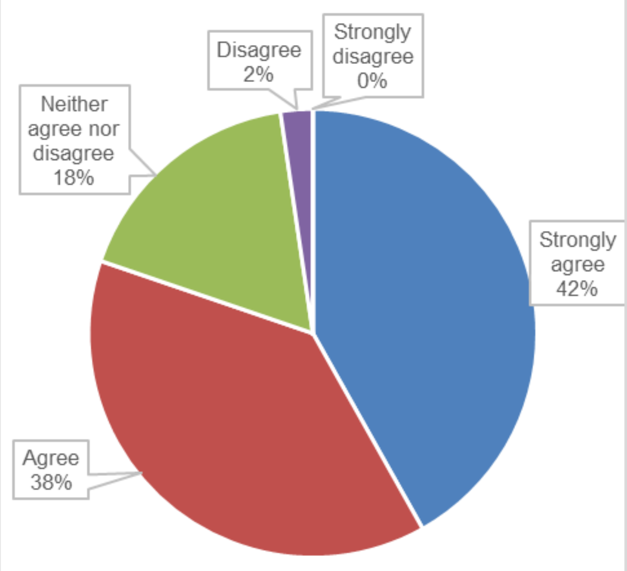


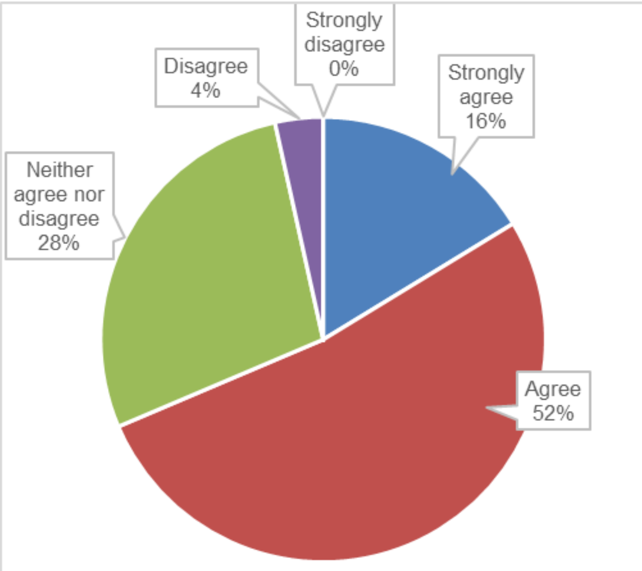
Figure 38: Use of technology to monitor energy consumption/production (Q14)

A set of questions and also enquired into personal characteristic/user type (Q12) as well as issues of personal comfort (Q20).[8]

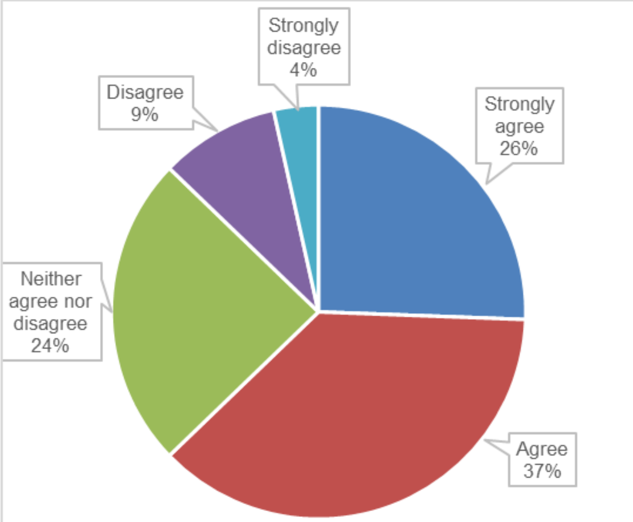
[8] This data is of special interest to the analysis of incentives in WP5.



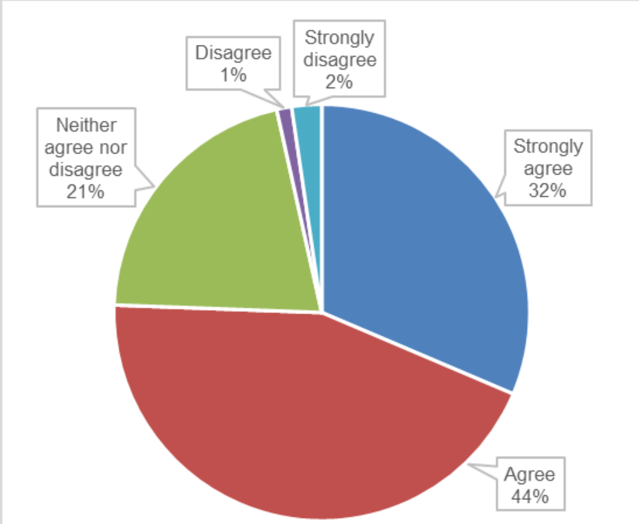
Q12a It is important to me to follow my own path



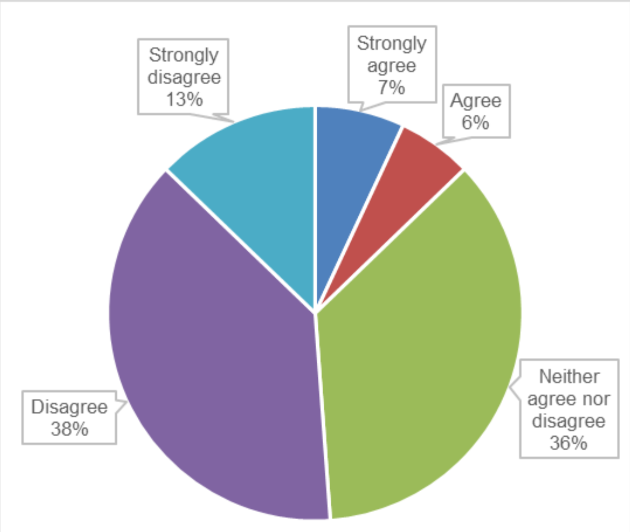
Q12b I like being part of a team



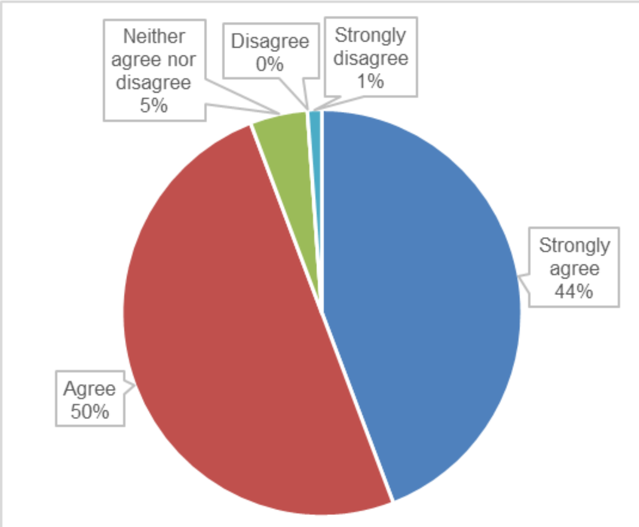
Q12c I like competitions where a prize can be won



Q12d Rewards are a great way to motivate me



Q12e I dislike following rules



Q12f I like sharing my knowledge

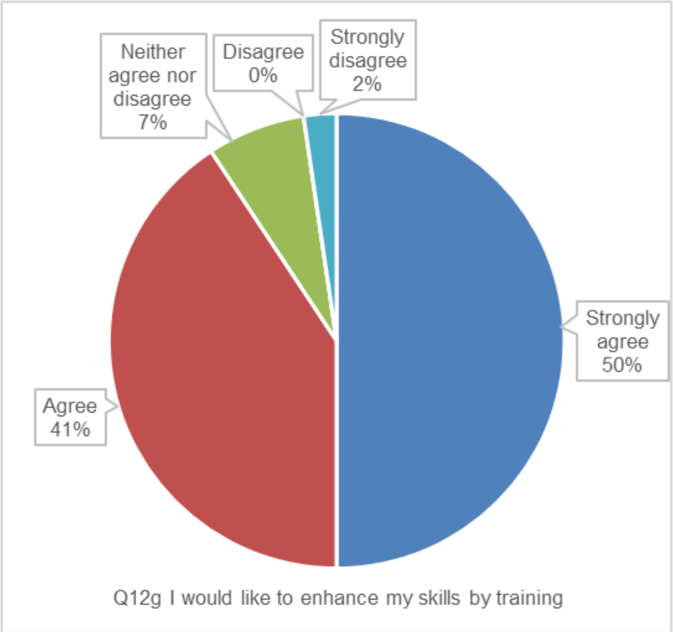


Figure 39: User type/personal characteristics (Q12)

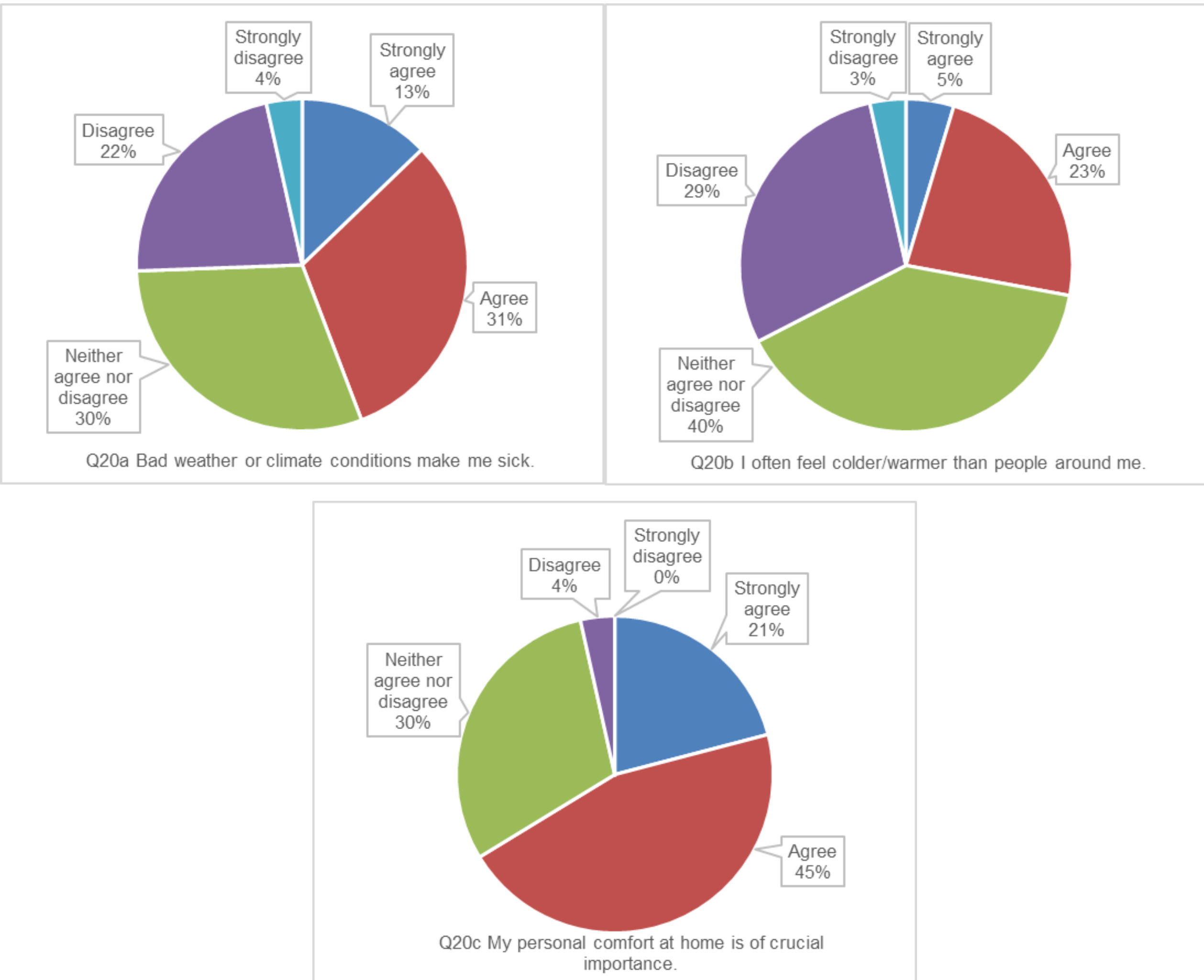
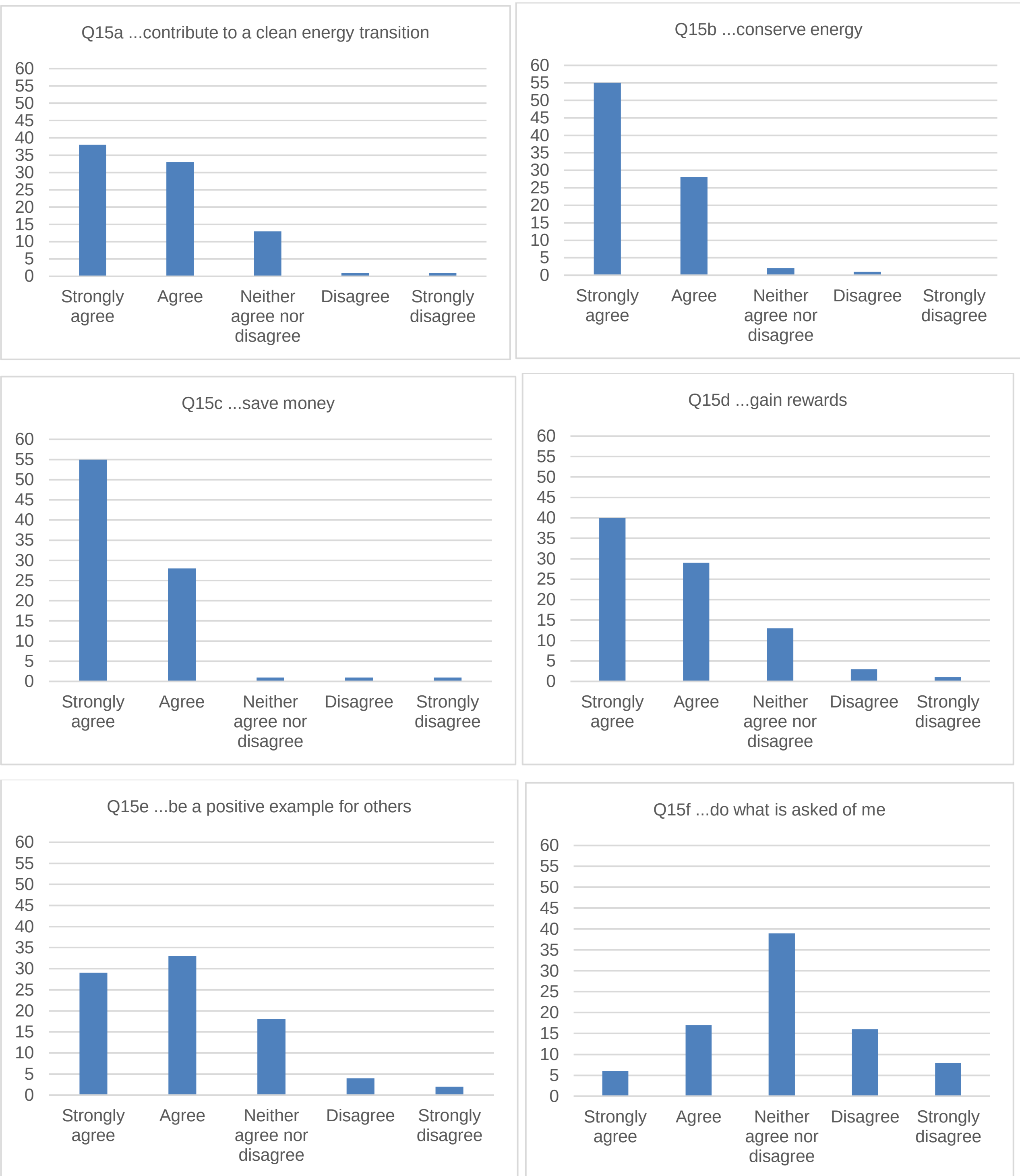


Figure 40: Personal characteristics (disadvantages and comfort) (Q20)

5.2.3.1 Energy and flexibility: awareness, incentives, willingness and requirements

The second part of the survey enquired into respondents' awareness of energy consumption and flexibility, their willingness and key incentives to participate in flexibility events. The questions here enquired into respondents' opinion asking them to indicate their level of agreement with different statements.

The first question (Q15), asked respondents to indicate what would motivate them to offer their flexibility ("I would offer my flexibility if I would…"). The answers are illustrated in the 7 graphs below (Figure 41).



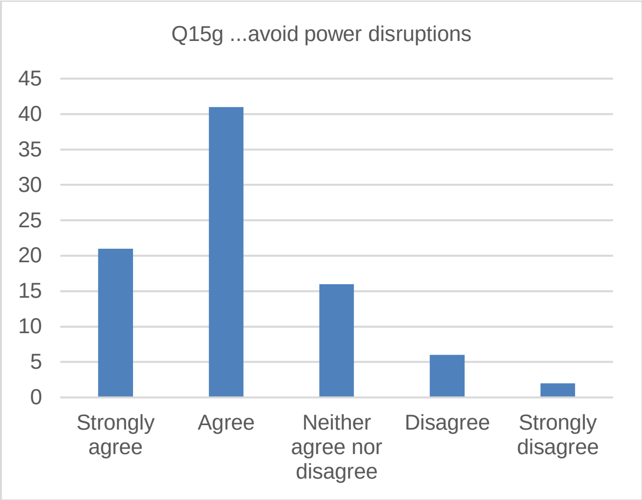


Figure 41: Reasons for offering flexibility (Q15)

The figures below illustrate how willing respondents are when it comes to changing specific energy behaviours with respect to offering energy flexibility.

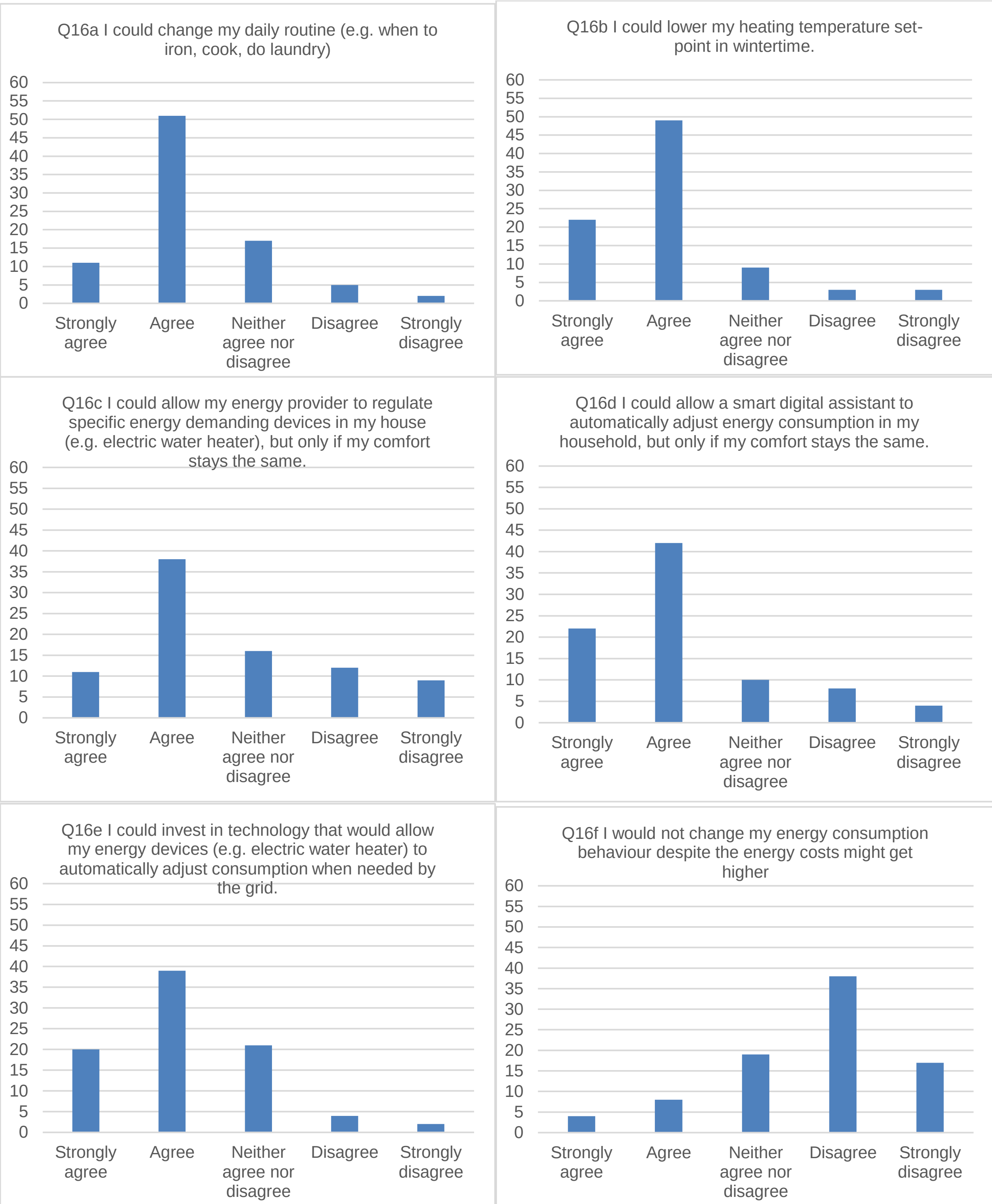


Figure 42: What are you willing to do to be able to offer flexibility in energy consumption (Q16)

The next four graphs (Figure 43) illustrate respondents' energy consumption and energy flexibility awareness.

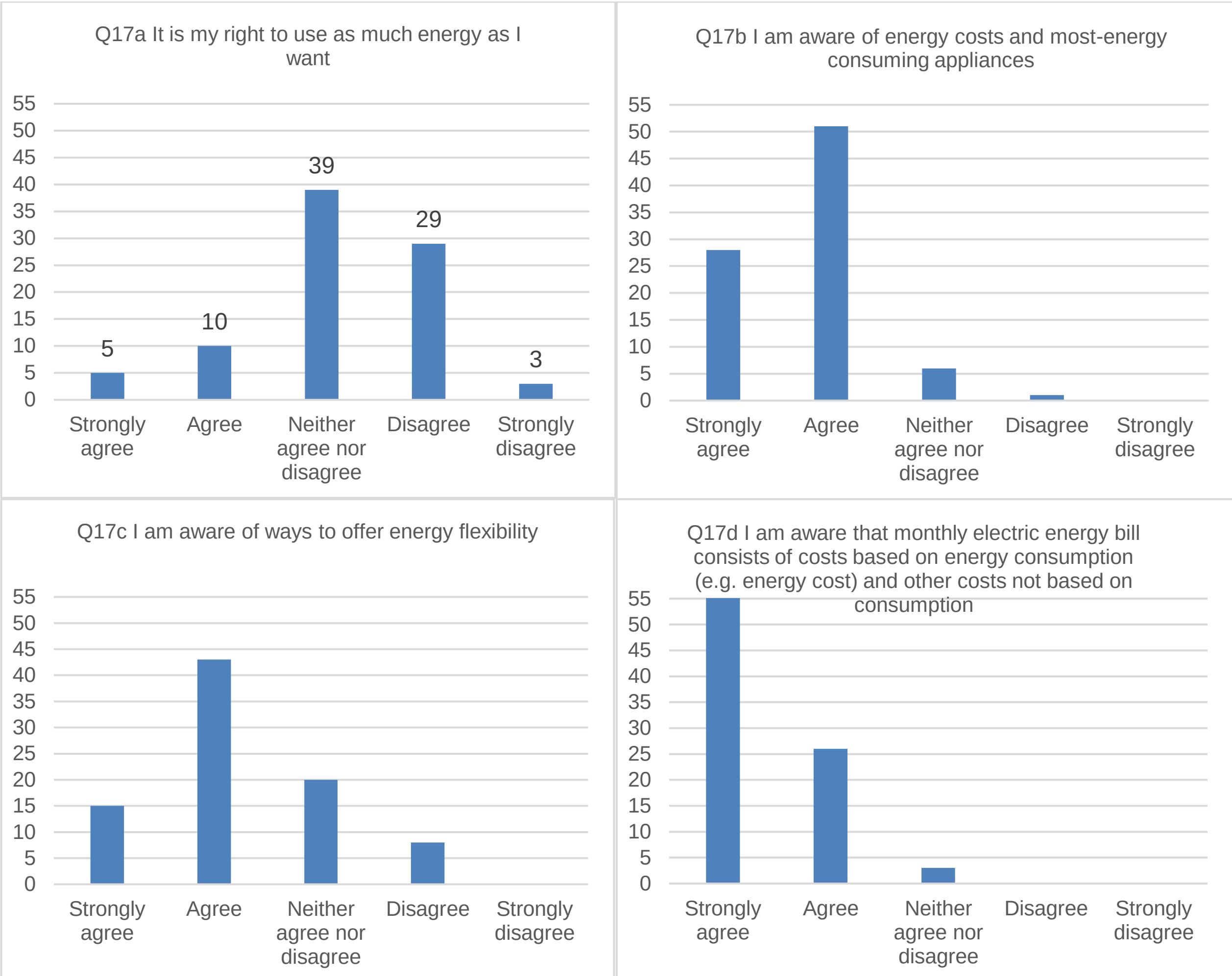


Figure 43: Energy and flexibility awareness (Q17)

In Figure 44 below, the question 18a "Conserving energy and natural resources is important to me" and 18b "Conserving energy is not my problem" generated a lot more extreme and clear opinions than question 17a "It is my right to use as much energy as I want" (Figure 43) which generate more neutral answers (45%). Still most lean towards disagreeing which corresponds well with the answers in Q18.

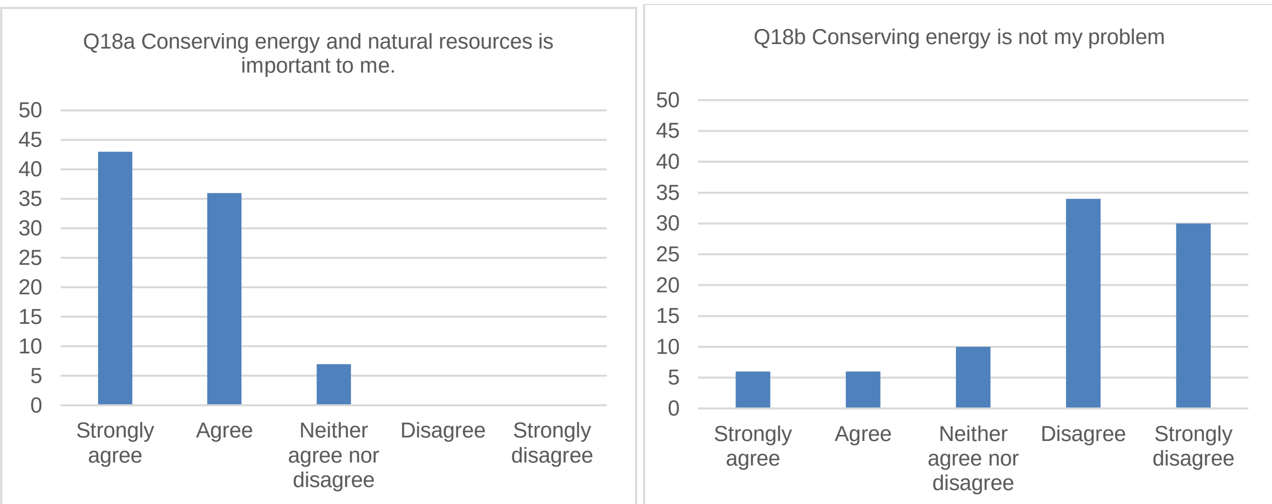


Figure 44: Attitude towards conserving energy (Q18)

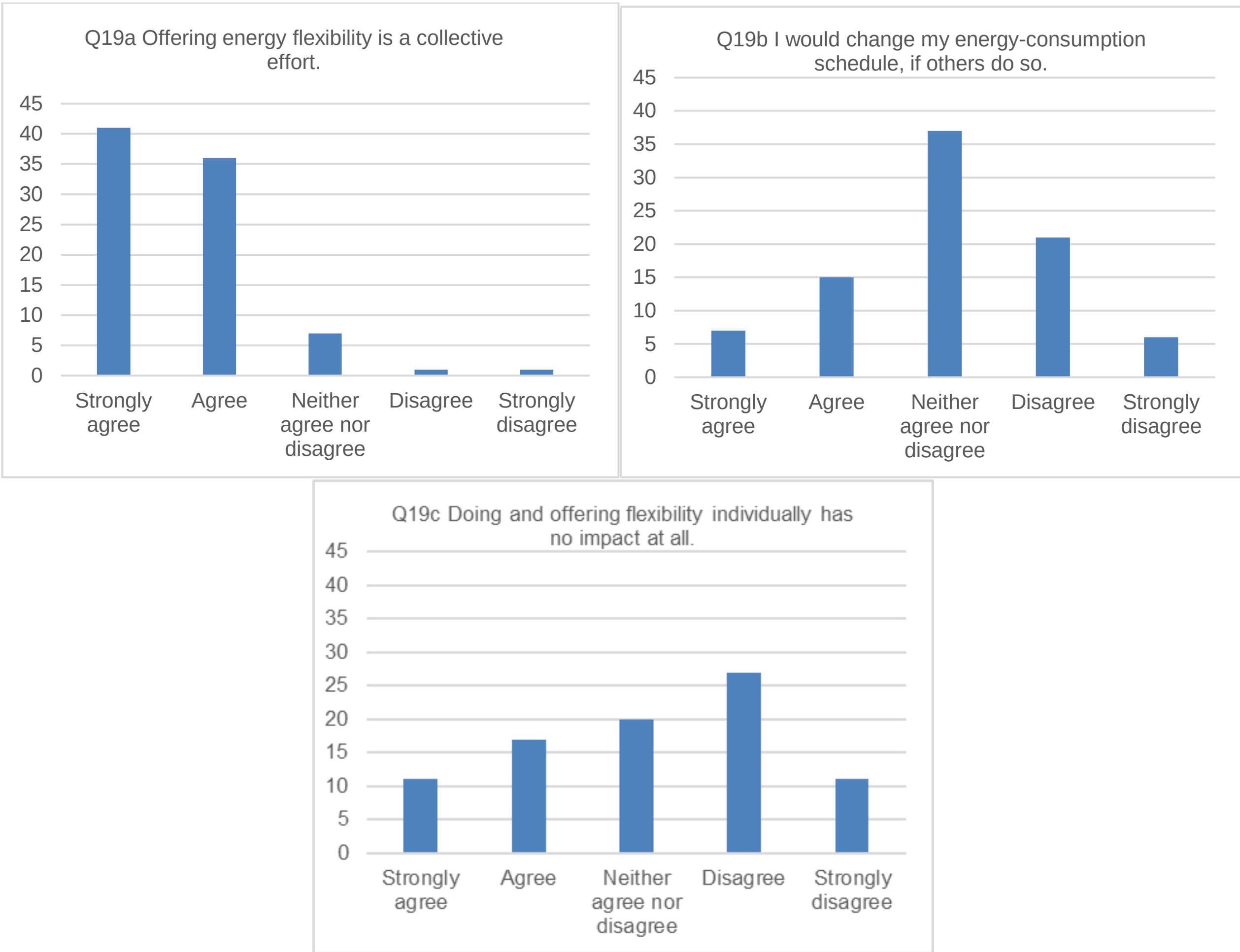
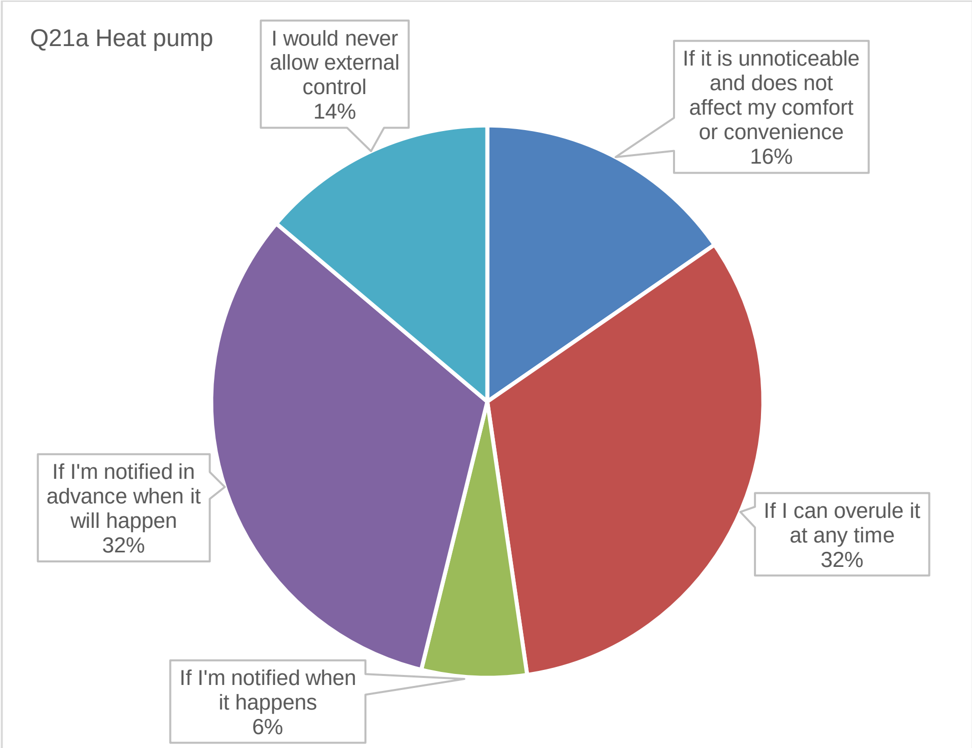
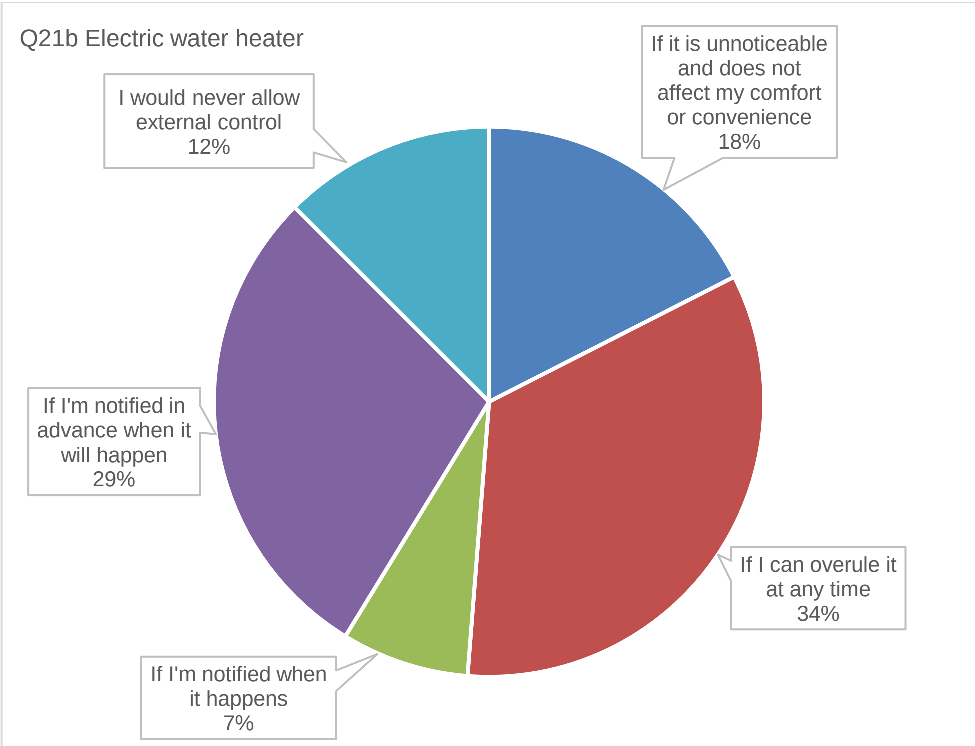


Figure 45: Attitude towards offering flexibility (Q19)

The next four graphs are based on answers to Q21 "Under which conditions would you be willing to allow external control of the following devices in your household?". Based on answers in Q11 (what devices respondents have in their household), it appears that some respondents have answered the question (Q21) irrespective of whether or not they actually have the device in question (despite there being a "not applicable" option). Respondents were most flexible with respect to their electric water heater. The data show that being able to "overrule at any time" is the most important condition for all devices. It is followed closely by "If it is unnoticeable and does not affect my comfort or convenience".

Respondents were the least flexible with respect to the electric/hybrid car. Generally, this is not surprising as not being able to use your car has a greater impact on comfort and convenience compared to e.g. turning the heating a couple of degrees down. However, when we look more closely at the data it is quite surprising to see that the respondents who are not flexible with respect to electric/hybrid car do actually *not* own one (according to their answers in Q11, see Figure 36). Only four respondents own an electric/hybrid car and two of them had answered "If I can overrule it at any time" and two had answered "If I'm notified in advance when it will happen".


Q21a Heat pump
I would never allow external control 14%
If it is unnoticeable and does not affect my comfort or convenience 16%
If I'm notified in advance when it will happen 32%
If I can overule it at any time 32%
If I'm notified when it happens 6%


Q21b Electric water heater
If it is unnoticeable and does not affect my comfort or convenience 18%
I would never allow external control 12%
If I'm notified in advance when it will happen 29%
If I can overule it at any time 34%
If I'm notified when it happens 7%

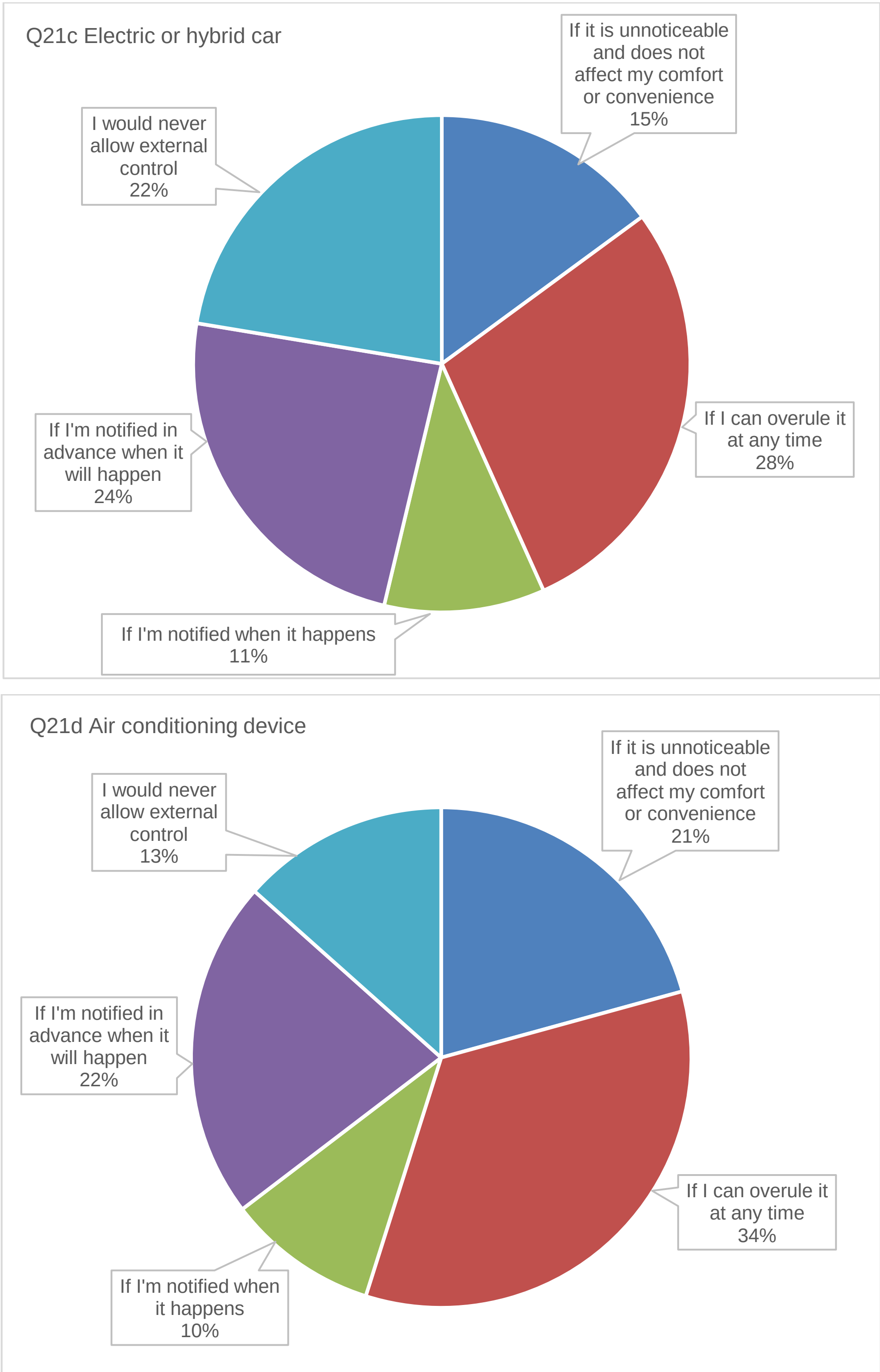


Figure 46: Conditions for allowing external control of devices (Q21)

The final questions are more closely related to the iFLEX Assistant and the functionalities respondents would like to see. The answers also give some indication of how attractive the concept of iFLEX Assistant is; the idea of an automated solution is overall received positively but (as also indicated above) manual control should still be possible.

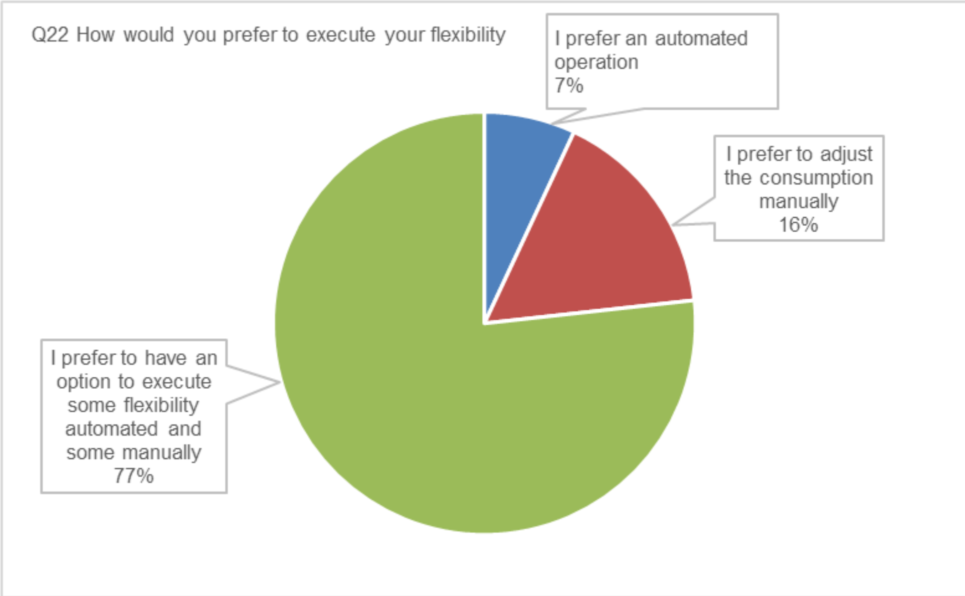
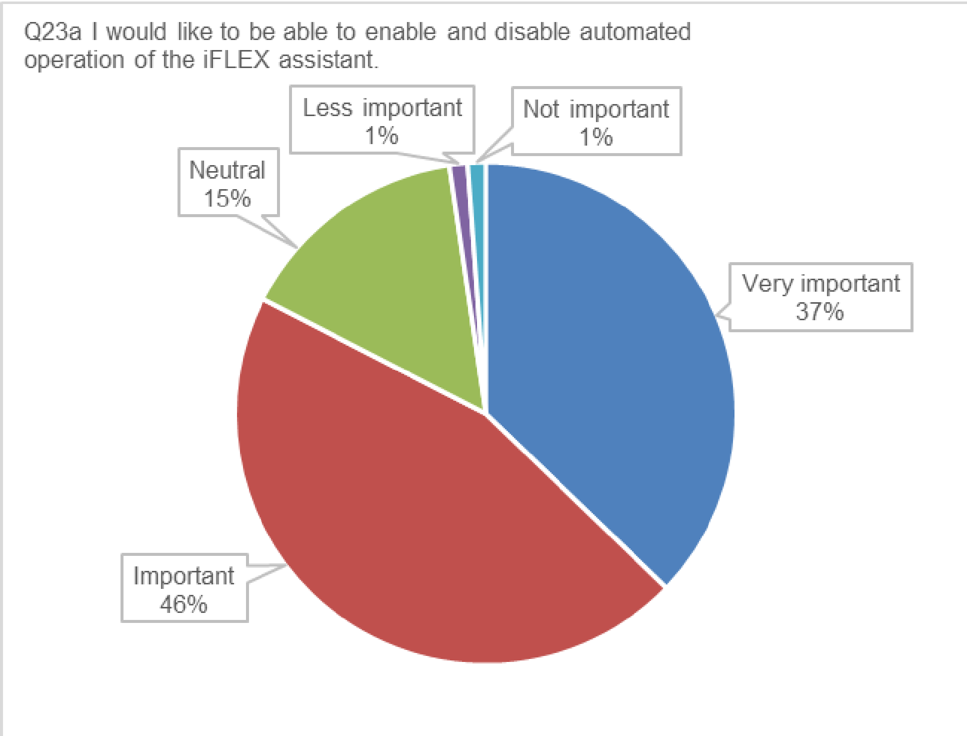
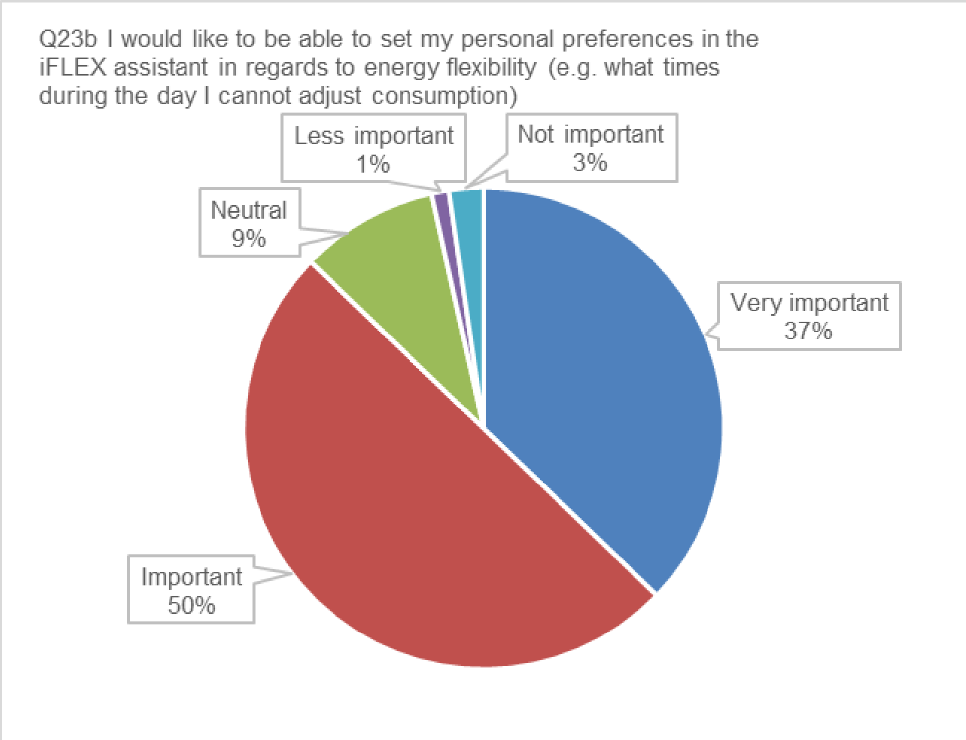


Figure 47: iFLEX Assistant and flexibility control preferences (Q22)





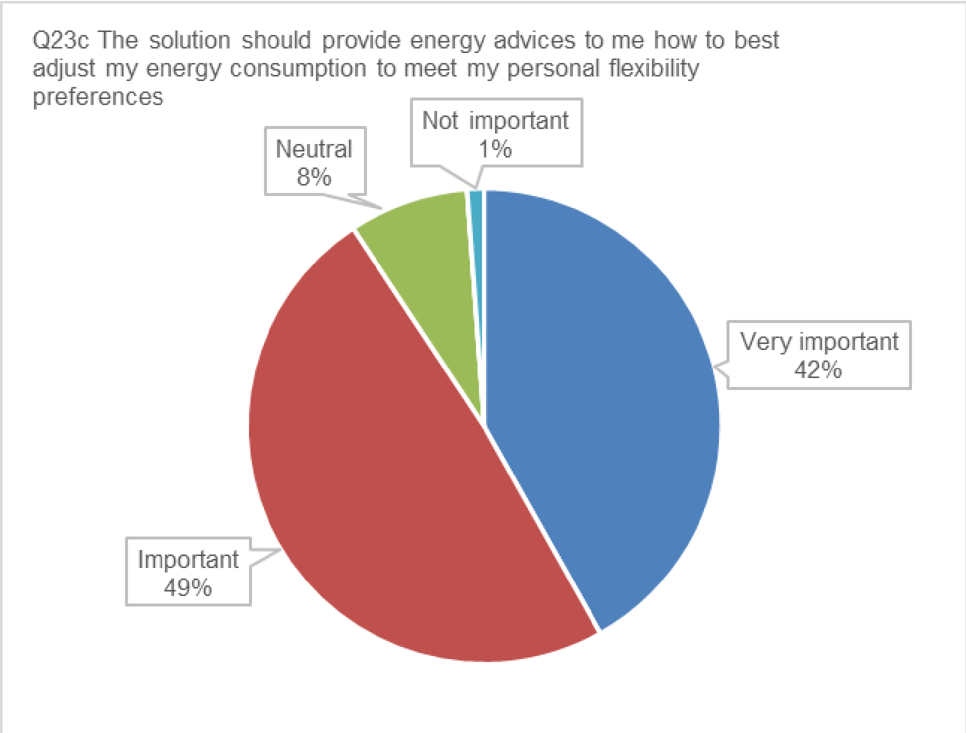
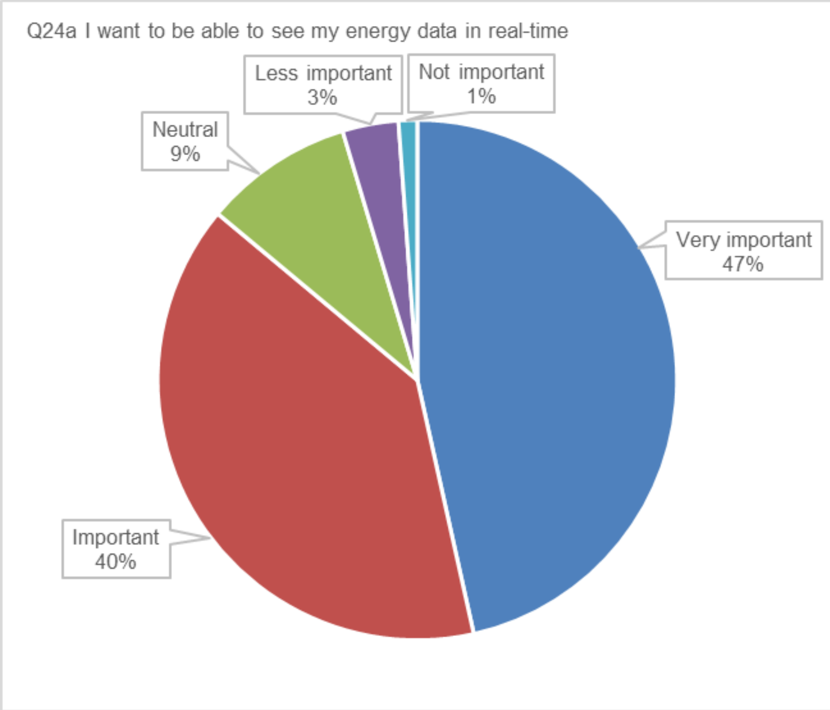
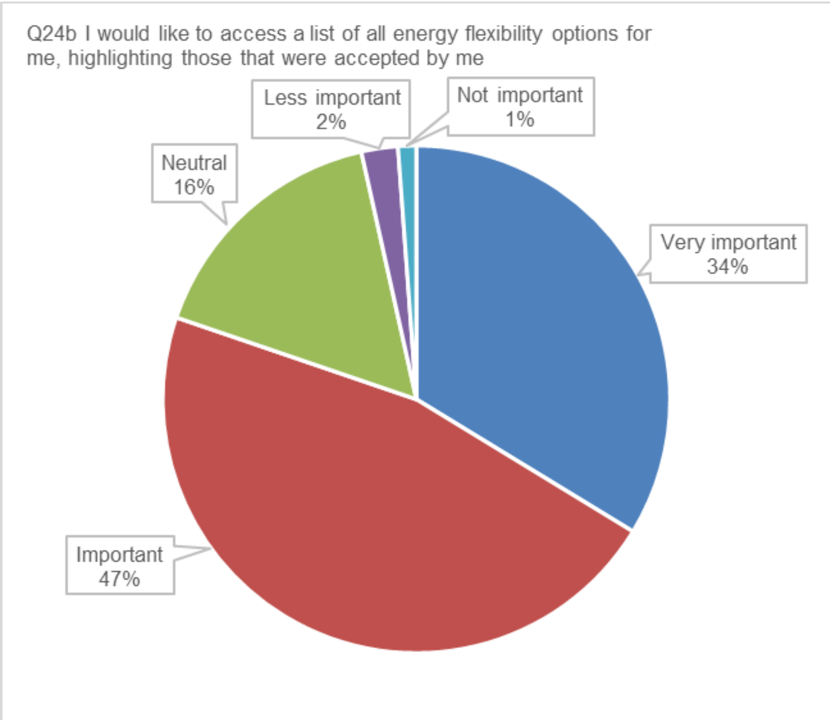
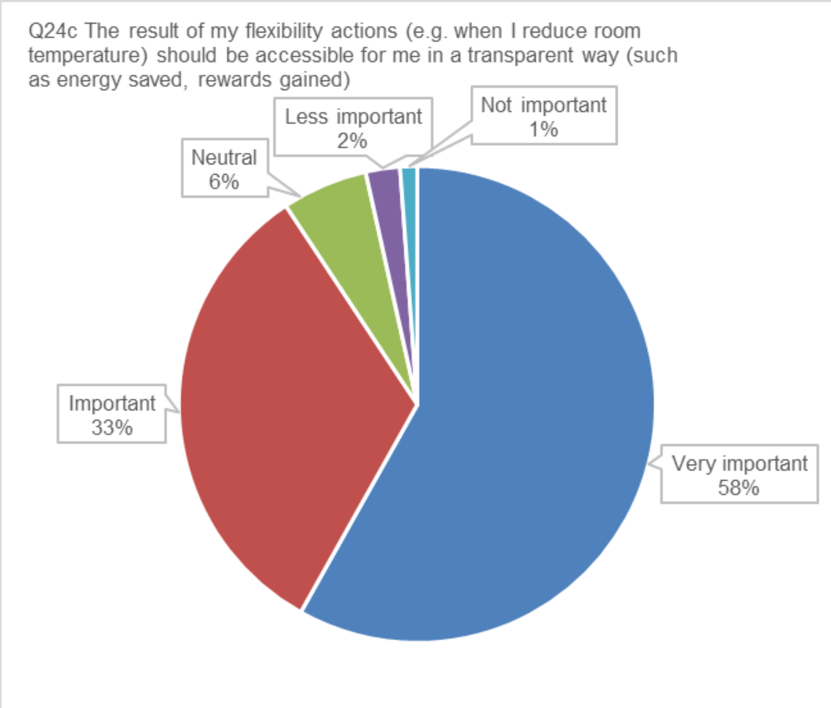


Figure 48: iFLEX Assistant functionalities (Q23)


Q24a I want to be able to see my energy data in real-time
Less important
3%
Not important
1%
Neutral
9%
Very important
47%
Important
40%


Q24b I would like to access a list of all energy flexibility options for me, highlighting those that were accepted by me
Less important
2%
Not important
1%
Neutral
16%
Very important
34%
Important
47%



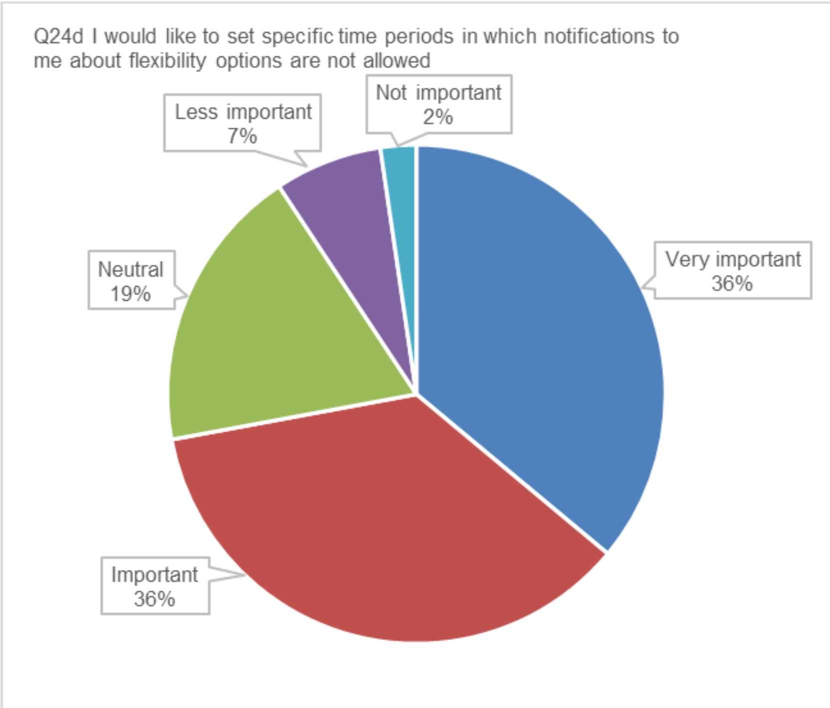


Figure 49: Importance of different functionalities (Q24)

5.2.4 Validation of the iFLEX concept – Greece

For the deeper analysis of the validation of the iFLEX concept, we looked at the data from a group perspective meaning that an individual can figure in more than one group. In other words, we accept that an individual may have several preferences and motivational drivers and may therefore figure in more than one group.

Looking at how respondents would like to participate in energy flexibility, we analyse the answers from question 16c, d and e which would result in 3 groups for further analysis. Each group (16c-16e) is made up of the respondents who have strongly agreed/agree with the statement in questions 16d-e; a respondent can therefore figure in more than one group. All three options are positively valued by the majority of respondents with the option "*I could allow a smart digital assistant to automatically adjust energy consumption in my* *household, but only if my comfort stays the same*" (16d) as the most preferable option by 74% of the entire data sample (i.e. respondents either strongly agreed or agreed with the statement). This was closely followed by (16e) "*I could invest in technology that would allow my energy devices (e.g. electric water heater) to automatically adjust consumption when needed by the grid*" (67%) and finally option 16c "*I could allow my energy provider to regulate specific energy demanding devices in my house (e.g. electric water heater), but only if my comfort stays the same*" (57%), see Figure 50. This result indicates that there is good potential for the iFLEX Assistant to be received positively and it will be interesting to evaluate pilot participants' experiences with using the assistant in the 2nd and 3rd phase of the pilot.

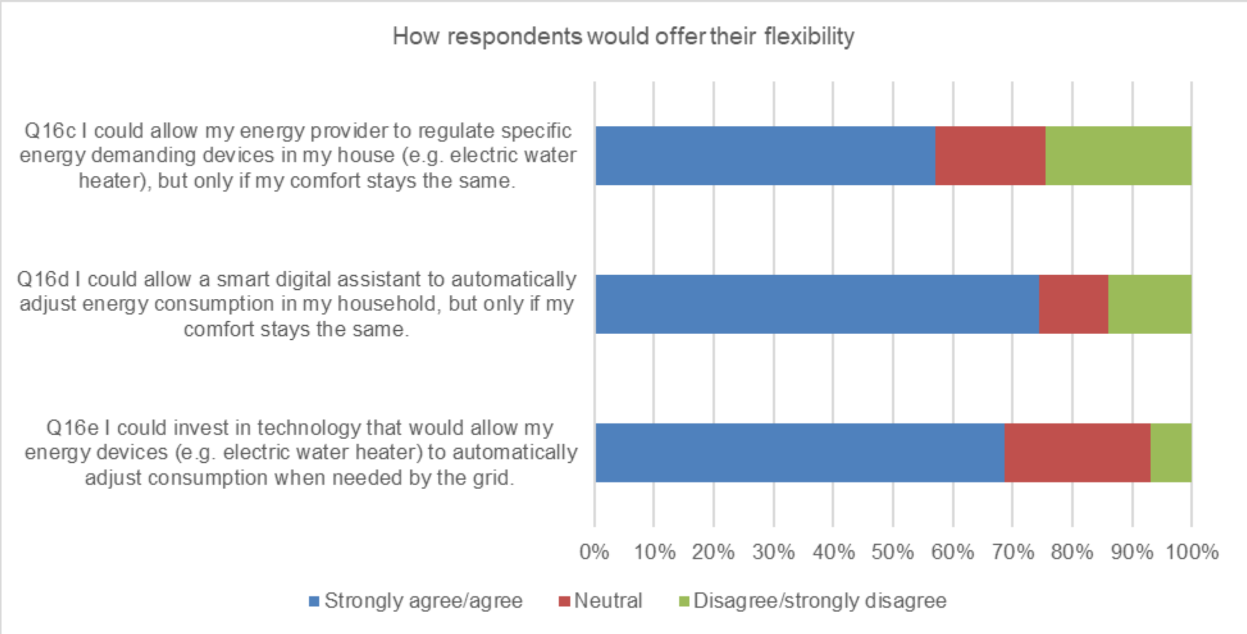


Figure 50: How all respondents would offer their flexibility (Greece)

There was slight gender difference in that while female respondents were most interested in option 16d, male respondents were practically equally interested in option 16d (N=42, 74%) and option 16e (N=43, 75%). Female respondents were, on the other hand, least interested in option 16e (N=16, 55%).

The next step in the analysis was to look at how many participants were willing to adopt flexible energy behaviours and what type of action appealed to most. For this purpose, we analysed the answers to questions 16a "*I could change my daily routine (e.g. when to iron, cook, do laundry)*" and 16b "*I could lower my heating temperature set-point in wintertime".* First, from the overall perspective (entire pool of answers and so irrespective of how they would like to participate in Q16c-e), the results showed that N=62 (72%) would change their daily routine whereas N=71 (83%) would lower the heating temperature (Figure 51).

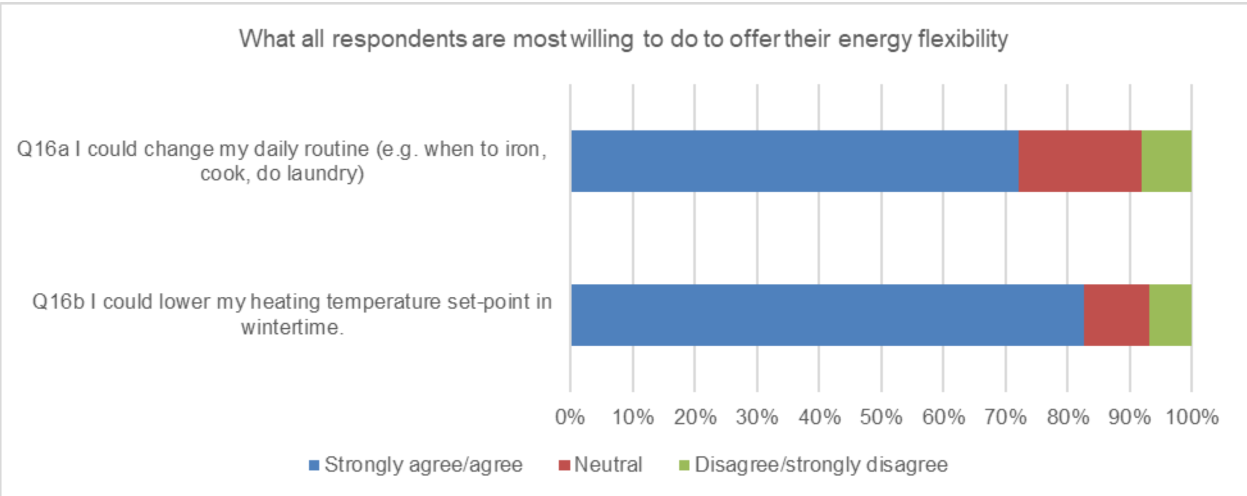


Figure 51: What all respondents are willing to do (Greece)

Overall, male respondents are slightly more positive towards offering their flexibility; male and female respondents who are positive towards offering their flexibility both prefer to turn down the heating (86% and 76% respectively).

The slight preference of lowering the temperature is repeated when looking at the results for each of the three groups based on their answers in Q16c-e (Figure 52).

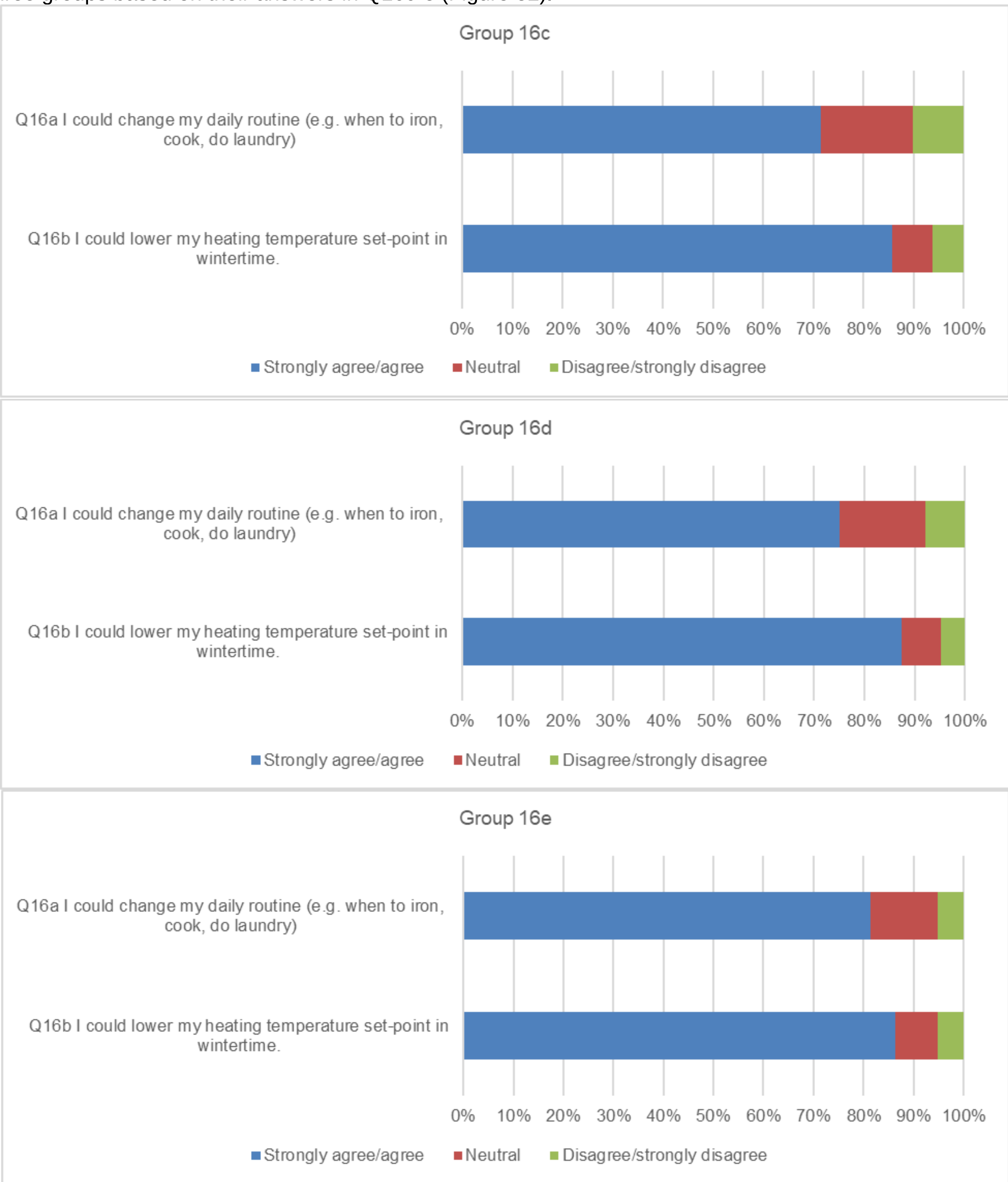


Figure 52: What individual groups are willing to do (Greece)

The final step is to see if there are any significant differences between the main motivational driver for each group. The motivational drivers have been divided into 3 categories: i) Save the world! (Q15a), ii) Save money! (Q15b & c), and iii) Told to do it! (Q15e&f).

The results are similar for all three groups and show that nearly all respondents are primarily driven by the idea of to “Save money” followed closely by to “Save the world”. However, group 16c is more positive towards the driver “Told to do it”. The following charts show the results for groups 16c-16e (Figure 53).

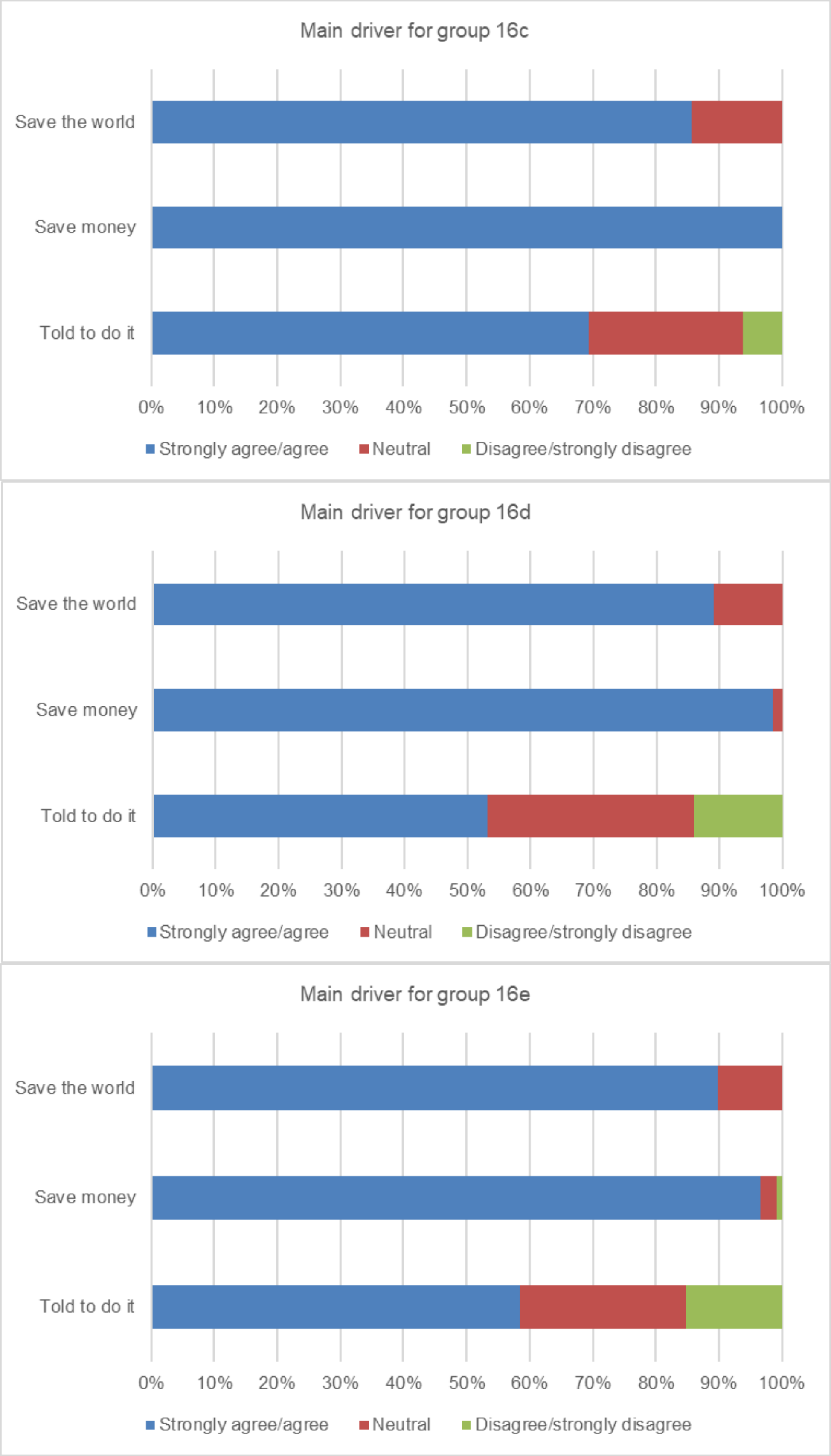


Figure 53: Main driver for each group (Greece)

There was a small gender difference related to the main driver. Whereas female respondents are overwhelmingly and practically equally driven by “Save the world” and “Save money”, practically all male respondents are driven by “Save money” and less so by “Save the world”.

5.2.5 Public survey results – Slovenia

The Slovenian survey was distributed to the members of ZPS. 278 responses were collected with a completion rate of 85% resulting in 237 completed questionnaires. The majority of responses were completed immediately after the distribution of the questionnaire.

5.2.5.1 Basic respondent and household characteristics

Nearly all of the respondents (N=224) were also (one of) the person paying the electricity bill for the household. Of the 224 respondents, only four answered that they were not the person making decisions related to electricity (e.g. switching supplier, buying energy saving appliances). Out of the remaining 220 respondents who both pay the bill and make decisions regarding electricity, 31 live alone.

On the other hand, nine of the total thirteen respondents who had indicated that they are not the person paying for electricity, stated that they were, however, the person making decisions related to electricity.

Overall, the data from Q1 and Q2 indicate that the respondents represent the relevant and appropriate population for the purposes of the survey.

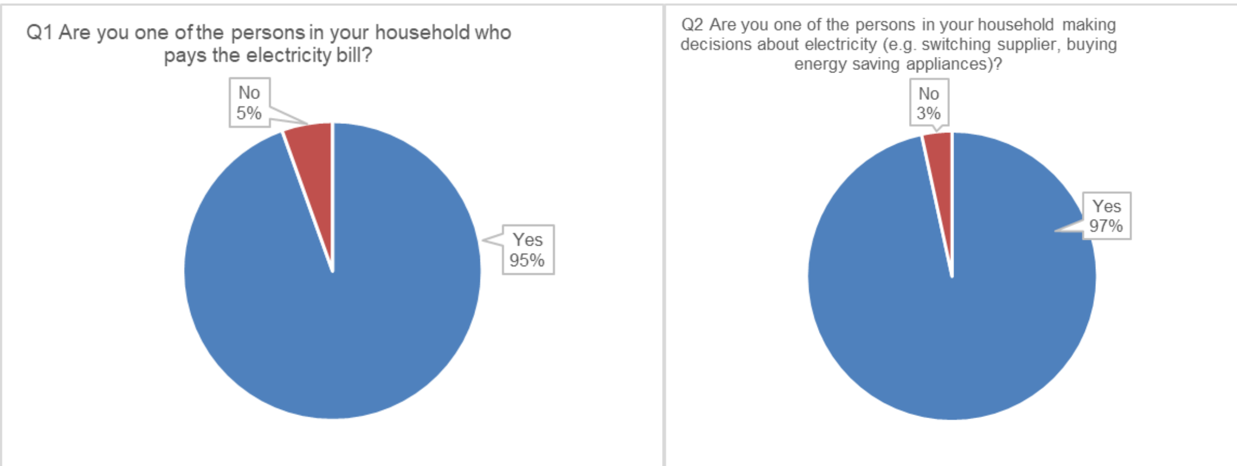
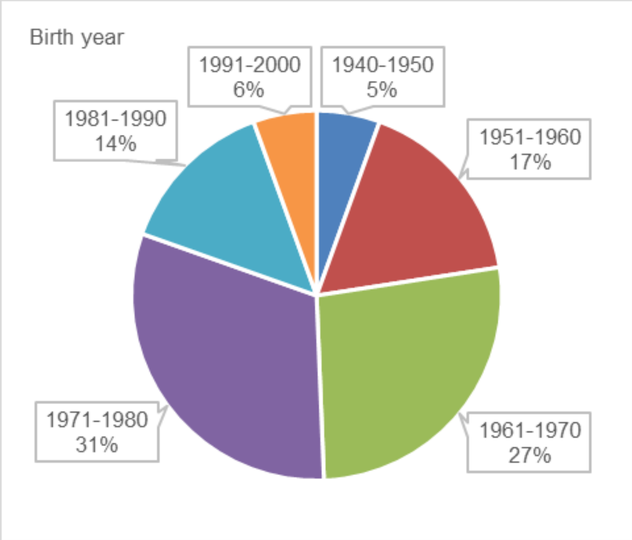


Figure 54: Percentage of respondents who bill the electricity bill (Q1) (left) and who making decision about electricity (Q2) (right)

In order to get a better idea and understanding of who the respondents were and their life situation, data on educational level, household characteristics, type and size of their dwelling was collected.

The majority of respondents were male (62%) and the most dominant age group was 41-50 years old (31%) (female N=24, male N=48, non-binary N=1) followed by 51-60 years old (27%) (female N=28, male=34). Two respondents provided unclear data with regards to their birth year (“1900” and “19570”) and have therefore not been included in the age count. The age and gender division of the people who completed the survey are illustrated below (Figure 55).



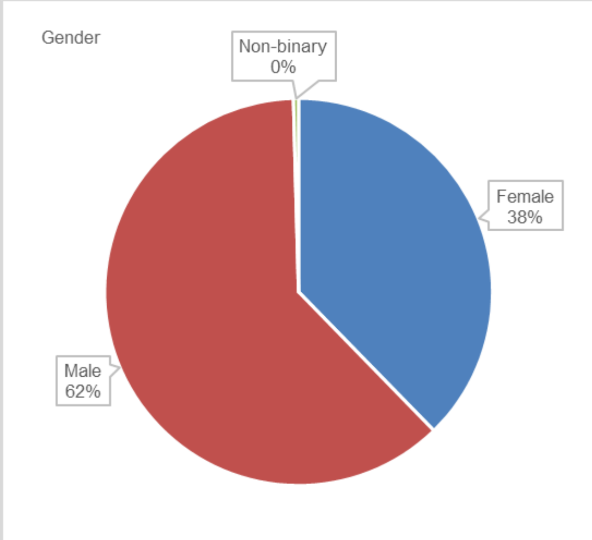


Figure 55: Age division (Q5) (left) and gender division (Q6) (right)

A little more than half the respondents (N=123, 52%) live with one other adult (over the age of 18).[9] Within this group, 54% (N=66) do not have any children living at home, while 32% (N=40) have with 2 children (under the age of 18) living at home.

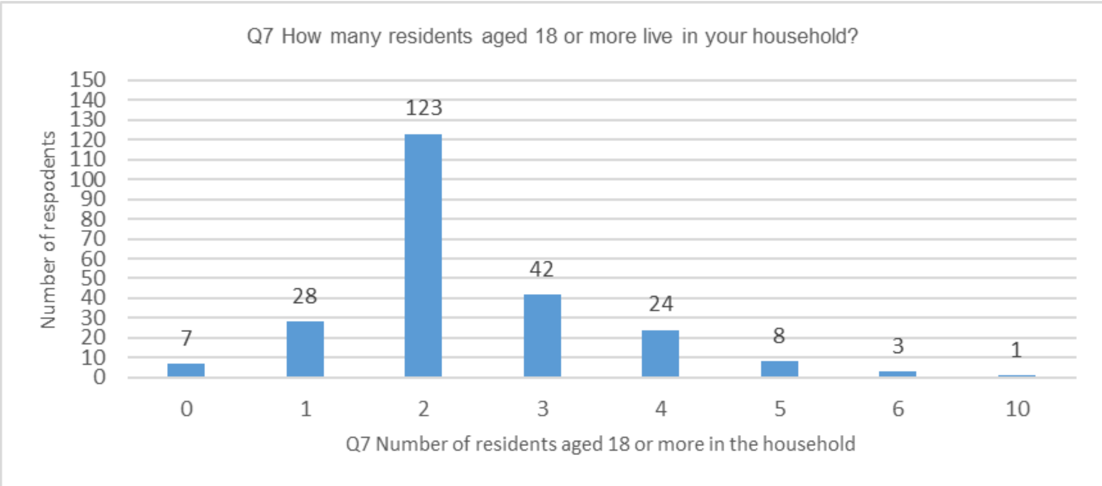


Figure 56: Number of residents over the age of 18 in the household (Q7)

7 respondents inserted the number "0" for Q7 (Figure 56) which presumably mean that they interpreted the question as meaning "in addition to themselves". Five of these 7 respondents had also inserted "0" in Q8 (Figure 57) indicating that no one under the age of 18 live in the household.[10] We may assume that they live alone (i.e. represent an additional 5 single households, making the total of single households N=30, see below).

A little more than half (61%) of the respondents do not have any children under the age of 18 living at home.

[9] One respondent had answered "3+3" for Q7 and "0" for Q8. Due to the ambiguousness of these two answers, the data was disregarded for the present graphs (Q7 and Q8), leaving a total of 236 responses.

[10] Unfortunately, it is also possible that other respondents also interpreted the question this way, however, we simply cannot tell if this is the case nor, if so, how many did so. A dropdown list with numbers in the questionnaire and/or inserting "in addition to yourself" could have avoided this misunderstanding.

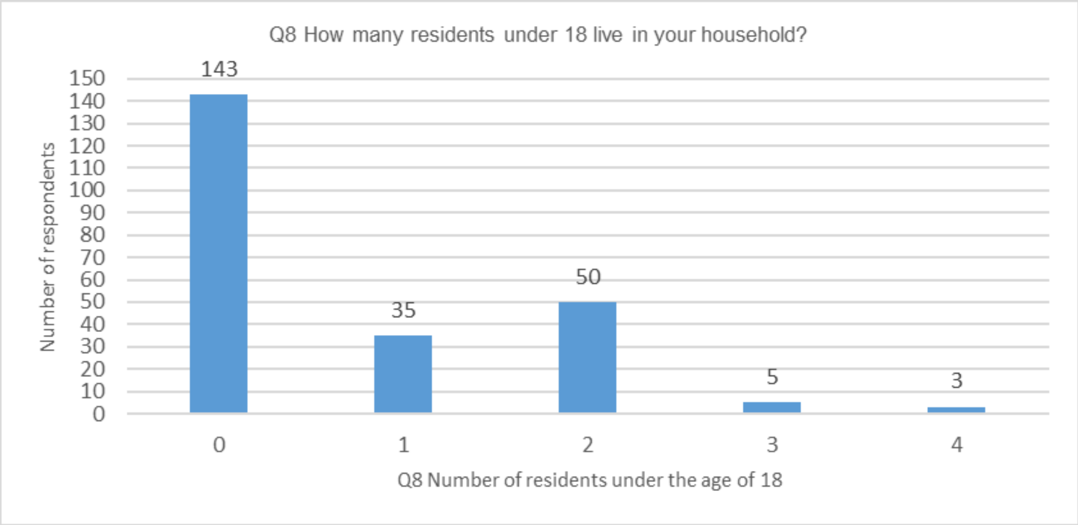


Figure 57: Number of residents under the age of 18 (Q8)

Of the people (N=143) who do not live with any children under 18, N=25 (presumably actually N=30, see above) were single households (1 person over 18), N=66 live with 1 other person over 18, N=27 live in a 3-person household where all residents are over 18, N=14 in a 4-person household where all residents are over 18, 4 live in 5-person household and 2 live in 6-person household.

With regards to educational level, the majority of respondents hold a Bachelor's degree or higher degree as illustrated in Figure 58 below.

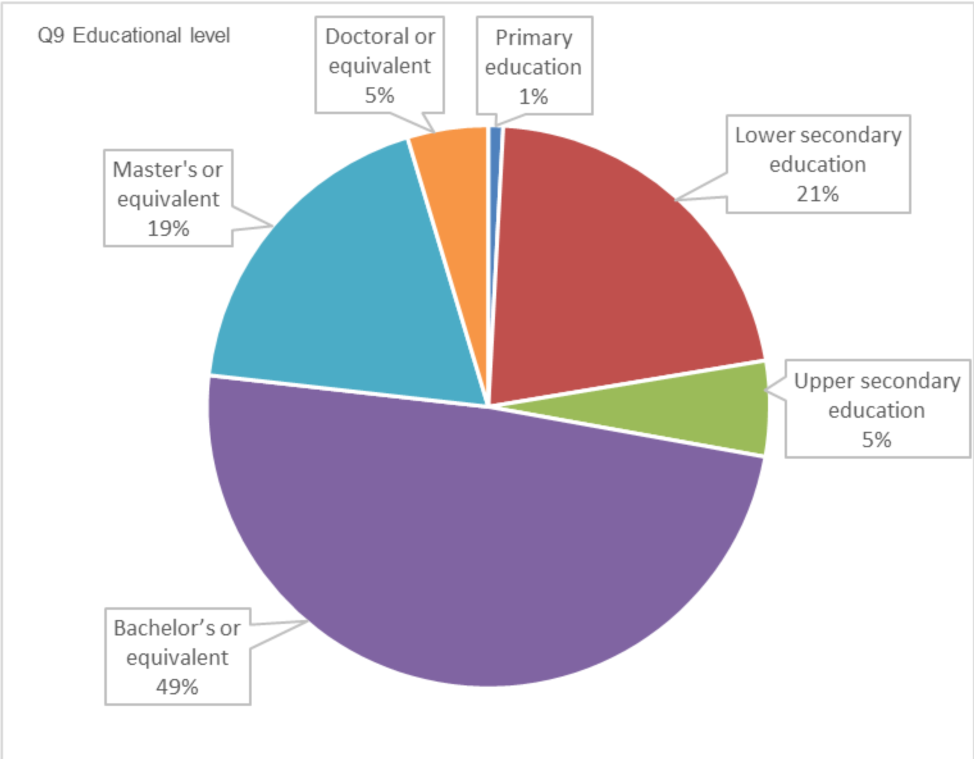


Figure 58: Educational level (Q9)

Basic knowledge on respondents' housing characteristics, i.e. type of home and its size (Figure 59 and Figure 60) and key appliances e.g. heating/cooling system, electric vehicles etc. (Figure 61), is illustrated below.

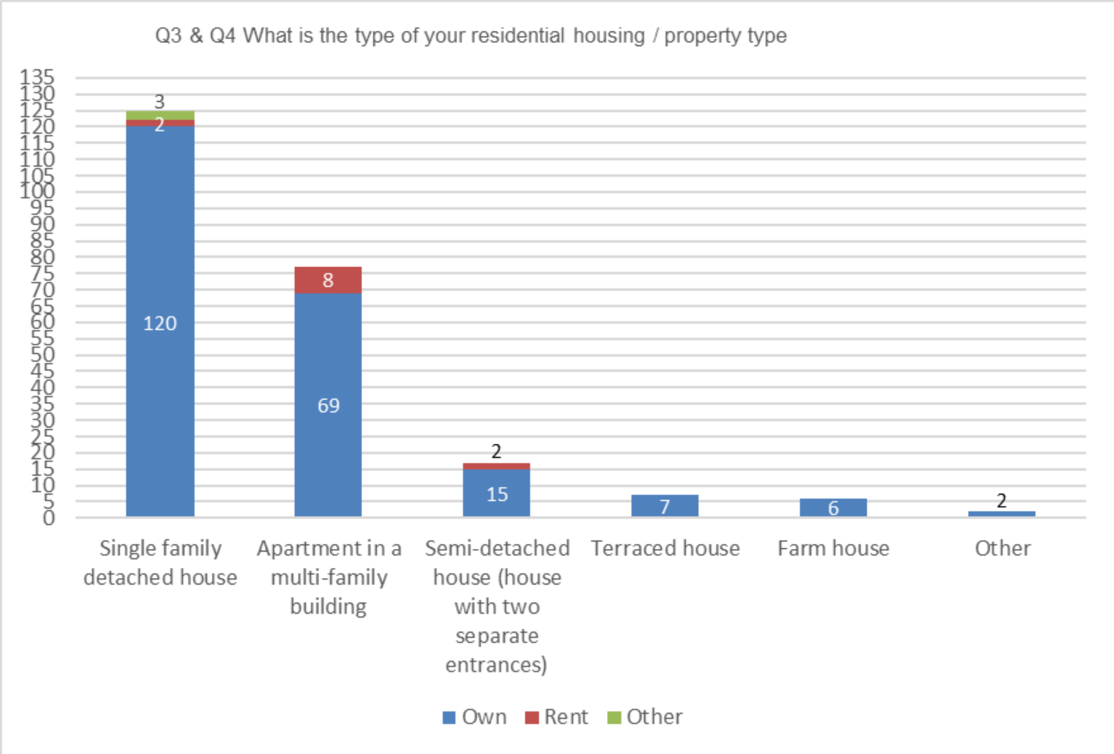


Figure 59: Type of residence (Q3 & Q4)

As Figure 59 above shows, nearly all respondents own their home (94%). With regards to size in m^2 of respondents' home, they can be roughly divided in 3 equal groups: 36% live in a home that 100 m^2 or less, 29% live in homes between 101-160 m^2, with the remaining 35% living in a home that is more than 160 m^2 (Figure 60 below).

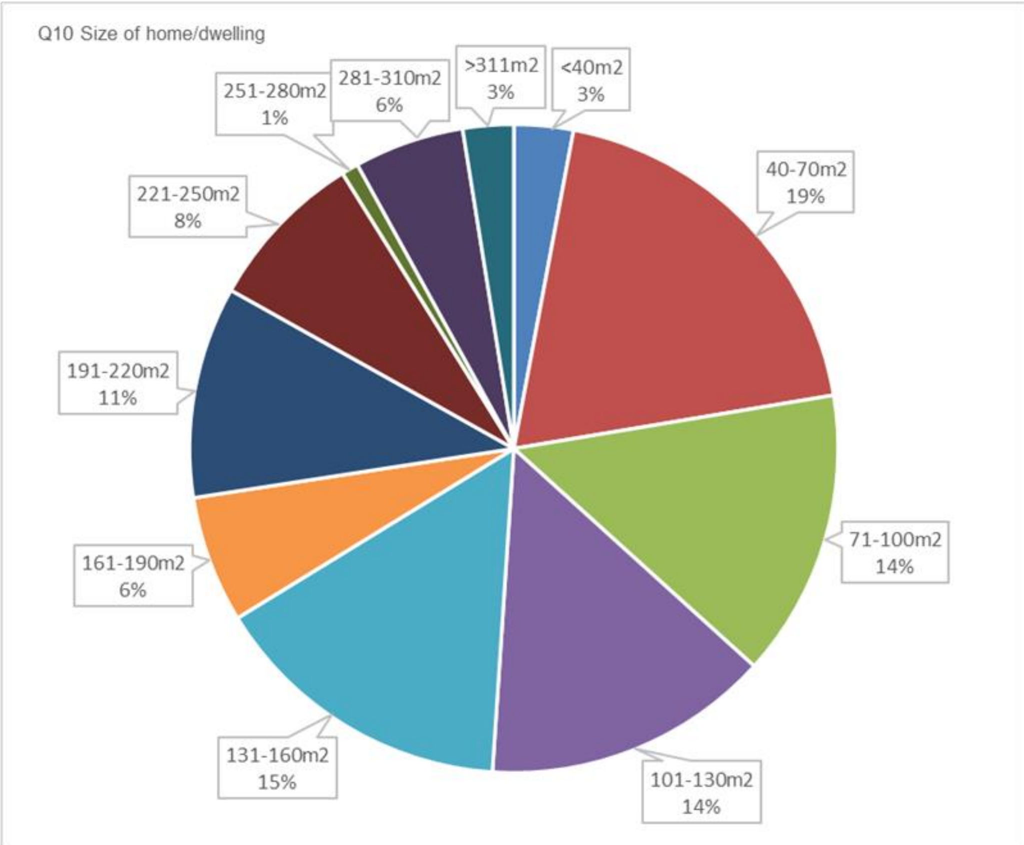


Figure 60: Size of dwelling (Q10)

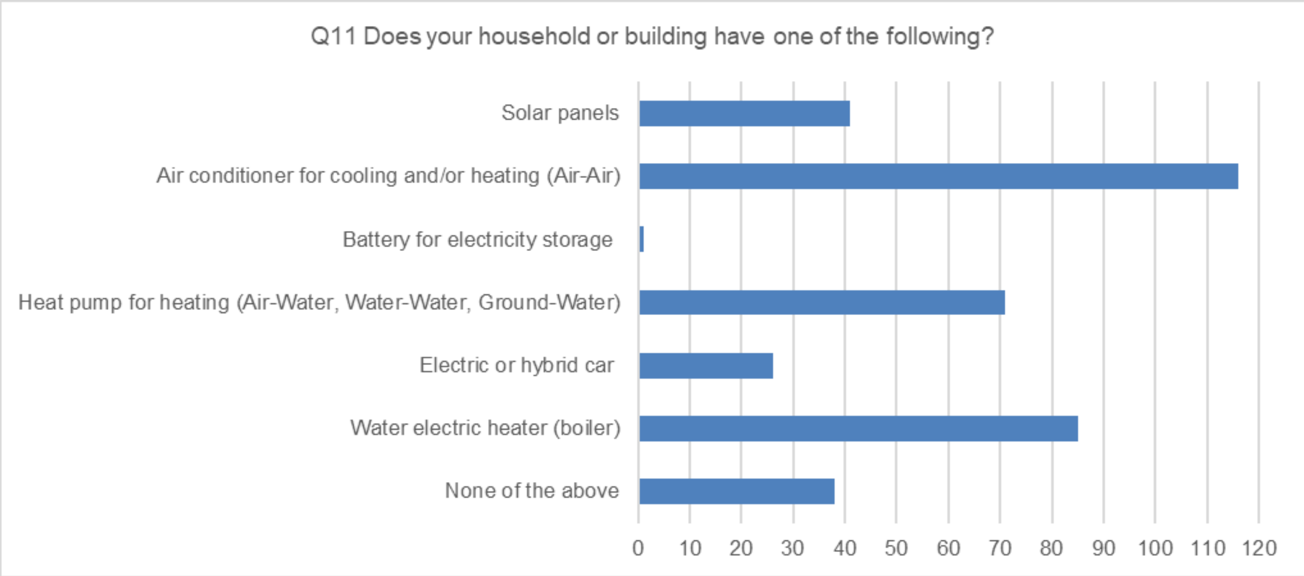


Figure 61: Key household appliances (Q11)

Within the group of the 41 (17%) respondents who have solar panels, the following applied:

- 14 respondents also have an electric or hybrid car
- 21 respondents also have air conditioner for cooling and/or heating (Air-Air)
- 29 respondents also have heat pump for heating (Air-Water, Water-Water, Ground-Water)
- 9 respondents also have water electric heater (boiler)

The one respondent who has a battery for electricity storage also had solar panels, an electric or hybrid car, and a eat pump for heating (Air-Water, Water-Water, Ground-Water).

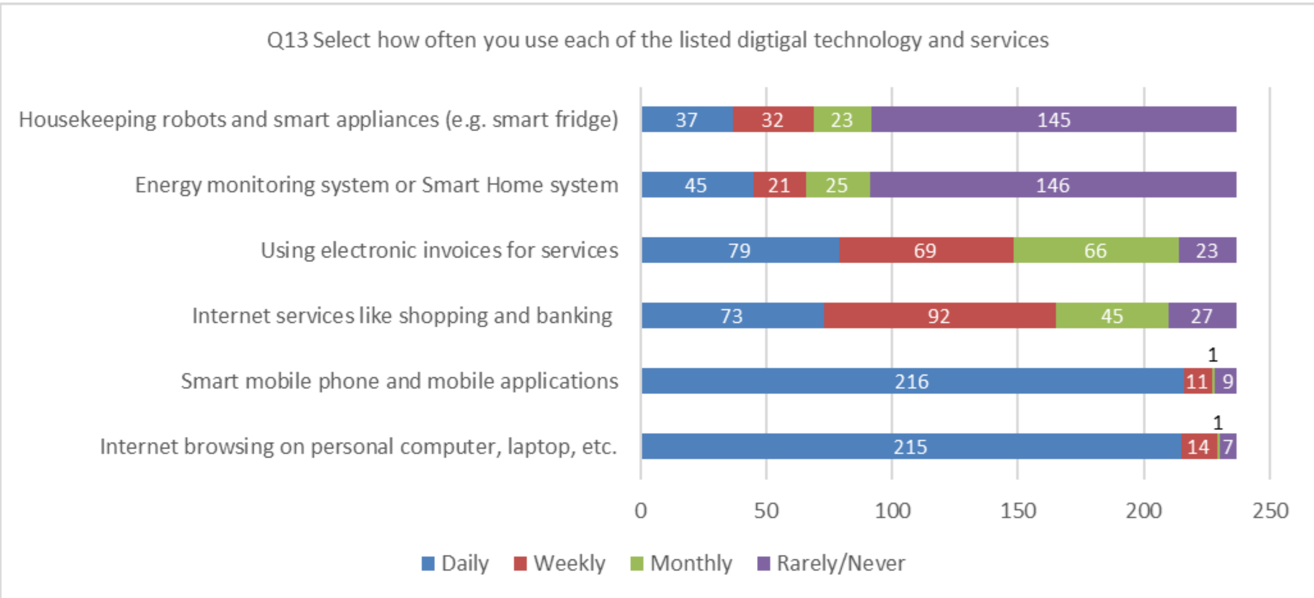


Figure 62: Frequency of use of different technologies and services (Q13)

Figure 62 above represents how often respondents use the listed technologies and services. 62% rarely or never use an energy monitoring system or smart home system and only 19% use such systems daily. Similarly, 61% rarely or never use housekeeping robots and smart appliances compared to 16% who use it daily. Respondents do, however, use a smart phone and mobile appliances: 91% does so on a daily basis, 5% on a weekly basis and 4% rarely or never.

Figure 63 below show that two-thirds of the respondents (N=158, 67%) use their bill (paper or electronic) to monitor their energy consumption. Within this group, a little more than half (56%) do not use other means to monitor their energy consumption. A few respondents also use one other option: 11 respondents (7%) also use mobile app and 10 (6%) also use a website whereas 25 respondents (16%) also use their in-home energy monitor (meter) for one or more appliances. The one-third respondents (N=79) who do not use their bill, mostly use a mobile app in combination with website (N=12, 15%) or in-home energy monitor (meter) for one or more appliances (N=11, 14%). 10 respondents (13%) *only* use a mobile app, 9 (11%) respondents *only* use their in-home energy monitor (meter) for one or more appliances followed by the use of *only* a website (N=7, 9%).

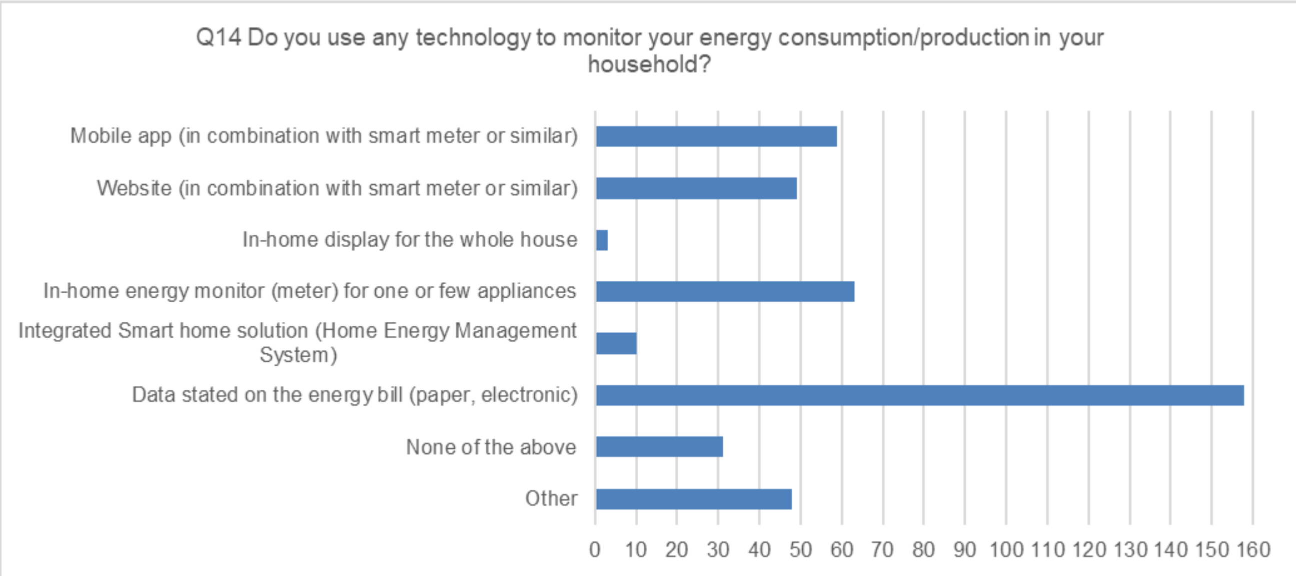
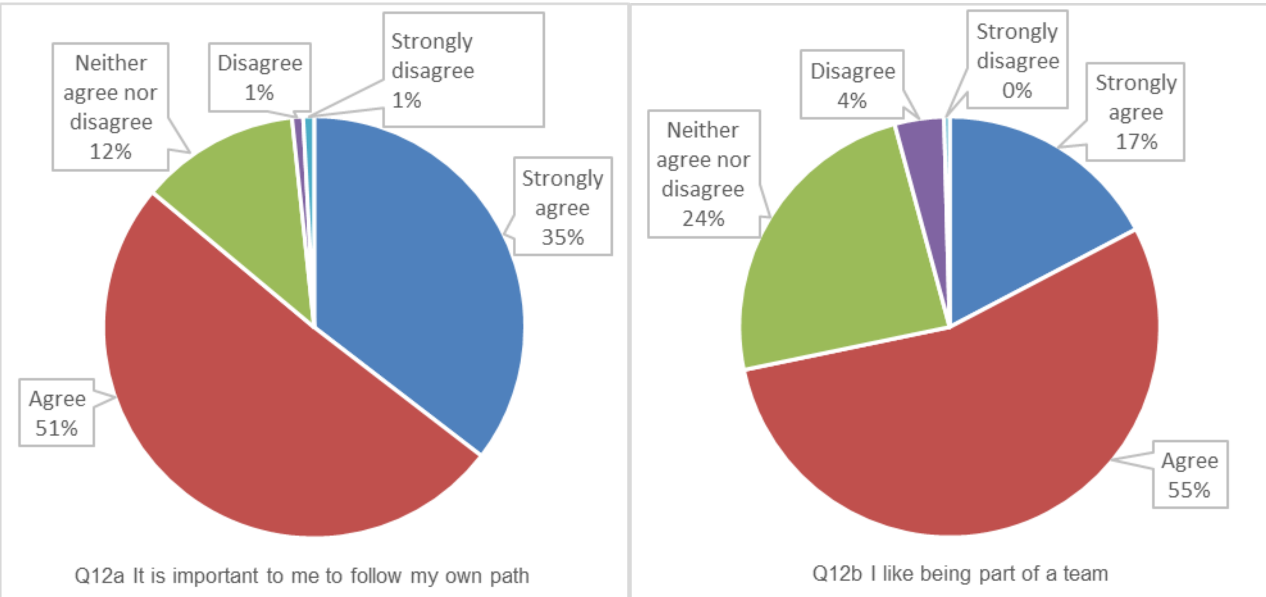
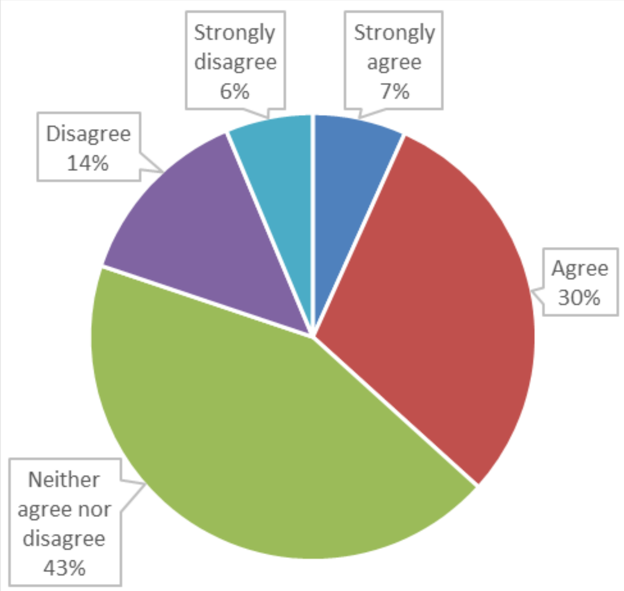


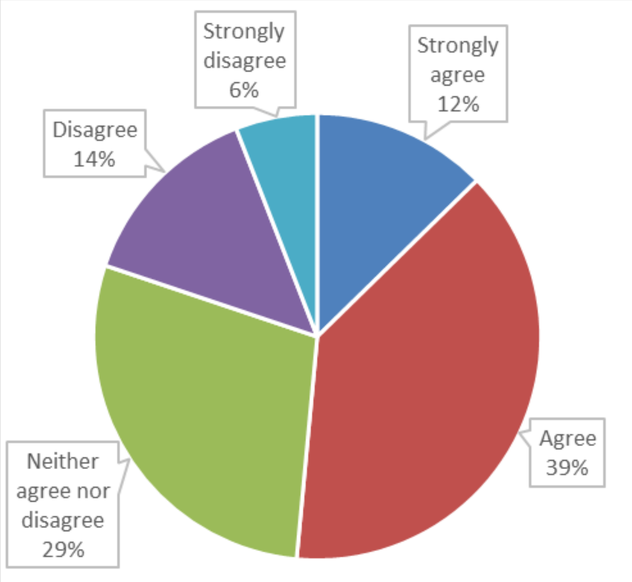
Figure 63: Use of technology to monitor energy consumption/production (Q14)

A set of questions and also enquired into personal characteristic/user type (Q12) as well as issues of personal comfort (Q20).

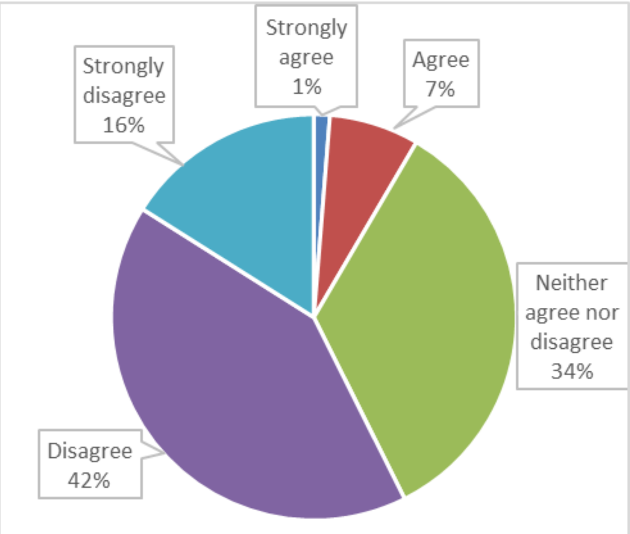




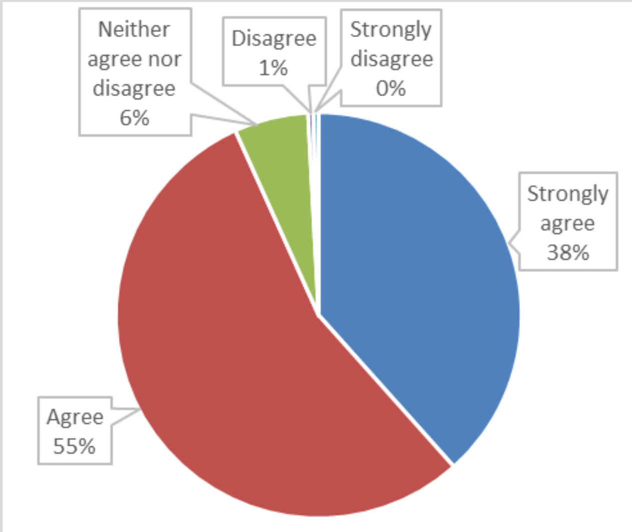
Q12c I like competitions where a prize can be won



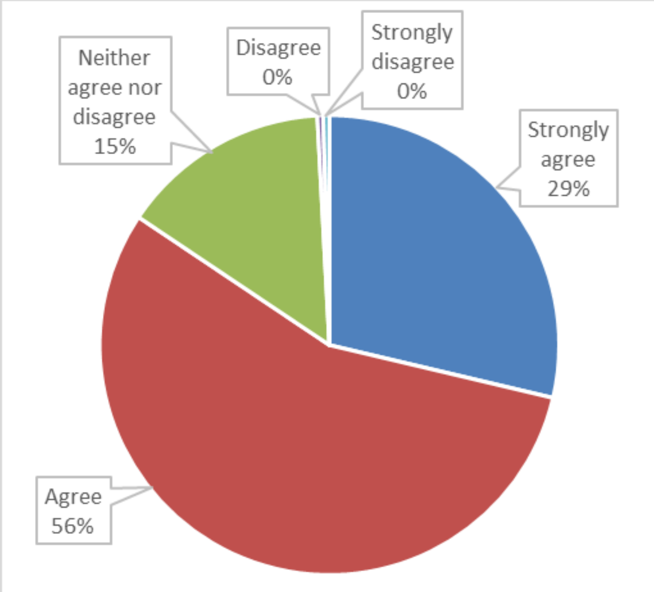
Q12d Rewards are a great way to motivate me



Q12e I dislike following rules

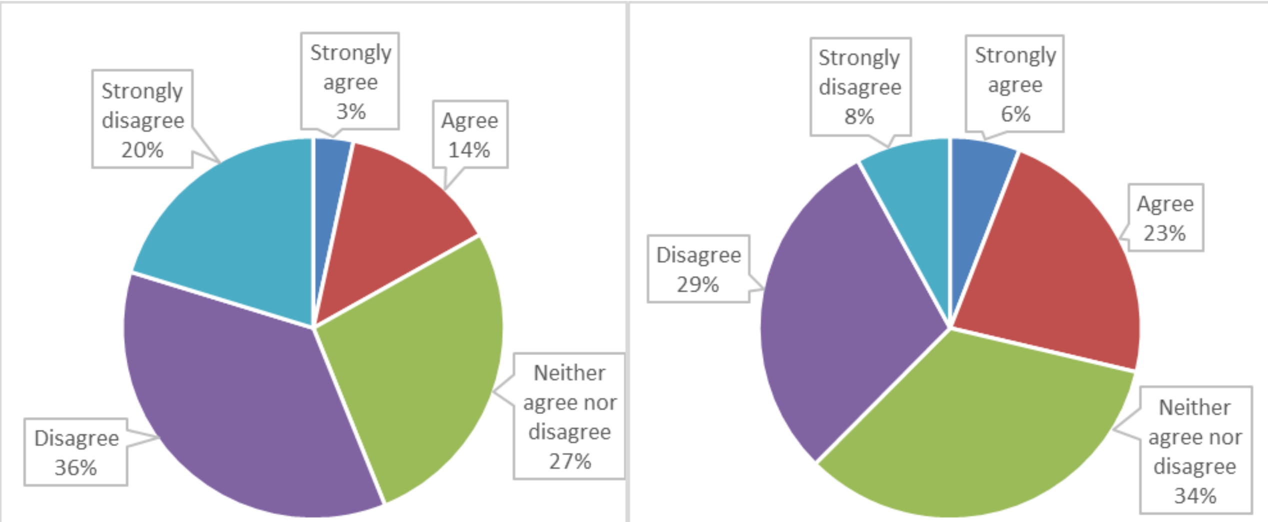


Q12f I like sharing my knowledge



Q12g I would like to enhance my skills by training

Figure 64: User type/personal characteristics (Q12)



Q20a Bad weather or climate conditions make me sick.

Q20b I often feel colder/warmer than people around me.

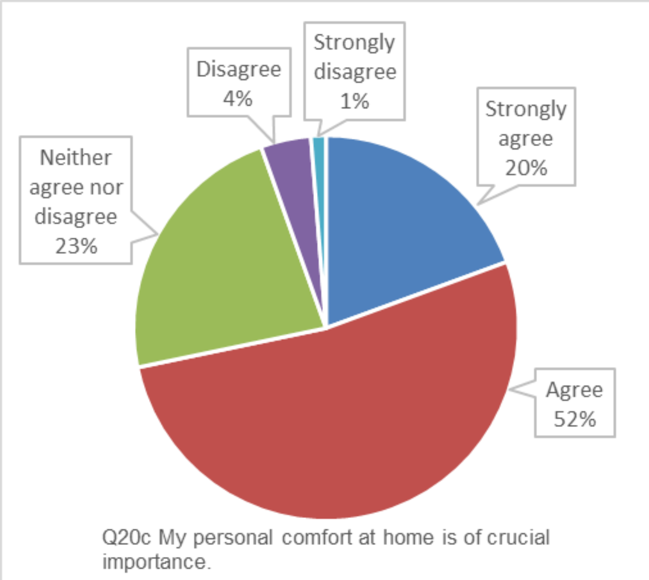
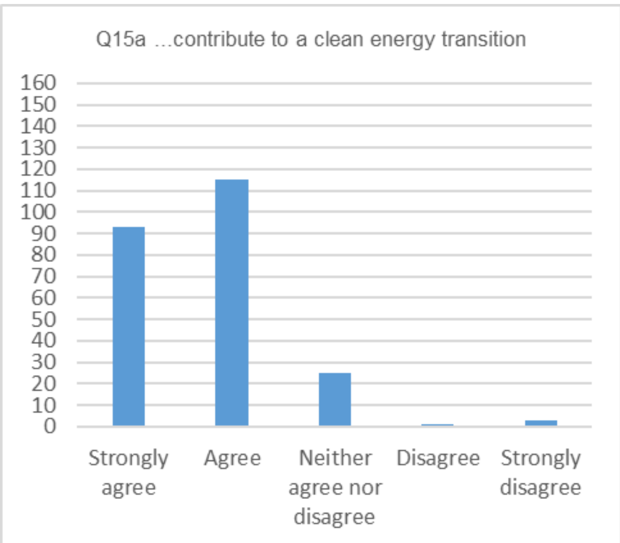


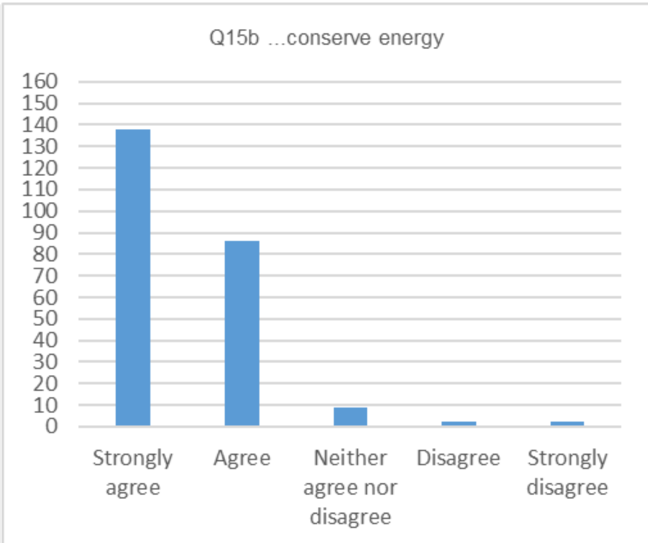
Figure 65: Personal characteristics (disadvantages and comfort) (Q20)

5.2.5.2 Energy and flexibility: awareness, incentives, willingness and requirements

The second part of the survey enquired into respondents' awareness of energy consumption and flexibility, their willingness and key incentives to participate in flexibility events. The questions here enquired into respondents' opinion asking them to indicate their level of agreement with different statements.

The first question (Q15), asked respondents to indicate what would motivate them to offer their flexibility ("I would offer my flexibility if I would…"). The answers are illustrated in the 7 graphs below (Figure 66).





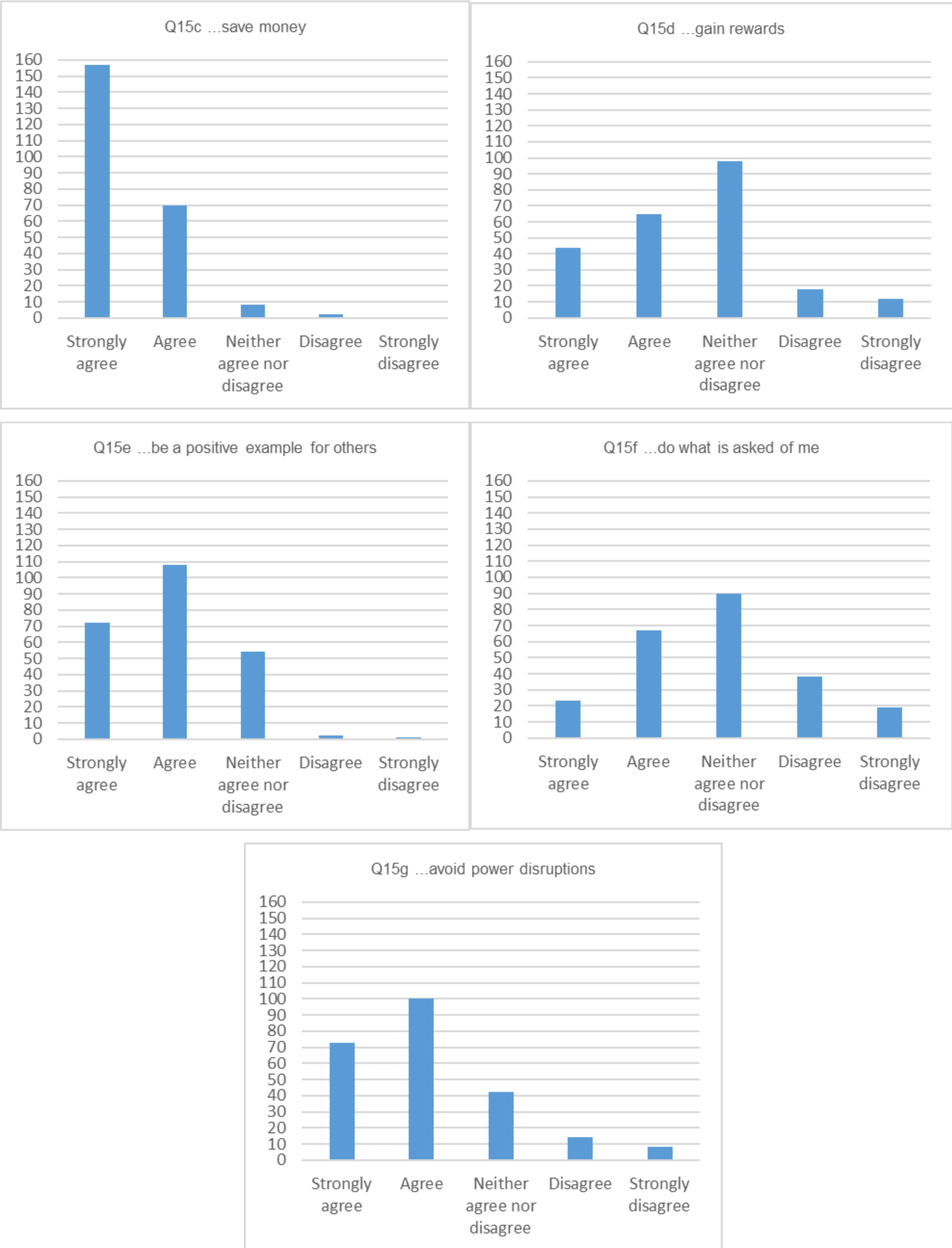


Figure 66: Reasons for offering flexibility (Q15)

The figures (Figure 67) below illustrate how willing respondents are when it comes to changing specific energy behaviours with respect to offering energy flexibility.

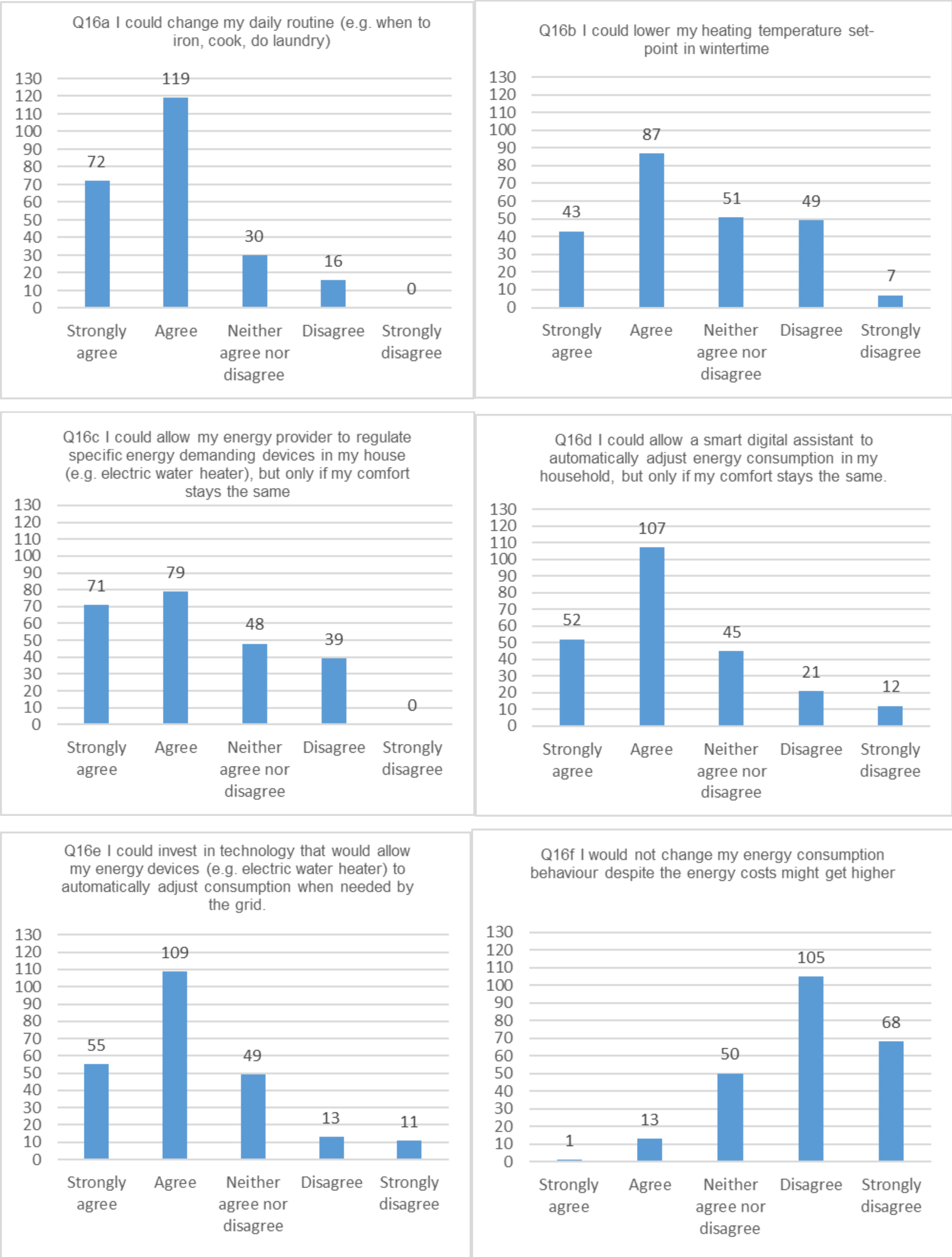


Figure 67: What are you willing to do to be able to offer flexibility in energy consumption (Q16)

The next four graphs (Figure 68) illustrate respondents' energy consumption and energy flexibility awareness.

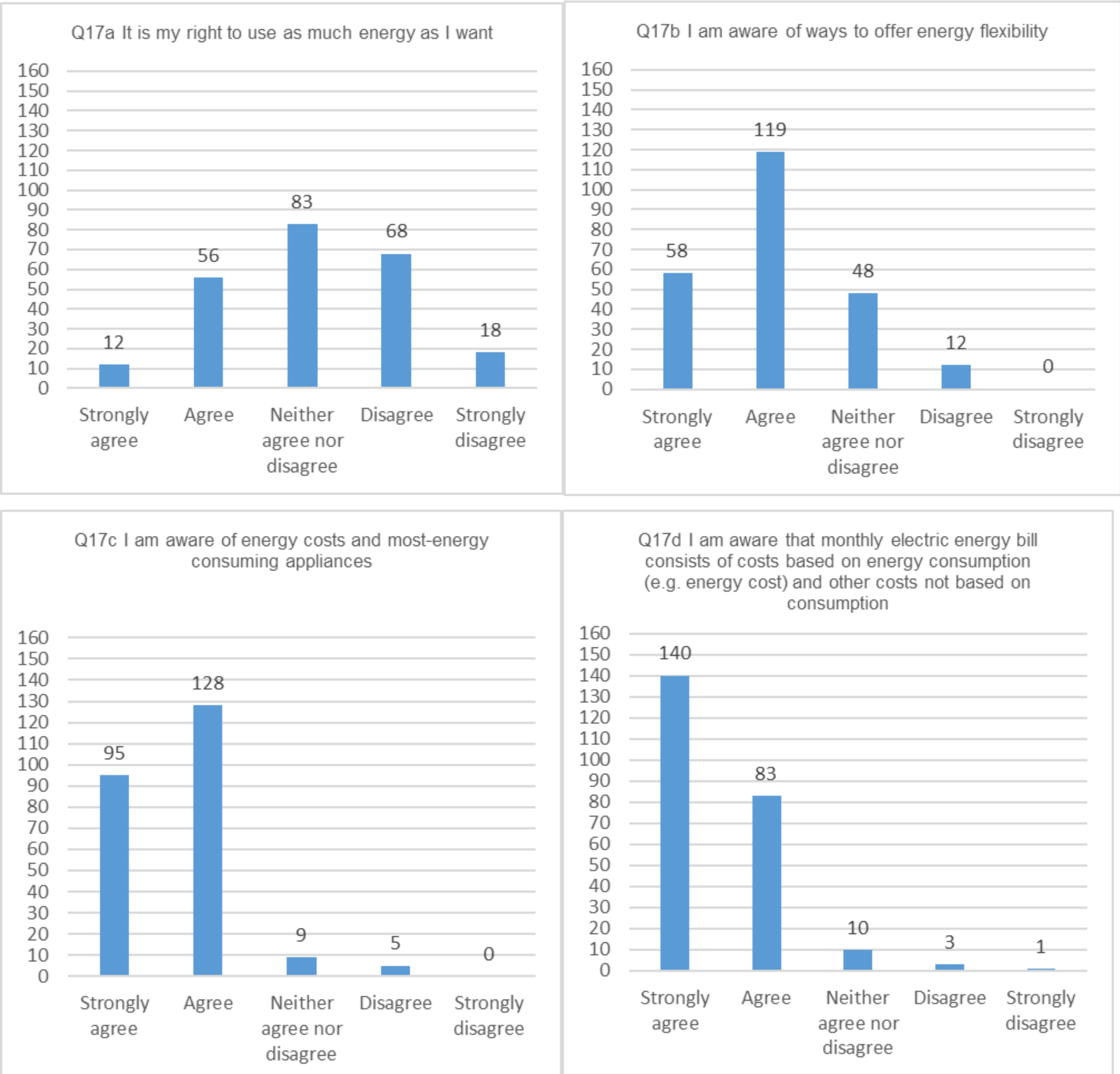


Figure 68: Energy and flexibility awareness (Q17)

In Figure 69, question 18a “Conserving energy and natural resources is important to me” and 18b “Conserving energy is not my problem” generated a lot more extreme and clear opinions than question 17a “It is my right to use as much energy as I want” (Figure 68) which saw respondents more neutral and more evenly spread out across the scale.

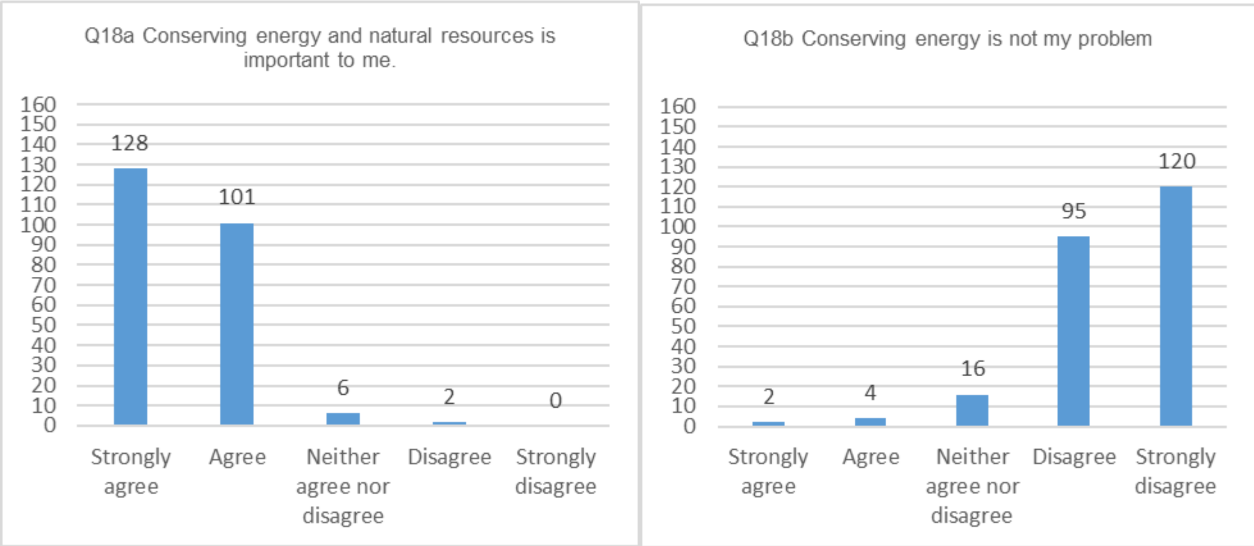


Figure 69: Attitude towards conserving energy (Q18)

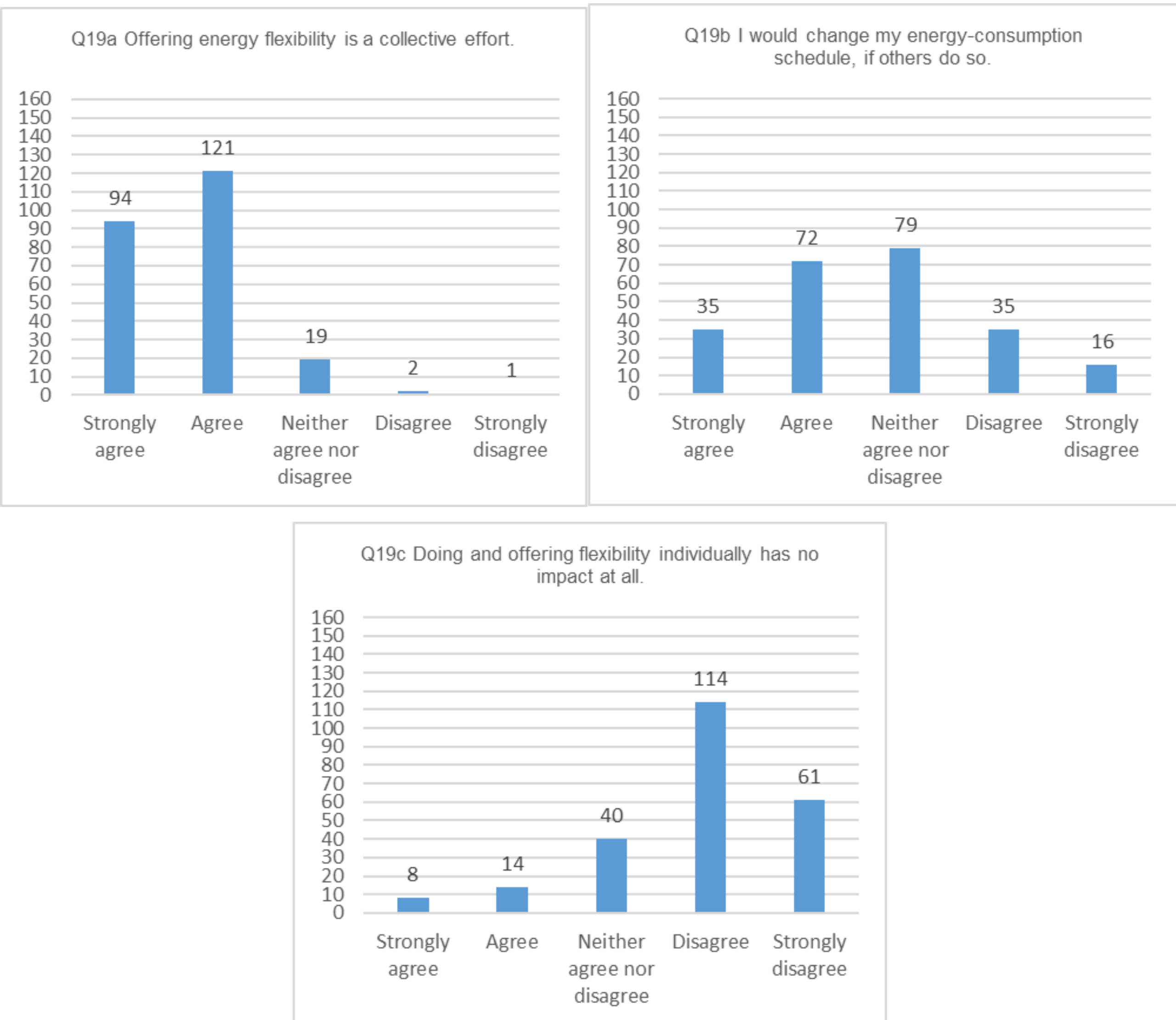
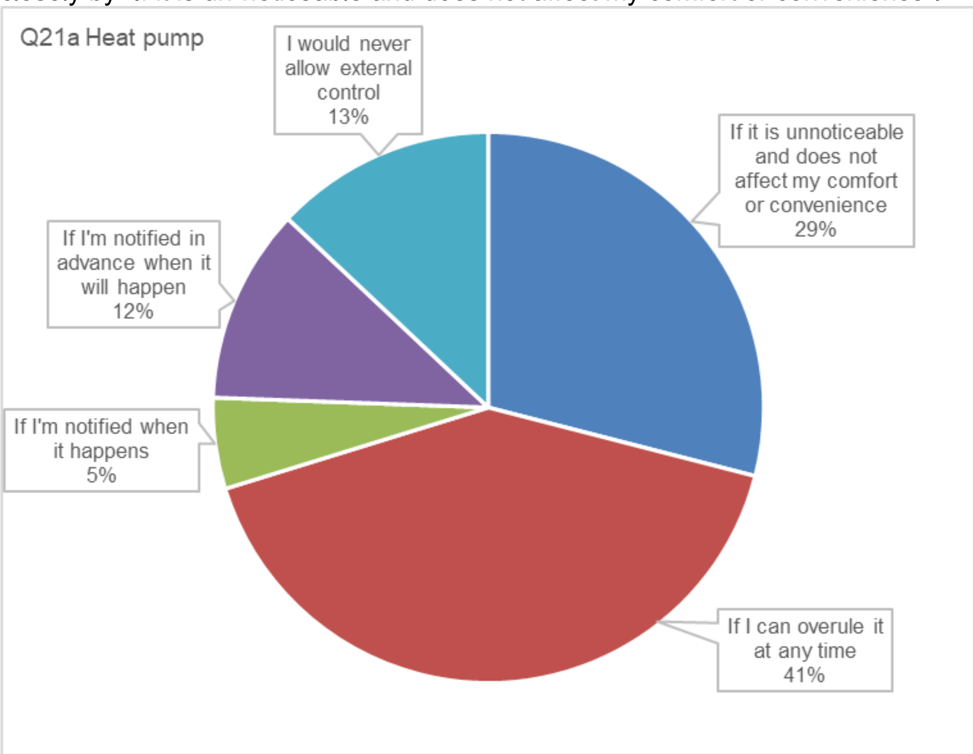
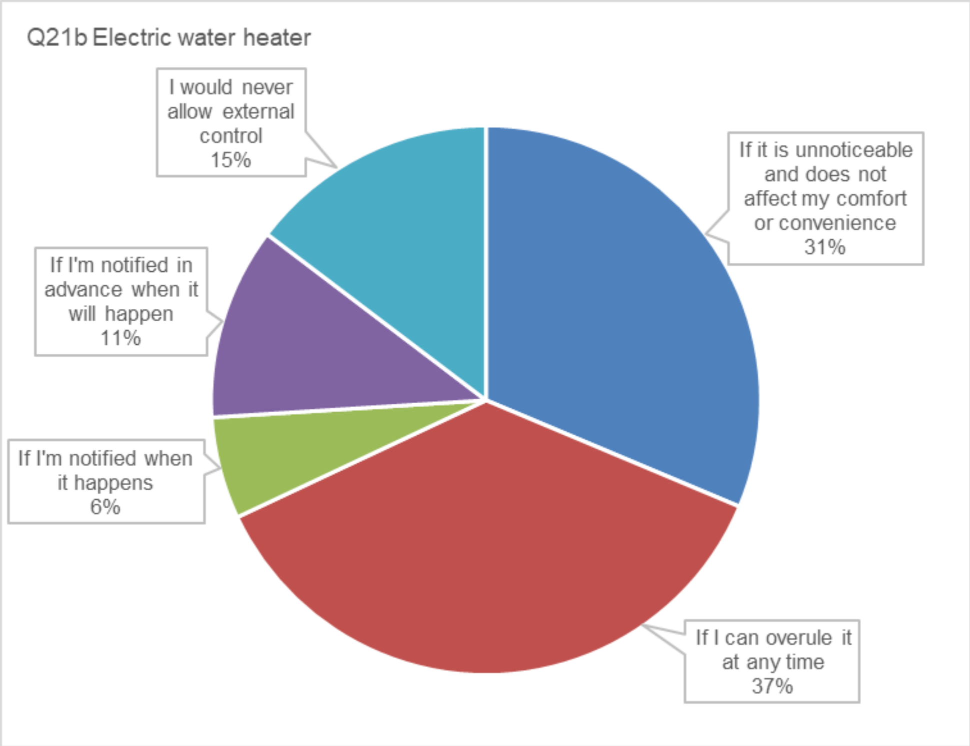


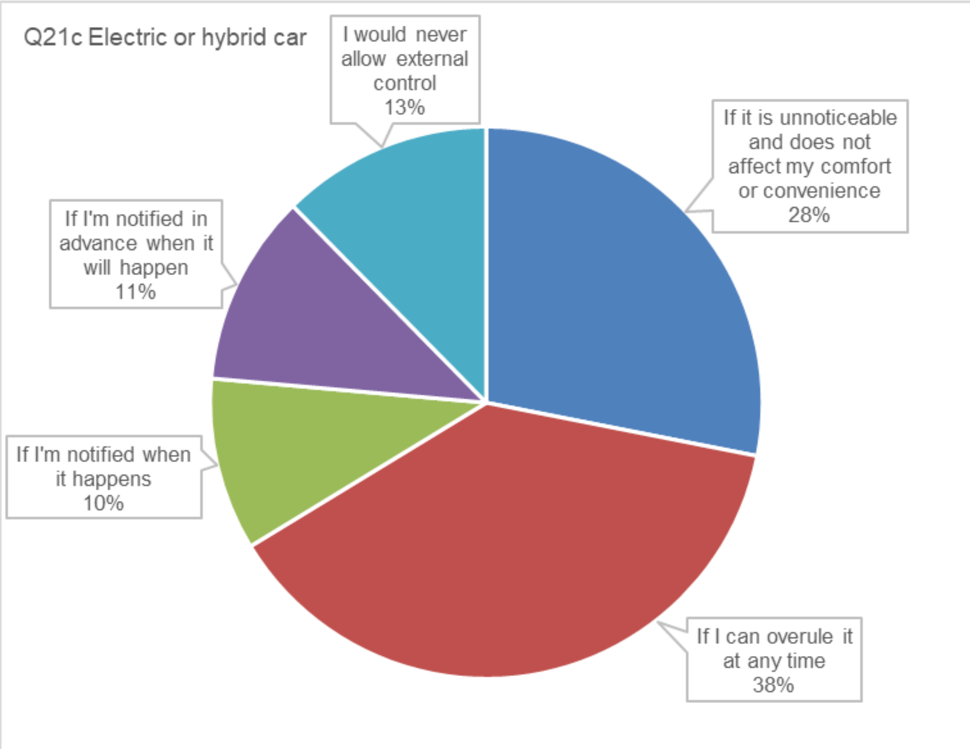
Figure 70: Attitude towards offering flexibility (Q19)

The next four graphs (Figure 71) are based on answers to Q21 “Under which conditions would you be willing to allow external control of the following devices in your household?”. Based on answers in Q11 (what devices respondents have in their household), it appears that some respondents have answered the question (Q21) irrespective of whether or not they actually have the device in question (despite there being a “not applicable” option). For example, only N=26 had indicated that they own an electric/hybrid car whereas N=89 had answered the question related electric/hybrid car in Q21. Interestingly, only 3 of these 26 respondents had answered “I would never allow external control”. In fact, there were no major differences between how respondents who own an electric/hybrid car had answered this question compared to respondents who do not own one. Thus, surprisingly, respondents were most flexible with respect to the electric/hybrid car and the heat pump whereas they were the least flexible with respect to their air conditioning device.

Overall, the data show that being able to “overrule at any time” is the most important condition for all devices. It is followed closely by “If it is un-noticeable and does not affect my comfort or convenience”.




Q21b Electric water heater
I would never allow external control 15%
If it is unnoticeable and does not affect my comfort or convenience 31%
If I'm notified in advance when it will happen 11%
If I'm notified when it happens 6%
If I can overule it at any time 37%


Q21c Electric or hybrid car
I would never allow external control 13%
If it is unnoticeable and does not affect my comfort or convenience 28%
If I'm notified in advance when it will happen 11%
If I'm notified when it happens 10%
If I can overule it at any time 38%

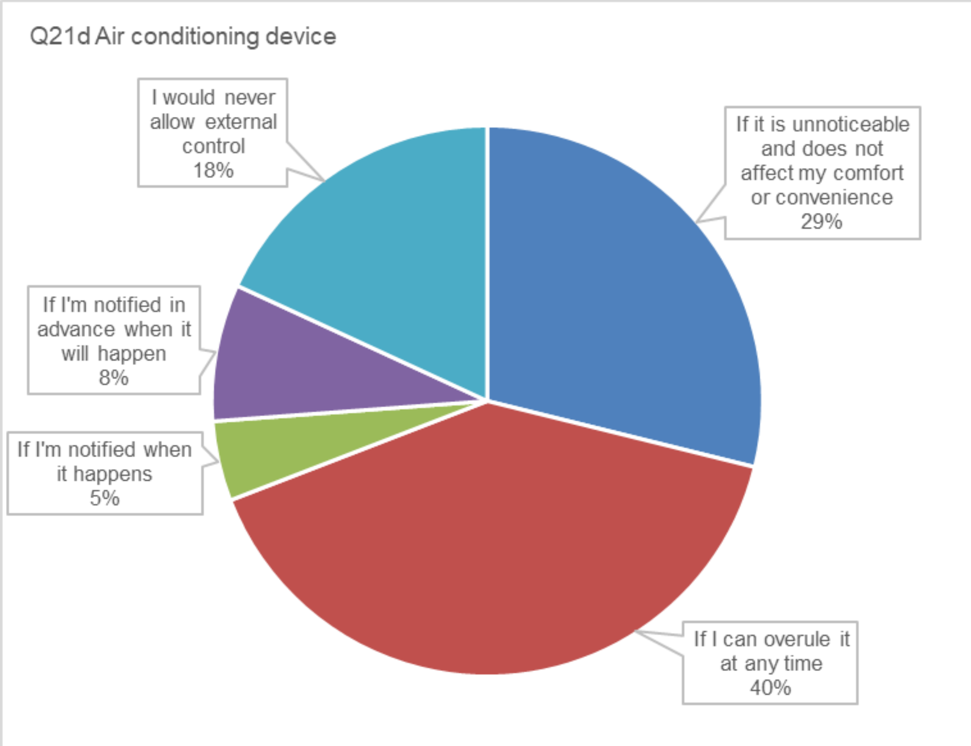


Figure 71: Conditions for allowing external control of devices (Q21)

The final questions are more closely related to the iFLEX Assistant and the functionalities respondents would like to see. The answers also give some indication of how attractive the concept of iFLEX Assistant is the idea of an automated solution is overall received positively but (as also indicated above) manual control should still be possible.

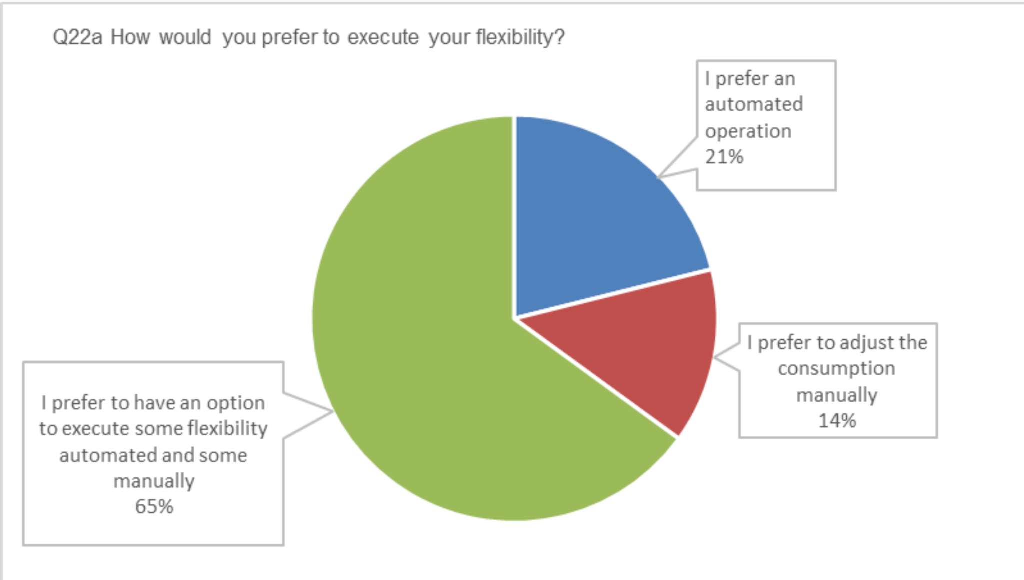
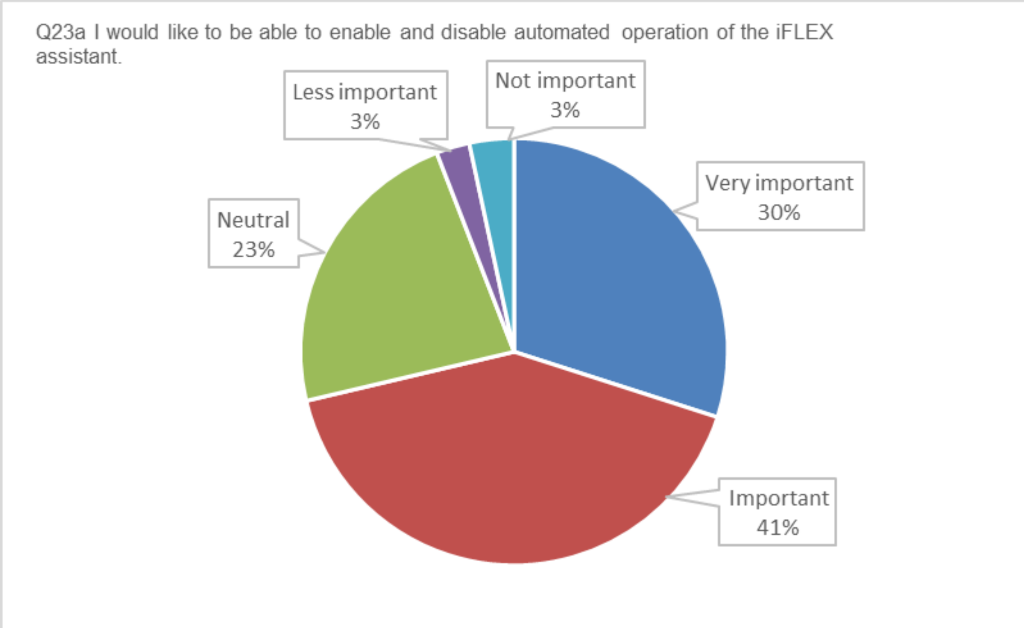
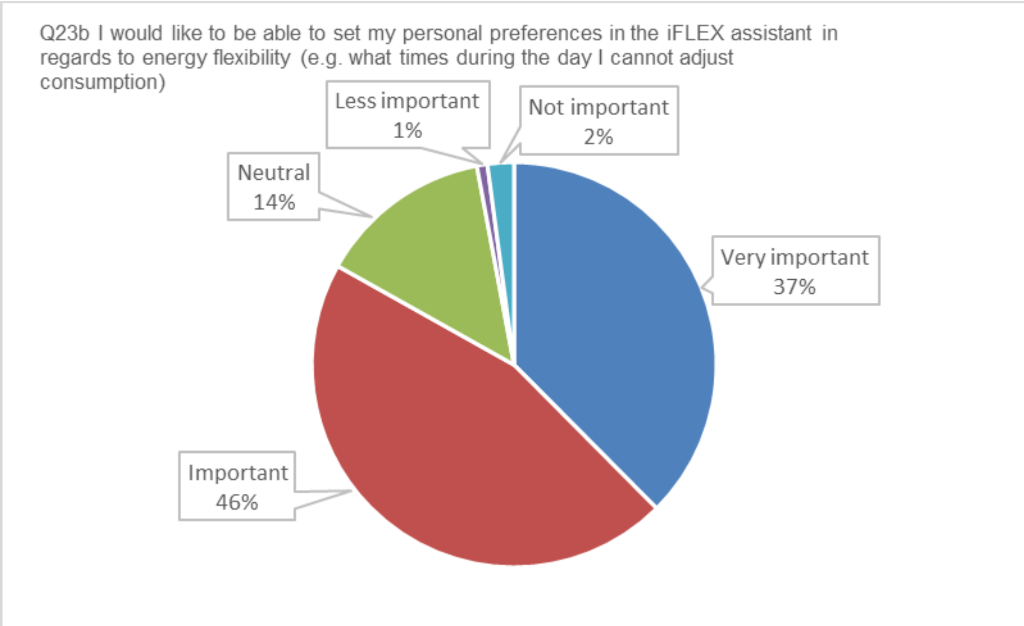


Figure 72: iFLEX Assistant and flexibility control preferences (Q22)


Q23a I would like to be able to enable and disable automated operation of the iFLEX assistant.
Less important 3%
Not important 3%
Very important 30%
Neutral 23%
Important 41%


Q23b I would like to be able to set my personal preferences in the iFLEX assistant in regards to energy flexibility (e.g. what times during the day I cannot adjust consumption)
Less important 1%
Not important 2%
Neutral 14%
Very important 37%
Important 46%

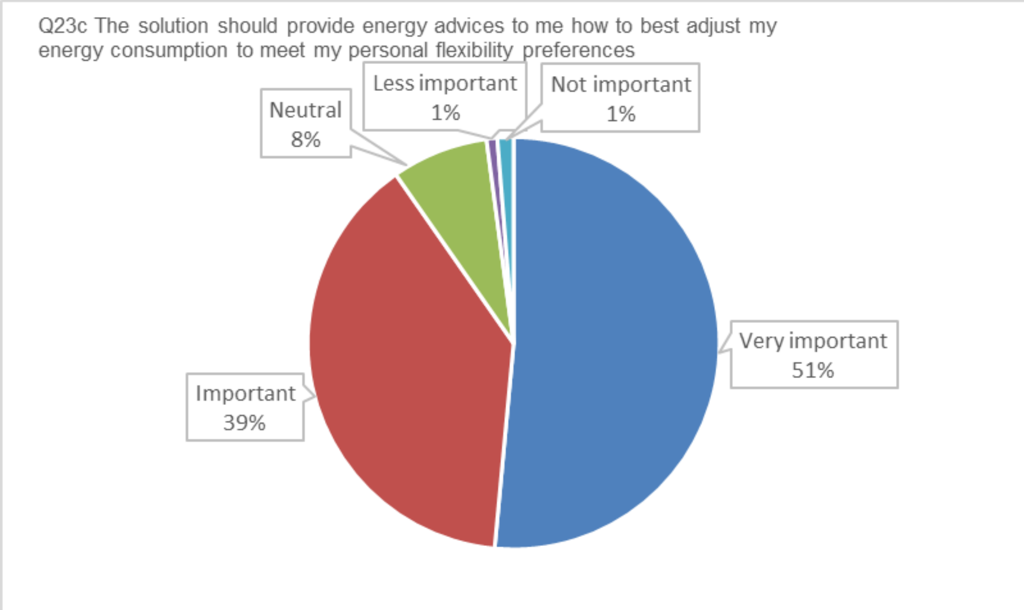
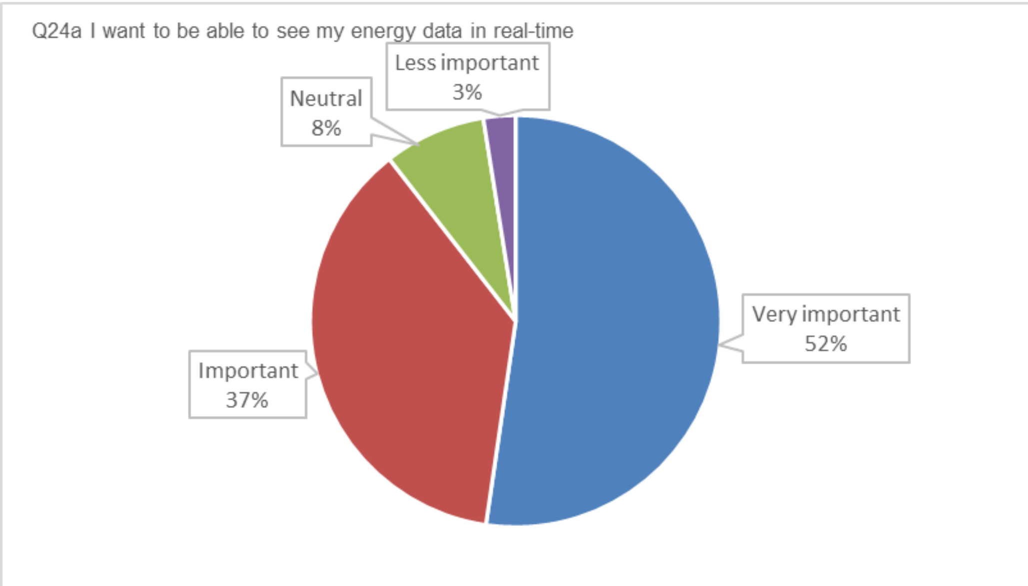


Figure 73: iFLEX Assistant functionalities (Q23)



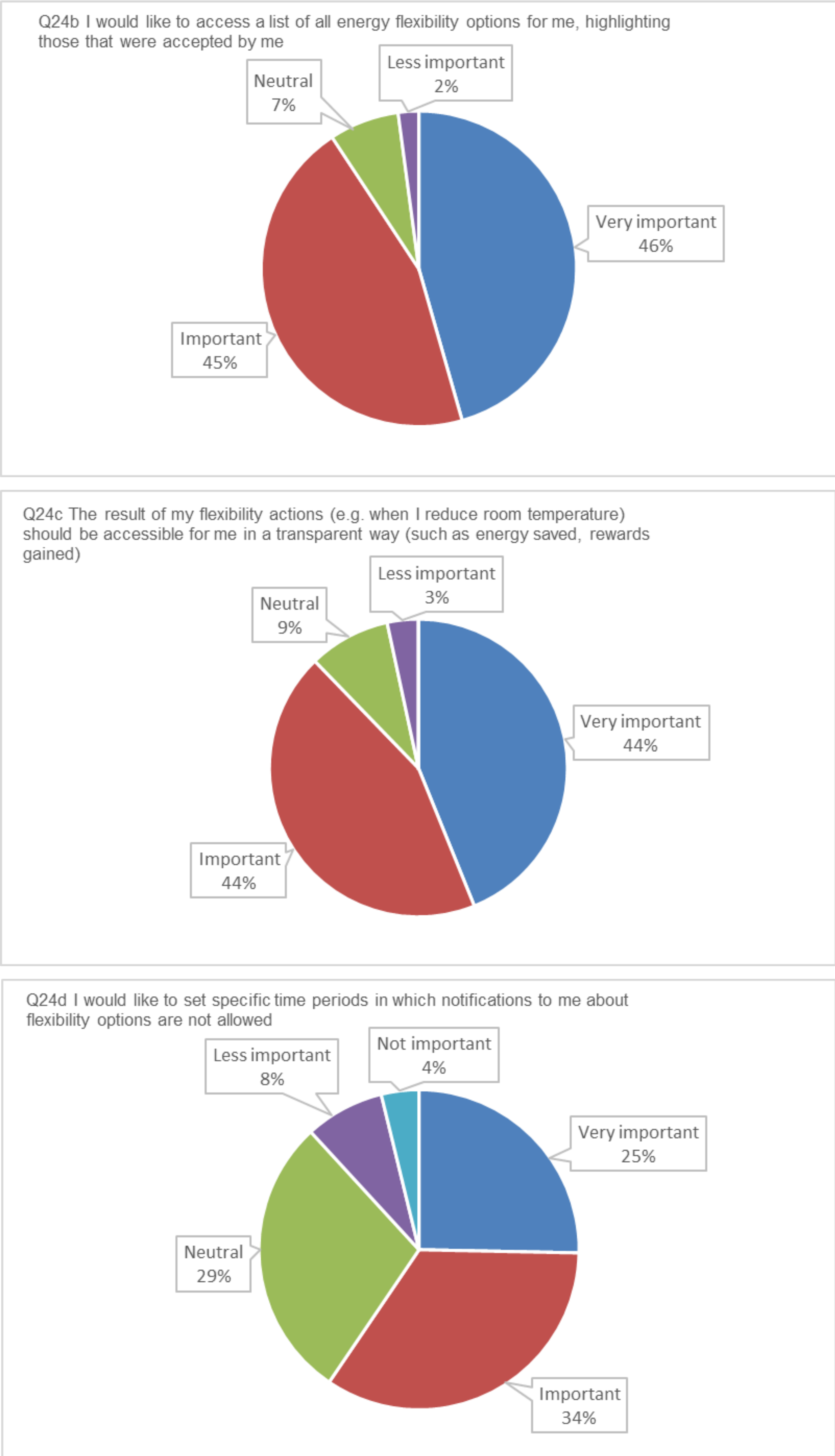


Figure 74: Importance of different functionalities (Q24)

5.2.6 Validation of the iFLEX concept – Slovenia

For the analysis here, we looked at the data from a group perspective meaning that an individual can figure in more than one group. In other words, we accept that an individual may have several preferences and motivational drivers and may therefore figure in more than one group.

Looking at how respondents would like to participate in energy flexibility, we analyse the answers from question 16c, d and e which would result in 3 groups for further analysis. As Figure 75 below illustrates, all three options are positively valued by the majority of respondents with the option 16e "*I could invest in technology that would allow my energy devices (e.g. electric water heater) to automatically adjust consumption when needed by the grid*" as the most preferable option by 69% of the entire data sample. This was closely followed by 16d *"I could allow a smart digital assistant to automatically adjust energy consumption in my household, but only if my comfort stays the same*" (67%) and finally option 16c "*I could allow my energy provider to regulate specific energy demanding devices in my house (e.g. electric water heater), but only if my comfort stays the same*" with only a little more than half (52%). There are no significant gender differences except that slightly more male respondents are positive towards each of the three options.[11] Overall, the result indicates that there is good potential for the iFLEX Assistant to be received positively and it will be interesting to evaluate pilot participants' experiences with using the assistant in the 2nd and 3rd phase of the pilot.

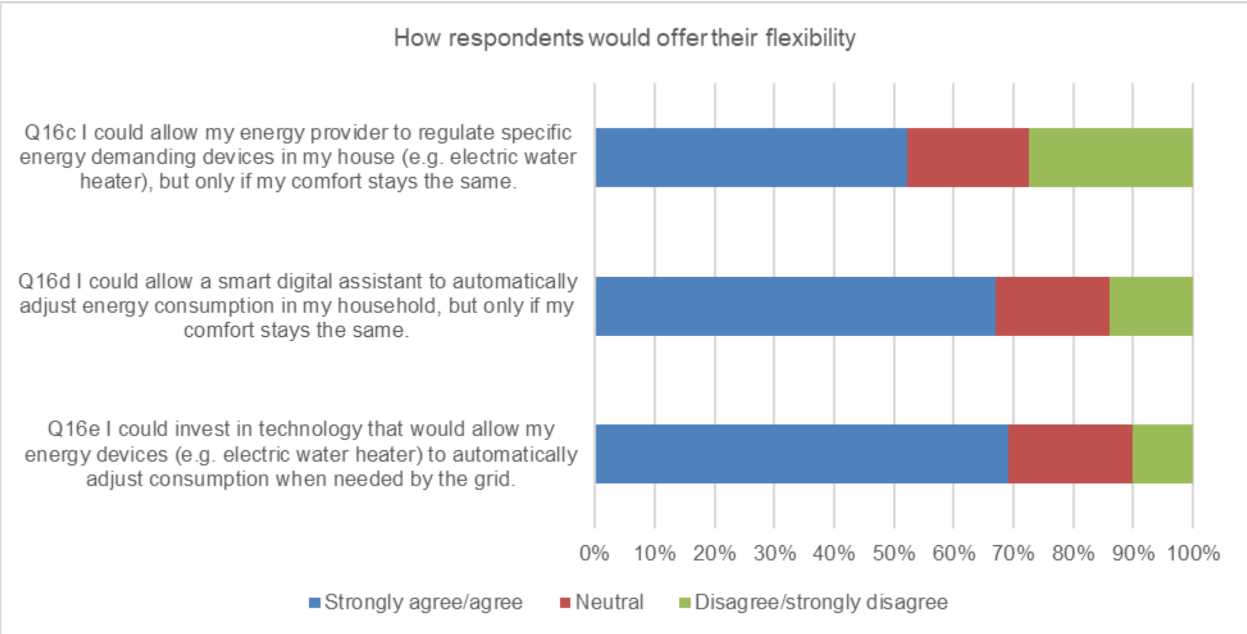


Figure 75: How all respondents would offer their flexibility (Slovenia)

The next step in the analysis was to look at how many participants were willing to adopt flexible energy behaviours and what type of action appealed to most. For this purpose, we analysed the answers to questions 16a "*I could change my daily routine (e.g. when to iron, cook, do laundry)*" and 16b "*I could lower my heating temperature set-point in wintertime*". We first of all looked at the data from an overall perspective, i.e. from the entire pool of answers and thus irrespective of how they would like to participate in Q16c-e. The results showed that N=188 (79%) would change their daily routine whereas N=130 (55%) would lower the temperature (Figure 76).

[11] One respondent in the Slovenian data sample identify as "non-binary"; this respondent has not been included in the analysis related to gender here.

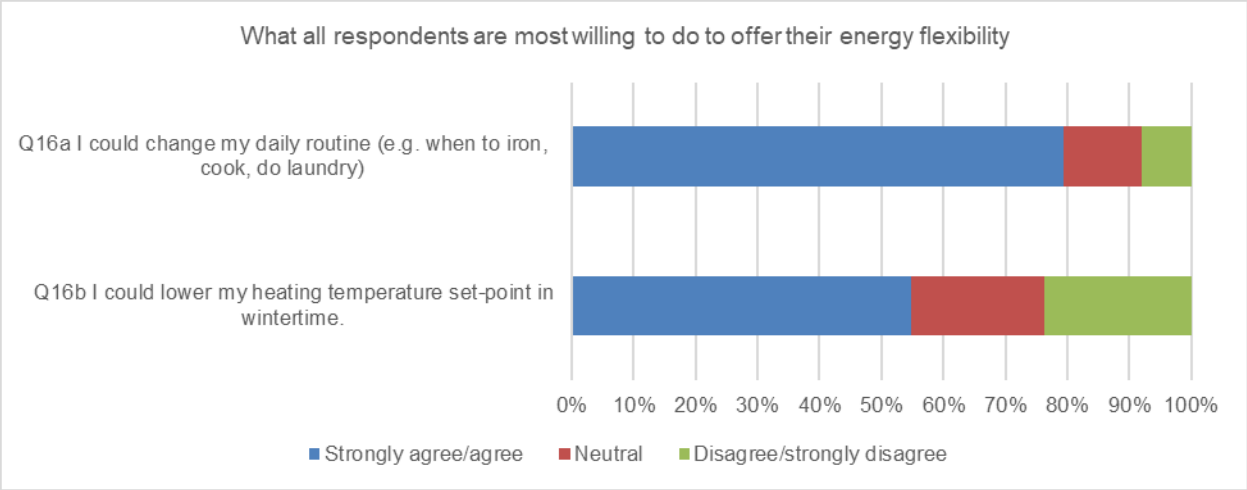


Figure 76: What all respondents are willing to do (Slovenia)

Overall, male respondents are very slightly more positive towards offering their flexibility; male and female respondents who are positive towards offering their flexibility both prefer to change their daily routine (80% and 78% respectively).

When we then look at what each group preferred to do the results are similar with a notable preference for changing their daily routine (Figure 77).

Figure 77: What individual groups are willing to do (Slovenia)

The final step is to see if there are any significant differences between the main motivational driver for each group. The motivational drivers have been divided into 3 categories: i) Save the world! (Q15a), ii) Save money! (Q15b & c), and iii) Told to do it! (Q15e&f).

If we first look at how all respondents answered, the results show that nearly all respondents are primarily driven by to “Save money” followed by to “Save the world” and there are no significant differences between groups 16c-e (Figure 78). There are no significant gender differences.

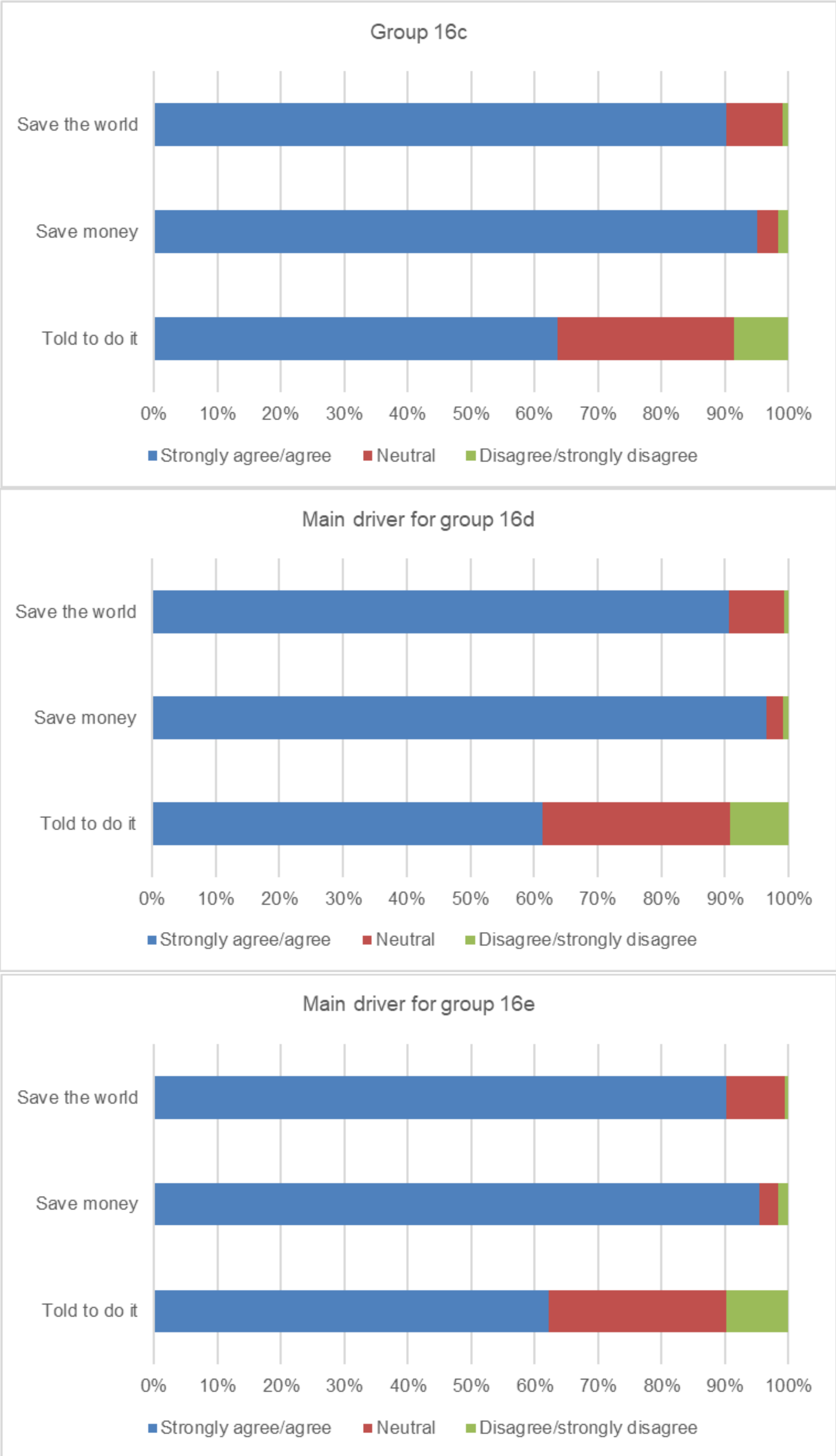


Figure 78: Main driver for each group (Slovenia)

5.2.7 Public survey results – Finland

The Finnish survey was distributed to contacts of VTT and in addition the Finnish Housing Association promoted the survey among their members. The survey was open for one month and received 955 complete responses.

5.2.7.1 Basic respondent and household characteristics

Nearly all of the respondents (N=829, 97%) were (one of) the person paying the electricity bill for the household (Q1) as well as the person making decisions related to electricity (Q2). N=258 (31%) of the respondents who pay the electricity bill and make decision related to electricity are the only adult in the household. N=37 of the respondents who pay the bill are not the person making decisions related to electricity.

Of the N=89 (3%) respondents, who do not pay the electricity bill, nearly half (44%) had answered they were still the making decisions related to electricity.

Overall, the data from Q1 and Q2 indicate that the respondents represent the relevant and appropriate population for the purposes of the survey.

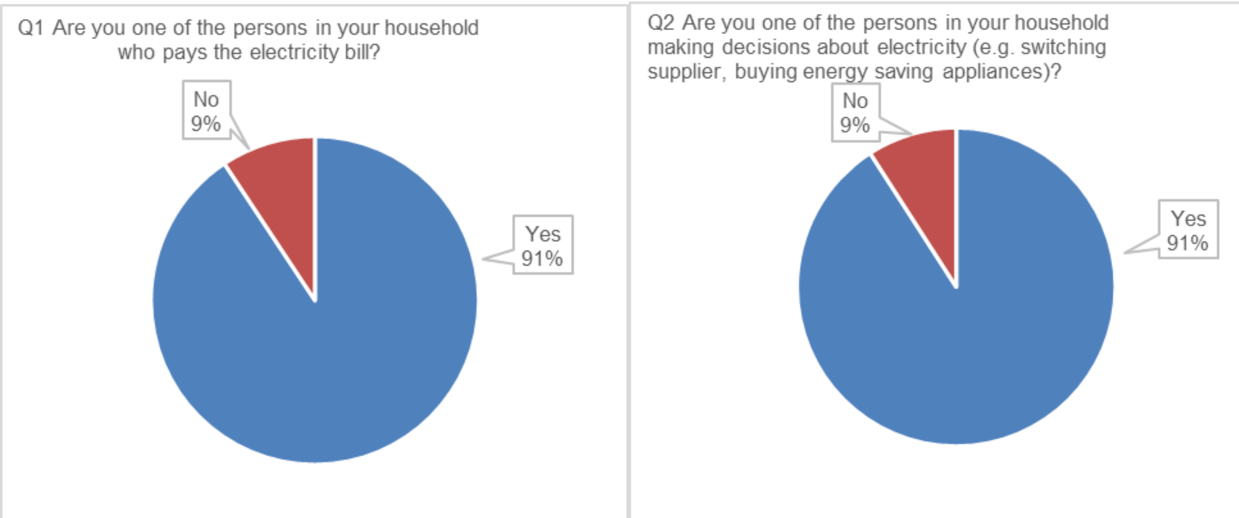


Figure 79: Percentage of respondents who pay the electricity bill (left) and who make decisions about electricity (right)

The majority of respondents were male (60%) and 65% of the respondents were +50 years old. The most dominant age group was 61-70 years old (28%) (female N=114, male N=156, non-binary N=2) followed by 71-80 years old (19%) (female N=45, male=134) and 51-60 years old (18%) (female N=57, male N=107, non-binary 4). The gender and age division of the people who completed the survey are illustrated below (Figure 80).

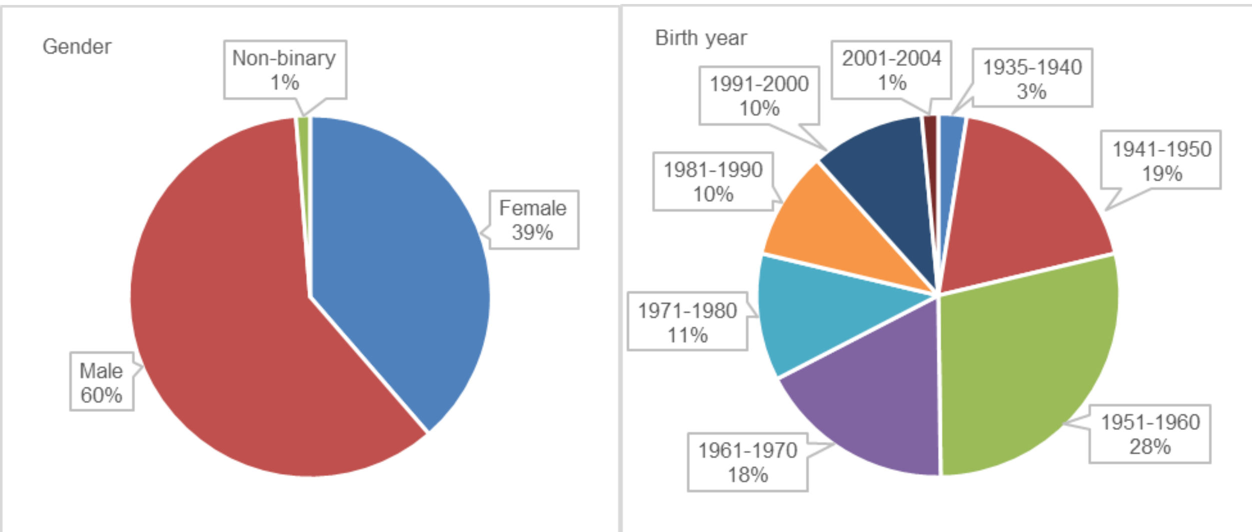


Figure 80: Gender division (Q6) (left) and Age division (Q5) (right)

In order to get a better idea and understanding of who the respondents were and their life situation, data on educational level, household characteristics, type and size of their dwelling was collected.

Nearly two-thirds (62%) live in a household with two adults. Within this group, 76% do not have any children (under the age of 18) living at home, 10% have one child living at home and 11% have two children living at home. This data is not surprising when considering that most respondents were +50 years old, with the age group 61+ being the most dominant.

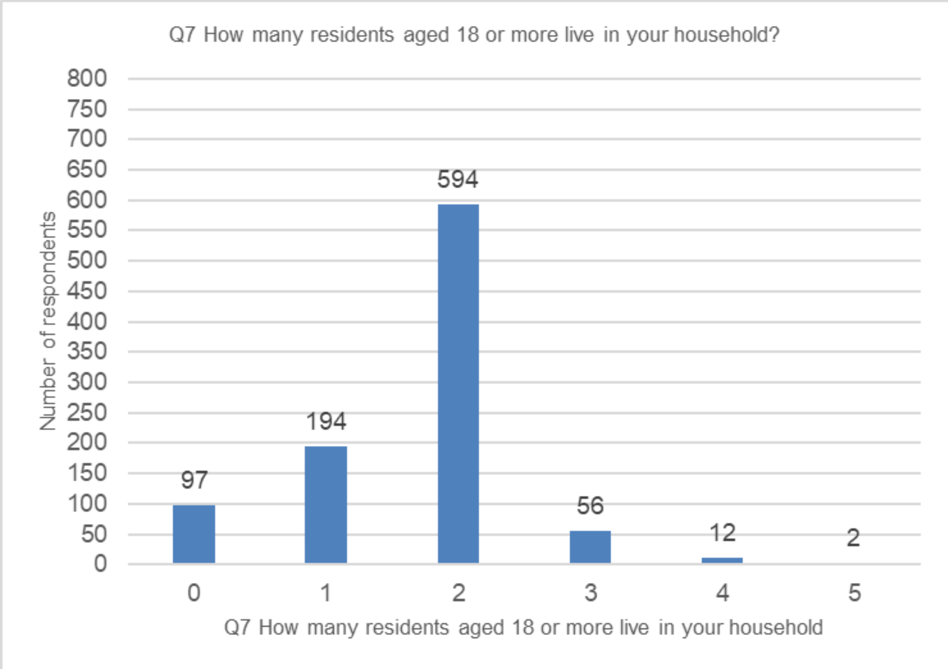


Figure 81: Number of residents over the age of 18 in the household (Q7)

Presumably, the respondents (10%) who had answered that no residents over the age of 18 live in the household had not included themselves (Figure 81), except one respondent, however, who was 17 years old and living alone. This group may therefore be considered as representing single household, so that the number of residents aged 18 or more is 194+96=290 (not counting the 17-year-old) (30%).

Of the total 955 respondents, 80% (N=761) do not have any children under the age of 18 living at home. As noted above, this fits well with the age of respondents.

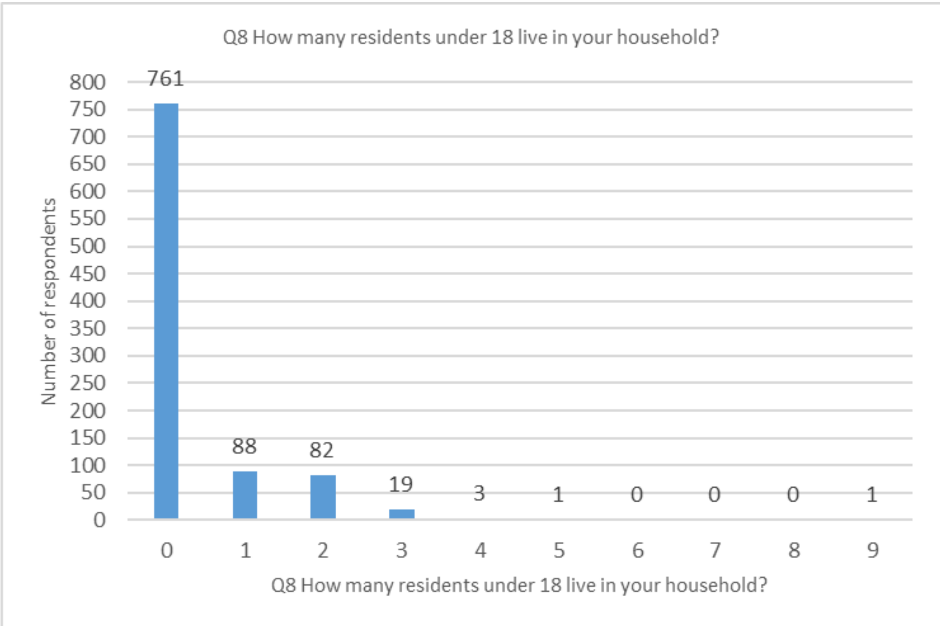


Figure 82: Number of residents under the age of 18 (Q8)

With regards to educational level, more than half hold a higher education: the majority of respondents hold a Master's degree follwed closely by a Bachelor's degree (Figure 83 below).

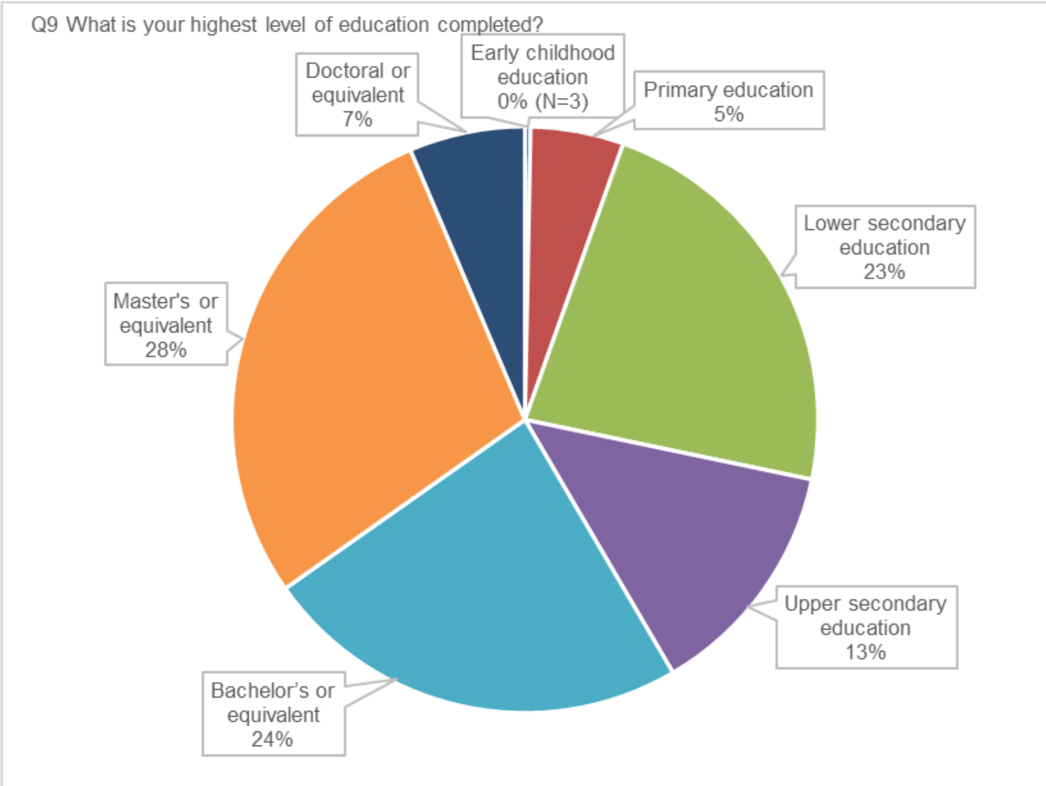


Figure 83: Educational level (Q9)

Basic knowledge on respondents' housing characteristics, i.e. type of home and its size (Figure 84 and Figure 85) and key appliances e.g. heating/cooling system, electric vehicles etc. (Figure 86), is illustrated below.

As Figure 84 below shows, more than half of the respondents live in a single family detached house and they all except one own their home (67%).

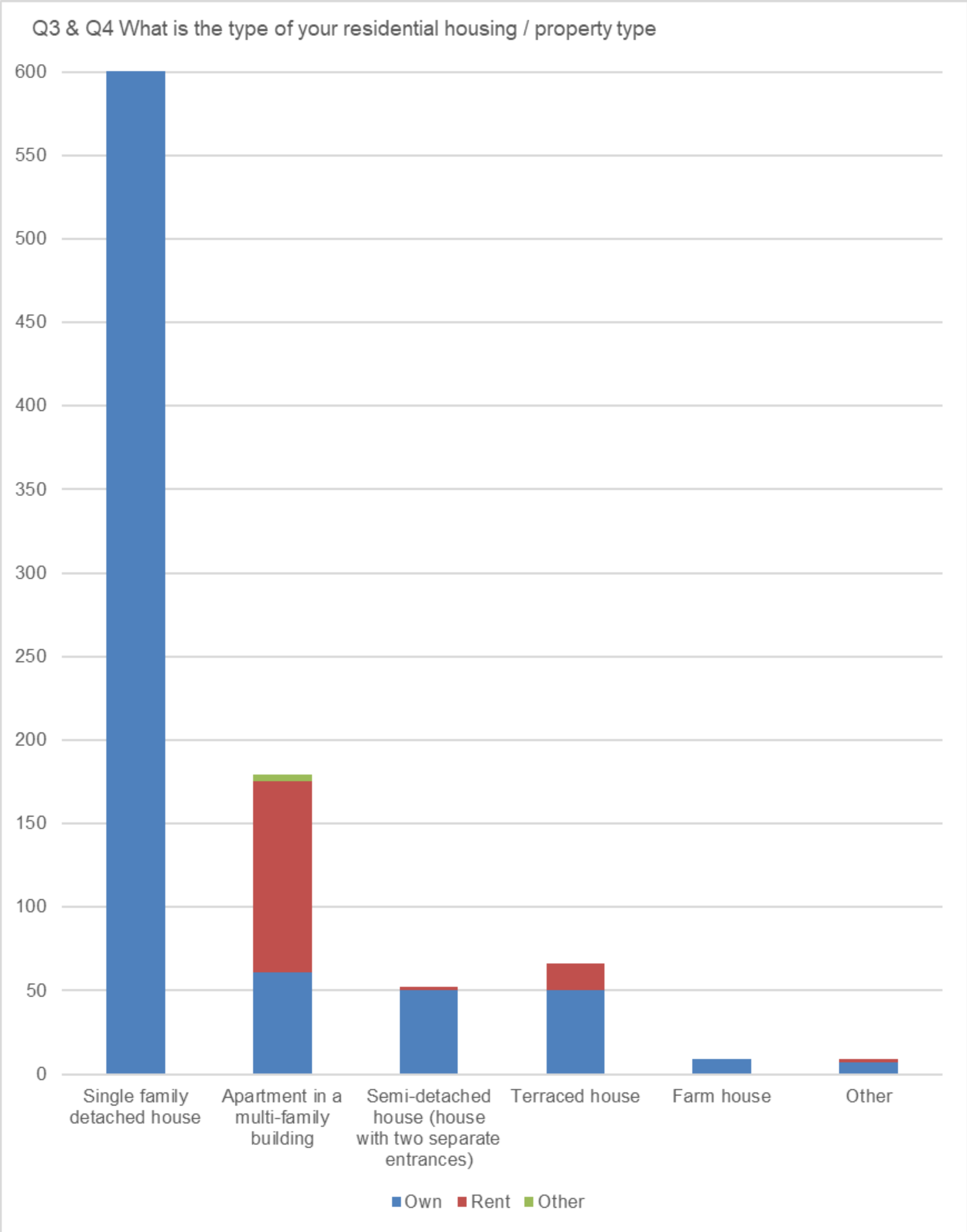


Figure 84: Type of residence (Q3 & Q4)

With regards to size in m^2 of respondents' home, approximately two-thirds of the respondents live in homes larger than 100 m^2 (64%) whereas the remaining 36% live in homes smaller than 100 m^2, with most living in homes between 71-100 m^2 (Figure 85).

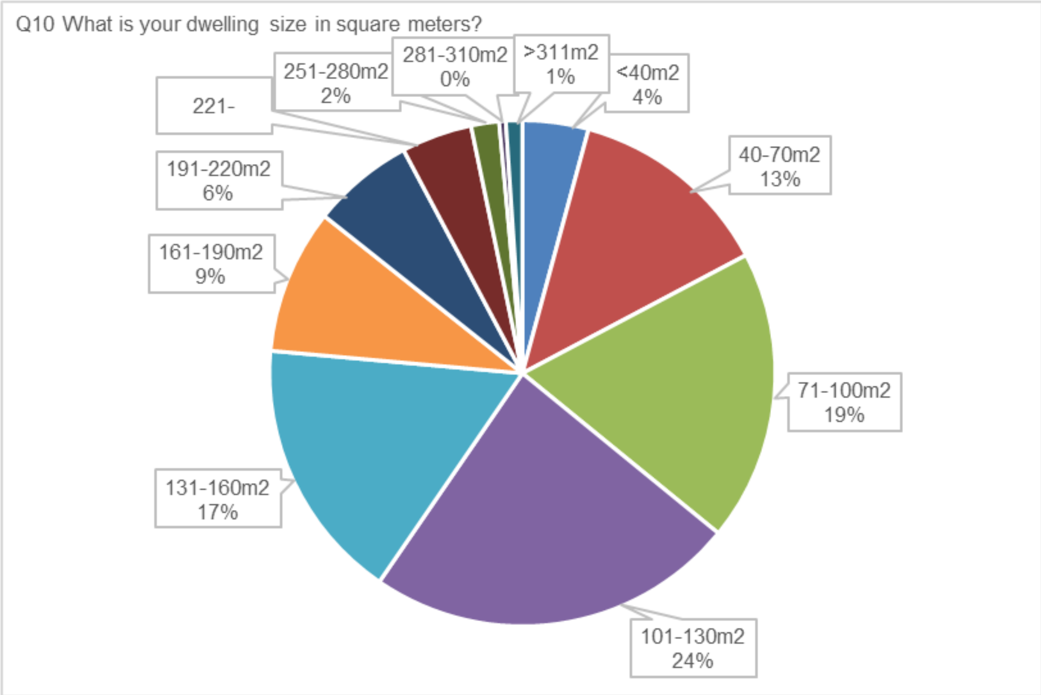


Figure 85: Size of dwelling (Q10)

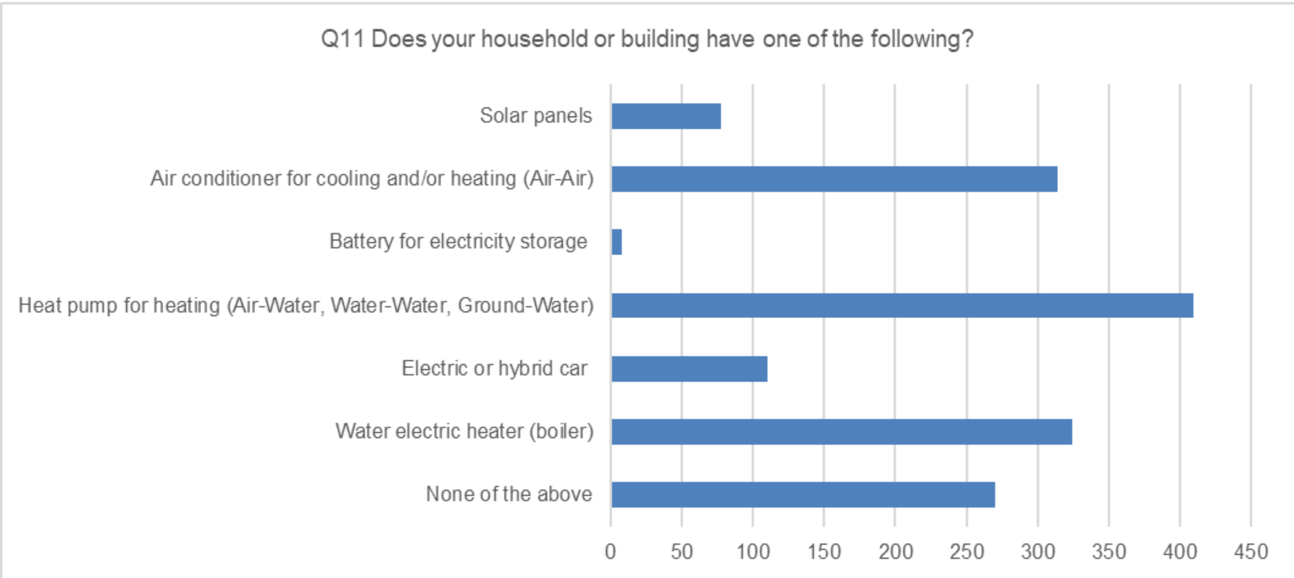


Figure 86: Key household appliances (Q11)

Within the group of the 77 (8%) respondents who have solar panels, the following applied:

- 15 (19%) respondents also have an electric or hybrid car
- 40 (52%) respondents also have air conditioner for cooling and/or heating (Air-Air)
- 54 (70%) respondents also have heat pump for heating (Air-Water, Water-Water, Ground-Water)
- 37 (48%) respondents also have water electric heater (boiler)
- 4 (5%) also have a battery for electricity storage (two respondents within this group had an electric/hybrid car).

With regards to the use of technologies and services in general and for energy consumption/production monitoring in particular, Figure 87 and Figure 88 below illustrates the results.

52% rarely or never use an energy monitoring system/smart home system and only 22% use it daily or weekly. Housekeeping robots and smart appliances are, however, the least used technology: 83% rarely or never use this. Smart mobile phones/mobile application and internet browsing is widely used: 93% use the former daily and 86% use the latter daily. These results are illustrated in Figure 87 below.

In Figure 88, we see that most respondents (64%) use their energy bill to monitor their energy consumption. This is followed by the use of "Website (in combination with smart meter or similar)" or "Other" (both 28%). Of the N=612 respondents who use their energy bill, N=373 (61%) only use this means to monitor their energy consumption, whereas N=156 (25%) also use a website and 102 (17%) also use a mobile app in addition to the energy bill.

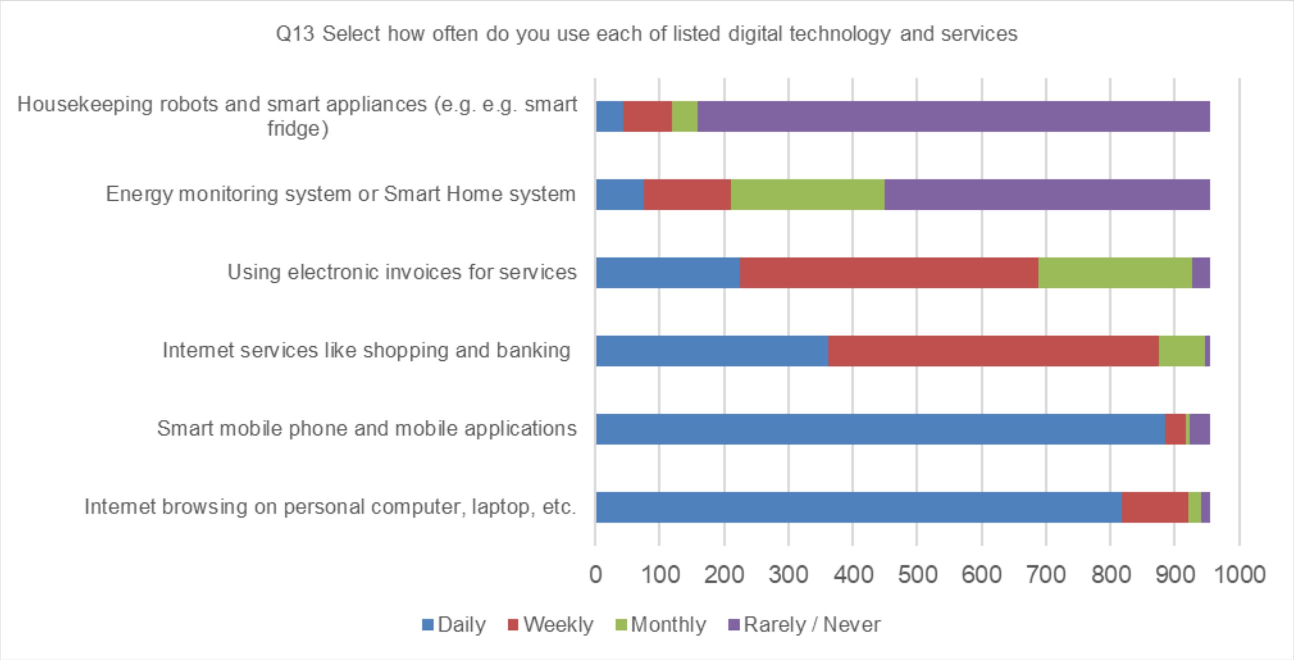


Figure 87: Frequency of use of different technologies and services (Q13)

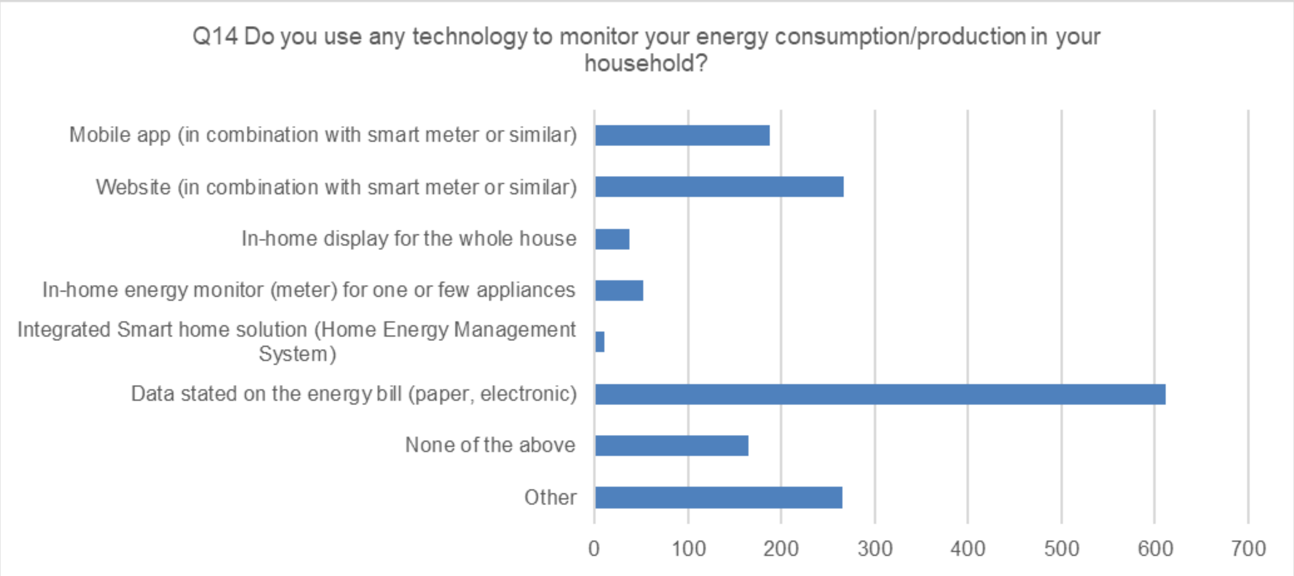
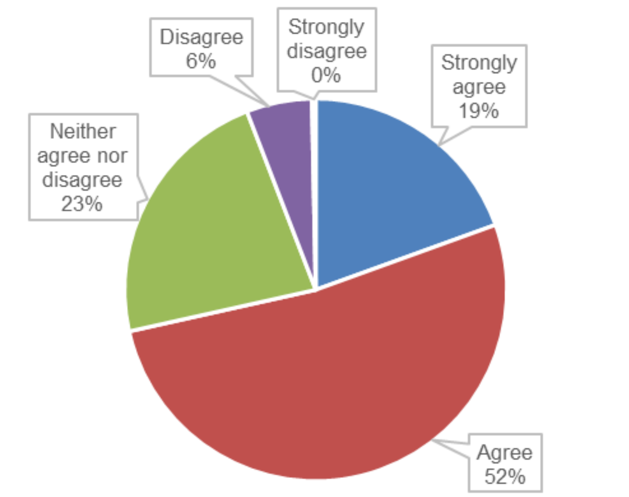
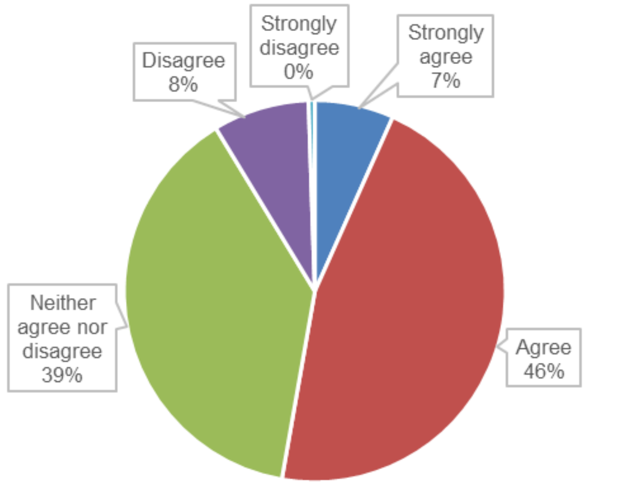


Figure 88: Use of technology to monitor energy consumption/production (Q14)

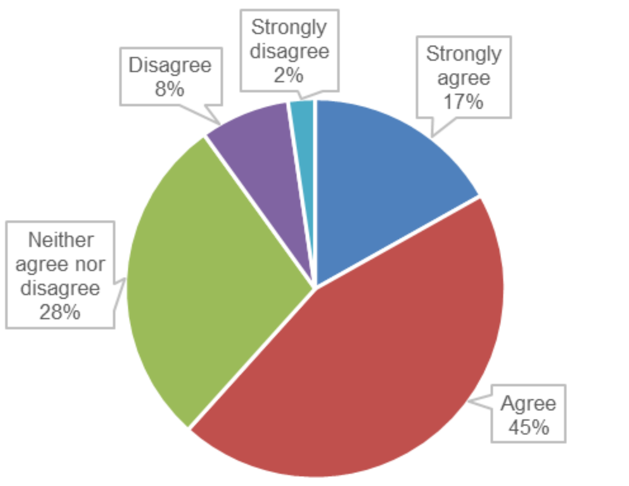
A set of questions and also enquired into personal characteristic/user type (Q12, Figure 89) as well as issues of personal comfort (Q20, Figure 90).



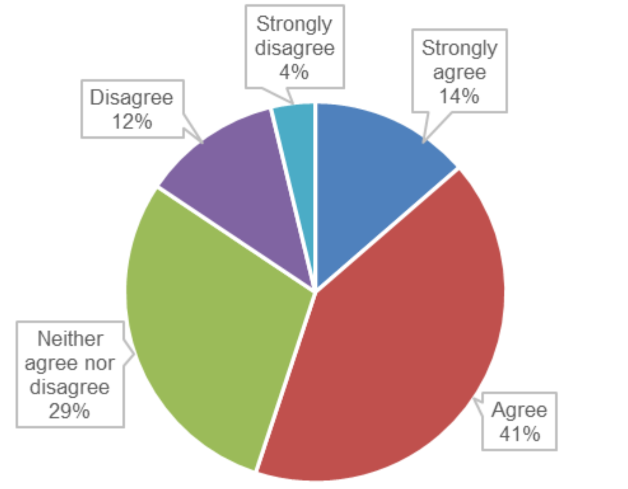
Q12a It is important to me to follow my own path



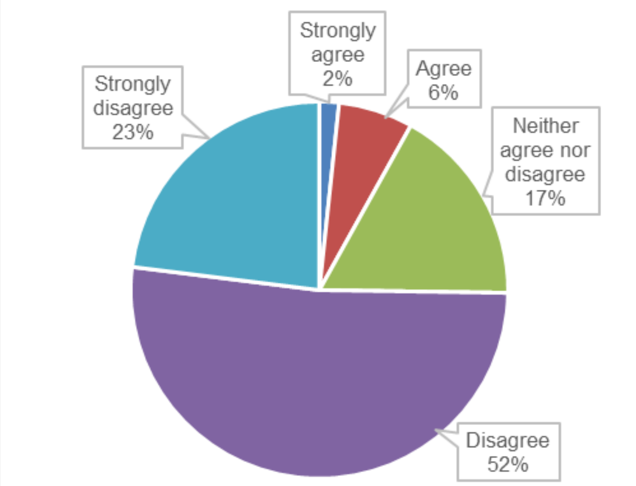
Q12b I like being part of a team



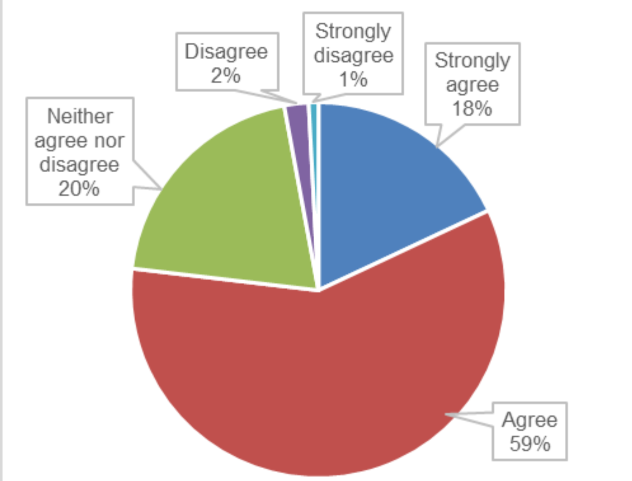
Q12c I like competitions where a prize can be won



Q12d Rewards are a great way to motivate me



Q12e I dislike following rules



Q12f I like sharing my knowledge

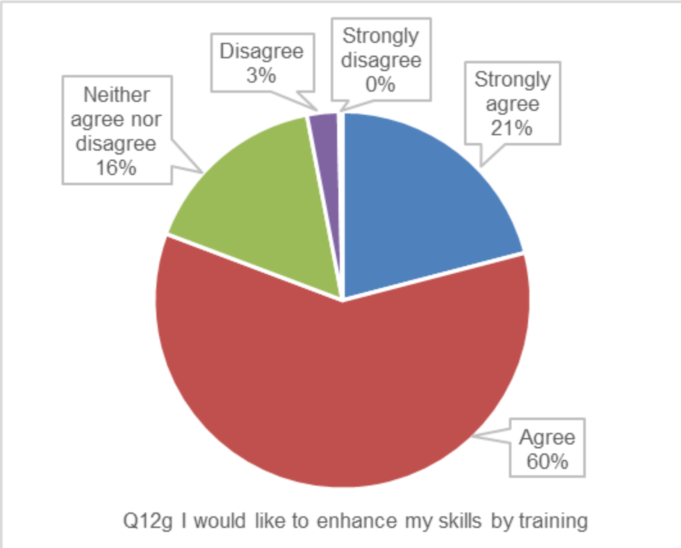
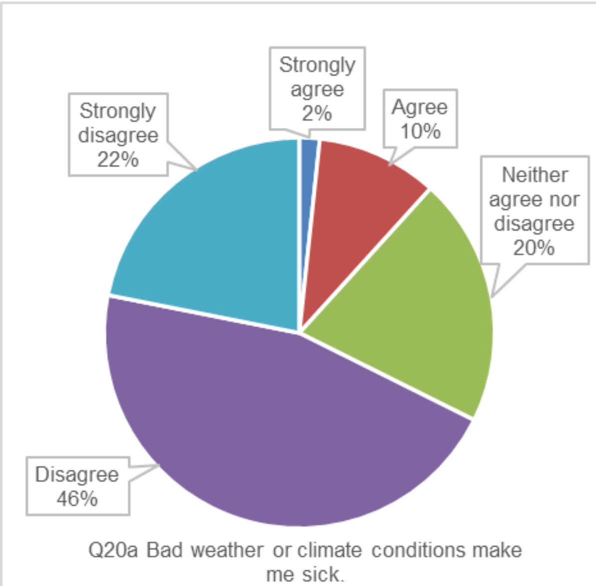
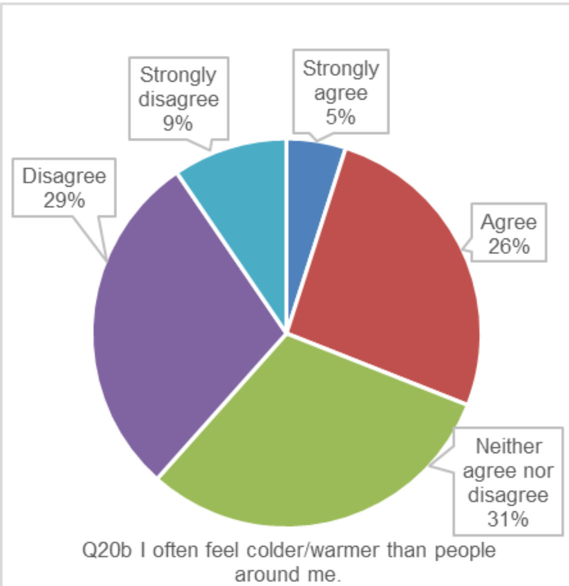


Figure 89: User type/personal characteristics (Q12)





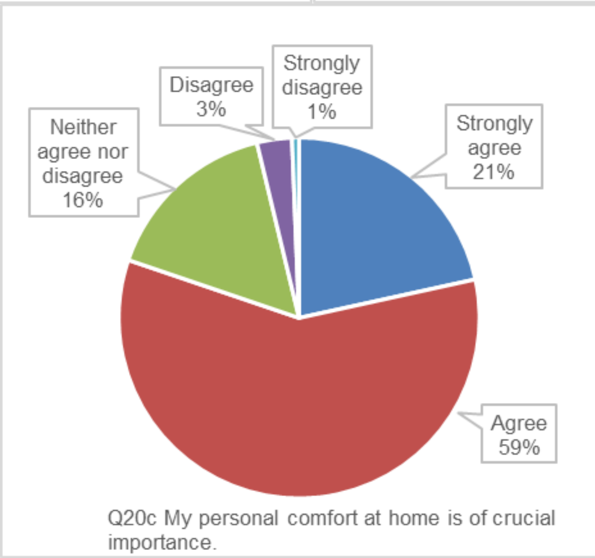
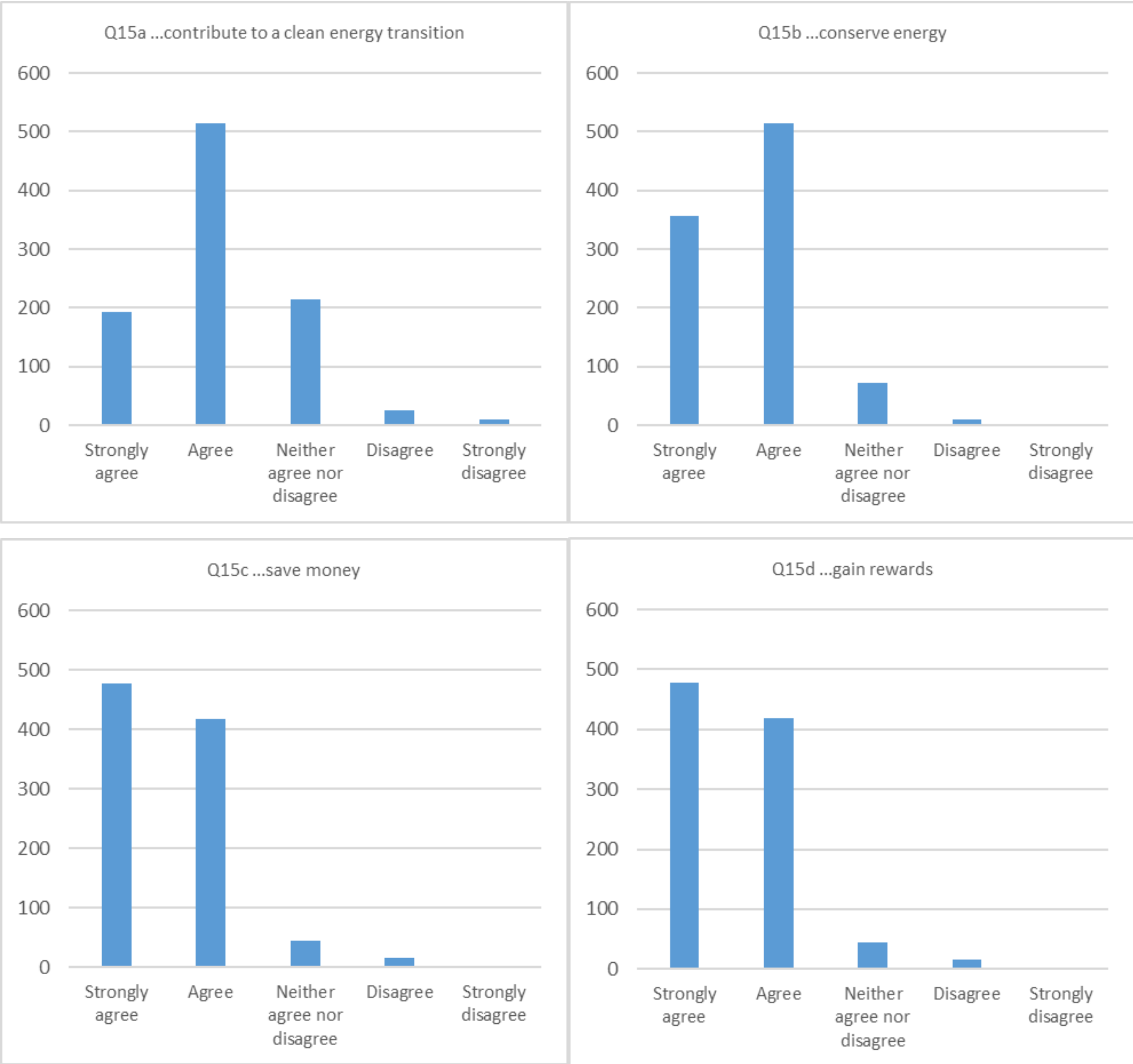


Figure 90: Personal characteristics (disadvantages and comfort) (Q20)

5.2.7.2 Energy and flexibility: awareness, incentives, willingness and requirements

The second part of the survey enquired into respondents' awareness of energy consumption and flexibility, their willingness and key incentives to participate in flexibility events. The questions here enquired into respondents' opinion asking them to indicate their level of agreement with different statements.

The first question (Q15), asked respondents to indicate what would motivate them to offer their flexibility ("I would offer my flexibility if I would…"). The answers are illustrated in the 7 graphs below (Figure 91).



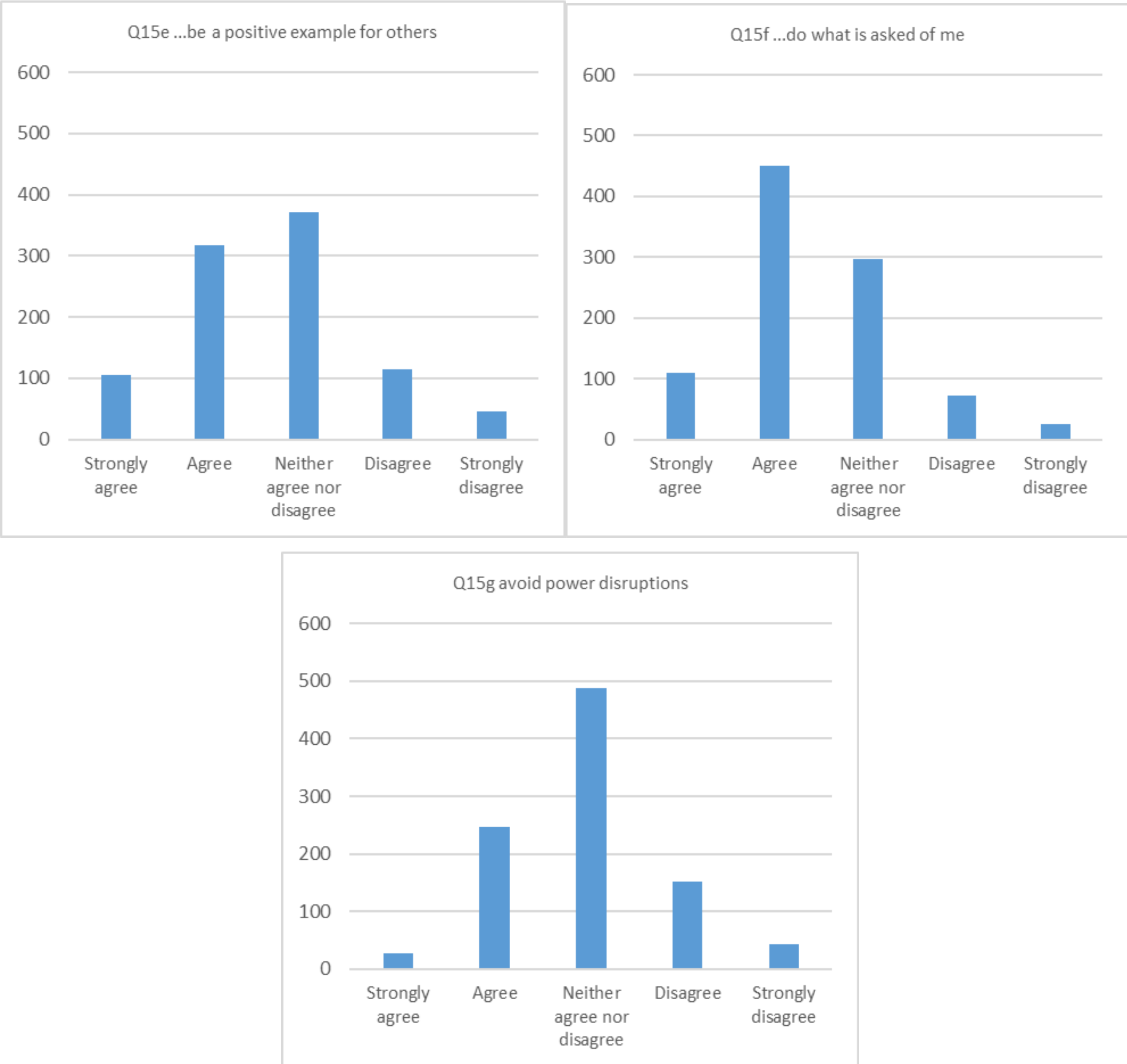


Figure 91: Reasons for offering flexibility (Q15)

The figures below illustrate how willing respondents are when it comes to changing specific energy behaviours with respect to offering energy flexibility (Figure 92).

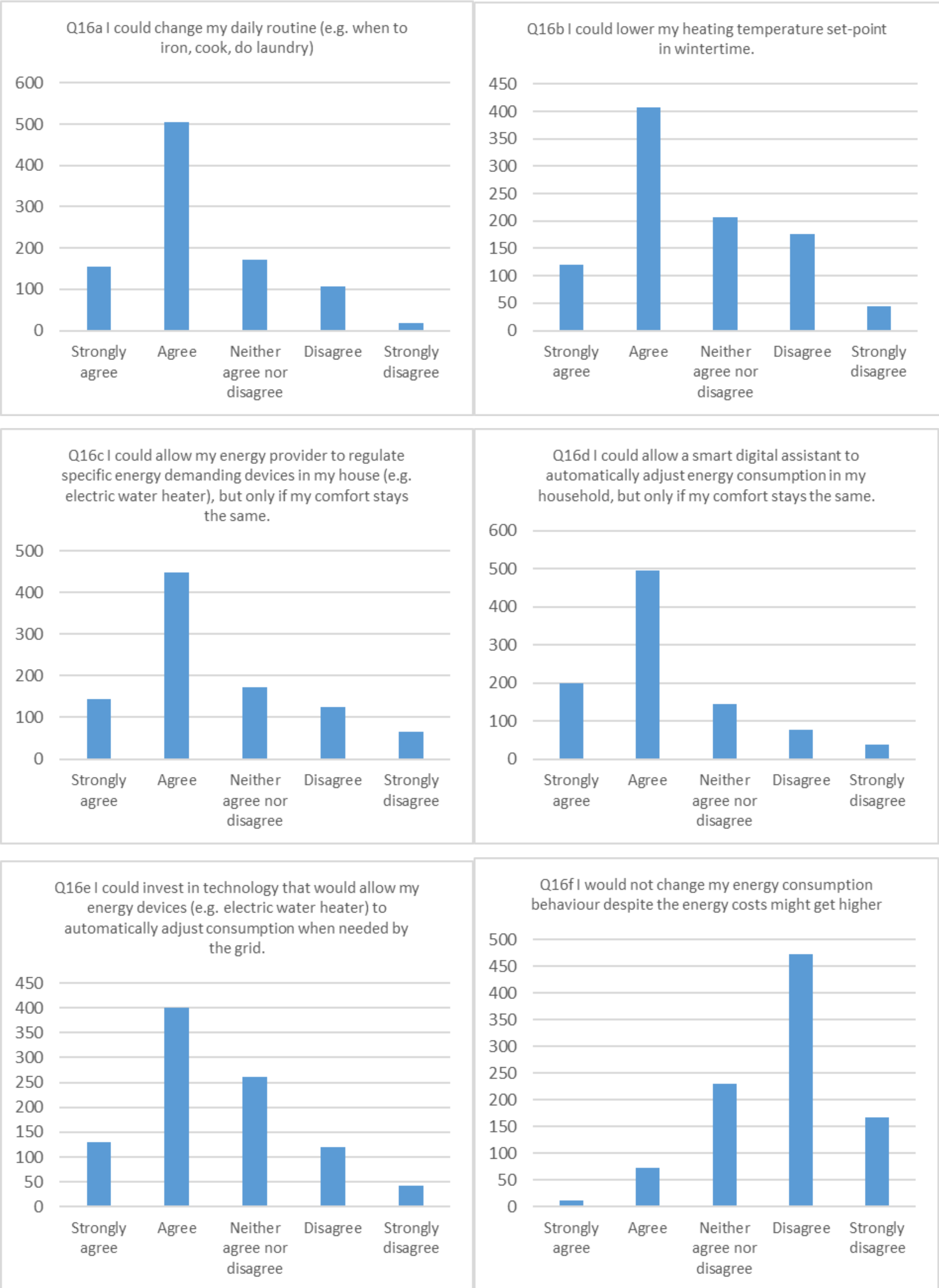


Figure 92: What are you willing to do to be able to offer flexibility in energy consumption (Q16)

The next four graphs (Figure 93) illustrate respondents' energy consumption and energy flexibility awareness.

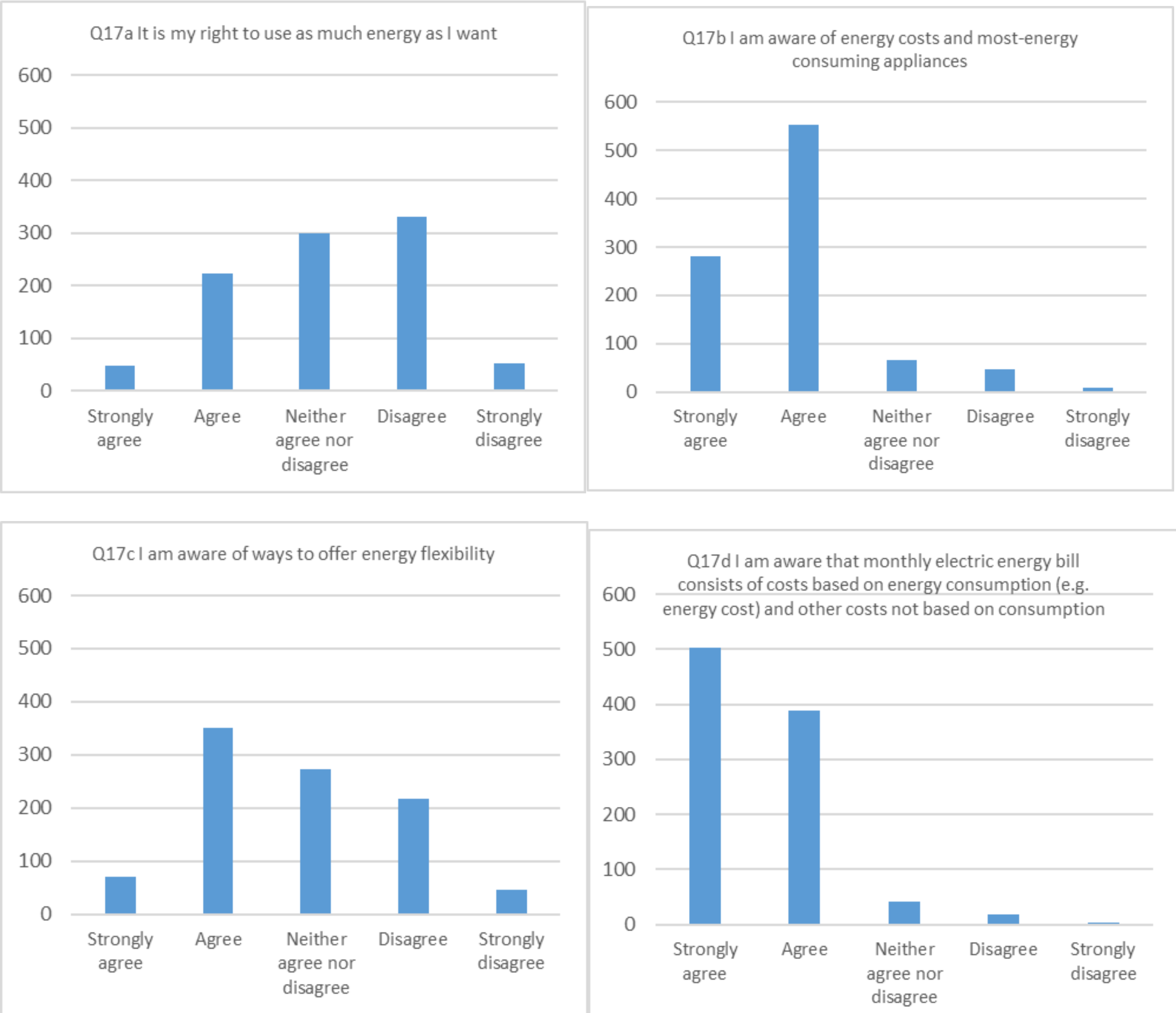


Figure 93: Energy and flexibility awareness (Q17)

In Figure 94 below, question 18a “Conserving energy and natural resources is important to me” and 18b “Conserving energy is not my problem” generated a lot more extreme and clear opinions than question 17a “It is my right to use as much energy as I want” (Figure 93) which saw respondents’ answers as more neutral and more evenly spread out across the scale.

There was some internal inconsistency in Q18, however, as nine respondents strongly agreed with both statements, and 22 respondents strongly agreed that “Conserving energy and natural resources is important to me” while also agreeing to the second statement, namely that “Conserving energy is not my problem”.

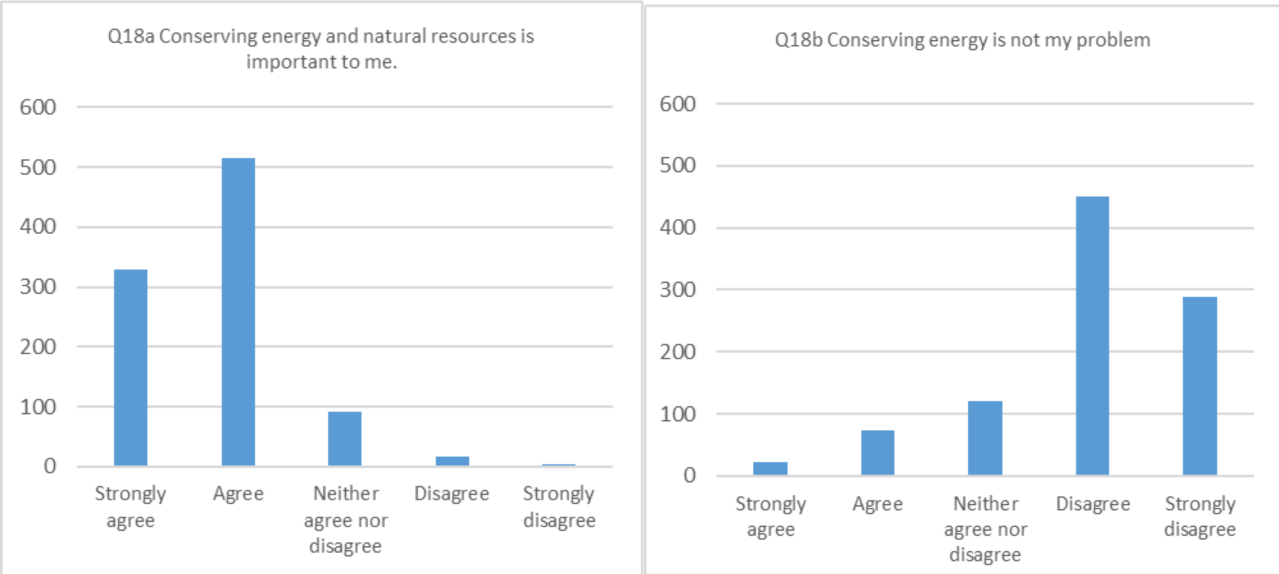


Figure 94: Attitude towards conserving energy (Q18)

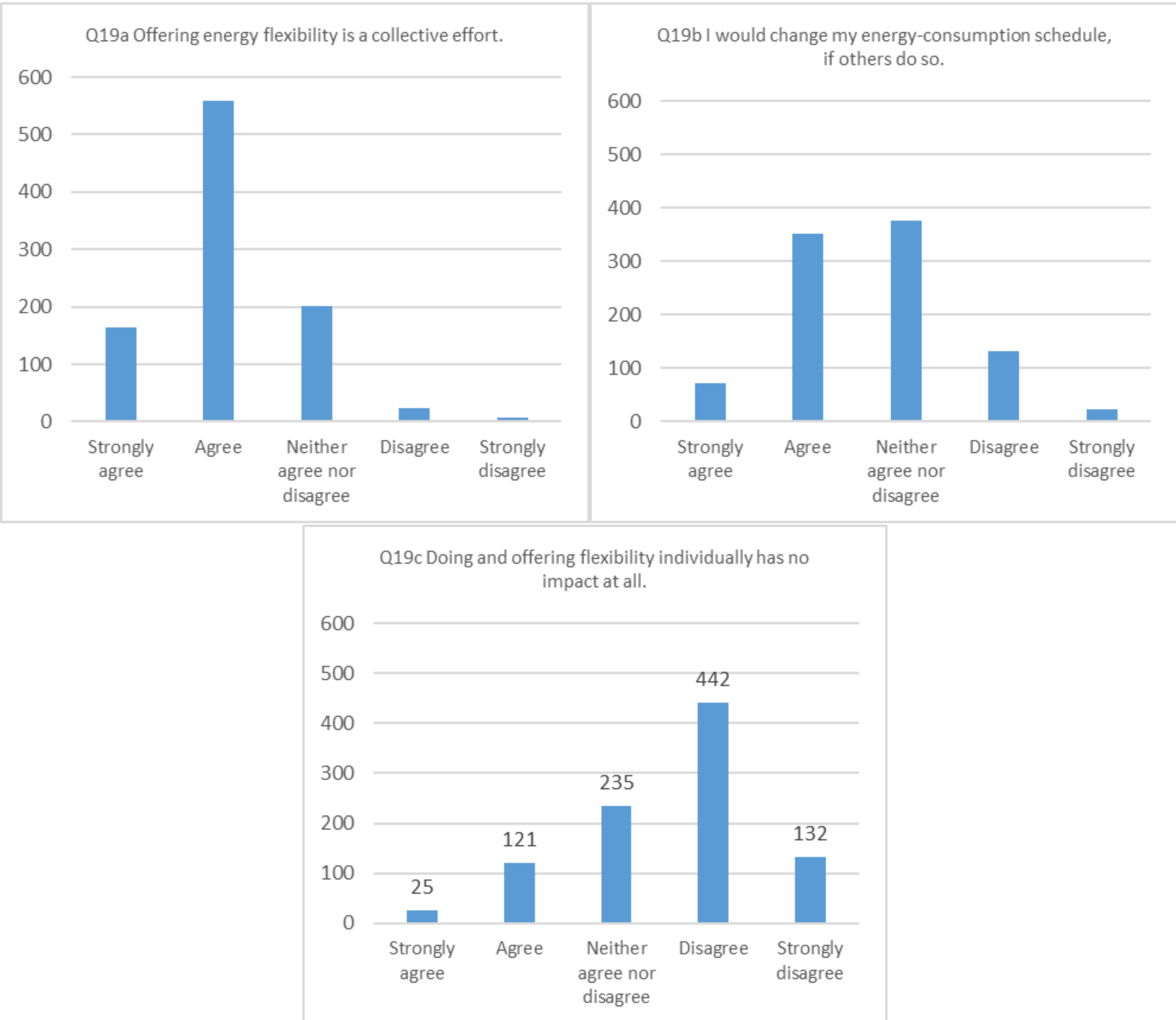
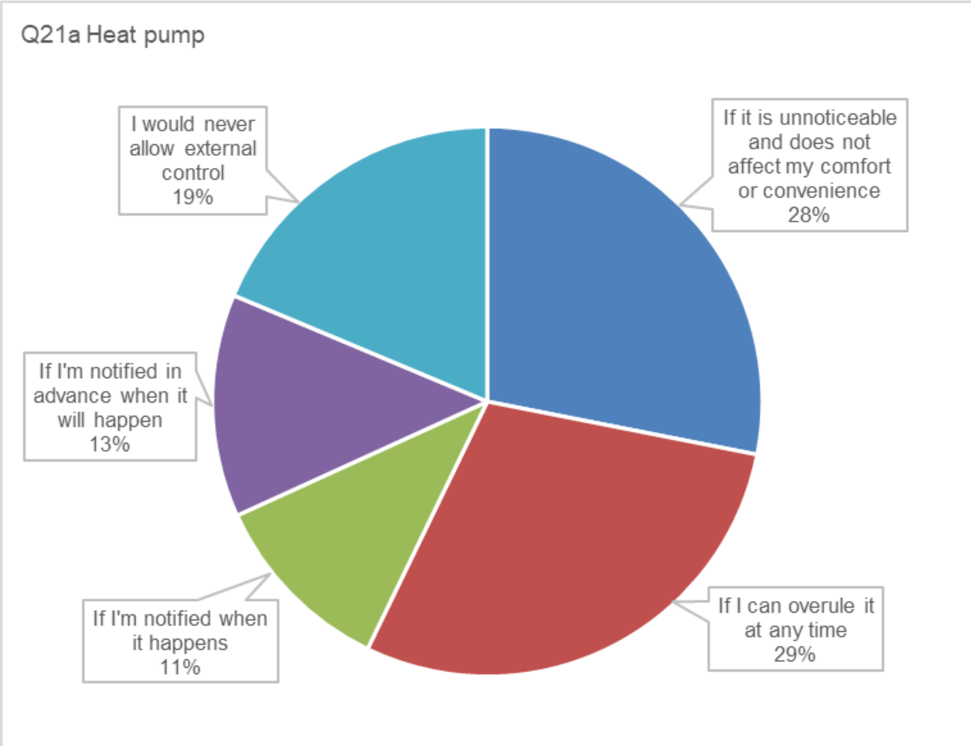


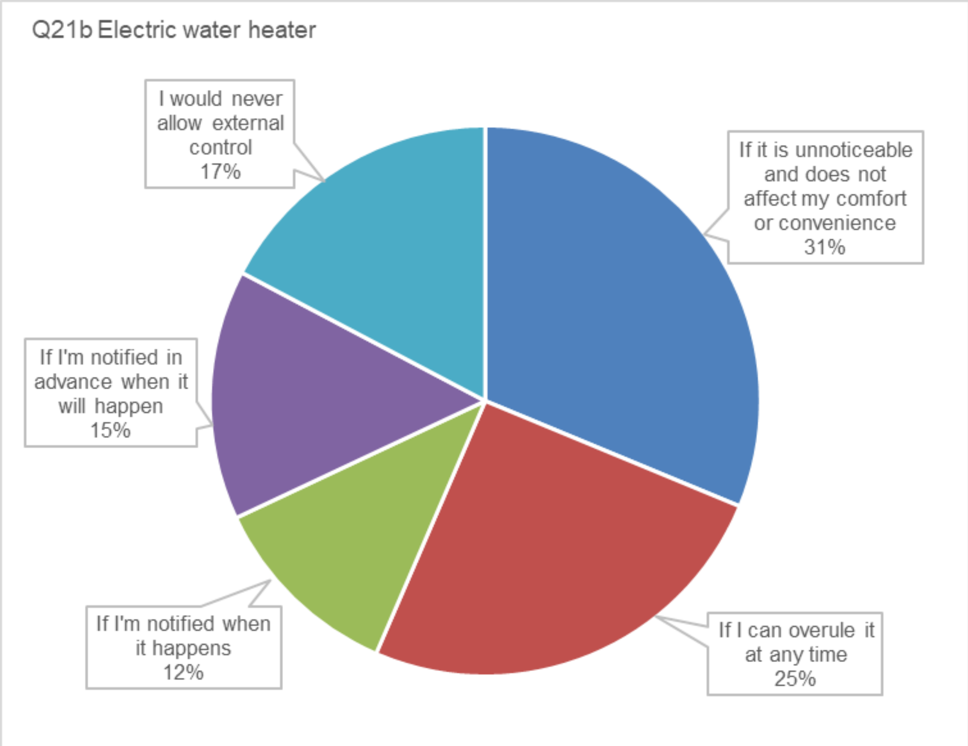
Figure 95: Attitude towards offering flexibility (Q19)

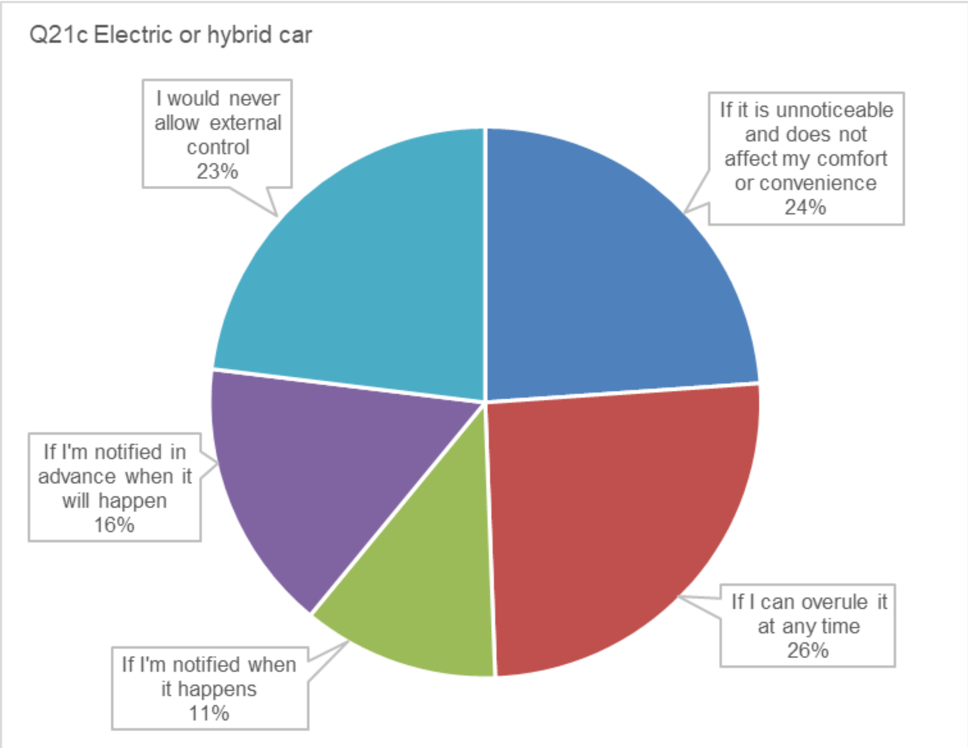
The next four graphs are based on answers to Q21 “Under which conditions would you be willing to allow external control of the following devices in your household?”. Based on answers in Q11 (what devices respondents have in their household), it appears that most respondents have answered the question (Q21) irrespective of whether or not they actually have the device in question (despite there being a “not applicable” option). For example, N=110 has indicated in Q11 that they have an electric or hybrid car, but in Q21c N=607 have indicated to what extent they would be willing to allow external control of their electric/hybrid.[12] As expected, respondents are the least flexible when it comes to their car – irrespective of whether they have one or not: 25% of car owners have said that they would never allow external control whereas 13% of non-car owners have said so.

Overall, the data show that being able to “overrule at any time” is the most important condition for all devices. And “If it is un-noticeable and does not affect my comfort or convenience” are the two most important conditions. Respondents are most flexible with regards to the electric water heater.



[12] N=8 of the respondents who had indicated in Q11 that they have an electric/hybrid car have answered “not applicable” to Q21.


Q21b Electric water heater
I would never allow external control 17%
If it is unnoticeable and does not affect my comfort or convenience 31%
If I'm notified in advance when it will happen 15%
If I'm notified when it happens 12%
If I can overule it at any time 25%


Q21c Electric or hybrid car
I would never allow external control 23%
If it is unnoticeable and does not affect my comfort or convenience 24%
If I'm notified in advance when it will happen 16%
If I'm notified when it happens 11%
If I can overule it at any time 26%

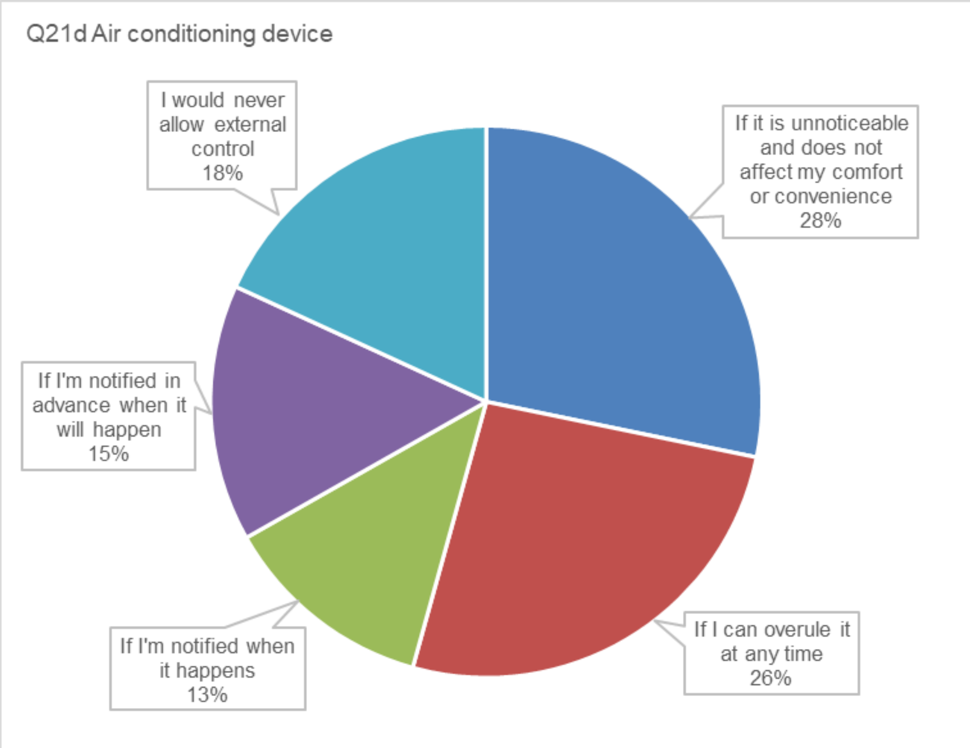


Figure 96: Conditions for allowing external control of devices (Q21)

The final questions are more closely related to the iFLEX Assistant and the functionalities respondents would like to see. The answers also give some indication of how attractive the concept of iFLEX Assistant is; the idea of an automated solution is overall received positively but (as also indicated above) manual control should still be possible. Approximately at quarter of respondents rated the mentioned functionalities as “very important” and half of them rated the functionalities as “important”.

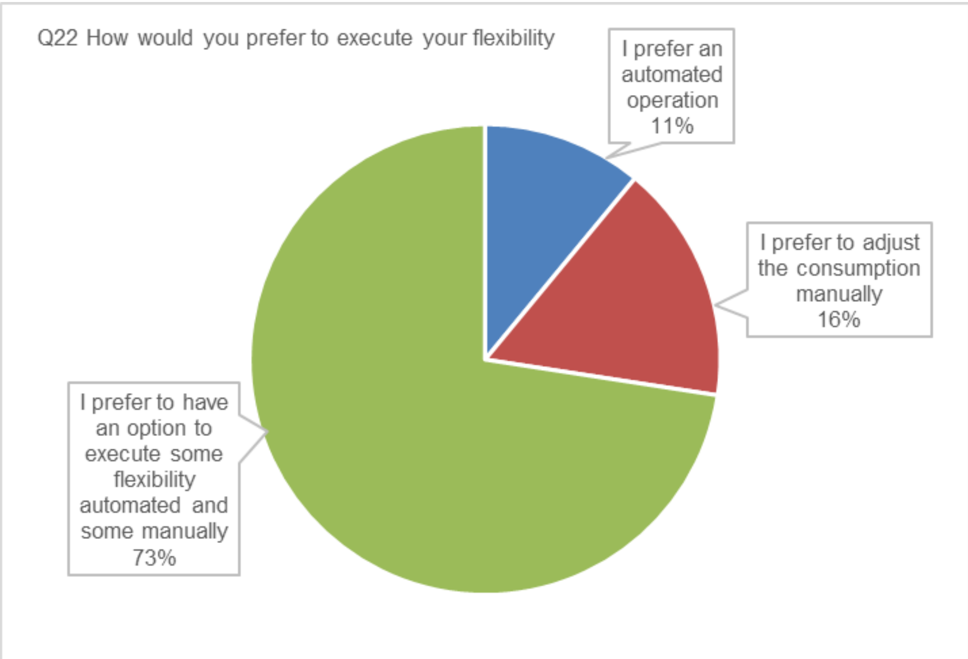
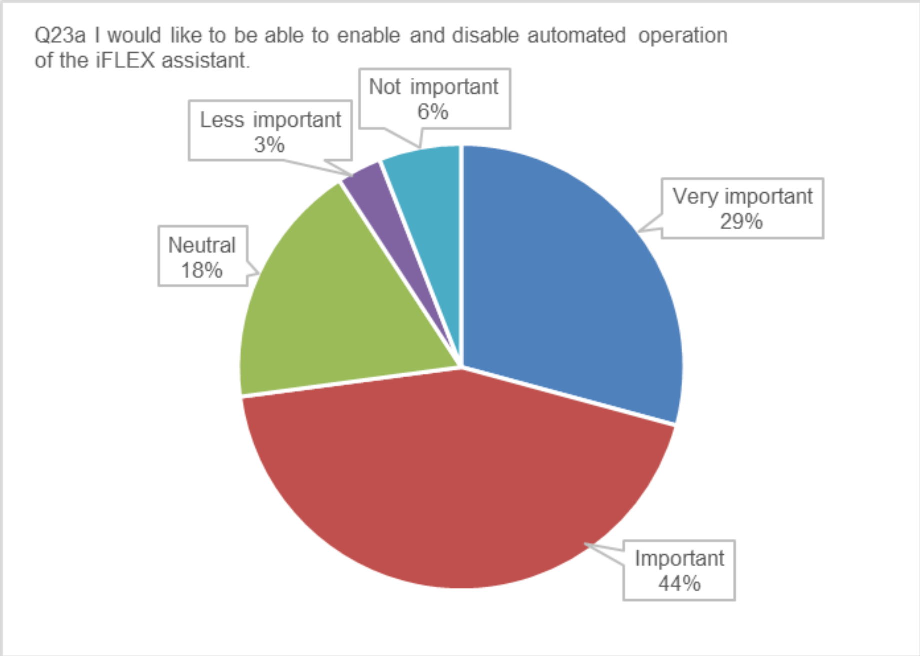
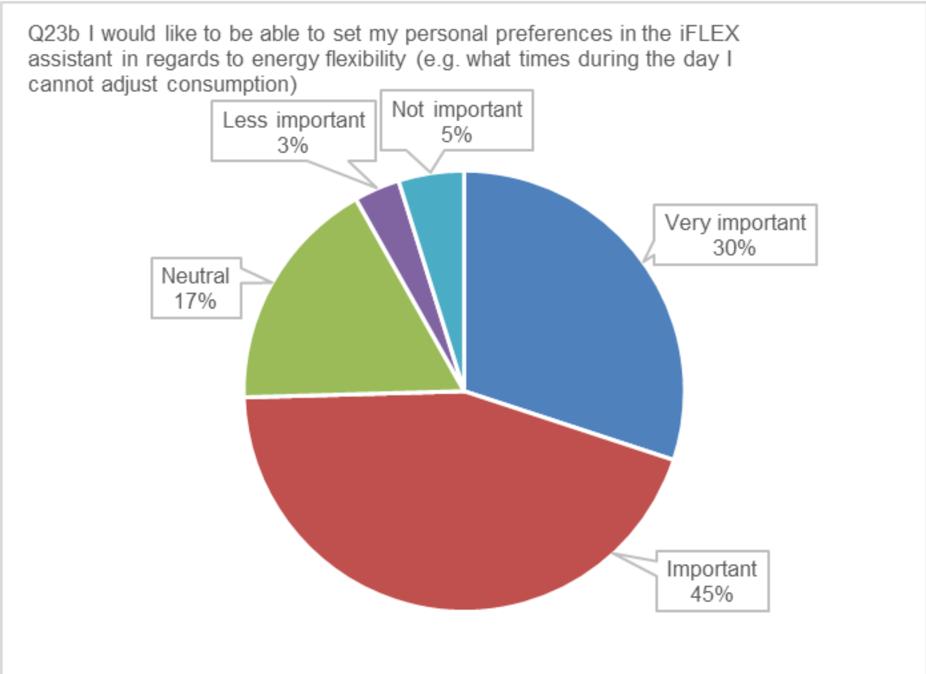


Figure 97: iFLEX Assistant and flexibility control preferences (Q22)


Q23a I would like to be able to enable and disable automated operation of the iFLEX assistant.
Not important 6%
Less important 3%
Very important 29%
Neutral 18%
Important 44%


Q23b I would like to be able to set my personal preferences in the iFLEX assistant in regards to energy flexibility (e.g. what times during the day I cannot adjust consumption)
Less important 3%
Not important 5%
Very important 30%
Neutral 17%
Important 45%

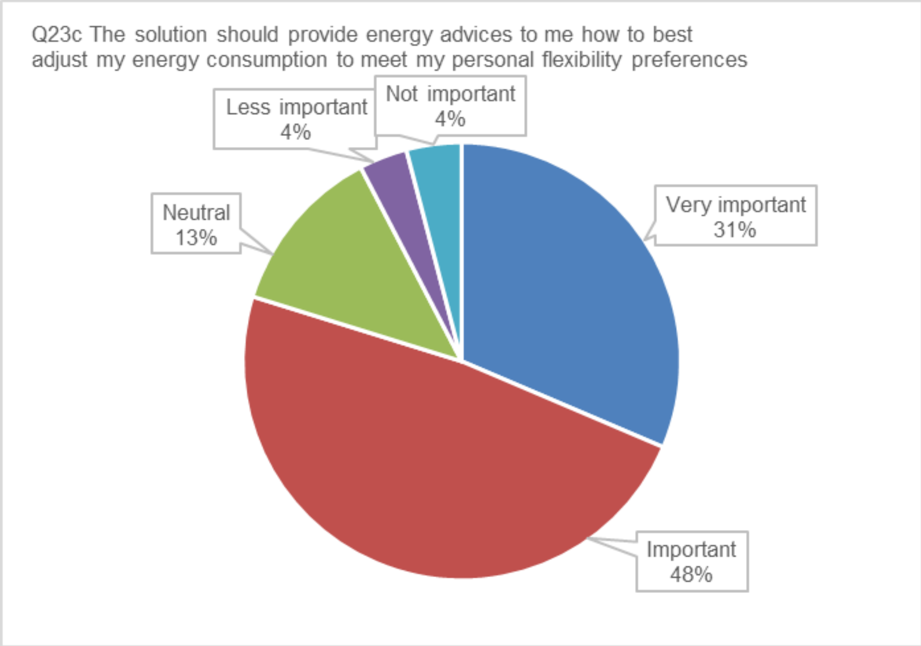
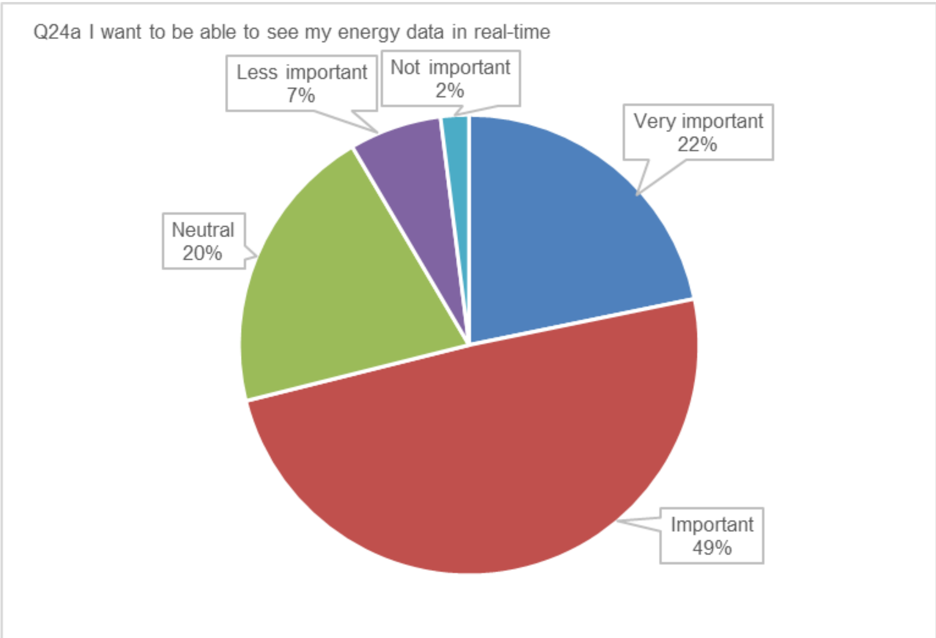
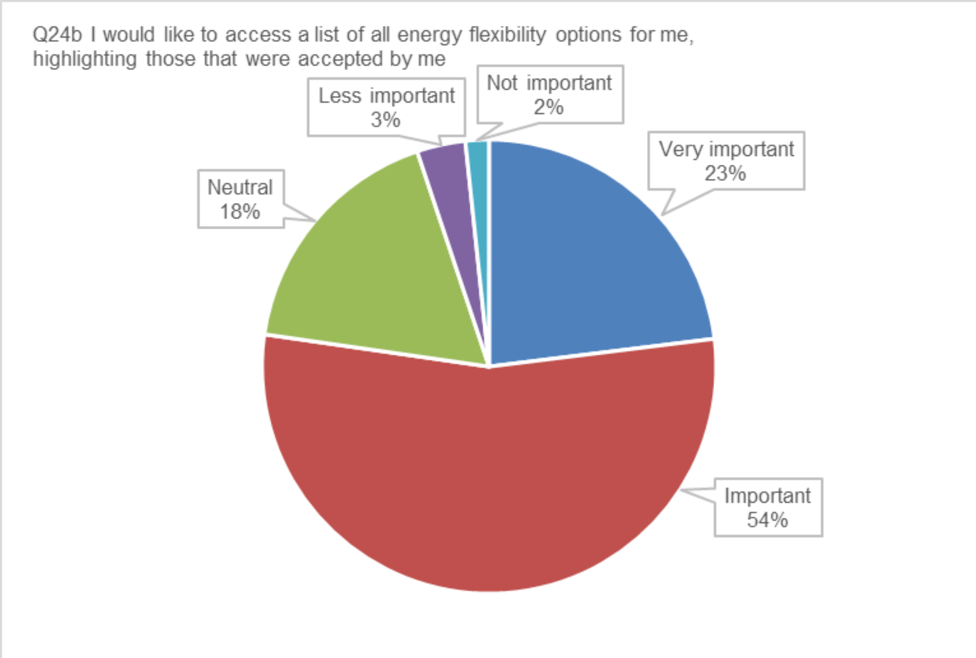
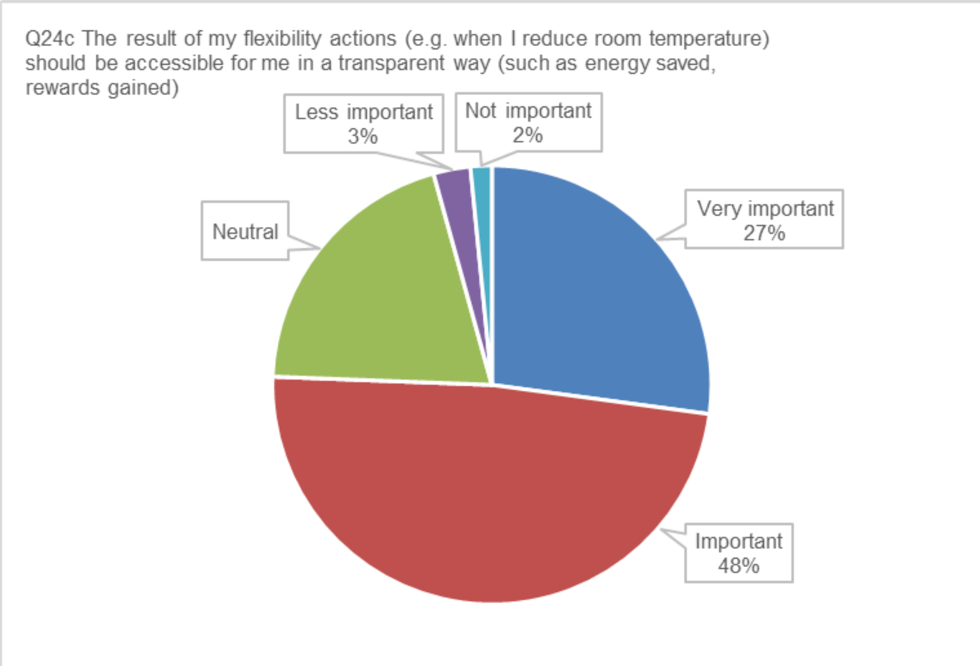


Figure 98: iFLEX Assistant functionalities (Q23)




Q24b I would like to access a list of all energy flexibility options for me, highlighting those that were accepted by me
Less important 3%
Not important 2%
Very important 23%
Neutral 18%
Important 54%


Q24c The result of my flexibility actions (e.g. when I reduce room temperature) should be accessible for me in a transparent way (such as energy saved, rewards gained)
Less important 3%
Not important 2%
Very important 27%
Neutral
Important 48%

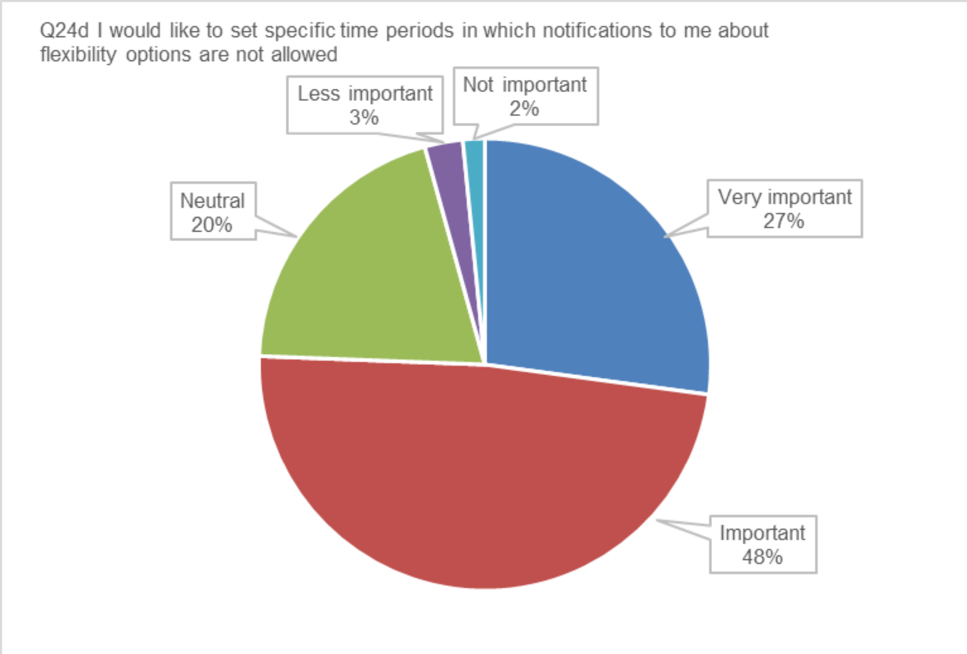


Figure 99: Importance of different functionalities (Q24)

5.2.8 Validation of the iFLEX concept – Finland

For the analysis here, we looked at the data from a group perspective meaning that an individual can figure in more than one group. In other words, we accept that an individual may have several preferences and motivational drivers and may therefore figure in more than one group.

Looking at how respondents would like to participate in energy flexibility, we analyse the answers from question 16c, d and e which would result in 3 groups for further analysis. All three options are positively valued by the majority of respondents with the option "*I could allow a smart digital assistant to automatically adjust energy consumption in my household, but only if my comfort stays the same*" (16d) as the most preferable option by 73% of the entire data sample. This was followed by 16c "*I could allow my energy provider to regulate specific energy demanding devices in my house (e.g. electric water heater), but only if my comfort stays the same*" (62%) and finally option (16e) "*I could invest in technology that would allow my energy devices (e.g. electric water heater) to automatically adjust consumption when needed by the grid*" (56%), see Figure 100. This result indicates that there is good potential for the iFLEX Assistant to be received positively and it will be interesting to evaluate pilot participants' experiences with using the assistant in the 2nd and 3rd phase of the pilot.

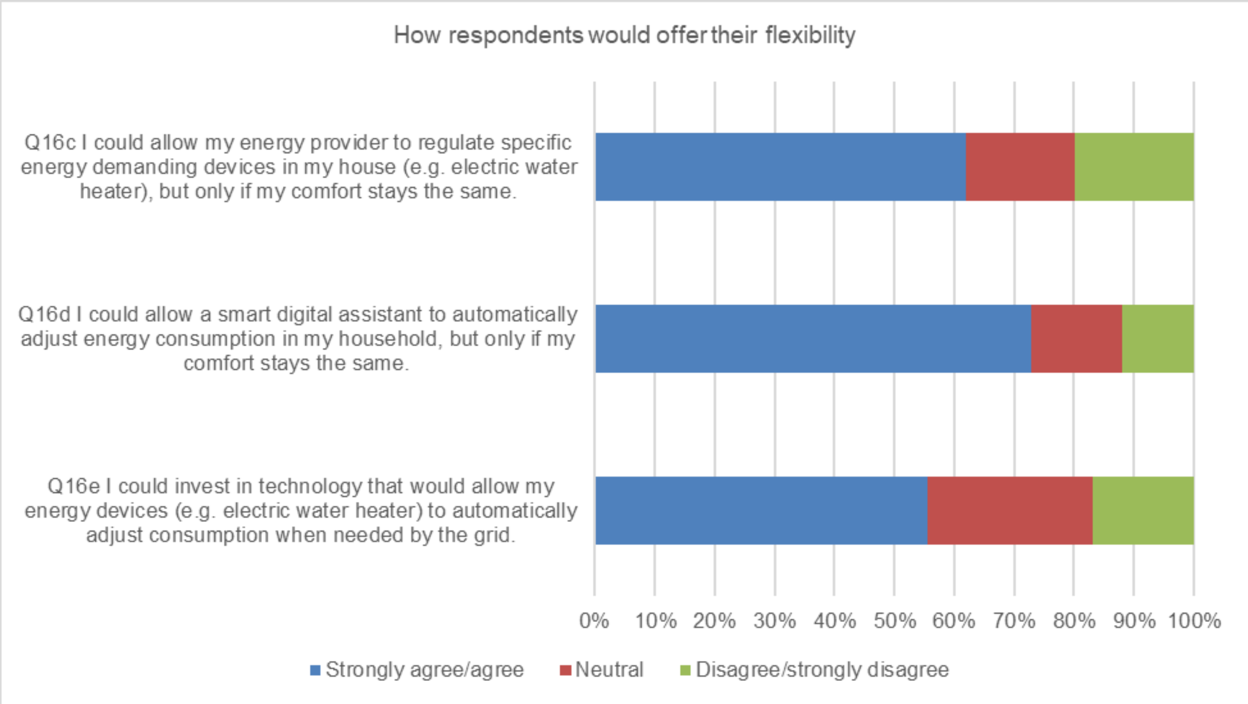


Figure 100: How all respondents would offer their flexibility (Finland)

Option 16d is preferred by most irrespective of gender (male, female and non-binary). Slightly more male respondents are positive towards each of the three options; in fact options 16c and 16d are both valued positively by 60% of male respondents whereas 65% of female respondents prefer option 16c compared to 50% who prefer option 16e.

The next step in the analysis was to look at how many participants were willing to adopt flexible energy behaviours and what type of action appealed to most. For this purpose, we analysed the answers to questions 16a "*I could change my daily routine (e.g. when to iron, cook, do laundry)*" and 16b "*I could lower my heating temperature set-point in wintertime*". First, from the overall perspective (entire pool of answers and so irrespective of how they would like to participate in Q16c-e), the results showed that N=659 (69%) would change their daily routine whereas N=528 (55%) would lower the heating temperature (Figure 101).

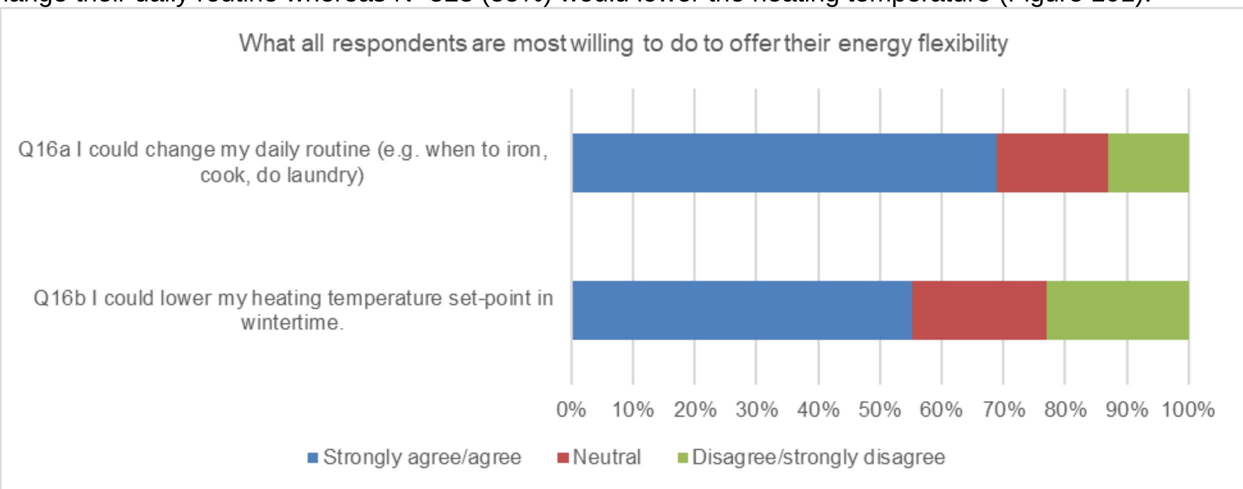


Figure 101: What all respondents are willing to do (Finland)

Overall, female respondents are more positive towards offering their flexibility; male and female respondents who are positive towards offering their flexibility both prefer to change their daily routine (65% and 76% respectively). Respondents identifying as non-binary are the least positive and they do not have a preference (58% for both options).

When looking at the results for each of the three groups based on their answers in Q16c-e, the preference of lowering the temperature is slightly higher compared to the overall result all groups combined, particularly for group 16e. Still, there is a noticeably preference for changing the daily routine for all three groups. (Figure 102).

Figure 102: What individual groups are willing to do (Finland)

The final step is to see if there are any significant differences between the main motivational driver for each group. The motivational drivers have been divided into 3 categories: i) Save the world! (Q15a), ii) Save money! (Q15b & c), and iii) Told to do it! (Q15e&f).

If we first look at how all respondents answered, the results show that respondents are primarily driven by the idea of saving money. For group d and e, nearly all respondents are also driven by the idea of saving the world. Only in group c, do we see that only a little more than one-third are driven by to “Save money” (89%) followed by to “Save the world” (75%) with a noticeable difference between the two drivers. Slightly more female respondents were driven by to “save the world”: 80% compared to 70% of male respondents, but to “save money” was what nearly all respondents (irrespective of gender) were motivated by: female 91%, male 87% and non-binary 83%.

We see the same trend when looking at the motivational drivers per group (irrespective of gender): “Save money” is what nearly all respondents are driven by and there’s a noticeable difference between this and to “Save the world” (Figure 103).

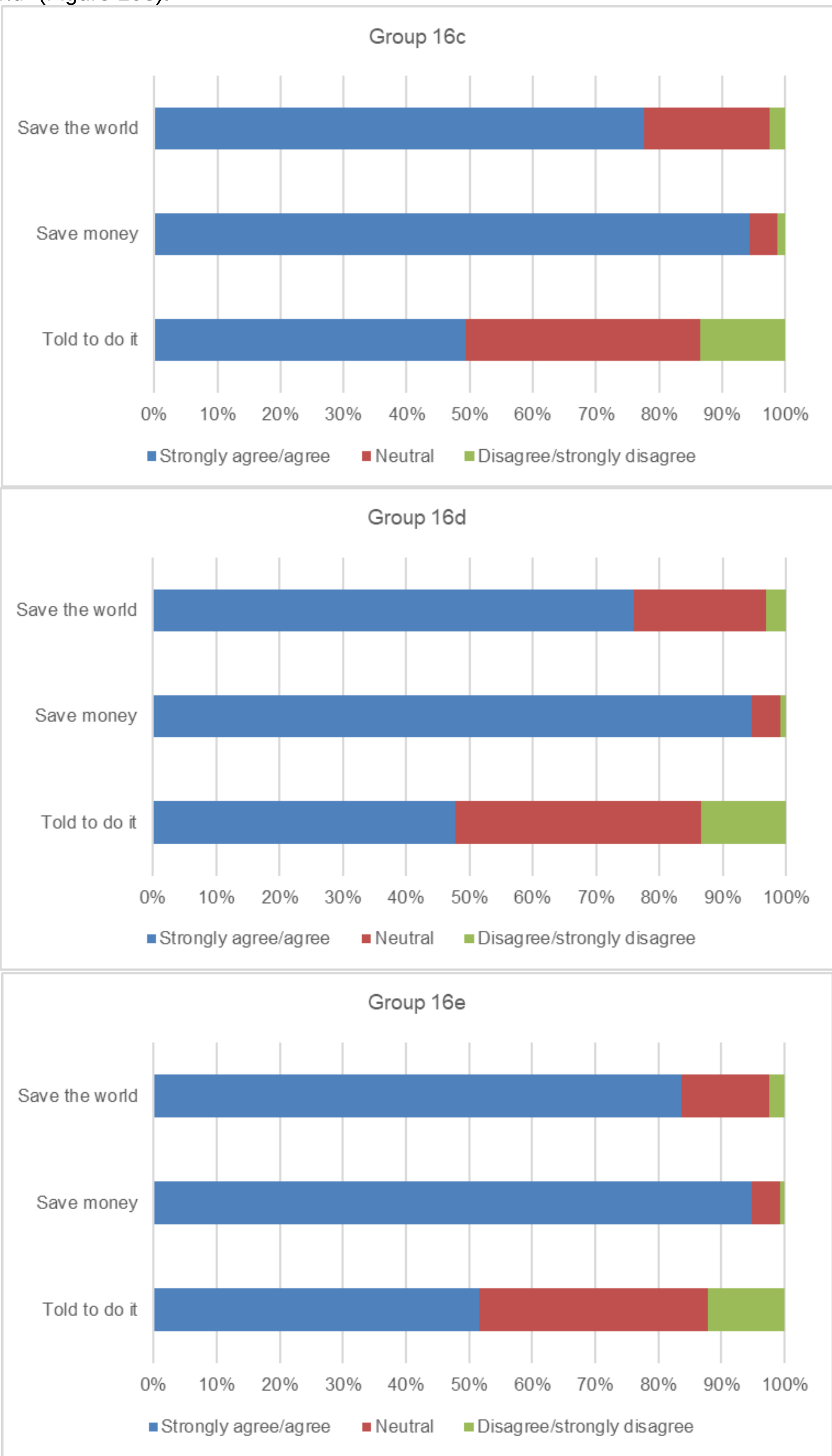


Figure 103: Main driver for each group (Finland)

5.3 Overall summery of public survey results

The public survey's primary focus was to assess consumers/prosumers' key motivations for offering their energy flexibility, what they would prefer to do and how. The results were quite similar for all three countries (or pilot sites) which is interesting as the characteristics of the data subjects differed notably across the three pilot sites with regards to age, household composition (i.e. with/without children) and dwelling type, size and tenure-ship.

Overall the concept of iFLEX was positively received as was the idea of offering energy flexibility. There was a very small difference between how Finnish respondents would engage in flexibility and how the Slovenian and Greek respondents would. Thus, while most respondents in Slovenia answered "*I could invest in technology that would allow my energy devices (e.g. electric water heater) to automatically adjust consumption when needed by the grid*" (69%), which was the Greek respondents' 2nd choice with 67%, this was the option which least of the Finnish respondents chose (52%).

There were also some slight, and very expected, differences between what respondents in the northern and central European countries and respondents in southern European countries prefer to do to offer flexibility. The former (Finland and Slovenia) prefer to change their daily habits whereas the latter, Greece, prefer to turn the heating down. All respondents were primarily motivated by saving money followed closely be saving the world (environment).

All respondents prefer a solution that combines manual and automated functionalities indicating that while respondents were positive towards offering energy flexibility and an automated and/or smart solution, they ultimately want to remain in control, suggesting that the balance between comfort and convenience versus saving money and contributing to a clean energy transition (save the world) is essential and subjective.

6 Technical validation

During this phase the work on technical validation focused mainly on internal verification activities which involved functional component and integration tests. In accordance to the fine-grained documentation of functionalities to be tested for each iFA component interfacing during the pre-pilot (i.e. in JIRA), different tests took place to validate the operation of these components as well as their interaction. On the other hand, validation of specific iFA instances (MVPs) was of reduced scope given the different maturity levels in the prototype components of iFA for the different pilots.

6.1 Greek pilot

In Phase 1 of the Greek pilot, technical validation concerns the functional testing of various iFA components or external systems. Functional and/or unit tests were conducted on the components with orange colour, as shown in the following Figure, whereas the grey-coloured components are mocked in the Greek pre-pilot.

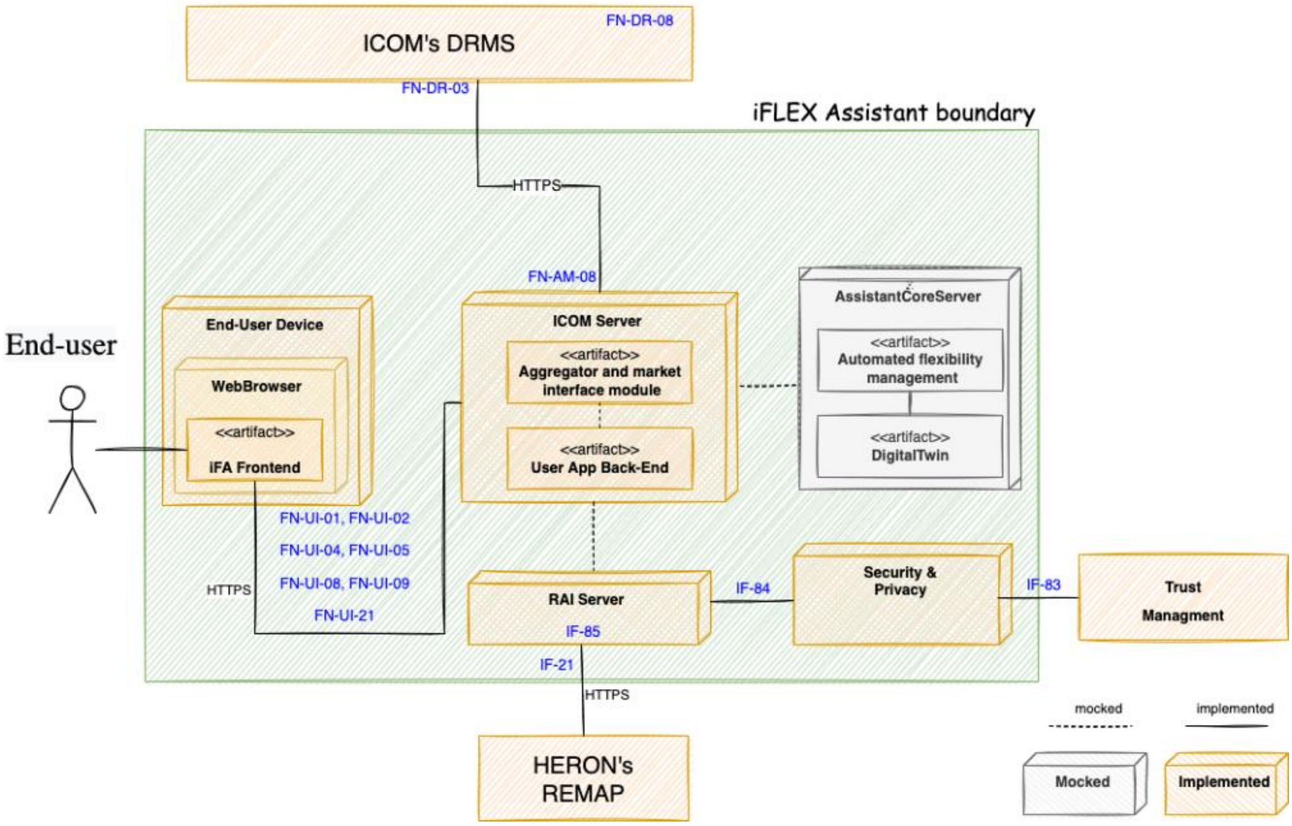


Figure 104: Technical Validation: Deployment diagram of the Greek pre-pilot

The implemented requirements pertain to the User Interface (UI), Aggregator and Market (A&M) Interface, Resource Abstraction Interface (RAI) and Secuirity&Privacy Interface components of the iFA and the external Demand Response Management System (DRMS) and Trust Management component, as shown in the above figure, and are presented in more details in the next Table. These requirements were also validated via functional or unit tests. Integration wise, the connection between RAI Server and HERON's REMAP system has been tested and functionally validated.

Table 4: Technical Validation: Implemented requirements in the Greek pre-pilot

Code	Title	Component/ System	Source
FN-UI-08	Provision of consent for the schedules of dispatchable assets	UI	PUC-9, PUC-10
FN-UI-21	DR event notification	UI	PUC-1, PUC-8

FN-UI-09	DR notification policy	UI	PUC-1
FN-UI-05	Automation level customisation	UI	PUC-1
FN-UI-04	Optimisation policy selection	UI	PUC-1
FN-UI-02	User-defined time and operational constraints	UI	PUC-1
FN-UI-01	Operation mode customisation	UI	PUC-1
FN-AM-08	Receiving Flexibility Signal	A&M	PUC-8
FN-DR-03	Sending Flexibility Signal	DRMS	PUC-8
FN-DR-08	Response to flexibility request	DRMS	Pilot-specific
IF-21	Sensor data	RAI	PUC-2
IF-83	Trust management	TM	/
IF-84	Authentication, Authorization and Accounting	S&P	/
IF-85	Communication security	RAI	/

6.2 Slovenian pilot

The deployment diagram of the Slovenian pre-pilot is shown in the following Figure. Functional testing was performed on the orange-coloured components of the iFA, whereas the others were mocked. As regards integration tests the functional integration between RAI server and external components, namely HEMS, FMI weather and weather forecast service and Smart Metering/AMI system was implemented and tested. The Trust management has been integrated and tested with regard the Security and Privacy Interface and RAI Server.

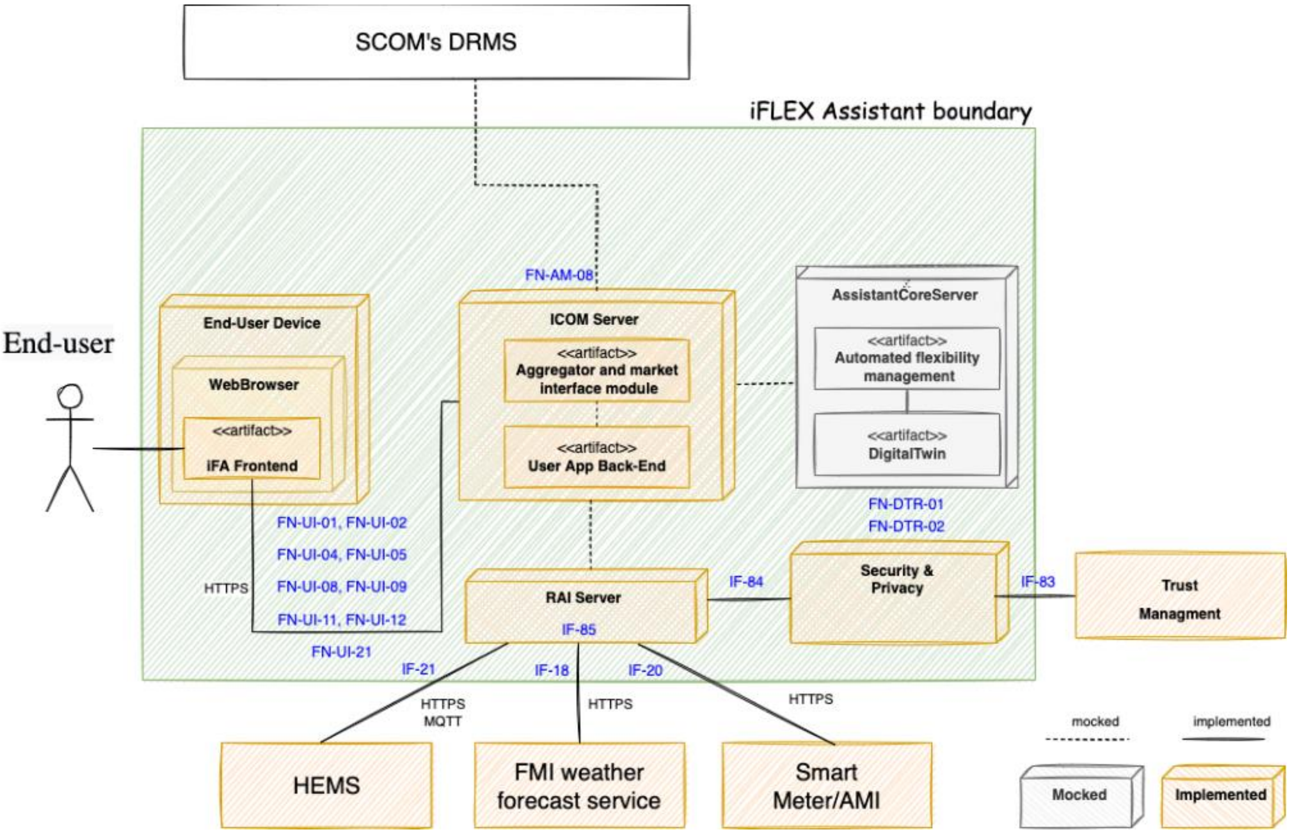


Figure 105: Technical Validation: Deployment diagram of the Slovenian pre-pilot

A list of the requirements, which have already been validated through unit testing in the Slovenian pilot, is presented in the following Table. These requirements are related to the Digital Twin Repository (DTR), RAI, S&P Interface, UI and A&M components of the iFA, and TM external component, as shown also in the above Figure.

Table 5: Technical Validation: Implemented requirements in the Slovenian pre-pilot

Code	Title	Component/ System	Source
FN-DTR-01	Household electricity model	DTR	HLUC-1, PUC-4, PUC-6, PUC-8, PUC-10
FN-DTR-02	Household thermal model	DTR	PUC-5
FN-AM-08	Receiving Flexibility Signal	A&M	PUC-8
FN-UI-21	DR event notification	UI	PUC-1, PUC-8
FN-UI-12	Past energy data	UI	PUC-7
FN-UI-11	Real-time energy data	UI	PUC-7
FN-UI-09	DR notification policy	UI	PUC-1
FN-UI-08	Provision of consent for the schedules of dispatchable assets	UI	PUC-9, PUC-10
FN-UI-05	Automation level customisation	UI	PUC-1
FN-UI-04	Optimisation policy selection	UI	PUC-1
FN-UI-02	User-defined time and operational constraints	UI	PUC-1
FN-UI-01	Operation mode customisation	UI	PUC-1
IF-21	Sensor data	RAI	PUC-2
IF-20	Smart metering data	RAI	PUC-2, PUC-4, PUC-5, PUC-6
IF-18	Weather data	RAI	PUC-10, PUC-5
IF-83	Trust management	TM	/
IF-84	Authentication, Authorization and Accounting	S&P	/
IF-85	Communication security	RAI	/

6.3 Finnish pilot

The deployed components of the Finnish instance of the iFA in Phase 1 are shown in the following Figure. This iFA has been so far validated via demonstrations in operational environment.

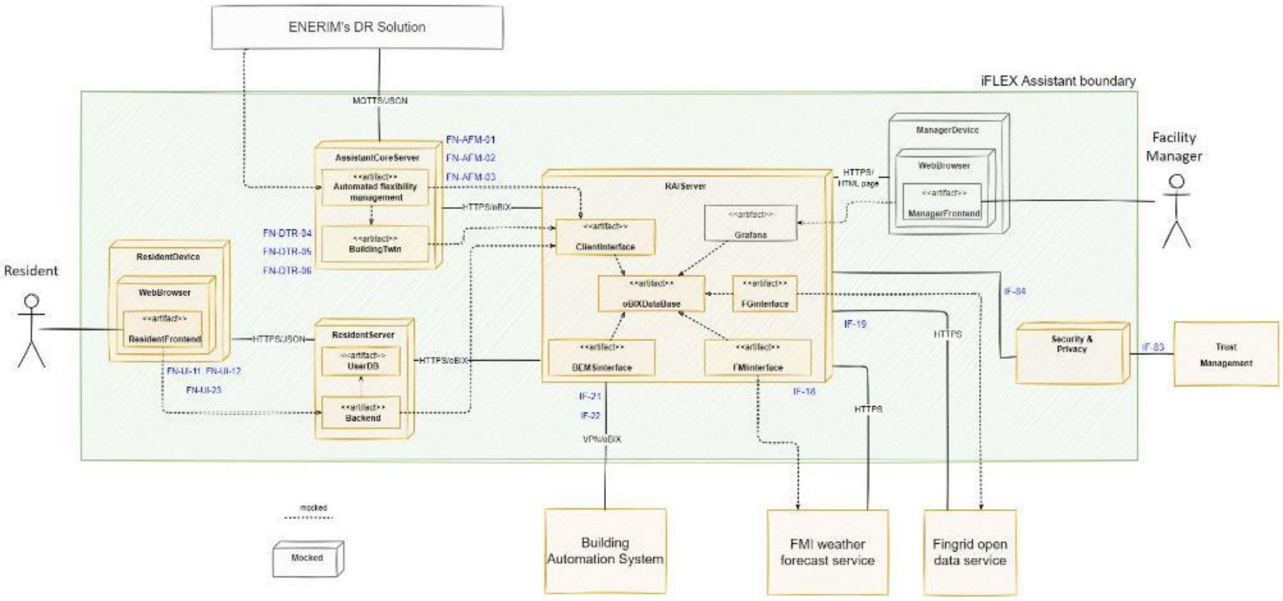


Figure 106: Technical Validation; Deployment diagram of the Finnish pre-pilot

The requirements which were implemented in Phase 1 of the Finnish pilot concern the Automated Flexibility Management (AFM), DTR and RAI components, as shown in the above Figure, and are presented in more details in the next Table.

Table 6: Technical Validation: Implemented requirements in the Finnish pre-pilot

Code	Title	Component/ System	Source
FN-AFM-01	Provide baseline forecasts	AFM	PUC-8
FN-AFM-02	Flexibility potential	AFM	PUC-8
FN-AFM-03	Activate offered flexibility	AFM	PUC-9
FN-DTR-04	Apartment building district heating model	DTR	HLUC-3, PUC-8, PUC-10
FN-DTR-05	Apartment building electricity model	DTR	HLUC-3, PUC-8, PUC-10
FN-DTR-06	Apartment building flexibility model	DTR	HLUC-3, PUC-6, PUC-8, PUC-9, PUC-10
IF-21	Sensor data	RAI	PUC-2
IF-18	Weather data	RAI	PUC-10, PUC-5
IF-19	CO2 emissions	RAI	PUC-3
IF-22	Flexible assets control	RAI	PUC-1, PUC-9
FN-UI-12	Past energy data	UI	PUC-7
FN-UI-11	Real-time energy data	UI	PUC-7
FN-UI-23	User Feedback on Satisfaction from DR/Flexibility Event	UI	PUC-
IF-83	Trust management	TM	/
IF-84	Authentication, Authorization and Accounting	S&P	/

7 Business validation

In this section, we perform a preliminary cost analysis based on the early data from pilot deployments. These cost parameters are going to be employed in the comprehensive cost-benefit and economic sustainability analysis, and the subsequent sensitivity analysis in WP5 (D5.6, D5.7). Note that any benefit calculation cannot be performed for the time being since the DR signals are not yet emitted to the users in the pilot studies.

7.1 Greek pilot

In the Greek pilot, based on the initial deployment of the equipment is given in the table below. It is assumed that the development effort for the Smart Home Monitoring app and the Smart Home Monitoring backend will take 2 years and it will cost 70000 €. For the purposes of development, a development server is assumed to be rent for the period of 2 years for the total cost of 4000 €. A 3-phase smart meter is supposed to be installed per house totalling an amount of 136.09 €.

CAPEX	Cost
3-phase smart meter purchase and tweaking (alignment with HERON's platform) cost	€ 70.51
3-phase smart meter installation cost	€ 65.58
HERON DR and Smart Home Monitoring app development	€ 50,000.00
HERON DR and Smart Home Monitoring backend and database infrastructure	€ 20,000.00
1 development server (for 2 years)	€ 4,000.00

For the operation of the iFlex software for the whole pilot deployment, 1 operational server is supposed to be rent for 2000 Euro per year, while 1 support engineer is assumed to be hired for 48000 Euro per year. These operational expenses are depicted in the table below.

OPEX	Cost	Cost frequency
1 Operational server	€ 2,000.00	Yearly
Support Personnel (1 person)	€ 48,000.00	Yearly
Installed devices power consumption (smart meters etc.)		

7.2 Slovenian pilot

In the Slovenian pilot, the one-off capital expenditures per house are depicted in the table below.

CAPEX	Quantity	Price	Total per position	Cost frequency	Power consumption
HEMS master controller	1 pcs	160 €/pcs	160.00 €	One-time	5.00W
Power meter (single and 3. phase power meter)	2 pcs	85.00 €/pcs	170.00 €	One-time	20.00W
Temperature sensors	1 pcs	11.93 €/pcs	11.93 €	One-time	0.0576W
Circuit braker (fuses)	4 pcs	2.70 €/pcs	10.80 €	One-time	0.00W

Surface-mounted el. enclosure	1 pcs	31.32 €/pcs	31.32 €	One-time	0.00W
Power supply cables (single and 3 phase cables)	5 m	2.34 €/m	11.70 €	One-time	0.00W
Signal cables (Ethernet UTP cable CAT 7, schilded MOD-BUS cable)	12 m	0.74 €/m	8.88 €	One-time	0.00W
Small inventory (screws, shrink tubes, el. ducts, signal terminals)	1 user	25.00 €/user	25.00 €	One-time	0.00W
System integration	2.5 h	20.00 €/h	50.00 €	One-time	0.00W
System configuration	0.5 h	20.00 €/h	10.00 €	One-time	0.00W
Travel cost	38 km	0.40 €/km	15.20 €	One-time	0.00W
API access (400 € initial for 100 users)	1 user	4.00 €/user	4.00 €	One-time	0.00W
Inspection of el. installation and system design	1.0 h	20.00 €/h	20.00 €	One-time	0.00W

Moreover, for running the iFlex software backend, cloud data services are supposed to be rent for 2€/month, while the power consumption of the iFlex equipment per house has been measured to be 25W. This data is summarized in the table below. Note that personnel costs for support also apply in this pilot, as in the Greek pilot, but they are currently not included.

OPEX	Quantity	Price	Total per position	Cost frequency	Power consumption
Cloud data services (for processing and storage data)	1 month	2.0 €/month	2.00 €	Monthly	0.00W
Installed devices power consumption (HEMS, smart meters etc.)	18.04 kWh/month	0.11 €/kWh	1.98 €	Monthly	25.06W
Support personnel	1 ticket	6 €/ticket	6.00 €	Ticket	0.00 W
iFlex Server hosting	0.5 €/h	0.5 €/h	0.5 €	Hourly	0.00W

7.3 Finnish pilot

In this pilot, the equipment and infrastructure costs per building (i.e., multiple apartments) are presented in the table below. Moreover, the cost analysis consider separately the cases of an old and a new building, in addition to the cost of installing an Internet connection for the whole building in case that it does not exist. It has to be noted that operational costs do exist for the Finnish pilot similarly to the ones in the Greek and the Slovenian pilots, however, they are not included in the current cost analysis.

CAPEX	Cost
Investment cost for BEMS upgrades	

New buildings:	
Meter upgrades (either A or B)	
A: 600€ for normal smart meter that provides data for BEMS (includes deployment and integration)	€ 600.00
B: 1 k€ - Electric frequency meter (optional)	€ 1,000.00
Required for participating in frequency containment reserves	
Software customization (2k€)	€ 2,000.00
Old buildings:	
In addition to the above: JACE gateway + upgrades (1k€)	€ 1,000.00
Sensor costs	
Apartment specific sensors	€ 800.00
Internet costs (this could be there anyway or not)	
Internet connection is missing about 5% of the buildings	
Internet deployment costs roughly (1k€) so on average 50€/building (needed for 5%)	€ 50.00
Total deployment costs (CAPEX):	
New buildings: 3,4 – 3,8k€/building	€ 3,400.00
Old building: 4,4 – 4,8k€/building	€ 4,400.00

OPEX	Cost	Cost frequency
1 Operational server	200€	Yearly
Support Personnel	500€ / building	Yearly
Installed devices power consumption (smart meters, etc.)	N/A	N/A

8 Validation progress monitoring (KPIs)

In the first pilot phase the validation of project KPIs focused on KPIs from VDOA 10 to 13. Summary of the validation results are presented in Table 7.

Table 7: Current values for KPIs monitored after each pilot phase.

ID	Validation item (description)	Current value	Target at the end of the project	Description	Validation method
VDOA10	KPI5a - Technology readiness of the iFLEX Framework and iFLEX Assistant prototypes	TRL 6	TRL 7	Refers to the technology readiness level of the solution. Please refer to Horizon 2020 General Annex G[13] for details. The current value (TRL 6) indicates that part of the full solution (i.e., technology) have been demonstrated in relevant environment.	The KPI is validated by demonstrating the iFLEX Assistants in operational environment in the three pilot sites.
VDOA11	KPI5b - Number of innovative demand response and holistic energy management services	3	5	Refers to the DR primary use cases (PUC) that have been implemented, integrated and demonstrated in iFLEX Assistants. Please refer to D2.1 Use Cases and Requirements for further details on the PUCS. The current value covers following PUCs: PUC-2, PUC-3, PUC-8.	Count innovative DR services – DR services not available among project partners and in pilot sites when the project started.
VDOA12	KPI6a - Number of consumers in the pilots	150	> 600	The KPI refers to the total number of people (customers) involved in the pilots. I.e., residents of the apartment buildings and detached house in the three pilots sites.	Count customers (people) involved into each pilot. Final count of all consumers involved in all pilots.
VDOA13	KPI6b - Number of consumer groups targeted with novel demand response services	2	3	The number of different customer segments (e.g. consumers in detached houses, industrial consumers, prosumers, etc.). The current value include residents of the apartment building (rental) and owners of detached houses.	Count customer groups involved into each pilot. Final count of all consumer groups involved in all pilots.

[13] https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

9 Conclusion

The purpose of the first pilot phase is to validate the basic technical issues of the project on the first pre-pilot users. In the Greek pilot case, the pre-pilot user was equipped with measurement and control equipment that measures electricity consumption and controls the boiler's electrical consumer via a relay. In Slovenian pilot cluster two different HEMS system provided from different manufacturers were deployed and technically tested. Different types of working regime and communication protocols with end user equipment were tested and validated. Finish pilot cluster is focused on the multi-apartment building in which mostly students reside. In the utility room located inside the building the gateway between heating devices and outside world wide web was installed. An installed gateway provides a bridge for monitoring and controlling data through deployed iFLEX assistant.

Furthermore in the document the results of the collected data via public survey was presented in the statistically oriented manner. Public survey was completely anonymous and collected data was related to basic residential data (type and size of housing, age group of housing users, user habits in electricity consumption etc.).

During the first pilot phase the iFLEX mobile application was develop and with first pre-pilot users the usability test was performed. In the usability test each individual user performed basic functional task on remotely accessed mobile application. Based on user feedback and completed questionnaires at the end of the usability test the useful information was collected which was important for further development of the iFLEX mobile application.

Document also presents technical validation which focused mainly on internal verification activities which involved functional component and integration tests. In accordance to the fine-grained documentation of functionalities to be tested for each iFA component interfacing during the pre-pilot (i.e. in JIRA), different tests took place to validate the operation of these components as well as their interaction. On the other hand, validation of specific iFA instances (MVPs) was of reduced scope given the different maturity levels in the prototype components of iFA for the different pilots.

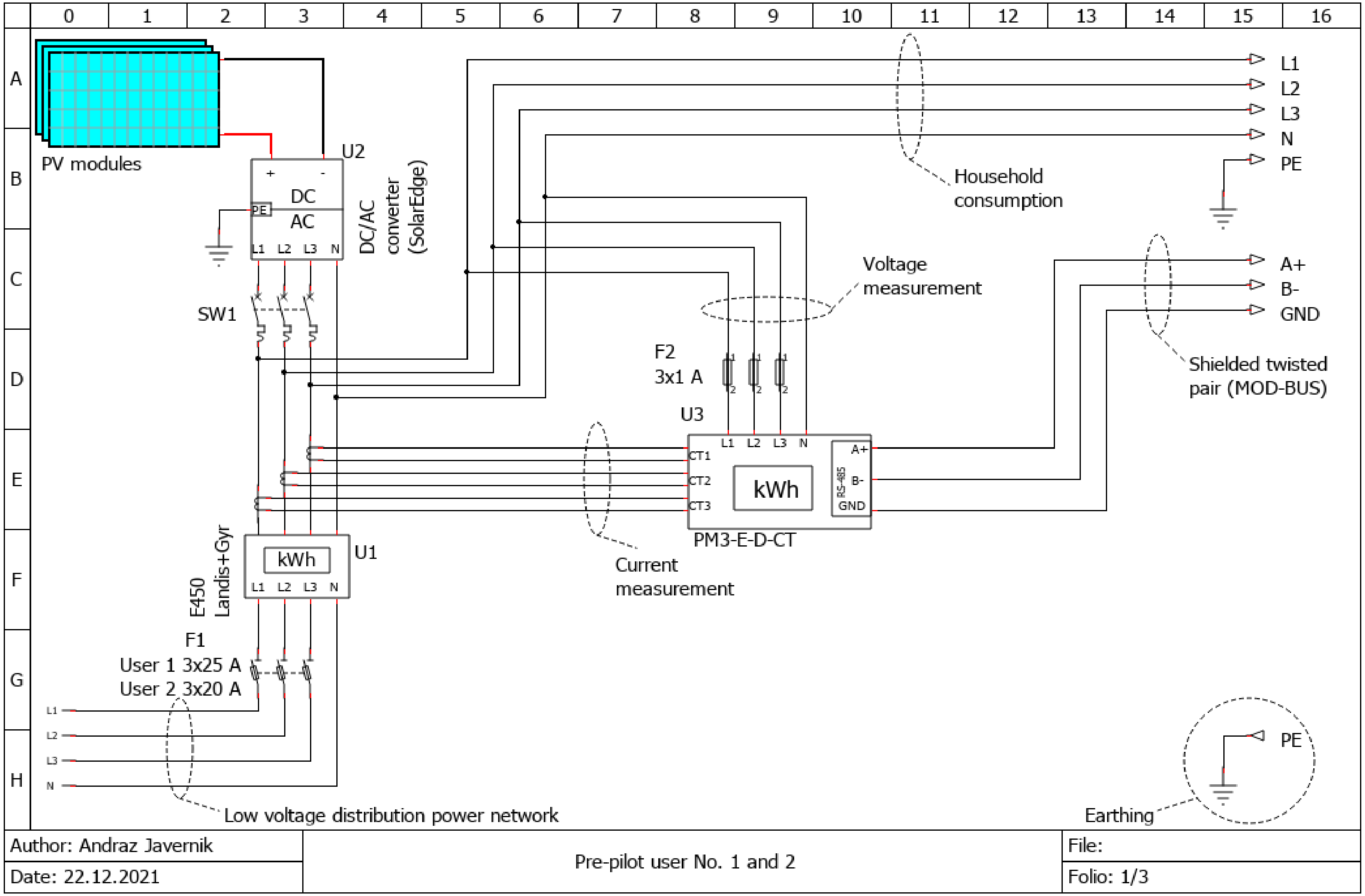
A preliminary cost analysis on the early data from pilot deployment was performed in the section which correspond to business validation. Business validation was done with the comprehensive cost-benefit and economic sustainability analysis and the subsequent sensitivity analysis.

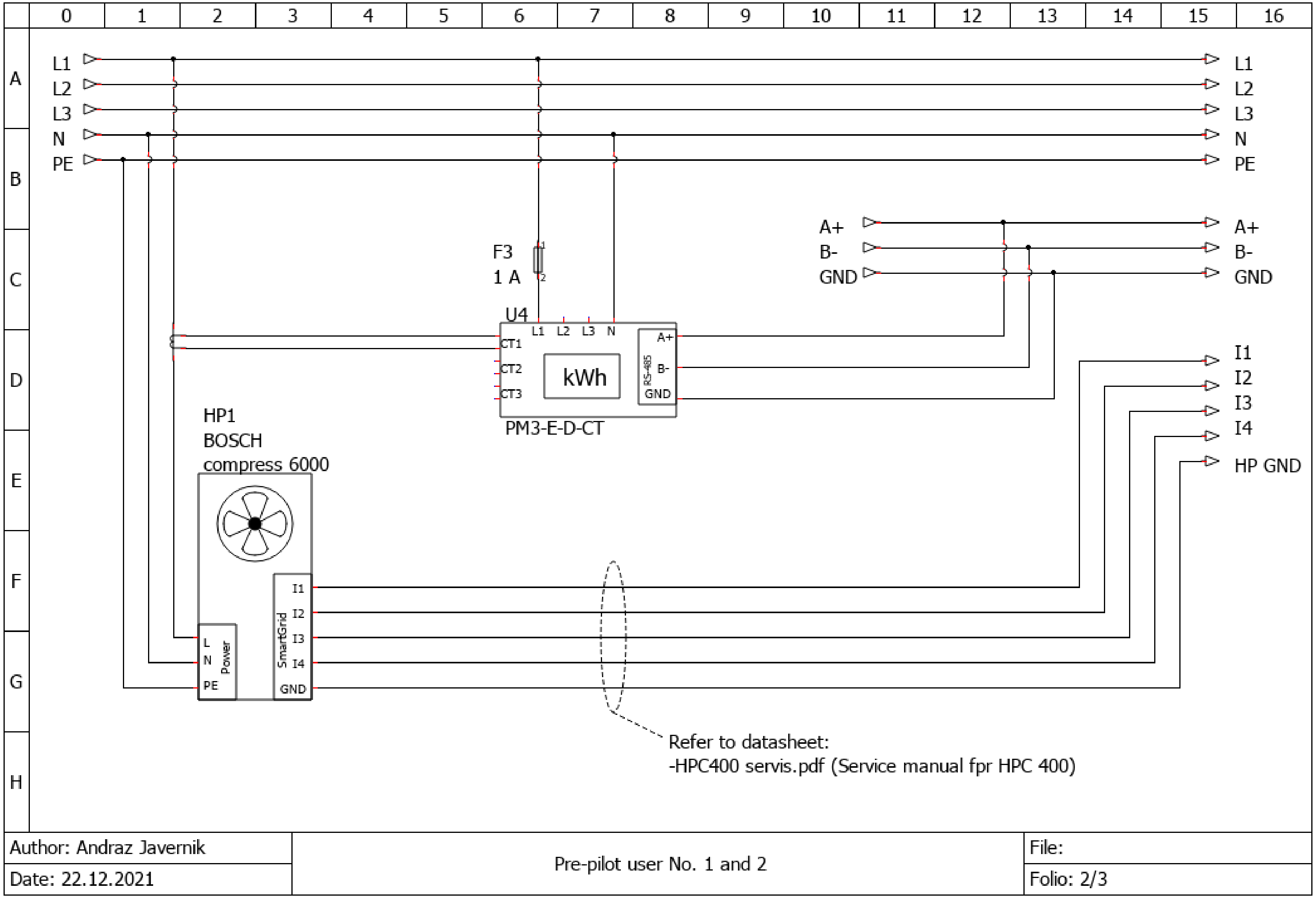
10 List of figures and tables

10.1 Figures

10.2 Tables

11 Annex 1 Slovenian pre-pilot user electrical schematic

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Date: 22.12.2021
Pre-pilot user No. 1 and 2
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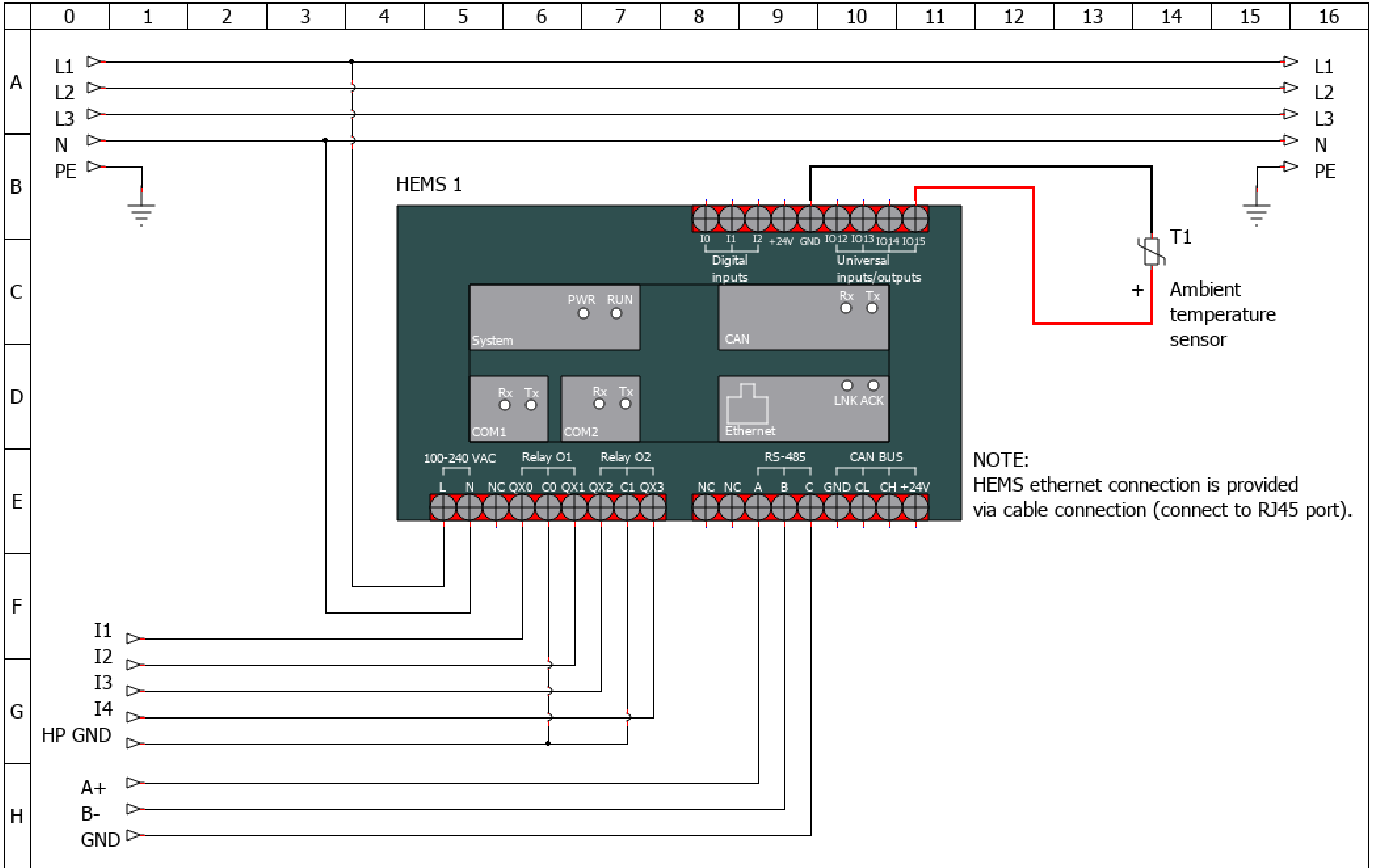

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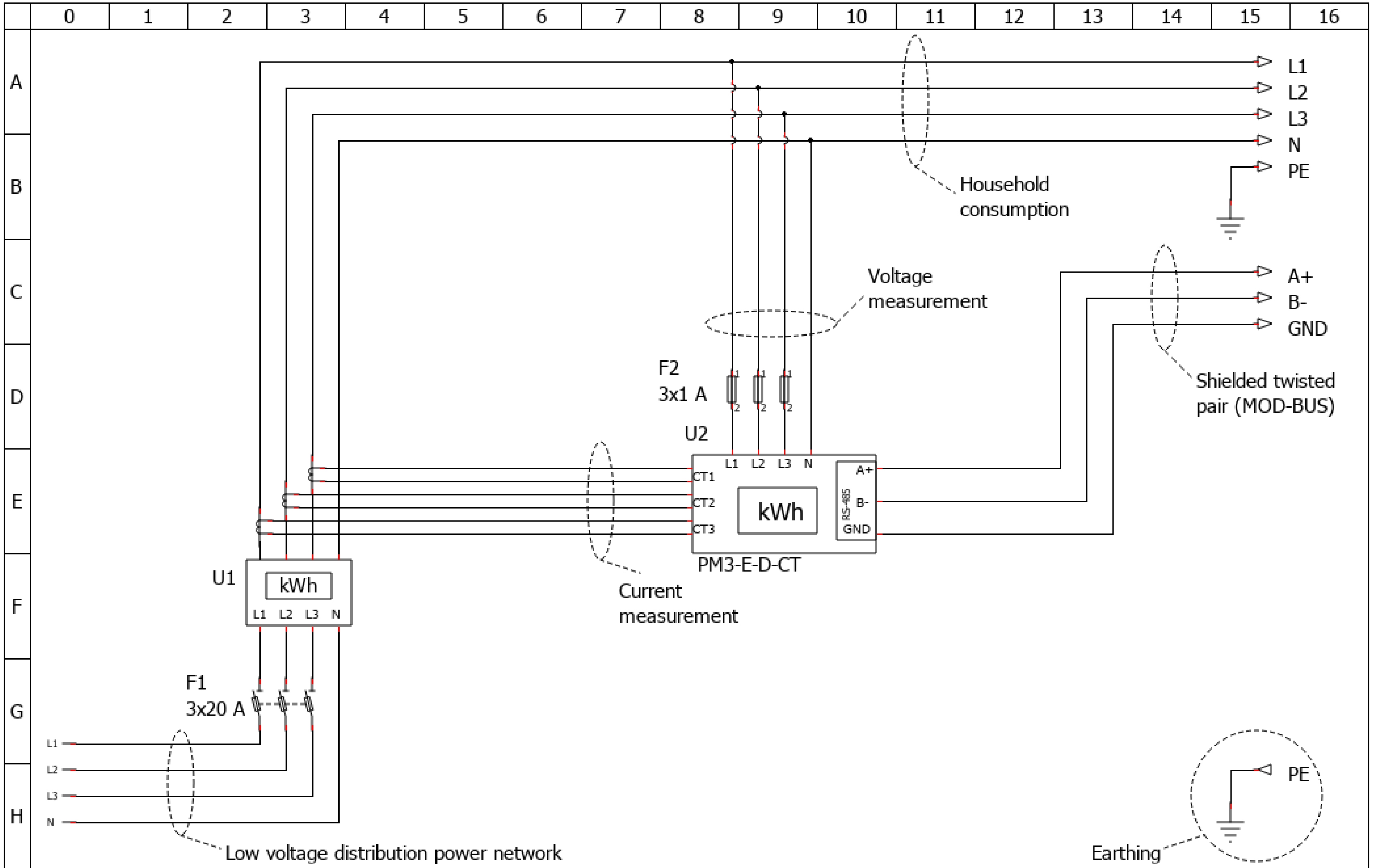

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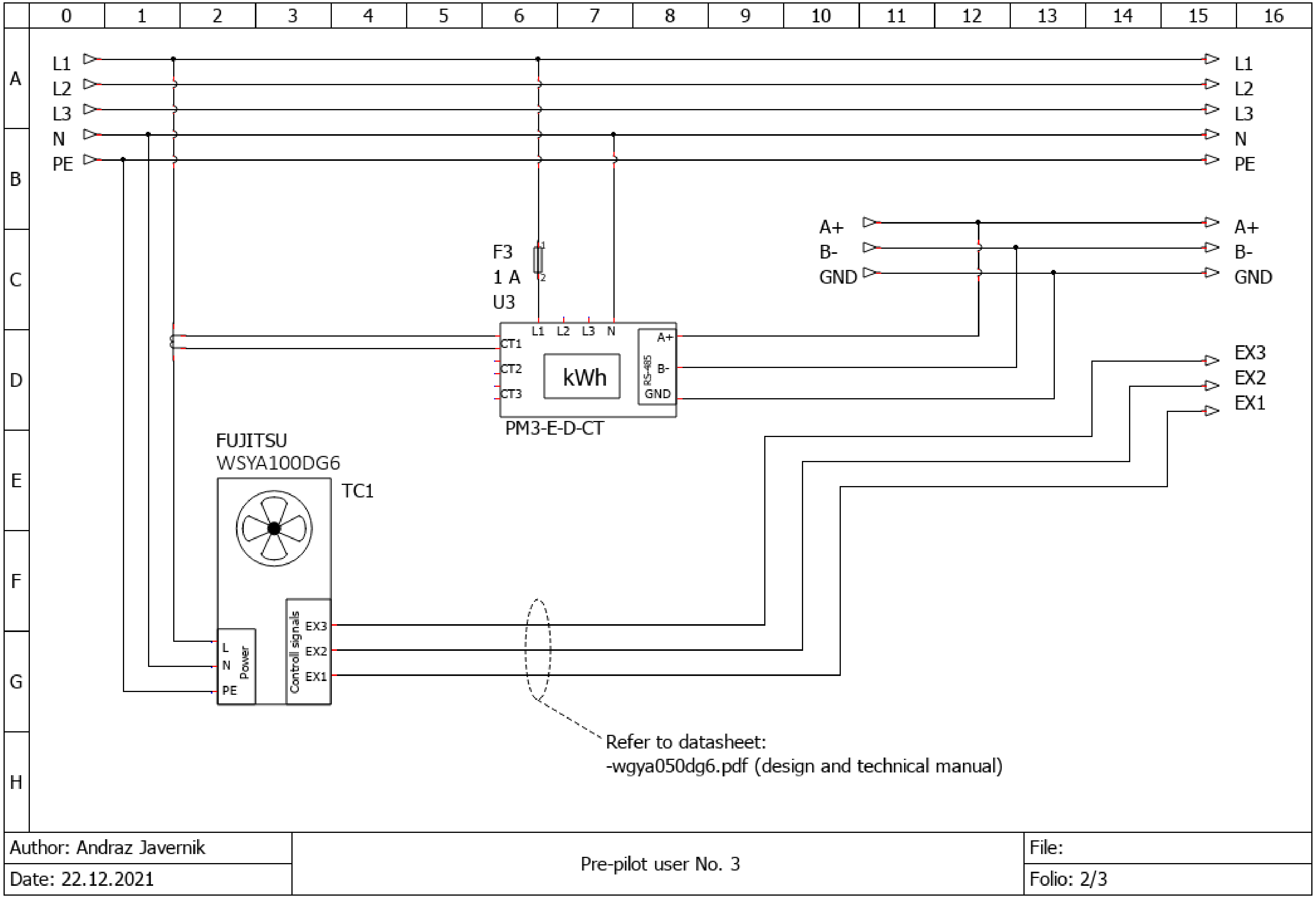
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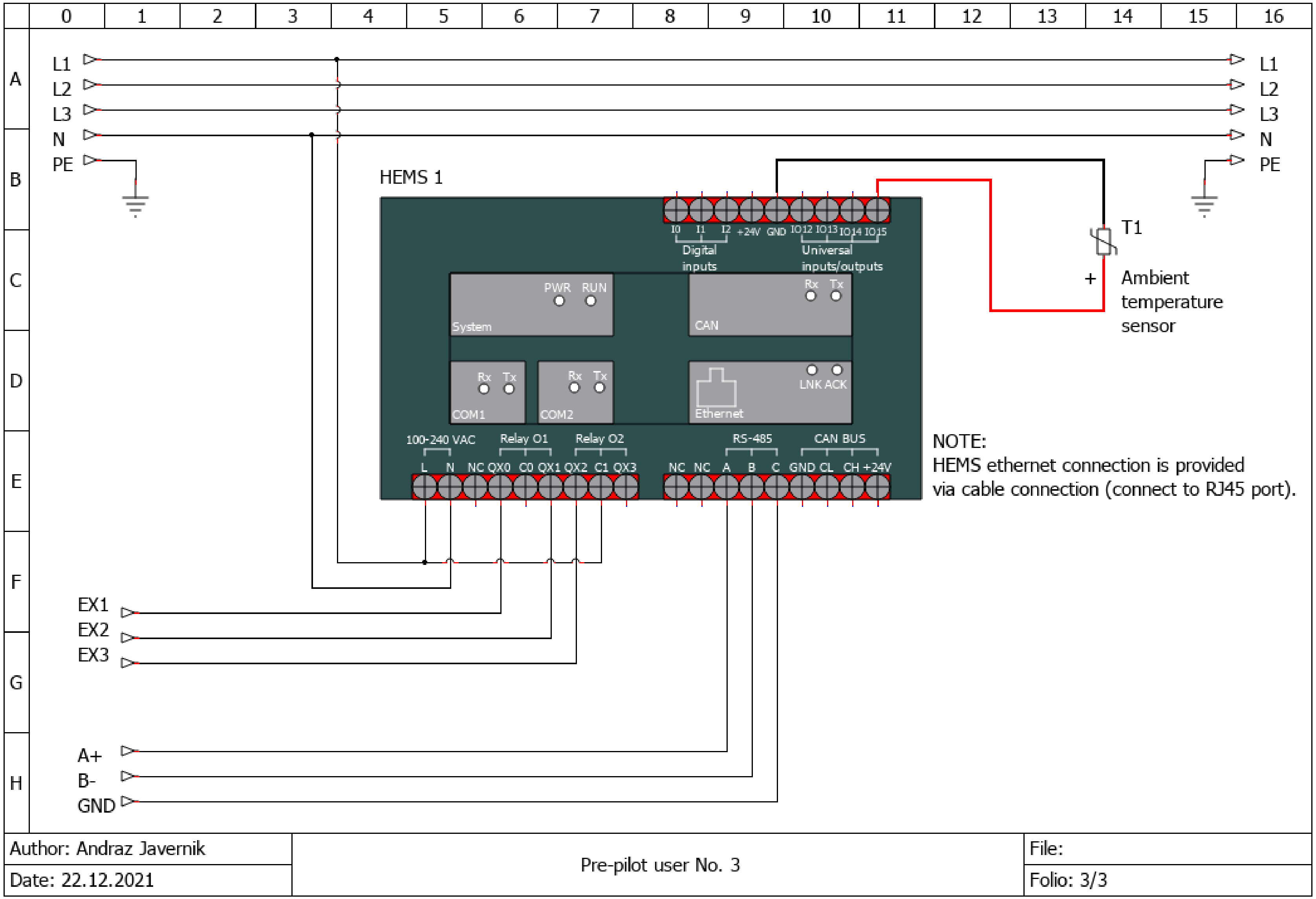
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Universal inputs/outputs
PWR RUN
System
Rx Tx
CAN
Rx Tx
COM1
Rx Tx
COM2
LNK ACK
Ethernet
100-240 VAC
Relay O1
Relay O2
L N NC QX0 C0 QX1 QX2 C1 QX3
RS-485
CAN BUS
NC NC A B C GND CL CH +24V
T1
+
Ambient temperature sensor
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EX1
EX2
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A+
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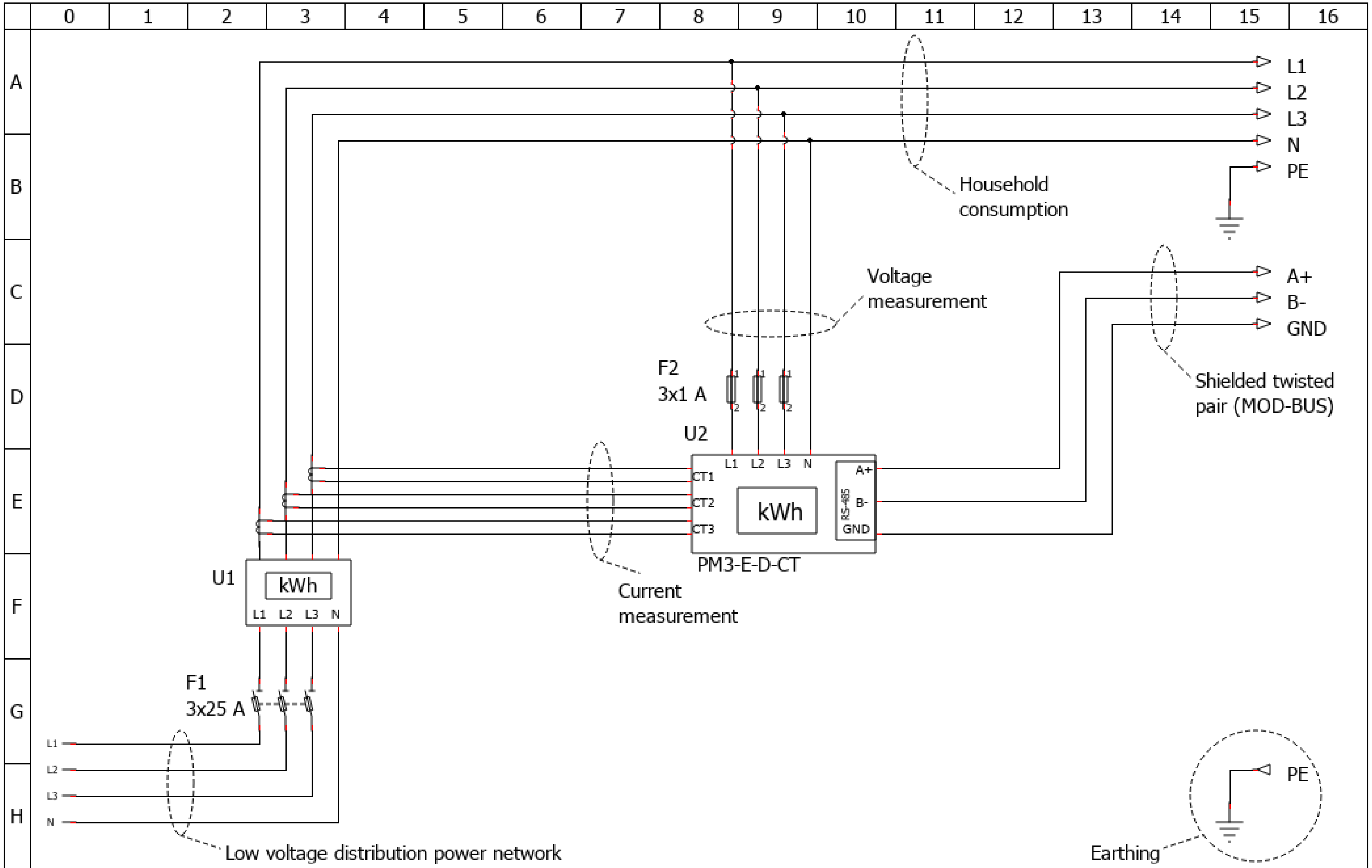

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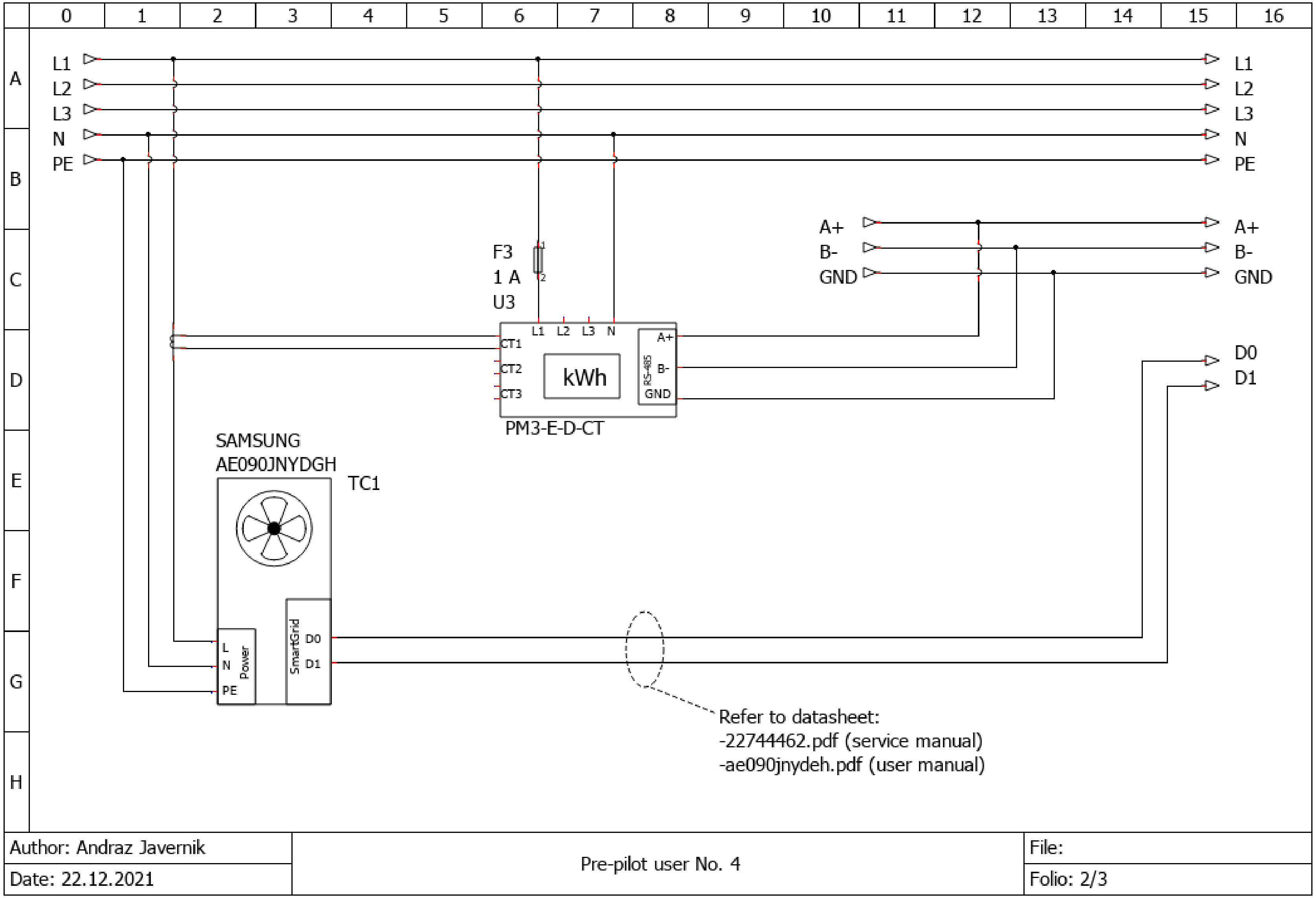
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Date: 22.12.2021
Pre-pilot user No. 4
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12 Annex 2: iFLEX questionnaire to general public

Welcome to the iFLEX research project survey on energy flexibility.

The aim of this survey is to get your input on what it would take for you to be flexible about your energy consumption and how you would like to manage this flexibility.

What is energy flexibility: The energy system is increasingly being dominated by renewable sources such as sun, wind and water. This means that we must adapt our electricity usage (energy flexibility) to a more fluctuating energy generation in order to secure the balance of supply and demand and to avoid costly reinforcement of the electricity grid.

With your help we believe we can develop better energy flexibility services and bring the best customer experience when balancing energy supply and demand in the future. Outcomes from this survey will be directly used to design the iFLEX solution that could soon become a digital assistant in many homes across EU that will help drive the green transition. While participating in this survey you are one of the pioneers of the future consumer experience in energy flexibility.

INSTRUCTIONS

The questions are structured into 3 categories and is estimated to take 15 minutes. Please answer all questions. Answers are mandatory to continue and conclude the survey.

It is possible to go back to a previous page and change your answer, just click the "previous" button at the bottom of the page.

Please make sure to click the "Done" button below to submit your questionnaire.

The questionnaire is anonymous. We do not collect your IP address or any other personal identifiable data.

The following was inserted here in the Finnish questionnaire:

A new Apple iPhone 13 (worth € 929) will be drawn among the respondents. If you would like to participate in the prize draw, you can leave your contact information at the end of the questionnaire. The contact details provided for the prize draw will be treated confidentially and separately from the responses to the questionnaire.

Household and Personal characteristics

The following questions are related to you and your household in general. The purpose is to gain background information that can help us better understand the answers about energy flexibility.

General Household and participant information

Q1 Are you one of the persons in your household who pays the electricity bill?	Choose one
Yes	☐
No	☐

Q2 Are you one of the persons in your household making decisions about electricity (e.g. switching supplier, buying energy saving appliances)?	Choose one
Yes	☐
No	☐

Q3 What is the type of your residential housing – what describes your home best?	Choose one
Apartment in a multi-family building	☐
Single family detached house	☐
Semi-detached house (house with two separate entrances)	☐
Terraced house (in a row of similar houses joined together)[14]	☐
Farm with a family house	☐
Other, please specify	[comment box]

Q4 Which of the following best describes the property type of your principal residence?	Choose one
Owned residence	☐
Rented residence	☐
Living in a free residence (e.g. as part of job)[15]	☐
Other	☐

Q5 What is the year of your birth?	Write a year
Year of birth	

Q6 What is your gender?	Choose one
Female	☐
Male	☐
Non-binary	☐

Q7 How many residents aged 18 or more live in your household?	Write a number
Residents aged 18 or more	

Q8 How many residents under 18 live in your household?	Write a number
Residents aged less than 18	

Q9 What is your highest level of education completed?	Choose one

[14] Not included in Greek survey.
[15] Not included in Greek survey-

Early childhood education[16]	☐
Primary education	☐
Lower secondary education	☐
Upper secondary education	☐
Bachelor's or equivalent	☐
Master's or equivalent	☐
Doctoral or equivalent	☐

Q10 What is your dwelling size in square meters??	**Write a number in m^2**
Dwelling size	

Q11 Does your household or building have one of the following?	**Select all that applies**
Solar panels	☐
Air conditioner for cooling and/or heating (Air-Air)	☐
Battery for electricity storage	☐
Heat pump for heating (Air-Water, Water-Water, Ground-Water)	☐
Electric or hybrid car	☐
Water electric heater (boiler)	☐
None of the above	☐

Personal preferences and characteristics

Q12 Select the level of your agreement with each of the following statements. It will help us understand the relation between personal preferences and energy flexibility preferences.	**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**
It is important to me to follow my own path	☐	☐	☐	☐	☐
I like being part of a team	☐	☐	☐	☐	☐
I like competitions where a prize can be won	☐	☐	☐	☐	☐
Rewards are a great way to motivate me	☐	☐	☐	☐	☐
I dislike following rules	☐	☐	☐	☐	☐
I like sharing my knowledge	☐	☐	☐	☐	☐
I would like to enhance my skills by training	☐	☐	☐	☐	☐

Technology usage

Q13 Select how often do you use each of listed digital technology and services	**Daily**	**Weekly**	**Monthly**	**Rarely / Never**

[16] Not included in Greek survey.

Internet browsing on personal computer, laptop, etc.	☐	☐	☐	☐
Smart mobile phone and mobile applications	☐	☐	☐	☐
Internet services like shopping and banking	☐	☐	☐	☐
Using electronic invoices for services	☐	☐	☐	☐
Energy monitoring system or Smart Home system	☐	☐	☐	☐
Housekeeping robots and smart appliances (e.g. e.g. smart fridge)	☐	☐	☐	☐

Q14 Do you use any technology to monitor your energy consumption/production in your household?	Select all that applies
Mobile app (in combination with smart meter or similar)	☐
Website (in combination with smart meter or similar)	☐
In-home display for the whole house	☐
In-home energy monitor (meter) for one or few appliances	☐
Integrated Smart home solution (Home Energy Management System)	☐
Data stated on the energy bill (paper, electronic)	☐
None of the above	☐
Other, please specify	[comment box]

Motivation, Behaviour intentions and Flexibility

The following questions deal with your motivations and behaviour for being energy flexible and the level of flexibility.

Motivation for flexibility (incentives) and behavioural intentions

Q15 I would offer my energy flexibility if I would…	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
contribute to a clean energy transition.	☐	☐	☐	☐	☐
conserve energy.	☐	☐	☐	☐	☐
save money.	☐	☐	☐	☐	☐
gain rewards.	☐	☐	☐	☐	☐
be a positive example for others.	☐	☐	☐	☐	☐
do what is asked of me.	☐	☐	☐	☐	☐
avoid power disruptions.	☐	☐	☐	☐	☐

Q16 What are you willing to do to be able to offer flexibility in energy consumption	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I could change my daily routine (e.g. when to iron, cook, do laundry)	☐	☐	☐	☐	☐

I could lower my heating temperature set-point in wintertime.	☐	☐	☐	☐	☐
I could allow my energy provider to regulate specific energy demanding devices in my house (e.g. electric water heater), but only if my comfort stays the same.	☐	☐	☐	☐	☐
I could allow a smart digital assistant to automatically adjust energy consumption in my household, but only if my comfort stays the same.	☐	☐	☐	☐	☐
I could invest in technology that would allow my energy devices (e.g. electric water heater) to automatically adjust consumption when needed by the grid.	☐	☐	☐	☐	☐
I would not change my energy consumption behaviour despite the energy costs might get higher.	☐	☐	☐	☐	☐

Energy and Flexibility Awareness

Q17 How would you agree with the following statements:	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
It is my right to use as much energy as I want	☐	☐	☐	☐	☐
I am aware of energy costs and most-energy consuming appliances	☐	☐	☐	☐	☐
I am aware of ways to offer energy flexibility	☐	☐	☐	☐	☐
I am aware that monthly electric energy bill consists of costs based on energy consumption (e.g. energy cost) and other costs not based on consumption	☐	☐	☐	☐	☐

Environmental personal norms

Q18 How would you agree with the following statements:	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Conserving energy and natural resources is important to me	☐	☐	☐	☐	☐
Conserving energy is not my problem	☐	☐	☐	☐	☐

Locus of Control

Q19 How would you agree with the following statements:	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Offering energy flexibility is a collective effort.	☐	☐	☐	☐	☐
I would change my energy-consumption schedule, if others do so	☐	☐	☐	☐	☐
Doing and offering flexibility individually has no impact at all	☐	☐	☐	☐	☐

Personal Disadvantages

Q20 Select the level of your agreement with each of the following statements	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Bad weather or climate conditions make me sick.	☐	☐	☐	☐	☐
I often feel colder/warmer than people around me.	☐	☐	☐	☐	☐
My personal comfort at home is of crucial importance.	☐	☐	☐	☐	☐

Energy flexibility execution

Q21 Under which conditions would you be willing to allow external control of the following devices in your household?	If it is unnoticable and does not affect my comfort or convenience	If I can overule it at any time	If I'm notified when it happens	If I'm notified in advance when it will happen	I would never allow external control	Not applicable
Heat pump	☐	☐	☐	☐	☐	☐
Electric water heater	☐	☐	☐	☐	☐	☐
Electric or hybrid car	☐	☐	☐	☐	☐	☐
Air conditioning device	☐	☐	☐	☐	☐	☐

Q22 How would you prefer to execute your flexibility?	Choose one
I prefer to adjust the consumption manually	☐
I prefer an automated operation	☐
I prefer to have an option to execute some flexibility automated and some manually	☐

The Concept of Managing flexibility

iFLEX project is developing a software solution, the 'iFLEX Assistant', with the aim of making it easy for you to manage your flexibility. The following questions deal with the functionality of such a solution.

Flexibility Operation

Q23 How important are the following functionalities to you?	Very important	Important	Neutral	Less important	Not important
I would like to be able to enable and disable automated operation of the iFLEX assistant.	☐	☐	☐	☐	☐
I would like to be able to set my personal preferences in the iFLEX assistant in regards to energy flexibility (e.g. what times during the day I cannot adjust consumption)	☐	☐	☐	☐	☐
The solution should provide energy advices to me how to best adjust my energy consumption to meet my personal flexibility preferences	☐	☐	☐	☐	☐

Flexibility Visualization and communication

Q24 How important are the following functionalities to you?	Very important	Important	Neutral	Less important	Not important
I want to be able to see my energy data in real-time	☐	☐	☐	☐	☐
I would like to access a list of all energy flexibility options for me, highlighting those that were accepted by me	☐	☐	☐	☐	☐
The result of my flexibility actions (e.g. when I reduce room temperature) should be accessible for me in a transparent way (such as energy saved, rewards gained)	☐	☐	☐	☐	☐
I would like to set specific time periods in which notifications to me about flexibility options are not allowed	☐	☐	☐	☐	☐

The following was inserted here in the Finnish questionnaire:

Prize draw

A prize will be drawn among the respondents (Apple iPhone 13, worth 929€).

If you would like to participate, we need your consent to collect your contact information. Your contact information will not be combined with the results of the questionnaire or used for any other purpose. Your information will be managed in compliance with data protection regulation and VTT privacy statement [link]. Please see also the iFLEX project's data privacy policy (link).

Q25 I would like to participate in the lottery and I consent to the given information being used by iFLEX project, represented by VTT, to contact me if I win	Choose one
Yes	☐
No	☐

[*If people answered "yes", they were directed to "contact information". If they answered "no" they were directed straight to the "Thank you" page.*]

Contact information

You can leave your contact information here for the lottery.

Q26 Name:

Q27 Email or phone number:

Thank you!

Thank you for your time and participation in our survey. Stay with us and follow our news and project progress on https://www.iflex-project.eu/.

iFLEX project team

The iFLEX project, Intelligent Assistants for Flexibility Management, receives funding from the European Unions Horizon 2020 research and innovation programme under grant agreement no 957670

The Slovenian questionnaire had the following customised thank you note after respondents had submitted their questionnaire:

Dear Sirs, We truly thank you for completing the survey. For a free copy of ZPStest magazine, open / copy the following link in a new browser window:[link]

13 Annex 3: iFLEX Assistant Usability Questionnaire

General Questions Section

1. **On a scale of 1 to 5, rate your experience using the mobile application.**

   [1 2 3 4 5 Scale]
2. **How difficult is reading characters on the screen?**

   [1 2 3 4 5 Scale – From Very Easy to Very Difficult]

3. **How difficult is the app to use?**

   [1 2 3 4 5 Scale – From Very Easy to Very Difficult]
4. **How is the navigation of the mobile application?**

   [1 2 3 4 5 Scale – From Very Bad to Very Good]
5. **After looking at the mockups, do you think you will be able to achieve your goals?**

   [Yes/No]
6. **If you do not think you will be able to achieve your goals, why not?**

   [Free Text]

7. **Are there any features that you think you need but are missing in the mobile application?**

   [Yes/No]
8. **If yes, please describe.**

   [Free Text]

9. **Are the terms that are used throughout the system understandable?**

   [Yes/No]
10. **Do you have any comments about the wording used in this application?**

    [Yes/ No]
11. **If yes, please specify.**

    [Free Text]

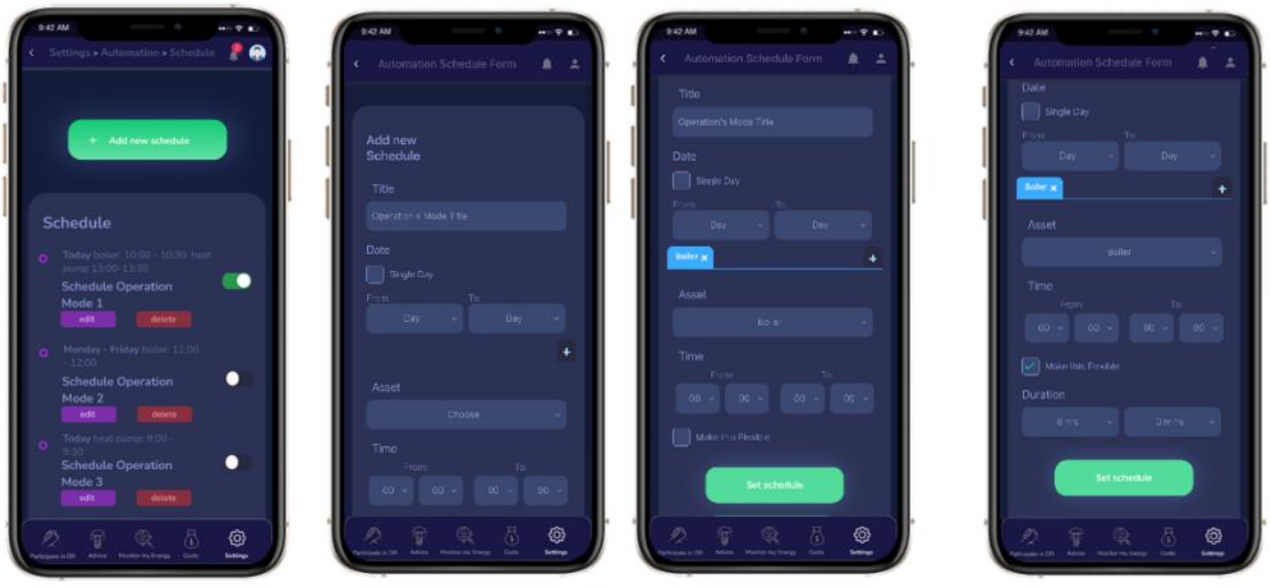
12. **Did you find anything difficult or unnecessarily complicated when using this application?**

    [Yes/No]

13. **If so, why?**

    [Free Text]

Scheduling and Flexibility Section



14. Is it clear to you what happens when choosing a Schedule Operation Mode to become flexible (Make this flexible)?

[Yes / No]

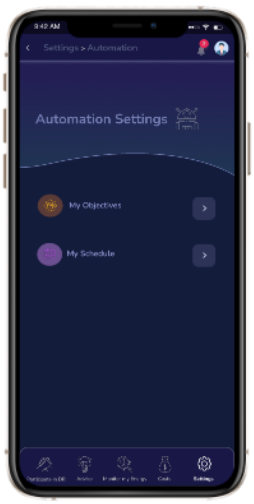
15. If you previous answered no, explain what is bothering you.

[Free Text]

16. When adding a schedule operation mode you would like to be able to:

[Set the exact time that the asset will operate /
Set a wider period of time within which the asset can operate /
Choose each time between the two previous options, depending on your needs]

Automation Settings Section



17. Did you find the automation settings unnecessarily complicated?

[Yes/No]

18. If yes, describe why.

[Free Text]

Home Screen/ Landing Page

19. Which screen would you prefer as your home (landing) page?

Monitor my Energy Participate in DR Events Other

[a) Monitor my Energy b) Participate in DR c) Other]

20. If you previous answered other, please describe the functions you would like your landing page to have.

[Free Text]

Optimization Policy Section

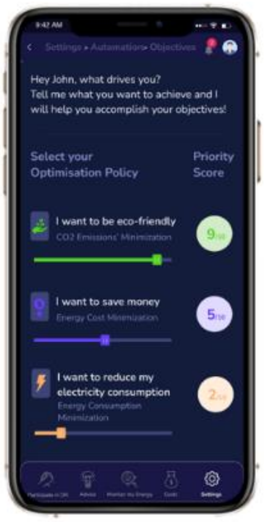
21. Is optimization policy selection important for you?

[Yes/No]

22. Is it useful for you to be able to select more than one options as drivers of the optimization?

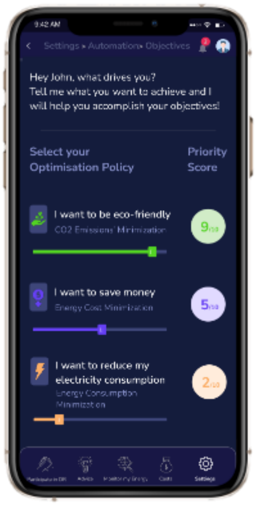
[Yes/No]

23. Which form would you prefer for selecting your iFLEX Assistant optimization strategy?



[One choice among many]

24. Is optimization policy prioritization clear to you?



[Yes/No]

25. If not, please specify why

[Free text]

Notifications Section

(Push notifications are messages that pop up on your mobile device. iFLEX Assistant can send them at any time; you don't have to be in the app or using your devices to receive them. iFLEX Assistant uses push notifications to ask you if you want to participate in a new DR Event, to notify about Alerts, etc.)

26. Do you want to be able to mute push notifications temporarily?

[Yes/No]

27. Do you want to be able to create silence rules in order to have fixed hours during the week that the application will be muted (i.e. you will not receive push notifications)?

[Yes/No]

28. Do you already know the hours of the week or month that you may not want to be bothered with push notifications on your mobile?

[Yes/No]

29. Is the concept of temporary silence and silence rules clear to you?

[Yes/No]

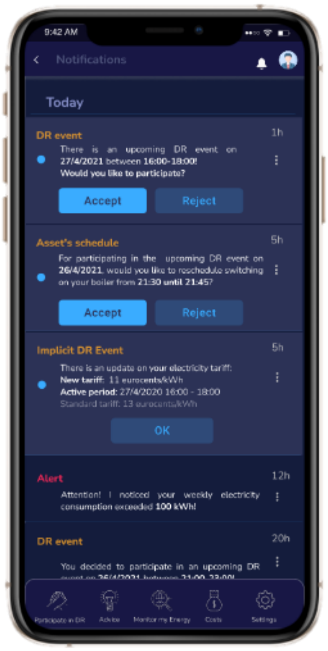
30. If the concept is not clear to you, please explain why?

[Free Text]

31. Do you find it easy to manage (accept / reject) notifications from the notifications page?

[Yes/No]

32. If you previous answered no, please explain why?



[Free Text]

Auto/Manual Profile Section

33. Would you be interested in being able to change your profile from Auto (i.e. iFLEX Assistant will choose if and how you will participate in a DR Event) to Manual and vice versa easily and quickly?

[Yes/No]

Upcoming Features Section

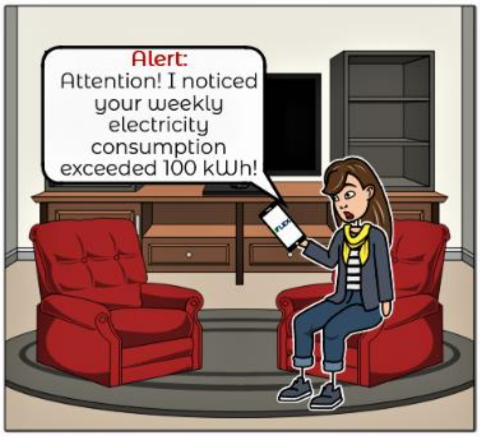
34. Would you be interested in being able to provide the iFLEX Assistant with information on your personal sustainability goals related to specific metrics (e.g. energy consumption in a period of time), so the application can provide you with visualization on the current status (e.g. energy consumption this month) vs. the sustainability goal(s)?

[Yes/No/ I Don't Care]

35. Would you be interested in being able to receive advice offered by the energy supplier adapted to your environment and past behavior with the aim of engaging in activities to lower your energy consumption, reduce cost and achieve other goals like being environmentally friendly?

[Yes/No/ I Don't Care]

36. Would you be interested in being able to receive Alerts according to certain (predefined) events e.g., status update of an appliance, or the total (or phase) power consumption exceeds a certain predefined threshold?



[Yes/No/ I Don't Care]

37. Would you be interested in being able to see some cost-related information in the application, such as hourly rates or an estimate of energy costs over a period of time?

[Yes/No/ I Don't Care]

Final Remarks Section

38. Are there are comments/suggestion that can help us improve the user interface for our users?

[Free text]