D 7.3 FIRST VALIDATION REPORT AND DATA SET

Interim Report of the three pilots

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EXECUTIVE SUMMARY

This deliverable is described in the DoA as:

“Interim report of the three pilots; integration of the consumption and comfort monitoring and deployment of behavior change apps, triggered community activity, outcome of energy saving actions, feedback from the community, interim evaluation of impact, based on KPIs set in D7.1.”

It contains the detailed documentation about the deployment of the metering and sensor infrastructure, the integration of the consumption and comfort monitoring and deployment of behavior change apps, the triggered community activity, the outcome of energy saving actions, the feedback from the community, and the interim evaluation of impact, based on KPIs set in *D7.1 Pilot baseline and action plan*. The reporting period lasts from June 1st until October 5th 2018.

Section 2 presents the deployed smart metering and sensor infrastructure and the privacy-aware transfer of electricity consumption data from the different smart meter technologies, as well as indoor climate data from the sensor devices. Details are also provided about the architecture and the deployment of the hardware components at the pilot sites, describing the integration of data in data flow charts and the sensor devices.

Section 3 details the recruitment and initialization of the user community, the populations at each of the pilot sites, followed by an account of the promotion campaigns carried out to recruit users for the enCOMPASS target groups, including e.g. presence at events, electronic and regular mail campaigns, as well as press contacts. The activities described in this section exploited the outcomes of *D6.3 Platform initial prototype*, where the enCOMPASS behavior change applications were delivered, and of *D6.4 Platform second prototype*, in which the collected feedback was exploited to produce an updated version.

The section differentiates between the results of the intervention and the control group of each pilot site at household level. The recruitment process received a high participation, especially in Germany, where nearly 200 households signed up to take part in the pilot (from which the final sample was selected). Both, the deployment of the hardware at the pilot sites and the initialization of the enCOMPASS app worked well in the pilot sites, even if the Greek pilot faces some delay due to the technical complexity of deploying infrastructure in more public buildings in two cities (Thessaloniki and Athens). Regular communication to the users was performed as needed, to keep user activity high.

The initialization process in the schools proved very important for the acceptance of the pilot. The teachers liked the idea of integrating the enCOMPASS app and the FUNERGY game into regular interaction with the pupils and the curriculum. To meet this need, it was asked if extra material for teaching energy efficiency topics could be provided, especially for the elementary schools. Extra effort has been done by the project partners to meet these requests and achieve high engagement in the school pilots. This includes making the enCOMPASS app and FUNERGY game useful for this purpose (e.g. including a variety of diverse children-friendly energy saving tips and FUNERGY quiz questions), and to provide methodological guidance of connecting the app use with different types of additional in-class activities

The initialization process in the public buildings of the three countries was concluded without significant issues and employees are interested to understand the saving potential that can be reached during their daily working process.

A first analysis of the adoption and usage of the enCOMPASS app in the first 17 weeks shows that the average usage of the app, at the level of the whole application as well as at the level of individual features, in the German and Swiss pilot is positive. The Greek pilot's start was delayed, so the amount of data to analyse was still limited. Nevertheless, the usage of the app is increasing steadily.

Section 4 documents the approach to the first (interim) evaluation of the enCOMPASS impact, executed with respect to the current state of the deployment. Preliminary evidence of electricity consumption reduction achieved so far (not considering the effect of seasonal variations) indicates the potential impact of the first release of the enCOMPASS platform (featuring smart metering, consumption visualisation, and saving tips). However, as expected at this stage of the project, the size of the pilot population and the duration of the data collection do not allow final conclusions to be drawn yet.

The activation of the enCOMPASS community is also reported in this section. An overview of the triggered community (households and public buildings) can be viewed in Table 1 and Table 2, where the most important numbers are summarized.

Note that the figures for the Greek pilot, both in households and in public buildings, have less significance, because the start of user activity dates by the end of September 2018.

Table 1: Summary of the activated household users

Households	Active users	Activity level – log ins (average)	Most popular pages	Awarded badges (average)	Tips read (average)
German pilot (four months)	93	45,2	Saving goal (43) Comfort (34)	4,9	63
Swiss pilot (four months)	66	44,2	Saving goal (54) Comfort (53)	5,4	47
Greek pilot (one month)	64	2,06	Comfort (5,3) Saving Goal (4,2)	1,3	20,1

Table 2: Summary of the key figures in the public building community

Public buildings	Active teams	Activity level – log ins (average)	Most popular pages	Awarded badges (average)	Tips read (average)
German pilot (four months)	3	45,2	Saving goal Comfort	4,0	28,5
Swiss pilot (four months)	5	44,2	Saving goal Comfort	3,4	30,6
Greek pilot (one month)	7	7,2	Saving goal Impact	1	1

The preliminary baseline questionnaire evaluated personal norms, ascription of responsibility, perceived behavioral control, behavioral intention to save energy and self-reported knowledge of energy saving actions of the participants in the three pilots. The questionnaire comprised the measurement instruments and the overall interim evaluation of impact on consumption and user-awareness KPIs, that have been outlined in *D7.2 Validation methodology and pilot action plan*.

All three pilots are nearly in the same size and the rollout of the platform and of the hardware equipment went quite well, given the high number of individual buildings (especially households) that were equipped with devices (cp. Table 3), which were party developed by partners on their own.

Table 3: Overview of deployed infrastructure in the three enCOMPASS pilots

Deployed infrastructure	Greek pilot	Swiss pilot	German pilot
Smart Meters	**Households**: 84 Sub metering equipment based on Arduino **Public buildings and school**: 7 large metering equipment (Carlo Gavazzi EM or Acuvim Accuenergy)	**All Buildings:** 614 Landis+Gyr, model E450	**All buildings:** 10.000 MTR 3000 Series IEC Poly Phase
Indoor Sensors	**Households**: 84 3-Series Door Sensor (Centralite) 84 3-Series Temp & Humidity Sensor (Centralite) **Public buildings and school**: 29 3-Series Temp & Humidity Sensor (Centralite)	97 Indoor Smart Sensor Node **PE_IoT_STONE_Multisensor**	149 AEOTEC multisensor
Outdoor Sensors	0	3 Outdoor Smart Sensor Node	0
Gateways	**Households**: 84 Ethernet ZigBee PRO HA 1.2 **Public buildings and school**: 10 Ethernet ZigBee PRO HA 1.2	4 Smart Gateways ("Swisscomfiber" optical network) 25 outdoor wireless repeater nodes 8 indoor wireless repeater nodes	128 Rabbithome Pro

1 INTRODUCTION

The main purpose of the enCOMPASS project is to deliver solutions that can induce a quantifiable, sustainable change in energy consumption and an increase in the awareness about energy. For this purpose, the social awareness app was deployed in three case studies: Switzerland (Contone, Gambarogno), Germany (Hassfurt, Wunsiedel) and Greece (Athens, Thessaloniki).

This deliverable is the first report of the three case studies validation and documents the deployment of the smart meter and sensor monitoring system, the deployment of the social awareness app, the associated promotion campaign among target user groups, the subsequent data analysis, and the user baseline collection and processing; it provides a first evaluation, based on the continuous monitoring of the KPIs validated in *D7.1 Pilot baseline and action plan* and defined in *D7.2 Validation methodology and pilot action plan*.

The deployed smart metering and sensor infrastructure, the user modelling in WP4, and the research on incentives of behavioural change processes in WP5 (including the factors that determine energy consumption) contribute to a better understanding of consumer behaviour. The user modelling in WP4, as reported in *D4.2 first user behaviour model and recommender*, provides a clustering of users that is instrumental to validation: the clusters will be used to compare consumption reduction levels between groups of users, and to relate platform usage to these clusters, as baseline consumption levels have proved to affect the effectiveness of energy efficiency interventions (e.g. [Schulz et al., 2014]).

The validation results will refine the understanding of user behaviour and the effectiveness of different incentive models, permitting adjustments of the gamification and rewards model introduced in *D5.1 Behavioural change models and determinants for energy consumption* and subsequently also for upcoming releases of the application. The continuous monitoring of KPI's and application adjustments resulting from real-world validation results aim at maximizing energy consumption saving and securing alignment with end-user needs and their awareness of energy consumption and saving.

In terms of deployment, this deliverable documents the technical deployment of the smart metering and indoor sensor infrastructure that provides the data for the enCOMPASS platform and awareness application. Furthermore, it reports on the deployment of the prototype described in *D6.3 Platform initial prototype*, containing the infrastructure to collect and organize the energy consumption and sensor data from households and public buildings.

The enCOMPASS platform is deployed in real-world settings, with real customers, public administrative employees, teachers and students. As a real-life application, at this stage of the project much attention has been devoted to the release of subsequent app versions that incentivize consumers to get used to the application. From this perspective, the first monitoring period has been used for fine-tuning the basic functionality of the app and ensure data flow processes and integration.

In the Swiss and German case study, the release of the enCOMPASS app was launched in June 2018 (version 1). The start of the Greek case study was delayed until the beginning of September 2018 due to technical problems with the hardware infrastructure. In this deliverable, we report on the electricity consumption data, questionnaire responses, and portal usage logging data, we have received from participants in all three case studies, who have used the first version of the enCOMPASS application until October 5th.

2 INTEGRATION AND DEPLOYMENT OF THE CONSUMPTION AND COMFORT MONITORING INFRASTRUCTURE

In this first section the Advanced Metering Infrastructure (AMI) and the sensor infrastructure deployed in the thee enCOMPASS pilots is described. Each pilot case is described due to the metering infrastructure, the hardware deployment and the integration of data in enCOMPASS platform.

2.1 SWISS PILOT

The neighborhood of Contone within the Municipality of Gambarogno has been fully equipped with a Smart-metering infrastructure since 2017. The adopted solution was chosen back in 2016 among the possible alternatives available on the market at that time.

2.1.1 Metering Infrastructure

As grid operator for the Municipality of Gambarogno, SES aimed to install a smart-metering infrastructure that had the possibility to be equipped with relay for the remote or clock-based shutdown of particular appliances (electric heating system and boiler) SES decided to install smart-meters from the Swiss Company Landis+Gyr, model E450 which nowadays is one of the most popular residential meters in the market.

Given the fact that the electricity grid in Contone formerly belonged to another grid operator, the ripple control of the appliances through SES's dispatching center was not working (the former Contone's grid operator used other frequencies), therefore the only solution was to install a new set of smart-meters with integrated load-management capabilities. A total of 614 smart meters have been installed, this number includes the 75 households which are part of the intervention group.

The following schema (cp. Figure 1) illustrates the configuration of the metering infrastructure in Contone.

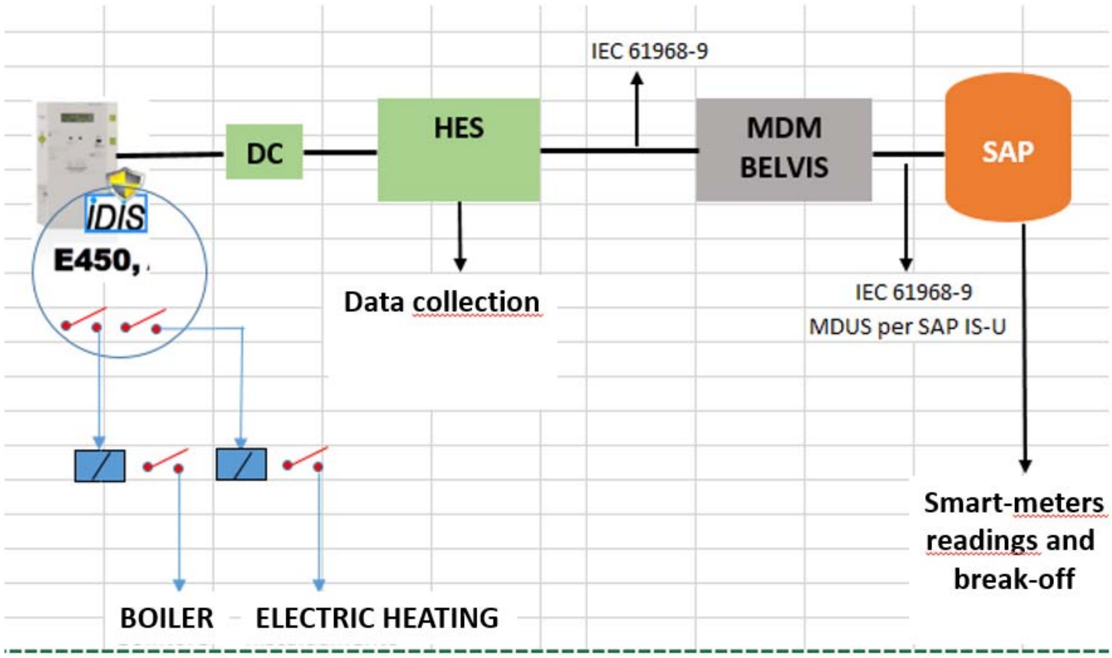

Figure 1: Configuration of the metering infrastructure in Contone

In every transformation station of Contone, a data concentrator (Landis+Gyr DC450) was also installed.

2.1.2 Sensor Infrastructure

In this section the overall architecture of the Swiss pilot is explained, followed by the listing of the deployed devices in the reporting period.

2.1.2.1 Architecture of the Sensor Infrastructure

The environmental sensors infrastructure for the Swiss case study is based on the “PE IoT STONE Multisensor platform” provided by Paradox Engineering SA (PDX).

The platform integrates two sub-systems:

- **Network connectivity system**: based on PDX PE.STONE core network technology, it provides wireless 6LoWPAN IPv6 MESH 868MHz Network connectivity, which allows the environmental sensors data collection and transmission to the enCOMPASS platform.
- **Third party environmental sensors**: Humidity, Pressure, Temperature, Motion and Luminance sensors, integrated into an “**Indoor Smart Sensor Node”** which is a “leaf node” of the above mentioned wireless 6LoWPANnetwork.

The platform is an **IP-based solution**, which uses the **IETF IPv6, 6loWPAN and IEEE 802.15.4** wireless network and a transport communication stack as well as manages the sensors data according to the **IP for Smart Objects (IPSO) Alliance** (see D8.2 TECHNOLOGY, MARKET AND REGULATORY WATCH REPORT for a survey and description of such standards).

The complete system consists of the following main modules:

- The **Indoor Smart Sensor Node**

  This is a battery powered wireless device (named **“PE_IoT_STONE_Multisensor”**), housed in a plastic case wall mounting, to open for convenient battery replacement. It provides for an ultra-low power standby operating mode ensuring long time operation and can optionally be powered by external wall power supply to support extraordinarily high sampling frequencies. The Node includes sensors measuring absolute pressure, relative humidity, temperature, luminance and movement (from which presence can be estimated).

  A picture of this device is provided in Figure 2; for a detailed description of its characteristics please refer to the relevant technical specification (datasheet and installation manual), made available to the enCOMPASS users to the following link: http://www.enCOMPASS-project.eu/pilots/swiss-pilot/it/sensore .

Figure 2: Indoor Smart Sensor Node (“PE_IoT_STONE_Multisensor” device) – Swiss Pilot

- The **PE Smart Gateway**

  It is the central element of the wireless network, acting as devices & network coordinator and data concentrator. It manages all Smart Sensor Nodes, synchronizing them and collecting data.

- The **PE Smart CMS** (Central Management System)

  Sensors data are collected and transmitted to the concentrator (Gateway) via the wireless sub-GHz network. From the Gateway, data is transmitted to the Central Management System (CMS) via a data collection microservice via W3C HTTP. An additional data publishing microservice finally exports data to the enCOMPASS platform (data exchange format in CSV, see next paragraph 2.1.3).

  On the wireless sub-GHz networksystem CMS offers also the device management and equipment inventory functions, network management functions, alarm and notification management as well as the possibility to set direct commands and scheduled activities.

The overall architecture of the sub-GHz wireless network system is shown in Figure 3.

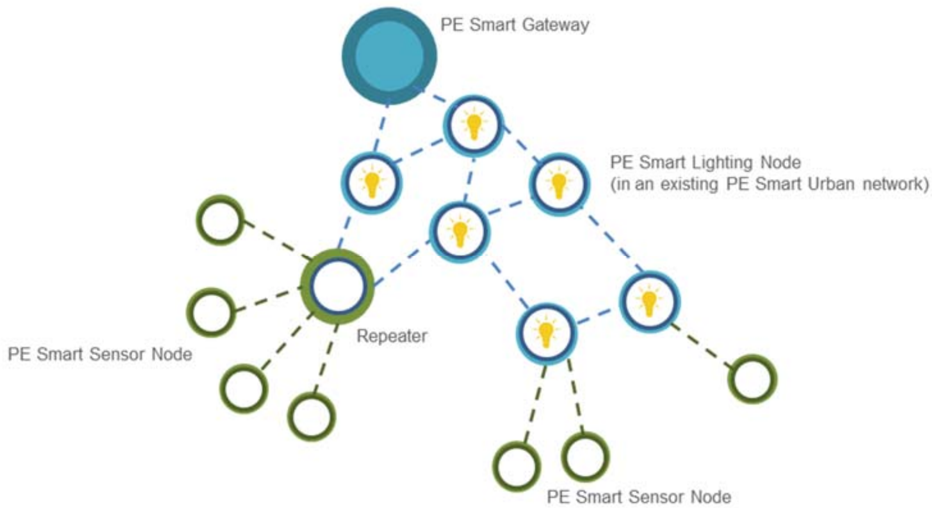

Figure 3: Architecture of the wireless sensor network system– Swiss Pilot

In the above wireless network architecture, the Smart Sensor Nodes are battery-powered devices that can be configured as “Leaf Nodes” of the network. They are designed for Smart Home / home automation projects and are designed to be installed in houses (**Indoor** Smart Sensor Node). The network architecture is designed to use limited transmission power in homes and apartments, and to leverage on external repeaters which extend the connectivity coverage of the mesh network. If existing, a PE Smart Urban Network can also be leveraged to extend the range. E.g., PE Smart Lighting Nodes can be used as repeaters. Repeater Nodes connect to PE Smart Gateways, acting as network concentrators.

For the purposes of the enCOMPASS Swiss pilot case study only, the Smart Sensor Node has been assembled and made available also as an **Outdoor** Smart Sensor Node, providing only temperature and humidity measurements (no luminance and movement). This version of the Node is based on the same wireless device **“PE_IoT_STONE_Multisensor”** used in the indoor sensor, but assembled into an outdoor third party radiation shield, as shown in Figure 4, allowing the sensor to accurately measure air temperature and humidity without the effects of direct radiation from sunlight.

Figure 4: Outdoor Smart Sensor Node – Swiss Pilot

For what concerns data flow, the data collected by the environmental sensors (Indoor and Outdoor Smart Sensor Node) are sent to the enCOMPASS platform through the CMS system, as shown in Figure 5. In particular, data provisioning from PDX CMS to enCOMPASS platform is achieved by SFTP file transfer (csv format, see next section 2.1.3). PDX WebPortal App (hidden to enCOMPASS users) is used to monitor and manage the PDX sensor network.

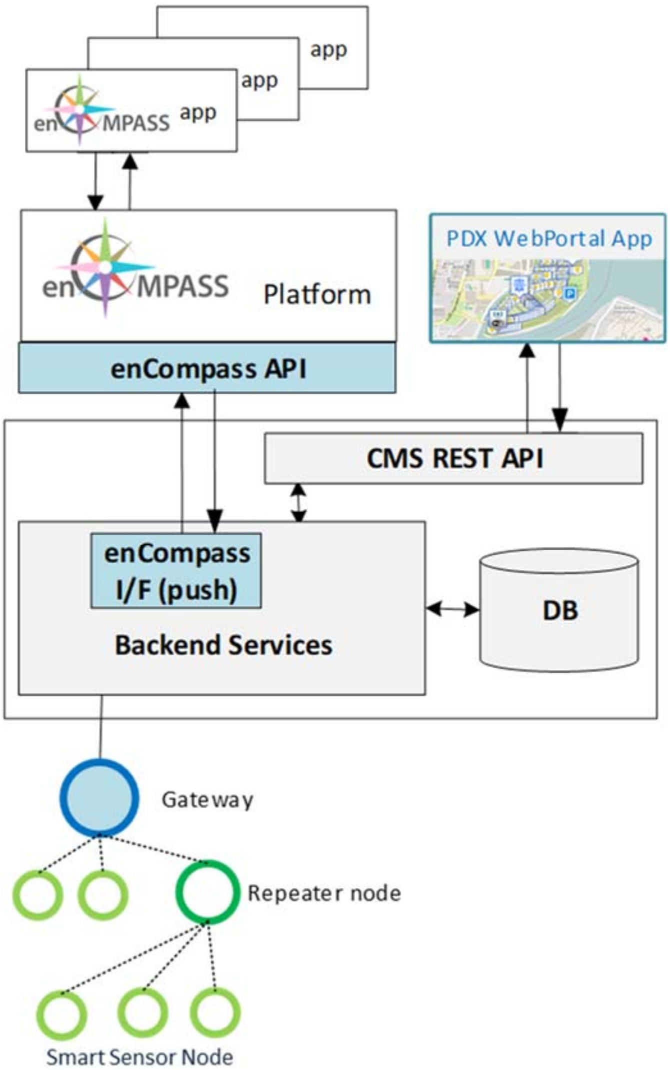

Figure 5: Sensor data flow: interface PDX CMS – enCOMPASS platform– Swiss Pilot

2.1.2.2 Deployment of the hardware Infrastructure

Based on the architecture of the sensor infrastructure described in the previous paragraph 2.1.2.1, the following deployments have been performed by Paradox Engineering SA for the Swiss case study.

1. **Residential users in Contone (75 households)**

- Each of the 75 households included in the Intervention group of the pilot deployment has been equipped with 1 Indoor Smart Sensor Node (**"PE_IoT_STONE_Multisensor" device**), providing measurement of temperature, pressure, humidity and luminance. The sensors have been installed in the living room by the users themselves.
- 1 Outdoor Smart Sensor Node (temperature, humidity), installed in the area where the 74 households are located.
- Wireless 6LowPAN sub-GHz network infrastructure, consisting of:
  - 2 Smart Gateways (1 as back-up in case of failures in the main gateway), with wired access to the internet network ("Swisscomfiber" optical network)
  - 25 outdoor wireless repeater nodes (typically mounted on the lighting poles of the existing public lighting infrastructures of SES).
  - 6 indoor wireless repeater nodes (only for those households with very poor radio coverage).

2. **School building in Quartino-Cadepezzo**

- 8 Indoor Smart Sensor Nodes (**"PE_IoT_STONE_Multisensor"** device), providing measurement of temperature, pressure, humidity and luminance.

  The sensors have been installed one for each of the 4 classes, plus additionally sensors in the canteen, the teacher's room, the foyer and the gymnasium.
- 1 Outdoor Smart Sensor Node (temperature, humidity), installed in the same area where the school is located.
- Wireless 6LowPAN sub-GHz network infrastructure, consisting of:
  - 1 Smart Gateways, with wireless access to the internet network (GSM network).
  - 1 wireless repeater node (internal to the school building)

3. **Municipality building in Gambarogno**

- 14 Indoor Smart Sensor Nodes (**"PE_IoT_STONE_Multisensor"** device), providing measurement of temperature, pressure, humidity and luminance.

  The sensors have been installed on the different floors of the building and indifferent offices / public areas.
- 1 Outdoor Smart Sensor Node (temperature, humidity), installed on one of the external walls of the building.

- Wireless 6LowPAN sub-GHz network infrastructure, consisting of:
    - 1Smart Gateways, with wireless access to the internet network (GSM network).
    - 1 wireless repeater node (internal to the school building)

2.1.3 Data Integration (data flows)

The target of this chapter is to provide a complete but schematic overview of the main steps involved in reading, handling, organizing and forwarding the power data from Landis &Gyr smart meters installed in SES's network. Figure 6 describes schematically the data flow. A more detailed description of each step can be found in the next paragraph.

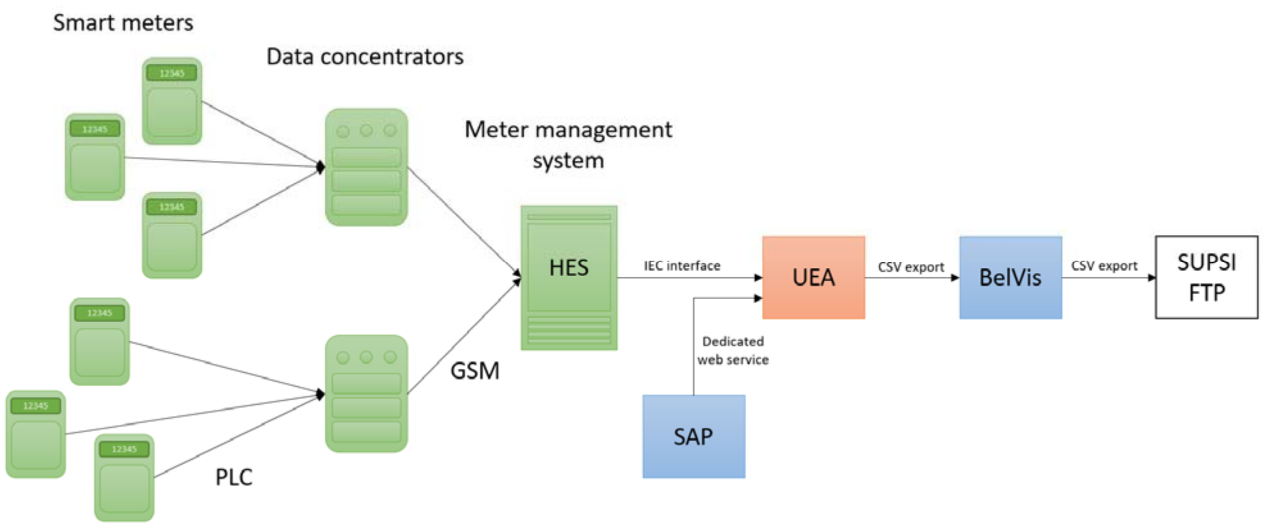

Figure 6: Data flow model in SES network - Swiss pilot

The data reading procedure follows these steps, going from left to right in the previous scheme:

- Smart meters installed at the points of delivery read the power consumption (or production) of the client in 15-minute intervals.
- Data concentrators (DC) scattered around the power network retrieve the data from the smart meters connected to them, using power-line communication.
- The smart meter management system (HES, in the case of Landis and Gyr smart meters) is a software running on SES's servers. Periodically it queries the concentrators and retrieves all the data gathered by them. This data exchange goes through the national GSM network.
- The meter management system stores all the readings in a local database.
- The next step of the procedure is the retrieval of the meter data and its association with the proper POD (point of delivery) number.

The raw data is extracted by the smart meter management system via the provided IEC interface and associated to the proper POD by matching the meter physical ID numbers; HES has no notion of which POD is associated to which smart meter (it only works with meter ID numbers), so this information has to be retrieved by another management system in our network (SAP) using a web service. The custom software that performs these operations is called UEA.

- After UEA has retrieved and matched the meter readings, it exports them in a data format readable by SES's energy data management system (BelVis).
- Finally, every morning BelVis runs a scheduled export profile tailored to send the data of a selection of PODs to SUPSI's FTP server.

2.2 Greek Pilot

In this Section the metering and sensor infrastructures along with the data integration techniques implementing in the Greek pilot are described. In general, the whole concept is based on the "**smartwatt**" home automation product, which as a product is sold and service provided by WATT+VOLT to the end customers. "**Smartwatt**" is a product enabling final users to fully control their smart devices[1].

Figure 7 presents the typical configuration of the "**smartwatt**" solution. As shown, a variety of sensors can be installed in the potential users.

Within the framework of the enCOMPASS approach gateways, humidity/temperature sensors and door/window sensors including the temperature module were installed. As an extra feature, smart bulbs and smart plugs are offered as prizes to the enCOMPASS users who participate to the online challenge.

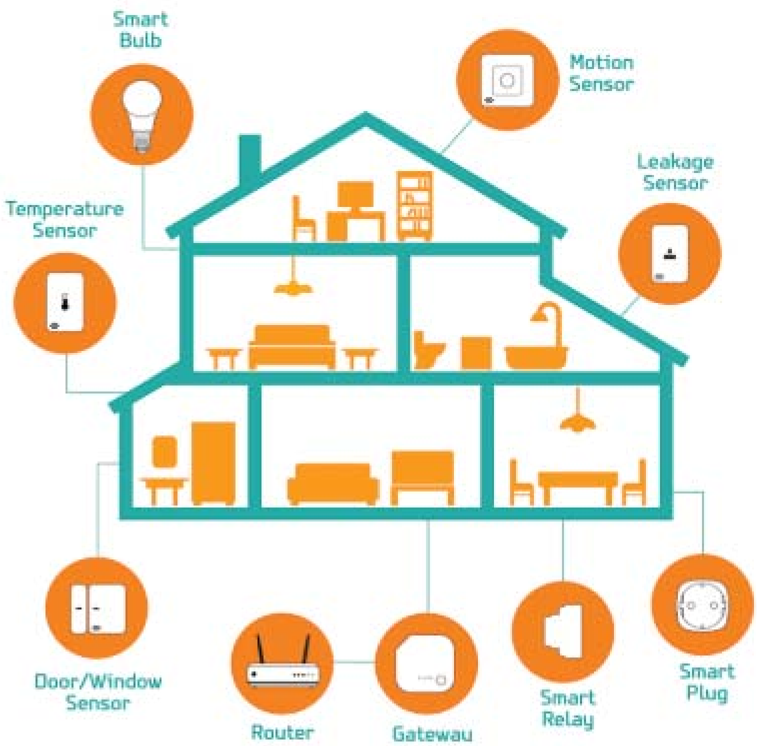

Figure 7: "smart watt" automation schema

Concerning the enCOMPASS project, the total architecture and configuration schema that is applied in the households, in the public buildings and the school is presented on Figure 8 and Figure 9.

[1] More details about this service can be found in the following link: https://www.smartwatt.gr/en

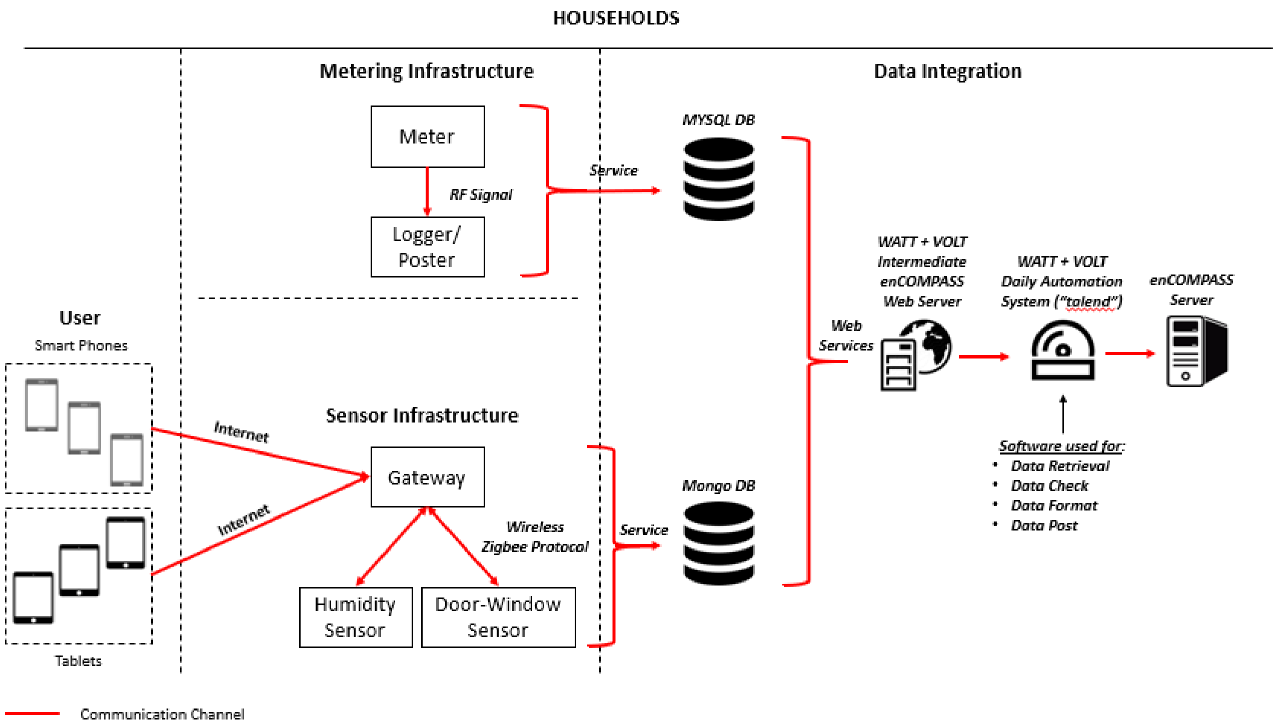

Figure 8: Metering and sensor infrastructures and data integration in households – Greek Pilot

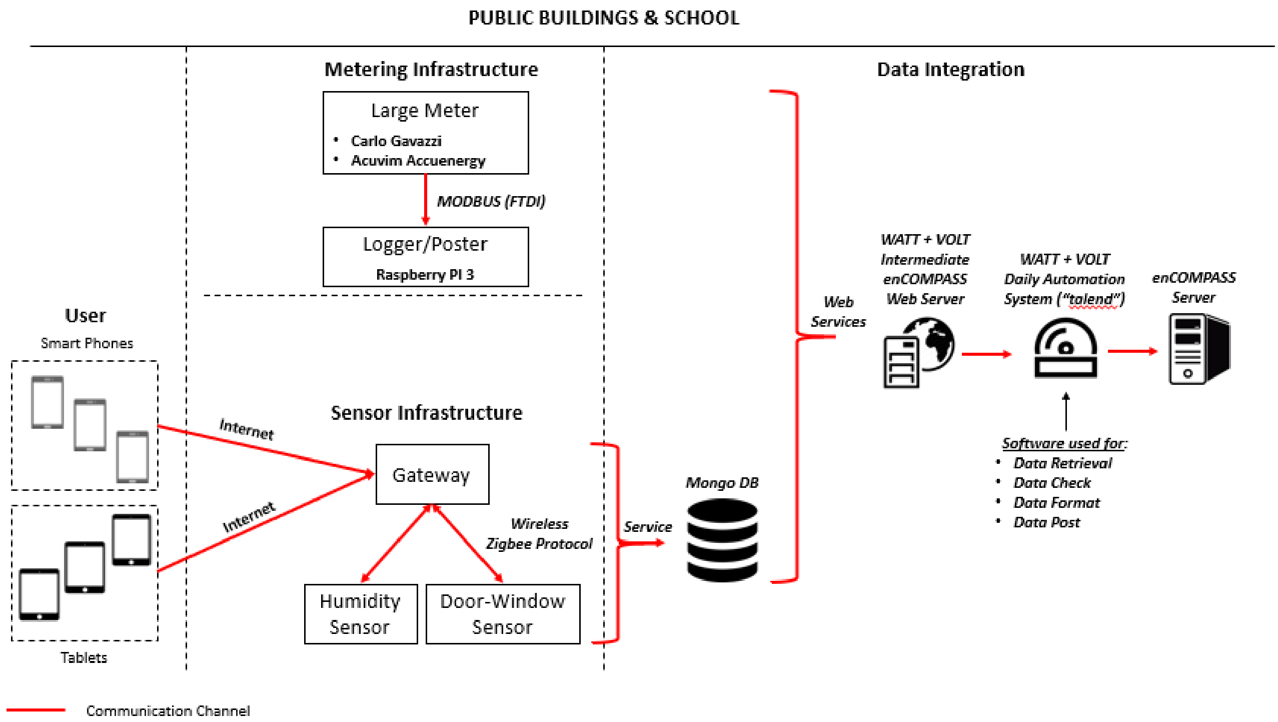

Figure 9: Metering and sensor infrastructures and data integration in public buildings/school – Greek Pilot

2.2.1 Metering Infrastructure

The applicable solution for the metering infrastructure in the Greek Pilot comprises pairs of meters and loggers/posters installed in each enCOMPASS site (household, public buildings and school).

Sub metering equipment based on Arduino[2] is installed in households while large metering equipment (Carlo Gavazzi – Acuvim) is installed in the Public Buildings Pilots as following:

1. **__Households__**: 84 pairs of meter-logger/poster were already installed and still more meters for new users are installed.
2. **WVT Headquarters in Athens:** 3 pairs of large meter-logger/poster installed on November 2016
3. **WVT Retail Store Thessaloniki:** 1 pair of large meter-logger/poster installed on November 2016
4. **NHRF Library:** 1 pair of large meter-logger/poster installed on May 2018
5. **NHRF Offices (6th floor):** 1 pair of large meter-logger/poster installed on May 2018
6. **Delta School:** 1 pair of large meter-logger/poster installed on February 2017

In addition, the meters installed in the public buildings and the school are either Carlo Gavazzi EMxx (cp. Figure 10) or Acuvim Accuenergy (cp. Figure 11). The devices communicate through a MODBUS (FTDI) (cp. Figure 8).

The meter-logger/poster pairs installed in the households communicate through secure RF signals

Figure 10: Carlo Gavazzi EM340 3 phase large meter – Greek pilot

[2] More details could be found in the following link: https://openenergymonitor.org/

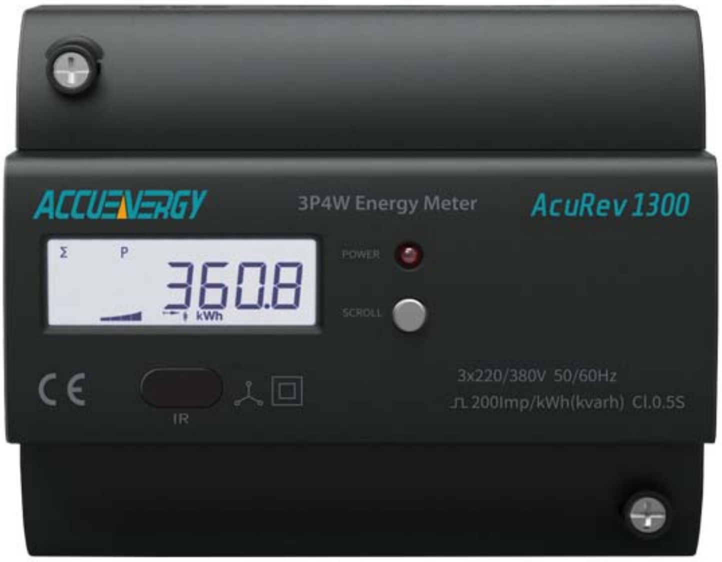

Figure 11: Accuenergy AcuRev Large Meter – Greek pilot

2.2.2 Sensor Infrastructure

In this section the overall architecture of the Greek pilot is explained, followed by the listing of the deployed devices in the reporting period.

2.2.2.1 Architecture of the Sensor Infrastructure

The sensor infrastructure is identical for the households, the public buildings and the school involved in the project. The main components of this infrastructure are the following:

- **Gateway**

  It is the central element of the wireless network, acting as devices and network coordinator and data concentrator. It manages all smart sensor nodes, synchronizing them and collecting data. Gateway is an Ethernet ZigBee PRO HA 1.2 device (cp. Figure 12) designed so that it can be easily configured and used in an Ethernet environment from a Cloud server. It is noted that the users can have access to the Gateway device via an Internet connection (secure tunnel). The users are connecting both through smart phones and tablets (cp. Figure 13).

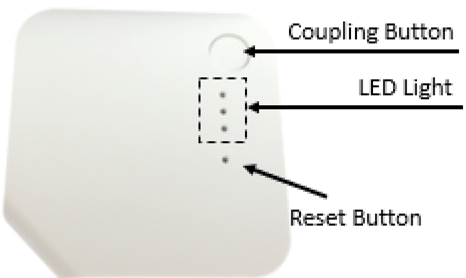

Figure 12: Gateway – Greek Pilot

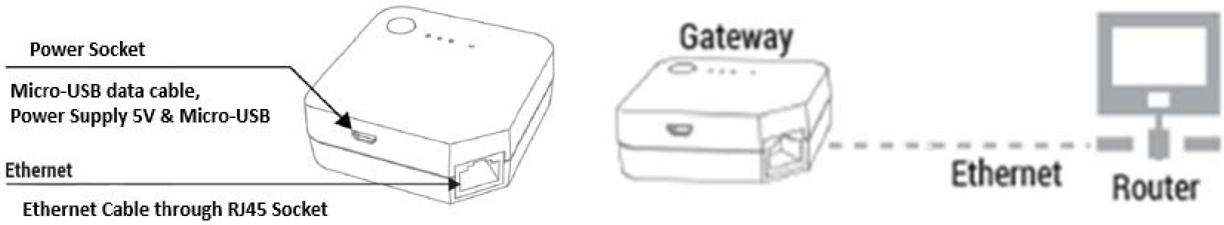

Figure 13: Gateway Sockets – Greek Pilot

Technical Specifications of the gateway[3]

- ✓ **Dimensions**: 67mm x 67mm x 23,3mm
- ✓ **Power/Voltage**: Micro-USB, 4.8-5.2 [V] / 500 [mA/min]
- ✓ **Operating Temperature**: 0° to 50°C (internal use)
- ✓ **Storage Temperature**: -10° to 60°C
- ✓ **Relative humidity**: up to 95% (non-condensed)

- **Humidity/Temperature Sensor**

It is a device that senses, measures and reports moisture, temperature and the device's battery level (Figure 14). It communicates with the Gateway device through a wireless Zigbee protocol.

Figure 14: Humidity Sensor – Greek Pilot

Technical Specifications of the humidity[4]

- ✓ **Power**: 3V
- ✓ **Operating temperature**: 0° to 40°C
- ✓ **Battery**: CR-2
- ✓ **Battery life**: up to 2 years
- ✓ **Temperature**: -20° to 50°C
- ✓ **Humidity range**: 0 to 90% RH

[3] The user manual is onine available (only in Greek) via the following link: https://www.smartwatt.gr/sites/default/files/manuals/GR-Zigbee-Ethernet-Gateway.pdf
[4] The user manual is online available via the following link: https://www.smartwatt.gr/sites/default/files/manuals/GR%20-%20Temp%20Humidity_insert.pdf

- **Door-Window Sensor**

  It is a device that detects when a door or a window opens and reports the temperature the opening's status and the device battery level (cp. Figure 15). It communicates with the Gateway device through a wireless Zigbee protocol.

Figure 15: Door-Window Sensor – Greek Pilot

Technical Specifications of the door/window sensor[5]

- ✓ **Power**: 3V
- ✓ **Operating temperature**: 0° to 40°C
- ✓ **Battery**: CR-2450
- ✓ **Battery life**: up to 2 years
- ✓ **Temperature**: -20° to 50°C
- ✓ **Humidity range**: 0 to 90% RH

2.2.2.2 Deployment of the hardware Infrastructure

The following deployments have been performed for the Greek pilot:

1. **Residential users in Thessaloniki (84 households)**

Each household included in the Intervention group of the Greek pilot has been equipped with:

- 1 Gateway with wired access to the internet network
- 1 Humidity/Temperature Sensor
- 1 Door/Window Sensor

The sensors have been installed by WVT.

2. **NHRF**

Each floor included in the public building group of the NHRF has been equipped with:

- 2 Gateways (1 in the library and 1 at the 6th floor) with wired access to the internet network
- 4 Humidity/Temperature Sensors (2 in the library and 2 at the 6th floor)

The sensors have been installed by WVT.

3. **WVT Headquarters**

Each floor included in the public building group of the WVT Headquarters has been equipped with:

- 2 Gateways (1 at the 2nd floor and 1 at the 3rd floor) with wired access to the internet network

[5] The user manual is online available via the following link: https://www.smartwatt.gr/sites/default/files/manuals/GR-Micro%20Door_Generic%20insert.pdf

- 8 Humidity/Temperature Sensors (4 at the 2nd floor and 4 at the 3rd floor)

The sensors have been installed by WVT.

4. **WVT Retail Store**

Each floor included in the public building group of the WVT Retail Store in Thessaloniki has been equipped with:

- 1 Gateway with wired access to the internet network
- 5 Humidity/Temperature Sensors and 2 Temperature Sensors

The sensors have been installed by WVT.

5. **IEK DELTA**

The sensor infrastructure to be installed in IEK DELTA School is the following:

- 3-5 Gateways (depending on the wireless connectivity attempts)
- 8-12 Humidity/Temperature Sensors

The installation will be completed by end of October 2018.

2.2.3 Data Integration (data flows)

On the right of Figure 7 and Figure 8, the processes followed for reading, handling, organizing and forwarding the data from the smart meters to the enCOMPASS server is schematically elaborated.

More precisely, in the above-mentioned figures the following can be noted:

- The installed smart meters measure the energy consumption of each user in 15-minute intervals.
- All these measurements are stored in a MySQL database using an http secure service. It is worth referring that this database is only applicable for the meters installed in the households.
- The Gateway concentrates all the data associated with the sensors installed in the households, the public buildings and the school. These data are stored in a Mongo Database.
- The two groups of data are integrated into the intermediate enCOMPASS server, managed by WVT.
- WVT has developed a state-of-the-art daily automation system using the open source “Talend” ETL software[6]. The automation system is retrieving the data from the intermediate server, formats the data correctly and delivers the data via secure FTP protocol to the endpoint (enCOMPASS server) managed by WATT+VOLT.

2.3 German Pilot

In this section, the infrastructure and the deployment of sensors and tablet computers of the German pilot study is described. In the end the process of data integration is listed.

2.3.1 Metering Infrastructure

In the German pilot, SHF uses Echelon Smart Meters (MTR 3000 Series IEC Poly Phase), which are installed in every household in Hassfurt since 2008. A total of more than 10’000 meters, and counting, have therefore been installed so far. All participants in the intervention group of the enCOMPASS project are monitored by these smart meters.

[6] More information for Talend ETL software is available on the following link: https://www.talend.com/resources/what-is-etl/

The Key Features of the MTR 3000 Series are:

- Forward and reverse active and reactive energy measurements
- 4x16 channels of load profile data; each with independent configuration of interval, size and collection settings.
- Time-of-use supporting multi-tariff energy measurements configurable to time of day, weekends, holidays and seasonal changes
- Advanced tamper and fraud detection
- Measurement technology designed to withstand magnetic fields
- Secure remote firmware upgrades
- Power quality measurements include: voltage, current, active power, reactive power, power factor

The meters are connected to a Data-Concentrator (DC) via Powerline technology. The DCs collect the data from each smart meter in its area and send the packages via DSL to the SHF server. SHF has its own network for the DSL connection to reach a high standard of security. Different software (e.g. SAP, Energy Assistant Portal) use the smart meter data from the server to generate bills or show the customer's consumption and tariff details.

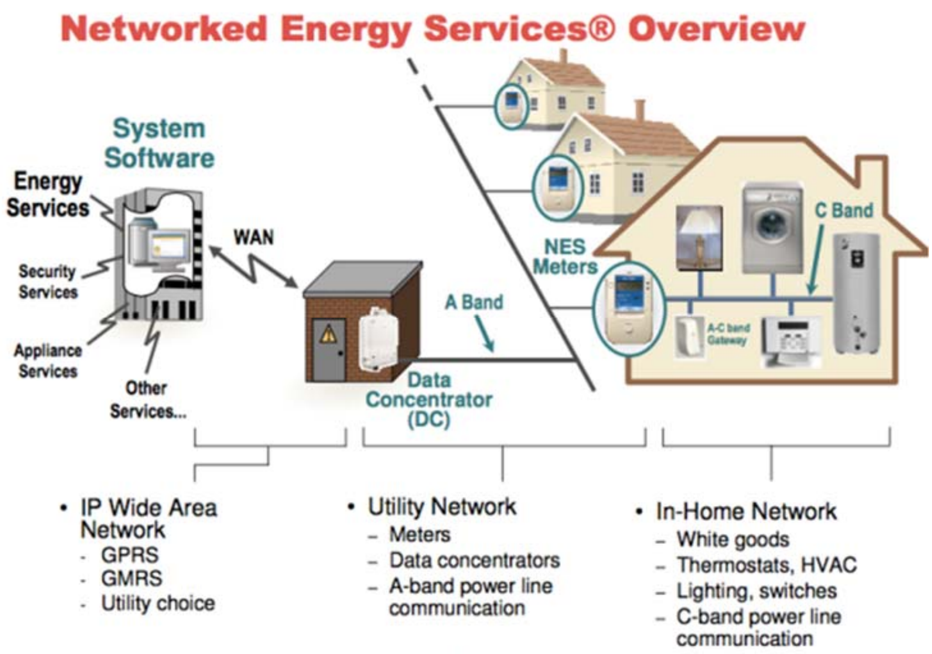

Figure 16: SHF Smart metering infrastructure – German pilot

2.3.2 Sensor Infrastructure

In this section the overall architecture of the German pilot is explained, followed by the listing of the deployed devices in the reporting period.

2.3.2.1 Architecture of the Sensor Infrastructure

To get all indoor data, which is required within the enCOMPASS project, SHF uses a smart-home system. The smart-home system's hardware is based on a Raspberry Pi 3 in combination with a *"RaZberry"* Z-Wave board and a multisensor device to collect the project relevant indoor data.

The whole smart home kit, delivered to the households/buildings/schools, consists of the following main parts:

- **Raspberry PI 3 with *"RaZberry"* [7] board** (cp. Figure 17): The Z-Wave board attached to the Pins of the Raspberry PI enables the Z-Wave communication network to the smart home devices. The RaZberry package comes with an open source software called *"Z-Way"* [8], that is installed on an SD-card and booted on the Raspberry PI. With that software the user can control the hole system and SHF was able to develop and adapt a data provisioning procedure to the individual needs in the enCOMPASS project.

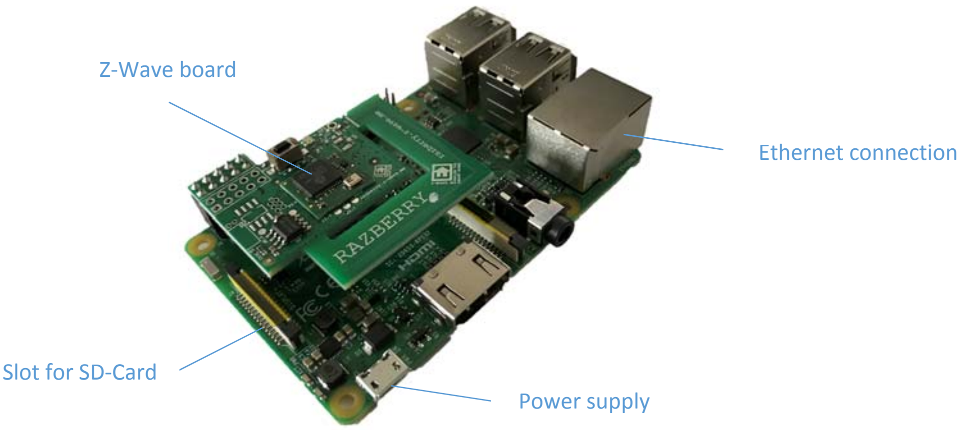

Figure 17: Raspberry PI 3 with RaZberry board (without casing)

- **AEOTEC multisensor Gen. 6** (cp. Figure 18)[9]: A 4-in-1 Multisensor device produced by the company Aeotec. It has several individual sensors installed to collect data of light/UV, motion (PIR), temperature and humidity.

Figure 18: Aeotec Multisensor Gen 6

2.3.2.2 Deployment of the hardware Infrastructure

Based on the architecture of the sensor infrastructure described in the previous paragraph 2.3.2.1, the following deployments have been performed by Stadtwerk Hassfurt GmbH in the German case study.

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[7] Description and instruction of RaZberry Z-Wave board: https://z-wave.me/products/razberry/
[8] Description and development instruction of Z-Way middleware: https://z-wave.me/z-way/develop-quick-intro/
[9] Further product information of Aeotec multisensor Gen. 6: https://aeotec.com/z-wave-sensor

1. **<u>Residential users in Hassfurt (120 households)</u>**

- Each of the 120 households included in the Intervention group of the pilot deployment have been equipped with 1 Indoor Smart Sensor (**"AEOTEC Multisensor"** device), providing measurement of presence, temperature, humidity and luminance. Each sensor has been installed in the living room by the users themselves.
- 1 Central smart home unit (Raspberry PI 3 with *"RaZberry"* Z-Wave board, an open source middleware called *"Z-Way"*, modified by SHF for project specific needs) installed at the user's internet connection point by the users themselves.

2. **<u>School building in Hassfurt</u>**

The installed hardware in the school building in Hassfurt is the following:

- 8 Indoor Smart Sensor (**"AEOTEC Multisensor"** device), providing measurement of presence, temperature, humidity and luminance.

  The sensors have been installed one for each of the 8 classrooms located on the ground floor.
- 3 Central smart home unit (same as household unit, but with slightly different code development) installed at favorable IT connection points to ensure good data transmission.

3. **<u>School building in Wunsiedel</u>**

The installed hardware in the school building in Wunsiedel is the following:

- 15 Indoor Smart Sensor (**"AEOTEC Multisensor"** device), providing measurement of presence, temperature, humidity and luminance.

  The sensors have been installed on 3 floors, one for each of the 15 classrooms.
- 4 Central smart home unit (same as for school in Wunsiedel) installed at favorable IT connection points to ensure good data transmission.

4. **<u>Municipality building in Hassfurt</u>**

The installed hardware in the public building in Haßfurt is the following:

- 6 Indoor Smart Sensors (**"AEOTEC Multisensor"** device), providing measurement of presence, temperature, humidity and luminance. The sensors have been installed in the different rooms of the office building and in the public areas.
- 1 Central smart home unit (same as household unit, but with slightly different code development) installed at favourable IT connection point to ensure good data transmission.

2.3.3 Data Integration (data flows)

This section provides a complete but schematic overview of the main steps involved in reading, handling, organizing and forwarding the consumption data from **"ECHELON"** smart meters and the indoor conditions from **"Aeotec Multisensors"** installed in SHF's pilot buildings.

Figure 18 describes schematically the data flow of the German pilot. A more detailed description of each step can be found down below.

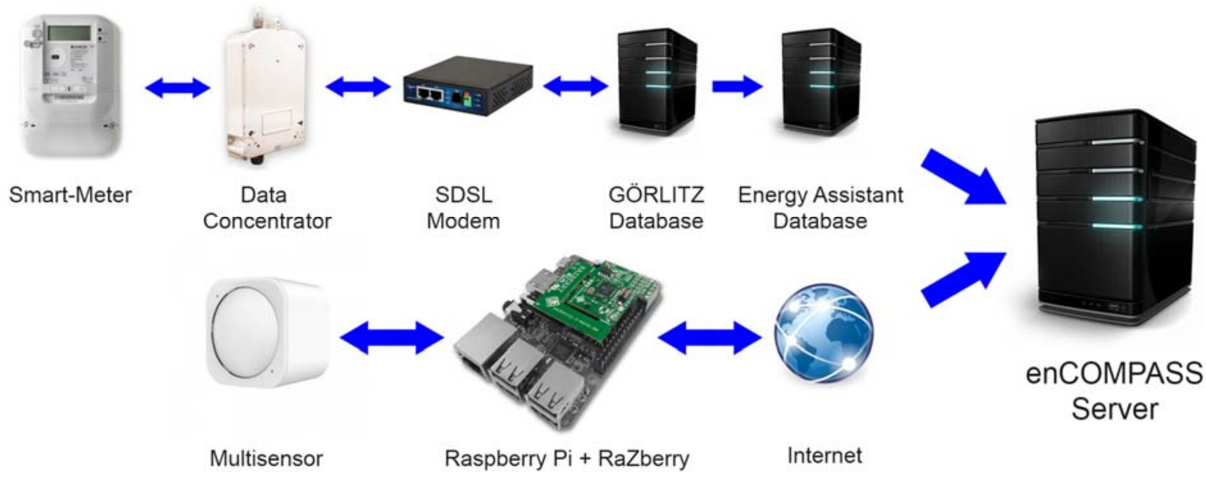


Figure 19: SHF Smart Meter data integration – German pilot

The data reading procedure of the **smart meters** follows these steps, going left to right in the upper flow of Figure 19:

- Smart meters installed at the points of delivery read the power consumption (or production) of the client in 60-minute intervals.
- Data concentrators scattered around the power network retrieve the data from the smart meters connected to them, using power-line communication (installed since 2008).
- The smart meter management system (Görlitz Database) is a software running on SHF's servers. Periodically the concentrators push the gathered information and the data is stored in the Görlitz Database. This data exchange runs either on the national GSM network or an isolated broadband connection network in SHF's property via SDSL modems.
- The Server of the Görlitz database is located in SHF's headquarters. From there the data of the individual pilot participants is pushed to the Energy Assistant Database, that is a management system for SHF's new customer portal (signed up customers can view their consumption/production data, deposited with the individual electricity tariff).
- In a next step, the meter data is exported and previously associated with the unique POD (point of delivery) number of each project participant. The POD-ID is generated and predetermined by the single smart home central unit devices of the pilot buildings. After setting up each device, the unique ID is matched with the customer receiving the smart home kit and the smart meter ID by only one employee of SHF. The export is performed via SFTP protocol to the enCOMPASS server, located in the SHF headquarters.
- After receiving and matching the daily smart meter readings, a python script exports the data to the enCOMPASS platform server every day at 07:00 (CET).

The flow of the **sensor data** works as described in the following (cp. Figure 19, downer flow):

- The multisensor collects the data and sends it to the Raspberry Pi via the local Z-Wave network.
- The Z-Way software on the Pi saves the raw data in JSON data format on the SD-card.

- A python script fetches the stored raw data, saves it as a CSV file with the unique POD-ID and in the project specific data format and sends it to the enCOMPASS server at the premises of SHF in Hassfurt once a day.
- After receiving and matching the daily sensor readings, a python script exports the data to the en-COMPASS platform server every day at 07:00 (CET).

3 DEPLOYMENT OF BEHAVIOR CHANGE APPS AND TRIGGERED COMMUNITY ACTIVITY AND FEEDBACK

3.1 RECRUITMENT AND INITIALIZATION OF THE USER COMMUNITY

This section explains the recruitment activities and communications in the pilots to fulfill the establishment of the user base. Also workshops with public buildings and schools to initialize the pilots are described. Furthermore, data samples about the stratification and composition of the recruited user of the intervention and the control group in the pilots are shown and clarified. The recruitment exploited the enCOMPASS behavior change applications, delivered at month 18 (*D6.3 Platform initial prototype*); the collected feedback was exploited to produce an updated version at month 24 (*D6.4 Platform second prototype*).

3.1.1 Schools

3.1.1.1 Workshops in the German, Swiss and Greek pilots

In the German pilot, two workshops with the schools were conducted to familiarize the teachers with the enCOMPASS application and to gather their feedback about how to best integrate the usage of the enCOMPASS application into the classroom. The workshop in the school in Hassfurt (Grundschule im Nassachtal) was conducted on 10th of July 2018 and the workshop in the Jean-Paul-Grundschule Wunsiedel – on 11th of July 2018. The procedure for the workshops was similar: first, an introduction of the project was given, followed by an overview of the enCOMPASS application and the first ideas to integrate the use of the application in the classroom. Then the discussion was started where ideas were collected from the teachers as to how best integrate the usage of the application so that it enhances the learning process of the students and allows them to reconsider their behavior in energy related matters. The workshops lasted between 1-1.5 hours. The workshop with the school in Hassfurt was attended by 10 teachers, the director of the school, as well as representatives from EIPCM and Stadtwerk Hassfurt. The workshop with the school in Wunsiedel was attended by ca. 15 teachers, the director of the school and the representatives from EPICM and Stadtwerke Wunsiedel (partner of Stadtwerk Hassfurt).

The atmosphere during the workshops was overall quite positive, the teachers saw the potential to integrate the application in the classroom. Some were concerned that they cannot do a lot to save energy in the school to achieve the targeted savings of the pilot, however others mentioned that also small behaviors, such as turning the lights in the hallway during the day might actually lead to significant savings over time. The teachers liked the idea that the enCOMPASS application is not only intended to encourage users to save energy, but also to raise awareness among students and teachers about energy-related matters and to initiate new behaviors in energy saving. Also, the teachers were positive about the possibility of knowledge transfer initiated by the app – from changing behavior in school to energy saving behaviors at home.

For what concerns the integration of the usage of the app in the classroom, they saw most potential in appointing an energy ambassador among the students every week and incorporating the use of the application in the morning hours when the class comes together every day. For example, they could have the energy ambassador read the tip from the application and then discuss it in class. The teachers liked the idea of competition between classes and were excited about the rotating cup as a reward to the winning team that would rotate every month. Especially in the school in Wunsiedel, the concept of competition was received well as it resonates with the existing scheme of the school where "order kings" are awarded every month to the class which contributes most to keep the school clean. The teachers in that school proposed to organize the meetings with the classes of the same grade, as they have quite many students in the whole school.

Overall, the teachers desired to receive some guidance about how to integrate the application into the classroom including posters or instructions.

In the Swiss pilot, three workshops were held with the teachers to introduce the enCOMPASS project, to get the teachers' feedback on how the project activities could be integrated in the didactic program for the coming school year and to familiarize the teachers with the software and hardware infrastructure of the enCOMPASS project. The first workshop was held on the 28th of September 2017 at the school site in Cadepezzo, Gambarogno. The teachers and the director of the school showed a keen interest in the ideas put forward by enCOMPASS and saw a concrete opportunity to make it an integral part of the school program for the coming school year (2018/2019). The aim of this workshop was mostly informative and it was reached a general agreement on the use of the enCOMPASS App in the classrooms.

The second workshop was held on the 21st of June 2018 and the aim was to define how the teaching activities in the four classes in the primary school of Cadepezzo could take advantage of the integration and the use with the enCOMPASS App and the Funergy game. In particular, it was agreed that the pupils would take part in an "energy challenge" where the four classes would compete to save more energy and gain more points related to various activities, just as in the enCOMPASS App, but the ranking would be displayed on a physical board and the points would come from different sources: enCOMPASS activities done with the App (online), classroom activities (offline), and points obtained by playing the Funergy game. A third workshop was held on the 5th of September where the usage of the App and the tablets were shown to the teachers.

In the Greek pilot, a workshop has been conducted at the Delta school in Thessaloniki with a group of students from the IT management specialization and two teachers. The workshop lasted about 1 hour, during which enCOMPASS application was presented to the students followed by a discussion about the possibility of integration of the use of the application in the classroom. As Delta college is a vocational education school where the ages of the students range from 18 and up, this represents a different case than in the Swiss and German pilots. The use of the app does not have to be specifically integrated into the classroom, but rather the students can use the application in their free time in order to learn about energy saving and initiate new habits in energy related behaviors. The level of student's knowledge in energy seemed to be quite high, however they were concerned that saving energy for the school does not mean anything to them, as they still have to pay the high fees for their education. In this case, the environmental impact of their actions that tracked in the enCOMPASS app can be put in the foreground. Overall, the concept applied here is similar to the public buildings.

3.1.1.2 Concept of integration of the enCOMPASS app in the classroom

As a result of conducted workshops, we adjusted our concept of integration of enCOMPASS app into the classroom for the primary school students (in the German and Swiss pilots). Elements of this concept can also be used in the Greek pilot. The concept of integration of the enCOMPASS application into the classroom has the following goals: 1) seamless integration of the concept into the classroom to stimulate student's desire to learn about energy; 2) initiation of energy saving habits through different motivational elements; and 3) a process to register behavior change in energy related matters due to the use of the enCOMPASS application. For this purpose, teachers will be provided with a set of materials as well as a survey and a quiz will be administered to teachers and students. We describe these elements in detail below.

In order to integrate the knowledge around energy saving conveyed in the enCOMPASS app into the school curriculum, teachers are given a guideline that contains detailed information about energy saving tips that are provided in the enCOMPASS app as well as suggestions of how to explain them in class. Each class will use the enCOMPASS app at most once a day (pupils should be told that the tablet and the app themselves consume energy and therefore must be used parsimoniously). In each class, one pupil will be assigned the role of "energy ambassador of the week": he/she will be responsible for using the tablet (under supervision of the teacher) and for reminding classmates about virtuous behaviors (e.g. turn off the lights before leaving the class). Teachers are also provided with a poster that they can hang out in the classroom on which they can track the progress of their class in saving energy, which above the activities in the enCOMPASS app can also include a variety of offline activities. The offline activities defined by the teachers (e.g. manual activities, homework, interactive discussions with pupils, questions raised in class –for example "who remembers the tip we read yesterday on the app?") will lead to broaden the educational value of the enCOMPASS project.

In order to initiate new energy saving habits, students will be regularly using the enCOMPASS application to read the tips and report which energy saving behaviors they carried out that day. The ability to track these behaviors on the board as well as the ability to see the results of these behaviors in the enCOMPASS application, should motivate the students to engage with the application. However, this intrinsic motivation alone might not be enough to motivate the students, so there will be a school-wide enCOMPASS competition (or for the larger schools such as the one in Wunsiedel - grade-wide). A poster will be located in the school hall, where the ranking of the classes will be displayed and updated every month. The points attributed to each class will be computed by adding the points gained by using the app and additional points attributed by the teachers for offline activities. The poster will be manually updated during a meeting involving all the pupils, which in the primary school of Cadepezzo (Swiss pilot) will take place the first Wednesday of each month (to be determined in the German pilot). A Funergy tournament will be held among representatives of each class, in order to attribute additional points to the winners. At the end of each month, the class on the top of the ranking will receive the rotating cup and they will keep it in the classroom until the next month, where they will know if they will retain it or they will have to hand it over to the new best team. At the end of the year, optionally the teachers can distribute a little gift to each pupil to celebrate the collective savings achieved in the school building (the purchase of the gifts will be covered by the school budget). We propose that this additional competition, through external rewards, will lead students to raise awareness of energy related issues and institutionalize saving energy as one of their habits.

In order to measure behavior, change as a result of the introduction of the enCOMPASS app, a survey needs to be administered. Considering the target group of primary school children 6-11 years of age as well as the necessity to integrate the usage of the app seamlessly into the classroom, the survey will be administered under the form of a quiz, aiming to test the student's knowledge in energy related issues. The teachers can then use this quiz to see on which energy related areas they have to spend more time, and which the students already know. The quiz is administered twice: at the beginning of the pilot – before the students and teachers started to use the enCOMPASS app –to test their existing knowledge about energy saving as well as their values and attitudes around the subject. The results of this quiz are used as the baseline against which the results of a second quiz, after the intervention with the enCOMPASS app, will be compared. As such, if the knowledge increase in energy related matters is registered, it can be attributed to the intervention – the use of the enCOMPASS app and the accompanying learning activities conducted by the teachers.

The quiz is designed to fulfill several requirements. The first requirement is to base the questions in the quiz on the same constructs as the ones that are being used in the questionnaires throughout the pilot. The second requirement is to create a quiz that is appropriate to the age group that it is being administered to. Since the respondents are primary school children in the age of 6-11 years, special attention is given to design the quiz in a manner that is taking their cognitive capabilities into account. In order to achieve the age-group appropriate design needed, research findings on children's cognitive development [6, 7, 8] are consulted and, where possible, integrated into design decisions, such as the phrasing and wording of questions and the overall visual design (e.g. by making it colorful, easy to read, and more attractive looking by decorating it with cartoon images).In order to ensure that most children understand the questions in the quiz and to minimize behaviors like editing ones answers in "an attempt to please, impress or acquiesce" [6] due to a lack of understanding, it is decided to base the quiz design on the average cognitive functioning of 8-year-olds, in an attempt to create a quiz that most children could understand without getting bored or over-challenged.

In the response to these requirements, the content of the quiz is mainly knowledge-based and links directly to the information about energy saving that the children will be learning when using the enCOMPASS app. This way, their learning progress can be tracked and the educational impact of the app can be fully measured. By linking the content of the questions to the knowledge that is being taught in the enCOMPASS app, the quiz becomes also a part of the “offline” enCOMPASS achievements, since the class that scores highest on the quiz will be rewarded with points that count towards winning the school-wide enCOMPASS competition.

Additionally, the teachers are asked to fill out the “enCOMPASS - Questions for the schools’ questionnaire”, both before the start of the pilot and after the pilot. This survey aims to fulfil two primary goals. First, it is aiming to test personal knowledge, values and attitudes of the teachers regarding energy saving. This information will later allow to estimate how the attitudes and behaviors of the teachers changed due to the usage of the enCOMPASS app throughout the pilot. Second, teachers will be asked to evaluate their students' knowledge, values and attitudes about energy saving based on their teaching experiences in the classroom. This information, in turn, will allow to explicitly assess the change in the perception of the teachers on the process of knowledge development in energy related issues in their class. These two measures taken together will allow to determine the impact of the enCOMPASS app on behavior change in the pilot.

3.1.2 Public buildings

Workshops in the German, Swiss and Greek pilots

In the Greek pilot, three workshops were conducted in the public buildings: one with the National Documentation Centre in Athens (NHRF), the Watt&Volt central office in Athens and the Watt&Volt retail store in Thessaloniki. The workshops had the goal to introduce the enCOMPASS application to the employees, and to encourage them to use it in such a way that it is seamlessly integrated into their usual daily working routine. To stimulate their motivations, the competition among the teams will be held and the team that achieves the highest score for the month will be awarded with a rotating cup. Every month, the employees from different teams would come together to award the cup and to exchange their tips about energy saving.

For the workshops, around 15 employees turned up in NHRF, 5 in Watt&Volt centre and 3 in Watt&Volt retail store. The workshops lasted about 1 hour. The feedback collected from participants allowed to conclude that they are encouraged to use the enCOMPASS app in their daily routines. The employees were especially motivated by the competition and the idea of the rotating cup. They also confirmed that they would organize the monthly meetings to award the cup to the winning team and to exchange their opinions on the new energy saving behaviors.

In the German pilot a workshop with the public building users was held on the 8th of June in the municipality building located in Hassfurt. The purpose of this workshop was to deploy the tablets in the different rooms and to form the teams and to instruct the users on how to access the enCOMPASS App. During the workshop three teams were formed: the “Open plan office 1 - 1” team with 3 users, the “Open plan office 1 - 2” team with 3 members and the “Open plan office 2” team with 2 members. The participants had doubts that the set goal of 20% energy savings per month could be reached, because they could not obviously imagine saving actions with such big impact. Having said that, they were curious about the saving potential to be reached in the overall project. In particular, the employees liked the idea of the rotating cup as it introduced a “fun” factor in the competition of saving the most energy.

In the Swiss pilot, a workshop with the public building users was held on the 5th of May in the municipality building located in Magadino Gambarogno. The purpose of this workshop was to deploy the tablets in the different rooms and to form the teams and to instruct the users on how to access the enCOMPASS App. During the workshop three teams were formed: the "Cancelleria" team with 6 users, the "Bolle" team with 6 members and the "Lago" team with 5 members. Here as well, the participants particularly liked the idea of the rotating cup as it introduced a "fun" factor in the competition of saving the most energy.

3.1.3 Households

3.1.3.1 Workshops in the German, Swiss and Greek pilot

The workshops, that were done with future pilot participants before start of the three pilots, were already described in section 2.5 of the deliverable "D2.2 FINAL REQUIREMENTS" and conclusions on the enCOMPASS concept were made there as well.

3.1.3.2 Intervention group

In the following, the recruitment activities and communications in the pilots are listed, which were done to establish the user base of the intervention group. Detailed information about the communication within the pilots is delivered in D9.5 SECOND YEAR DISSEMINATION REPORT.

In the **German pilot**:

- Presentation of project goals and invitation to join pilot study at SHF's citizen energy forum (07/2017).
- Invitation letter via postal mail to 5.000 customers of SHF (03/2018).
- Feedback of approx. 200 interested households.
- Selection of 120 households to take part in the pilot, informed by email.
- Rollout of smart home starter kits via postal mail with user guide for installation.
- Newsletter to all participants for the release 1 of enCOMPASS App with instruction how to login.
- Reminder to log in the app and use it via Email (07 and 08/2018).
- Personal support.

In the **Swiss pilot**:

- Invitation letter sent by SES via postal mail to all residents of Contone (400 households) January 2018
- Feedback of approximately 100 interested households in February 2018.
- Selection of 75 households matching the criteria in early Mach 2018.
- Rollout of multisensory via postal mail with user guide for installation during April/May 2018
- Personal email sent to all participants to download the App and start the pilot: May 2018.
- Monthly newsletters have been sent to announce the monthly winners.

In the **Greek pilot**:

- Direct contact with the customers through the WVT's flagship retail store in Thessaloniki.
- Selection of 100 households to participate in the project, informed via a mass e-mail.
- Installation of the gateways and the various sensors in the participants' houses (WVT has undertaken this task).
- Notification to log in the app and use it via mass e-mail.
- Personal support.

3.1.3.3 Control group

In the following, the recruitment activities and communications in the pilots are listed, that were done to fulfill the establishment the user base of the control group.

In the **German pilot**:

- Invitation letter via postal mail to 5.000 customers of SHF (03/2018).
- Feedback of approx. 80 interested households, some doubled with intervention group.
- Sorting out of doubled users, asking them in what group they wanted to take part.
- Sending of the first Questionnaire via email with a signup code.
- Rewards for filled in questionnaires sent out directly after receiving of confirmation.

In the **Swiss pilot**:

- Invitation sent to all SES customers through the SES bulletin.
- Personal invitations sent to 400 households in Gambarogno where smart metering is available.
- Sending the first Questionnaire via email with a signup code.

In the **Greek pilot**:

- Direct contact with the customers through the WVT's flagship retail store in Thessaloniki.
- Selection of 120 households to participate in the project, informed via a mass e-mail.
- Sending of the first Questionnaire via a mass e-mail with a signup code.

3.2 User adoption and usage analysis

The user adoption and usage analysis is presented in this section, for each of the respective pilots (German, Swiss and Greek) and for each of the user types. As reported in D7.2, there are 3 types of users: Households, Public Buildings and Offices, and Schools. Household and public building pilots in Germany and Switzerland started in June 2018, whereas the Greek pilot uptake was delayed due to technical difficulties in that pilot. All analyses reported here show the usage data from the 1st of June 2018 to 5 of October 2018, for a total of 17 weeks, unless otherwise noted.

Since the school year starts only in September/October, there is no data for analysis to be reported in this deliverable. The activities from the onboarding process in the schools that included workshops and further preparation before using the app have been described in Section 3.1.1).

Regarding user adoption and usage analysis, the focus of the analyses presented in this chapter is placed on the frequency with which the users are engaging with the app, the type of content they are accessing when logging-in, the effort in learning about how to save energy and the rewards provided to them for increasing their knowledge and achieving energy savings.

The following metrics are used:

- Login counts: the number of times that the user actively logs in or reengages with the application after 20 minutes not using the application.
- Page views: the number of times each page of the application is accessed by the user. The enCOMPASS App is divided into several pages each serving its unique purpose:
    - Achievement Page shows the number of badges users have received.
    - Comfort Feedback page asks the user to provide feedback about the temperature and humidity in the room (living room for households, office for the public buildings and classroom for the schools).

- Comfort Page shows the comfort level relative to the energy savings achieved in the past month.
    - Consumption Page provides detailed consumption information for different time periods.
    - Goal Page displays the consumption of the current month, allows to set a savings goal (as opposed to the same month in the previous year) and monitor achievement of the goal.
    - Impact Page displays three different metaphorical representations of the impact of achieved and potential energy savings – monetary (how much money has been saved?), environmental (what is the impact of savings on the environment?) and hedonic (how many points have been earned?).
    - Leaderboard Page shows the users who have achieved most points in the current month and overall the pilot.
    - Profiling Page allows household users to complete the profile information
    - Rewards Page provides information about which rewards users can receive.
    - Tips Page provides the users with a list of tips on how to achieve energy savings.
- Tips Read: number of times a user reads an energy saving tip in the course of the week. For a tip to be counted as read, the user has to stay on the page for at least 3 seconds to have time to read the tip.
- Badges Received: number of badges awarded to participants.
- Notifications Opened: the number of times the user opened notifications received through the application.

The key highlights of this section include the following statistics[10]:

For household users:

- Activity levels are similar across pilots: the average of the total log ins in the Swiss pilot is 44,2 whereas in the German – 45,2; the average monthly log ins in the Swiss pilot are 9,1 whereas in the German – 8,8.
- Most users have logged in to the application in June in Switzerland and in July in Germany.
- There are 5 lead users (8%) in the Swiss pilot and 7 lead users (8%) in the German pilot who on average use the application much more than the average.
- The pages that are visited most frequently are: the goal page with 54 average accesses in Switzerland and 43 accesses in Germany; and the comfort page with 53 average accesses in Switzerland and 34 in Germany.
- Interestingly, users in Germany accessed the tips page less frequently than in Switzerland (20 on average vs. 53), however they have read more tips (63 vs. 47).
- Users in Switzerland have been awarded with 5,4 badges on average, whereas in Germany – with 4,9 badges, they have reached the moderate energy saver level and trainee level in learning.

Table 4: Summary of the activated of the household users

Households	Active users	Activity level – log ins (average)	Most popular pages	Awarded badges (average)	Tips read (average)
German pilot (four months)	93	45,2	Saving goal (43) Comfort (34)	4,9	63
Swiss pilot (four months)	66	44,2	Saving goal (54) Comfort (53)	5,4	47

[10] - please note that the highlight data is only provided for the German and the Swiss pilots.

Greek pilot (one month)	64	2,06	Comfort (5,3) Saving Goal (4,2)	1,3	20,1

For public building users:

- Some teams seem to be more active than others (in Switzerland 3 out of 5 teams are considerably more active, whereas in Germany – 2 out of 3 teams).
- Pages most frequently accessed by public buildings users are Comfort and Saving goal.
- In Switzerland users are more interested in the Awards page than in Germany.
- Public building users have read 28,5 tips on average in Switzerland and 30,6 in Germany.
- Teams have received 3,4 badges on average in Switzerland and 4 in Germany.

Table 5: Summary of the reached triggering numbers of the public building community

Public buildings	Active teams	Activity level – log ins (average)	Most popular pages	Awarded badges (average)	Tips read (average)
German pilot (four months)	3	45,2	Saving goal Comfort	4,0	28,5
Swiss pilot (four months)	5	44,2	Saving goal Comfort	3,4	30,6
Greek pilot (one month)	7	7,2	Saving goal Impact	1	1

3.2.1 Swiss Pilot

In this subsection the user adoption and usage analysis for the Swiss pilot is described.

3.2.1.1 Households

There are 66 users registered for the group of Households.

Login

First, we present the total log in statistics and then we explore these per month for the household users in the Swiss pilot in the reporting period between June and October 2018.

In total, users in this pilot have logged-in to the application on average 74.3 times during the reporting period. However, they have not done so evenly as the standard deviation is 285 and the Median is 14. In this sample there is one 1 user with a login count of 2030, which is in orders of magnitude greater compared to the average, so that user can be considered an outlier[11]. To provide a better picture of actual number of log-ins, Figure 20 shows the total number of log-ins by all users not considering outliers, where the average of *the total number of logins is 44.2* with a standard deviation of 83.2. In this graph, we see that the number of log-ins per user is unevenly distributed. There are *5 (8%) users who logged in 150 times or more* during the reporting period, who can be called "lead users". At the same time, there are also 3 (5%) users that have not logged-in at all. These differences are commonly found in such behavioral change systems as enCOMPASS application where lead users can be observed to be substantially more active than the majority of others.

[11] The reasons for this outlier are being investigated.

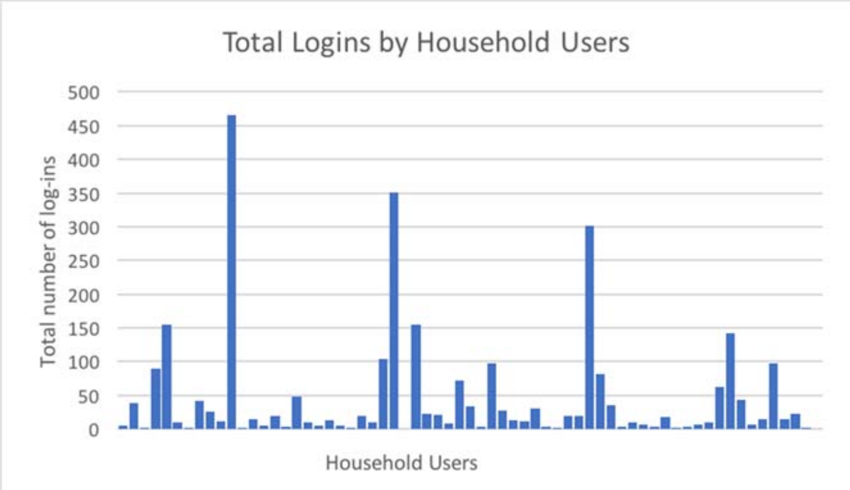
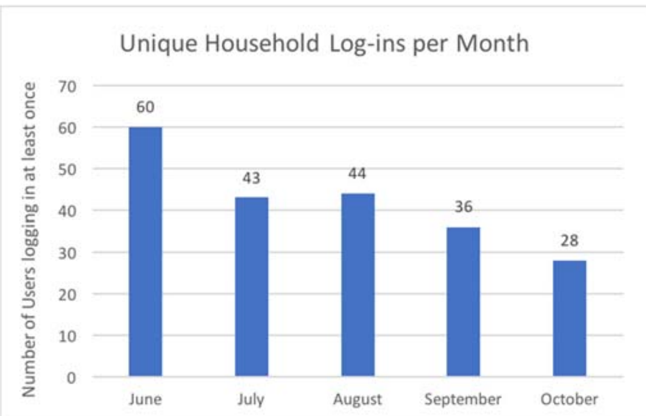


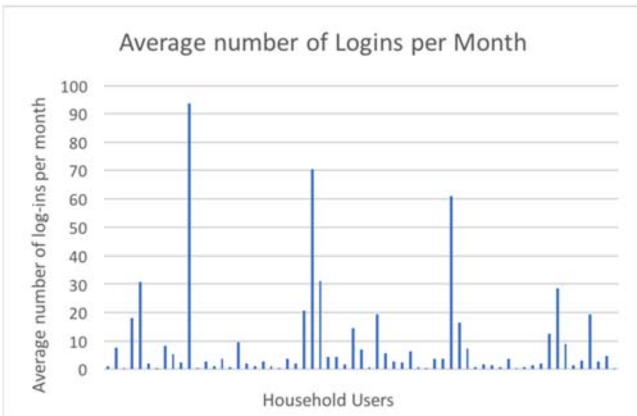
Figure 20: Total number of logins of Swiss household users without outliers.

Per month statistics of the frequency of user log-ins during the reporting period are displayed in Figure 21. First, in Figure 21(a) is displayed the number of users logging in at least once to the application in each of the months during the reporting period. Out of the total 66 users registered for the pilot, the majority of the users are logging in at least once per month, with the highest number of unique log-ins in June (*91% of the users*) and the lowest number of 36 (54%) unique log ins in September[12]. This is an expected finding for two reasons. First, it displays usual pattern of application usage, where in the beginning more user activity is observed, as the motivation to use a new system is high, and then the usage can drop as only a part of the users will make a habit of using the application on a regular basis. Second, the period we are exploring falls over the summer period, where people might have been on vacation with less free time to devote to the usage of the enCOMPASS app. Having the data only from the period of four months, we cannot make any definite conclusions, as the usage might well rise again as the interest levels increase.

Second, in Figure 21 (b) the average number of logins per month is displayed not considering the outlier mentioned above. We see that the users *log in on average 9.1 times a month* with a standard deviation of 16.9. We can see, however, that the 5 lead users mentioned in the previous paragraph logged in on average 30 times or more per month, which is much higher than the average. Overall, these usage patterns are quite common for the behavior change applications: we do not expect people to use them every day, but they should be used one or several times a week in order to help people adopt new behaviors.



(a)



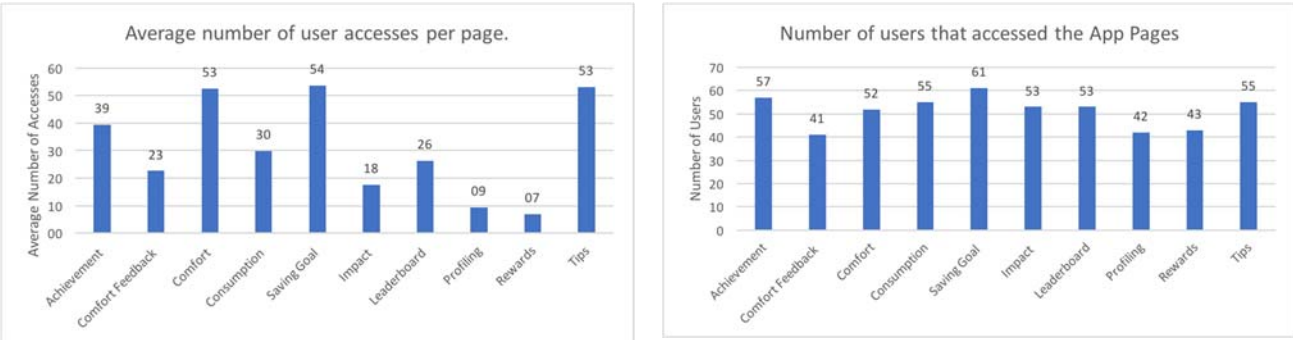
(b)

Figure 21: Swiss Households that have logged in per month in the App. (a) Shows how many unique users have logged-in in each month of the pilot so far. (b) The average number of logins per month per household (without outliers).

[12] The month of October is counted until the 5.10.18, so more households could login before the month ends.

Pages Visited

Figure 22 shows which pages the users accessed in the application. Figure 22 (a) shows the average number of accesses per page during the reported period. From the graph we can see that the users are engaging with all the main pages of the app. The pages with the highest number of accesses are (in order of frequency of access): the *goal page with 54 average accesses*, the *tips page with 53 average accesses*, and the *comfort page with 53 average accesses*. This result shows that the users are interested in setting and monitoring their energy savings goals, learning how to save energy, and seeing whether they could maintain their comfort while saving energy – thus allowing them to fulfil the main goals of the application. We can also observe differences between the users when accessing the pages: for example, lead users have accessed the goal page over 300 times during the course of the pilot. The pages with the lowest number of accesses are the profiling page and the rewards page, but as these pages are not essential to the functionality of the application, this result can be expected.



(a) (b)

Figure 22: Pages accessed by Swiss Household Users. (a) Average number of user accesses per page. (b) The number of users that have accessed the pages at least once.

Figure 22 (b) shows the number of users who have accessed the pages during the reported period to make sure that the page accesses reported in the previous paragraph are not done by a subset of active users. This graph reveals similar dynamics: the majority of the users accessed all pages of the application, specifically: 61 (92%) users accessed the goal page, 57 (86%) accessed the achievement page, and 55 (85%) accessed the comfort and tips pages. Even the profiling and the rewards pages – the least frequently visited pages of the application were accessed by 42 (63%) and 43 (65%) of users, respectively. This shows that the majority of users have been able and interested to explore the main functionalities of the application.

Tips

Figure 23 displays the total number of tips read by household users in the Swiss pilot during the reporting period. We see that the users read quite a lot of tips, specifically: 56 (84%) users have read at least two tips. On average, users have read 47 tips, with a standard deviation of 26.1. In the graph we see that the distribution of tips read by household users is a bit more even as opposed to the frequency of use of the application and the page visits, showing the relatively high interest in reading tips among the users.

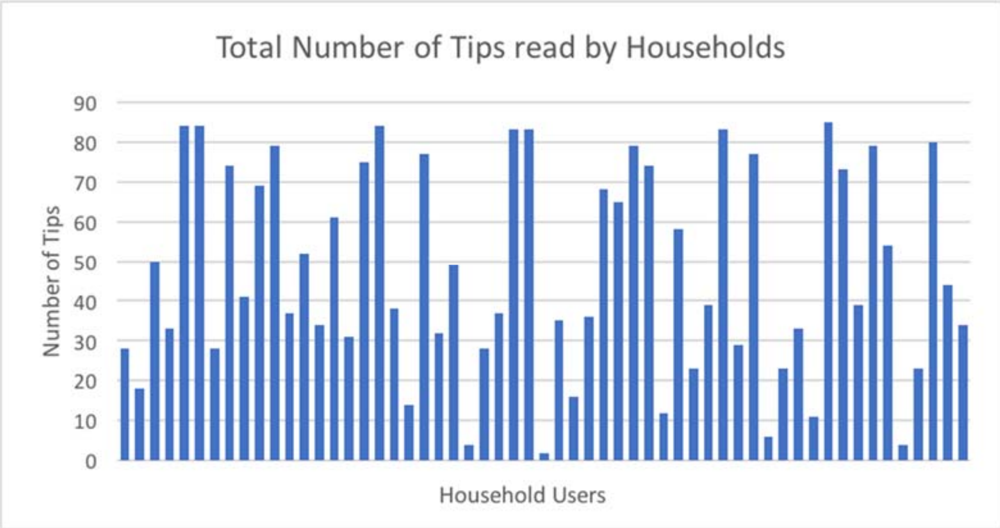


Figure 23: Total number of tips read by Swiss Household users.

Badges

Users receive badges as they collect points for the actions they perform in the application, such as accessing pages, reading tips, as well as in real life: such as saving energy. 65 (98%) users have received at least two badges, although some of them have never logged in. It is possible that users receive a badge even if they are not interacting with the application, as the Energy Saving Badge is awarded automatically when the user saves energy equal or higher to the goal that was set. Figure 24 shows the number of badges awarded to the users: on average, the users were awarded with 5.4 badges. The distribution of the badges is quite even, with 58 (87%) users receiving between 2 and 7 badges, whereas the lead users receiving 15 badges or more.

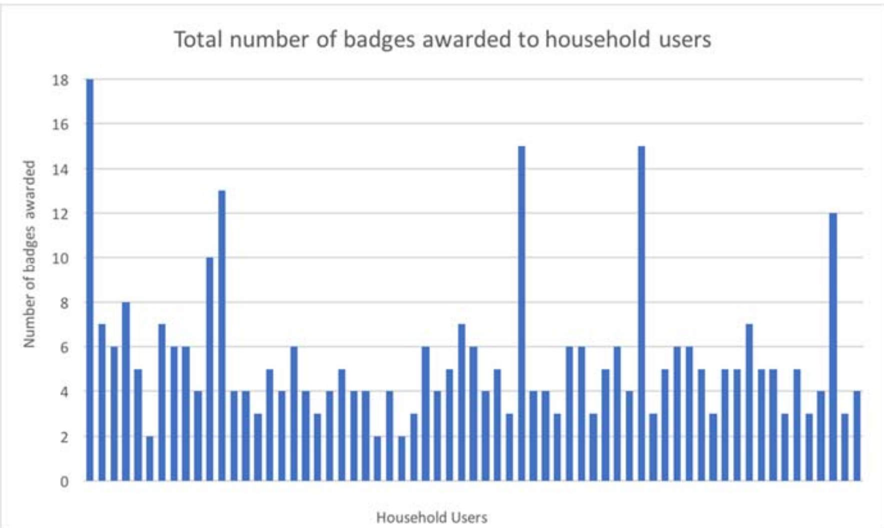


Figure 24: Total number of badges received by Swiss household users.

The badges the users can receive are divided between 3 categories:

- Learning
- Savings and
- Profiling.

Each is awarded for different actions in the app and real life. The badges allow the users to monitor how their knowledge and behavior with regards to energy saving is changing. The distribution of the badges awarded in the application is depicted in Figure 25 which at the same time displays the number of users to whom these badges have been awarded, as a badge can be awarded to each user only once. Learning badges (colored in yellow in the figure) are awarded for monitoring energy consumption, reading tips about energy saving, setting goals, etc. We see that most users 55 (83%) have surpassed the level of trainee and 25 (37%) of the users are on the level of the apprentice. Energy savings badges (colored green in the figure) are awarded for saving energy and thus are only displayed in the application, but mainly depend on the real-life actions of the users. We see that most of the users 65 (98%) have been awarded Starter energy saving badges and 63 (95%) of users – moderate energy savers, even with 17 (25%) of users having achieved the advanced stages in energy saving already. Profiling actions include such actions as filling out their profile and surveys, with 54 (81%) of users are novices in this regard.

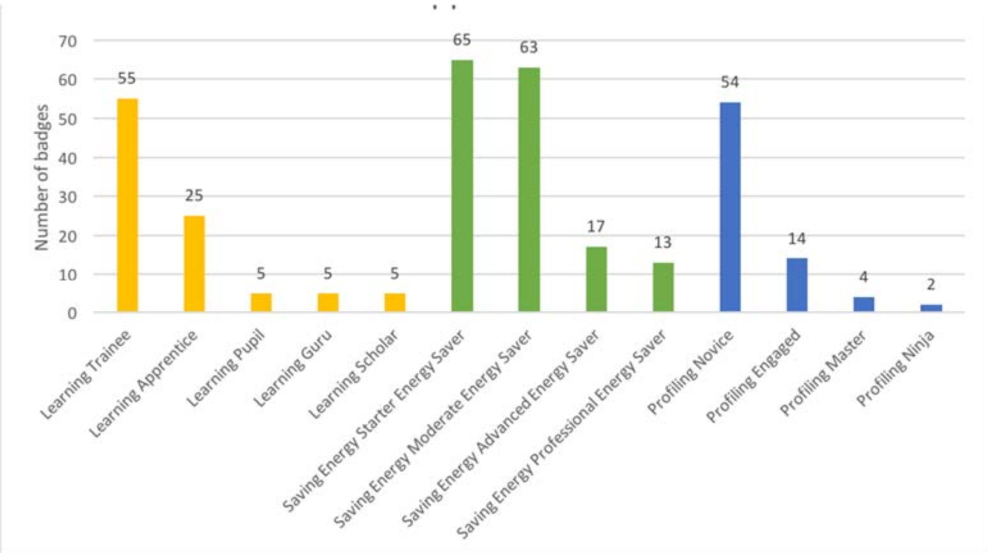


Figure 25: Types of badges received by Swiss household users across the categories and levels.

Notifications

In order to provide triggers to the users and remind them about using the application, enCOMPASS sends out notifications about different actions that can be performed in the application. Once the users receive a notification, they can open it and it will redirect them to that part of the application which is mentioned in the notification. From the data we have we see that only 30 (45%) users have opened at least one notification. Figure 26 displays the total number of notifications that these users opened (if they opened at least one). On average, the users have opened 4.1 notifications, with a standard deviation of 4. All users have notifications enabled for the App, so it is possible that even though they are not opening them, they might be still reading them.

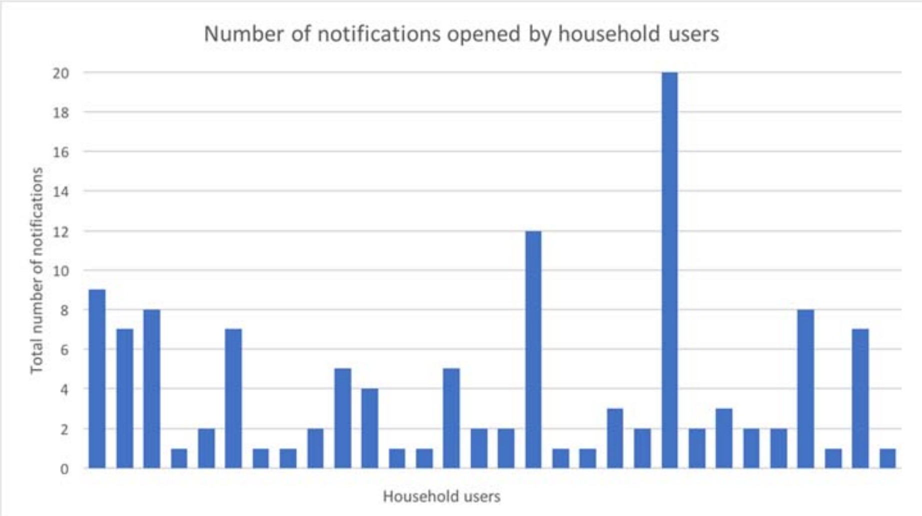


Figure 26: Total number of notifications the Swiss household users opened (a subsample of those who have opened at least one)

3.2.1.2 Public Buildings

As described in D7.2, in the public buildings the enCOMPASS application is used in teams. There are 5 teams for public buildings in the Swiss pilot and each team has several members. The municipal building in which the pilot takes place in Switzerland has three floors and the teams are organized according to the floor levels, apart from the last floor which is a rather big open space, and therefore it has been split in two main areas. One area is south facing and it has been named the "Lago" (lake) team as they have a lake view. The other area is north facing and is has been named "Bolle" team as it faces the naturalistic reserve of the Bolle di Magadino. The other teams are the Servizi Finanziari (admin department) at the first floor, and the Cancelleria (customer facing) at the ground floor. Therefore, the usage analysis and statistics presented below is done per team.

Login

Figure 27 displays the total number of log ins by public building users during the reporting period. We see that 3 out of 5 teams have logged in over 200 times to the enCOMPASS application, whereas the teams 4 and 5 have done so only 21 and 27 times, respectively and only during the two weeks out of the reporting period. We can explain this by the fact that some teams might have more motivation and more time to use the enCOMPASS application, whereas others might be constrained due to the nature of their work or other motivational factors.

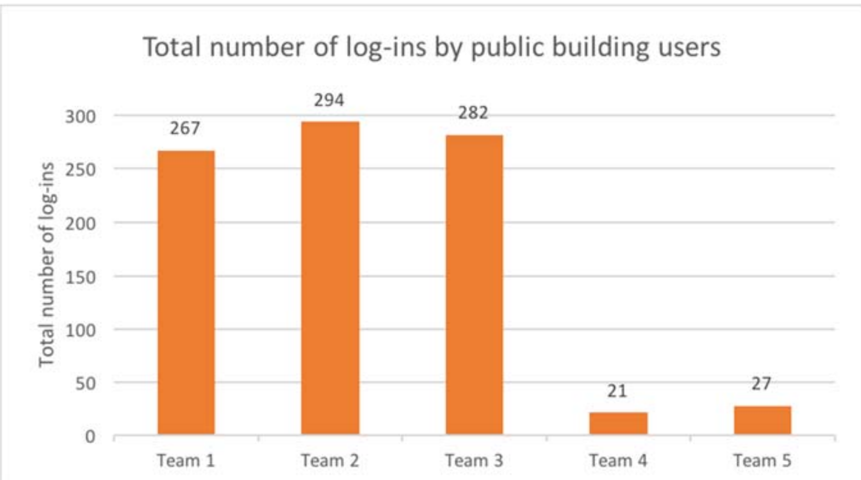


Figure 27: Number of logins by Swiss Public Building users.

Page Access

Figure 28 displays the average number of accesses per team of each page during the reported period. We can see that the pages that are accessed most are (in order of their frequency): comfort page with 169 average accesses, saving goal page with 145 accesses and the rewards page with 123 accesses. As with the household users, the public building users are mostly interested in setting and monitoring their energy saving goals, as well as viewing if they could maintain their comfort levels while saving energy. The public building users are also accessing the awards page, likely because of the competition that they are taking part in between the teams. The pages with the lowest number of accesses by public buildings users are the profiling and the rewards. The distribution of page access among the teams is uneven: with the three more active teams accessing the pages more and the two less active teams – less.

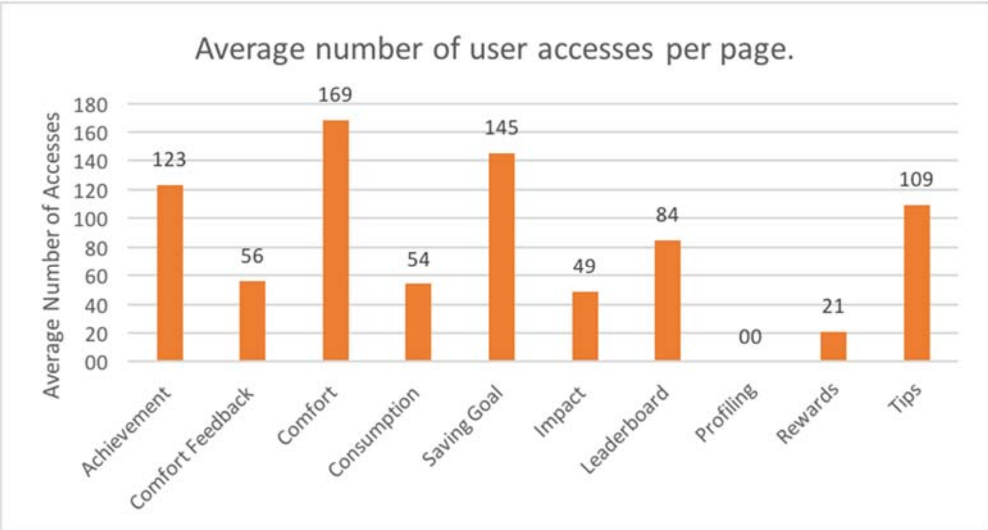


Figure 28: Average number of user accesses per page of the public building users

Tips

Figure 29 shows the number of tips read by the public building users. We observe similar dynamics here as with the log-in frequency to the application: users of three active teams read 28-29 tips in total, whereas the two passive teams read only 3 tips. Measures need to be undertaken to make sure that the users from the other two teams are encouraged to use the enCOMPASS application more often.

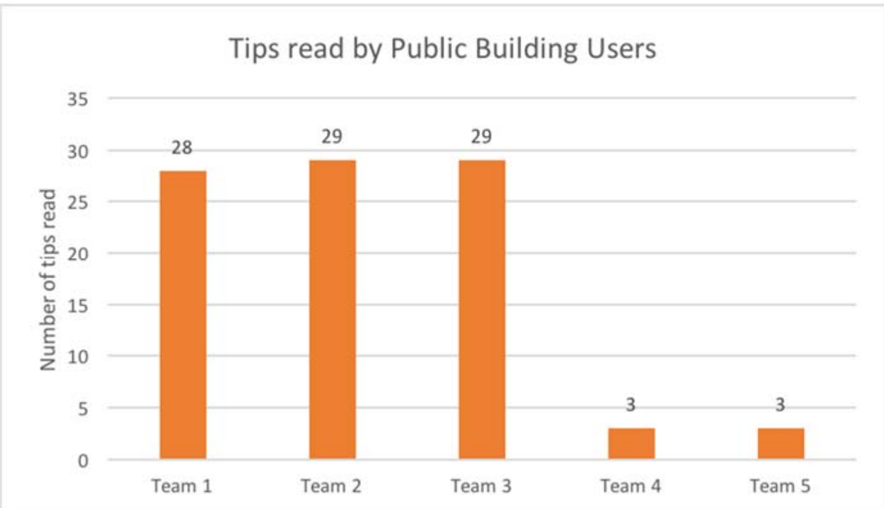


Figure 29: Total number of tips read by Swiss public building users.

Badges

Figure 30 shows the number of badges received by Swiss public building users. On average, users have received 3.4 badges, with a standard deviation of 1.3. Team 3 received most badges, whereas teams 4 and five received the least.

Figure 30: Number of badges received by Swiss public building users

Figure 31 displays the types of badges awarded to the public building users. All teams have received the Learning Trainee and the Profiling Novice badges, four teams have received the Learning Apprentice and 3 teams the Profiling Engaged badges. The teams have not yet received any badges for energy saving. Please note as the energy savings can be achieved for the whole building, all teams will acquire the same badges in this category.

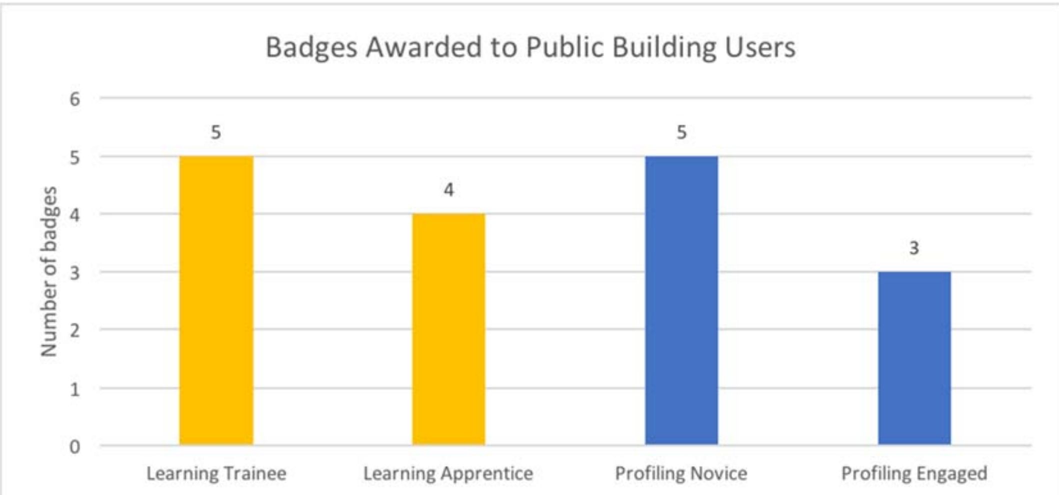


Figure 31: Types of badges received by Swiss Public Building users

Notifications

Figure 32 displays the total number of notifications that the teams in the public buildings pilot opened. We see that only 4 teams out of 5 opened notifications, with an average of 2.75. Team 2 seems to be the team which is mostly interested in receiving notifications.

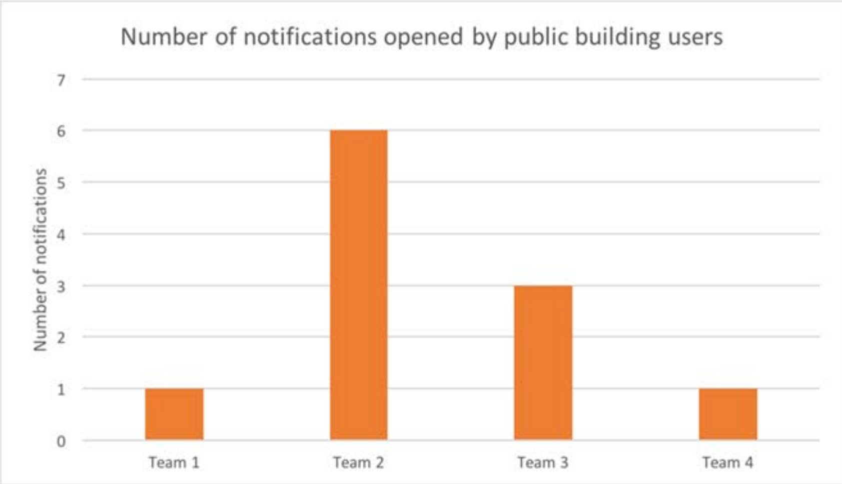


Figure 32: Total number of notifications the Swiss public building users opened

3.2.2 Greek Pilot

In this subsection the adoption and usage analysis for the Greek pilot is described. Due to technical issues, the data for the Greek pilot is only available for the time from the 1st to the 29th of October 2018. Therefore, we cannot carry out all the analyses that were done for the Swiss pilot (especially the per month analyses) and the data reported below cannot be compared to that of the Swiss and the German pilots.

3.2.2.1 Households

There are 64 users registered for households.

Login

Figure 33 shows the total number of log-ins by all users during the month of October, where the average of *the total number of logins is 2.06* with a standard deviation of 2.24 and median of 1. In this graph, we see that a majority of users have logged in only once to the application. This can be explained by the fact that the data presented here is only based on the month of October, so the log-in frequency cannot be compared to that of other pilots. We also see the trend in this graph for "lead users" – 4 users have logged in 8 times or more which compared to most others is considerably higher.

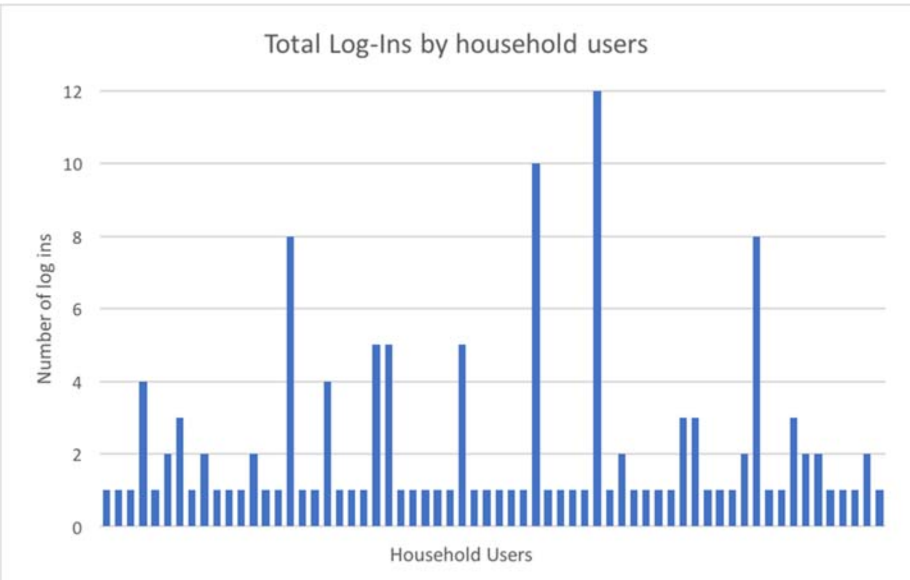
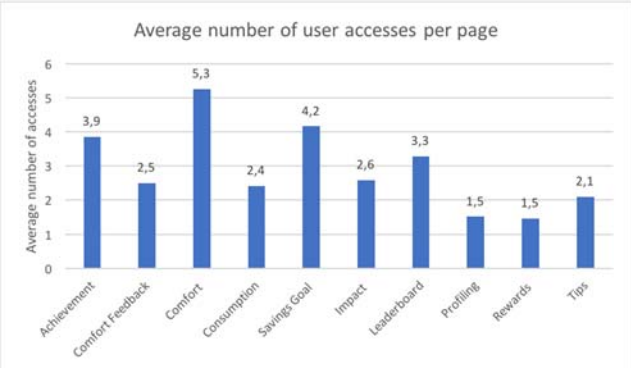


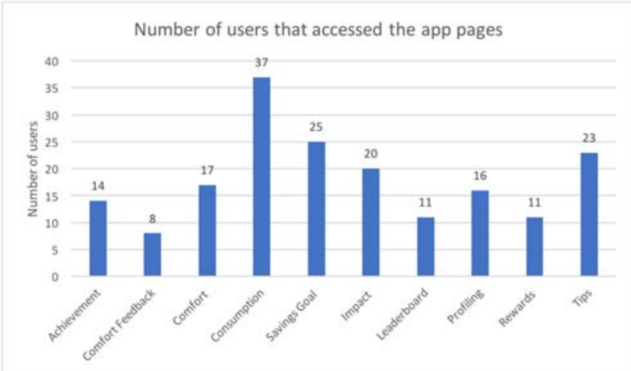
Figure 33: Number of log-ins of Greek household users in October 2018.

Pages Visited

Figure 34 shows which pages the users accessed in the application. Figure 34 (a) shows the average number of accesses per page during the reported period. From the graph, we can see that the users are engaging with all the main pages of the app. The pages with the highest number of accesses are (in order of frequency of access): comfort page with 5,3 average accesses, savings goal page with 4,2 accesses, and achievement page with 3,9 accesses. Although the order of magnitude of the frequency of access is much lower than in other pilots, the types of pages the users access most are quite similar across the pilots.



(a)



(b)

Figure 34: Pages accessed by Greek household users in October 2018. (a) Average number of user accesses per page. (b) The number of users that have accessed the pages at least once.

Figure 34 (b) shows the number of users who have accessed the pages during the reported period. This graph reveals slightly different dynamics: the majority of users 37 (58%) have accessed the consumption page, whereas other pages were accessed by a smaller part of users: 25 (39%) accessed the savings goal page, 23 (36%) the tips page and 20 (31%) the impact page. We can explain this by the fact that we are only dealing with a subset of data for these users and it does not represent the complete picture.

Tips

Figure 35 displays the total number of tips read by household users in the Greek pilot during the reporting period. We see that only 11 users have read tips. At the same time, above we reported that 23 users accessed the tips page during that month. This discrepancy can happen because only when a user spends more than 5 seconds on the tip, it is counted that the user read it. Out of the 11 users who read tips, on average they read 20 tips (with a standard deviation of 16.7).

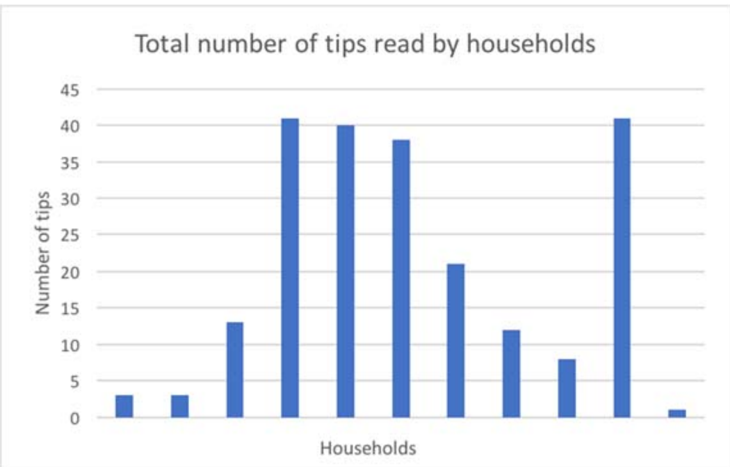


Figure 35: Number of tips read by Greek Household users (October 2018).

Badges

Users receive badges as they collect points for the actions they perform in the application, such as accessing pages, reading tips, as well as in real life: such as saving energy. As is evident from Figure 36 below, only 18 users received badges in October, most of them received just one badge and few of them received two.

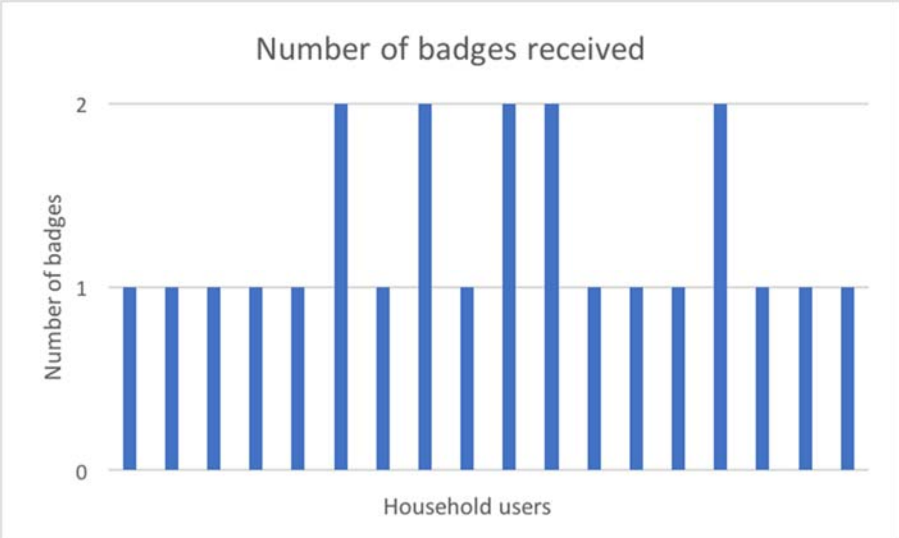


Figure 36: Number of Greek Household users that have received badges in October 2018.

The distribution of the badges awarded in the application is depicted in Figure 37 which at the same time displays the number of users to whom these badges have been awarded, as a badge can be awarded to each user only once. We see that 17 users have been awarded the learning trainee and 8 users – profiling novice.

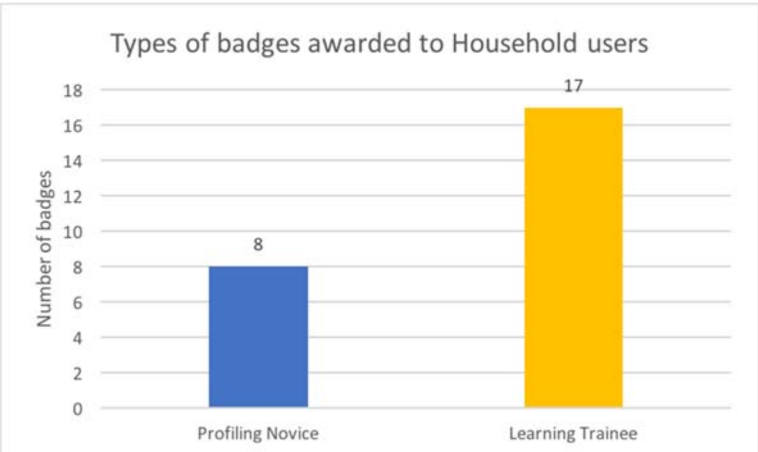


Figure 37: Types of badges awarded to Greek Household users.

Notifications

In order to provide triggers to the users and remind them about using the application, enCOMPASS sends out notifications about different actions that can be performed in the application. Once the users receive a notification, they can open it and it will redirect them to that part of the application which is mentioned in the notification. *Figure 38* displays the total number of notifications that the users opened We see that only 5 users have opened at least one notification, 2 of them opened 2.

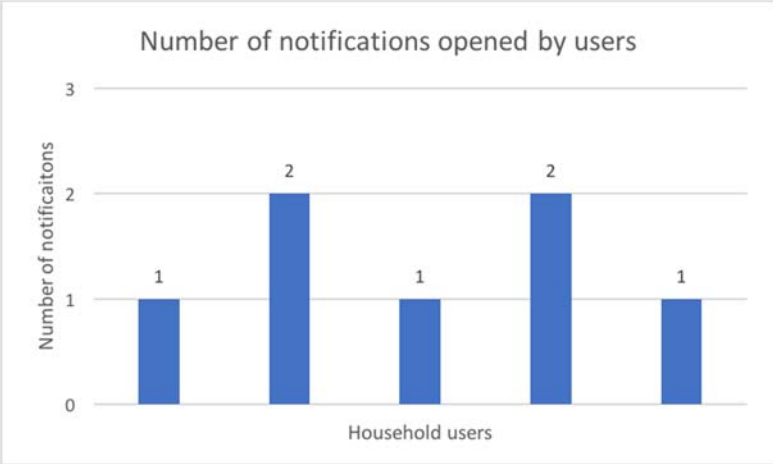


Figure 38: Greek Household users that have opened notifications

3.2.2.2 Public Buildings

The pilot in the public buildings in Greece is done in three locations: NHRF (National Documentation Centre) in Athens, Watt & Volt Headquarters in Athens and Watt & Volt retail store in Thessaloniki. The users in these buildings are assigned to teams which take part in the encompass application. Each team has several members. A detailed description can be found in D7.2.

Here we report the usage data from 7 teams. Two of these teams are in the retail store in Thessaloniki (teams 1 and 3), four in the NHRF library (teams 4-7) and one in Watt & Volt HQ in Athens (team 3). In each of the locations there are also accounts for visitors, however as the data is yet sparse for these users, we will not report it in this deliverable.

Login

Figure 27 displays the total number of log ins by public building users during the reporting period. We see that three teams are more active (10 log ins or more) than the other four teams (3-4 log ins). This again can be due to the different amount of workload of the employees comprising these teams.

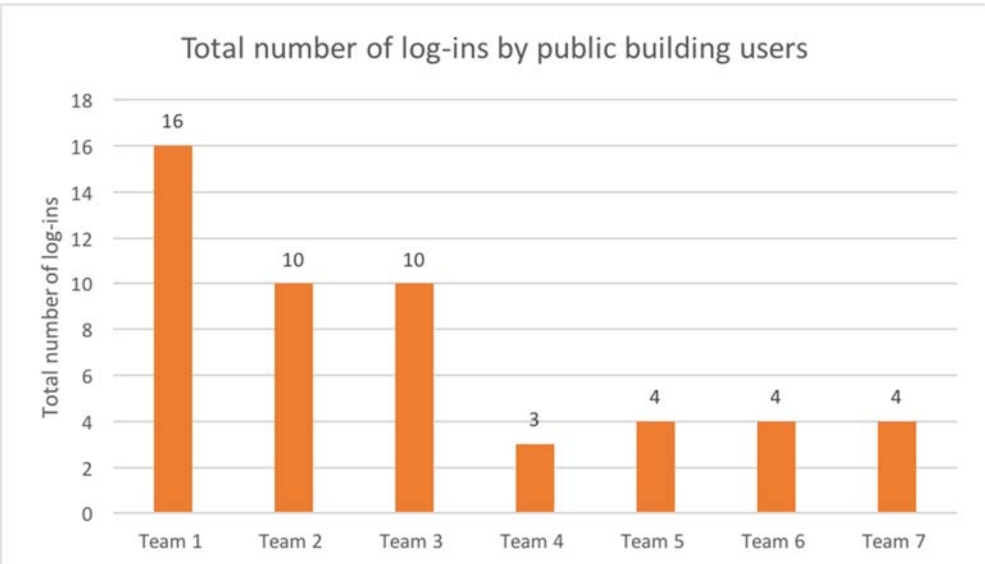
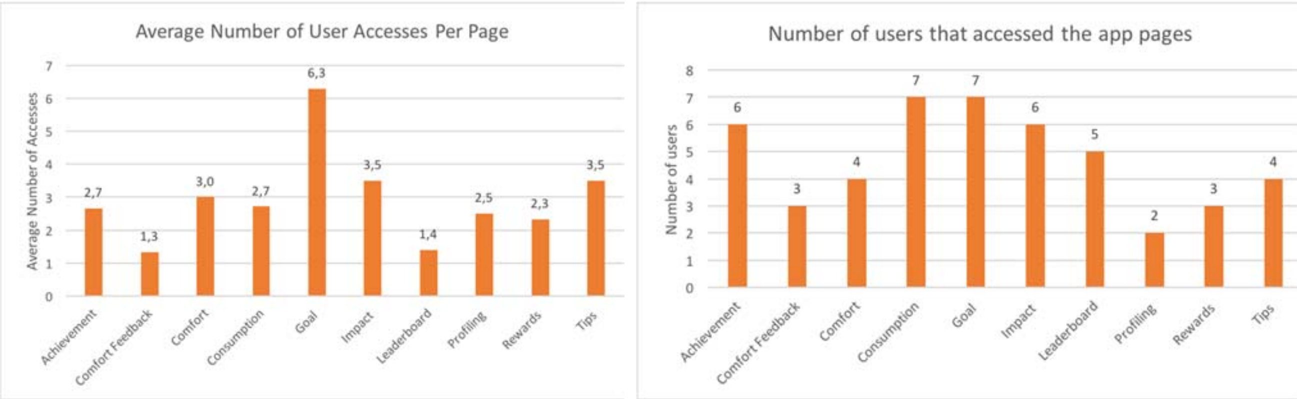


Figure 39:Number of logins by Greek Public Building users.

Page Access

Figure 40 shows which pages the users accessed in the application. Figure 40 (a) shows the average number of accesses per page during the reported period. From the graph, we can see that the users are engaging with all the main pages of the app. The pages that the public building users access the most are: the savings goal page with 6,3 average accesses, followed by the impact and tips pages with 3,5 average accesses. Figure 40 (b) shows the number of users who have accessed the pages during the reported period. We see that all users accessed the consumption page and the goal page as well as most of the users accessed the achievement, goal, impact and leaderboard pages.



(a) (b)

Figure 40: Access to the pages of the App for Public Building users. (a) Average number of user accesses per page. (b) The number of users that have accessed the pages at least once.

Tips

In October only two of the public building users read one tip each. The reasons for this low performance need to be investigated.

Notifications

In October 2018, the public building users in Greece did not open any notifications.

Badges

In October 2018 only two of the public building users in Greece received one badge (profiling novice).

3.2.3 German Pilot

In this subsection the user adoption and usage analysis for the German pilot is described.

3.2.3.1 Households

There are 93 users registered as household users in the German pilot.

Login

First, we present the total log in statistics and then we explore these per month for the household users in the German pilot in the reporting period between June and October 2018.

Figure 41 shows the total number of log-ins by all users, where the average of *the total number of logins is 45.2* with a standard deviation of 83.3 and a median of 17.5. All participating users have logged-in at least once. In this graph, we see that the number of log-ins per user is unevenly distributed. There are *7 (8%) us-*

ers who logged in 150 times or more, during the reporting period, who can be called “lead users” who are substantially more active than the majority of others (similar to the Swiss pilot).

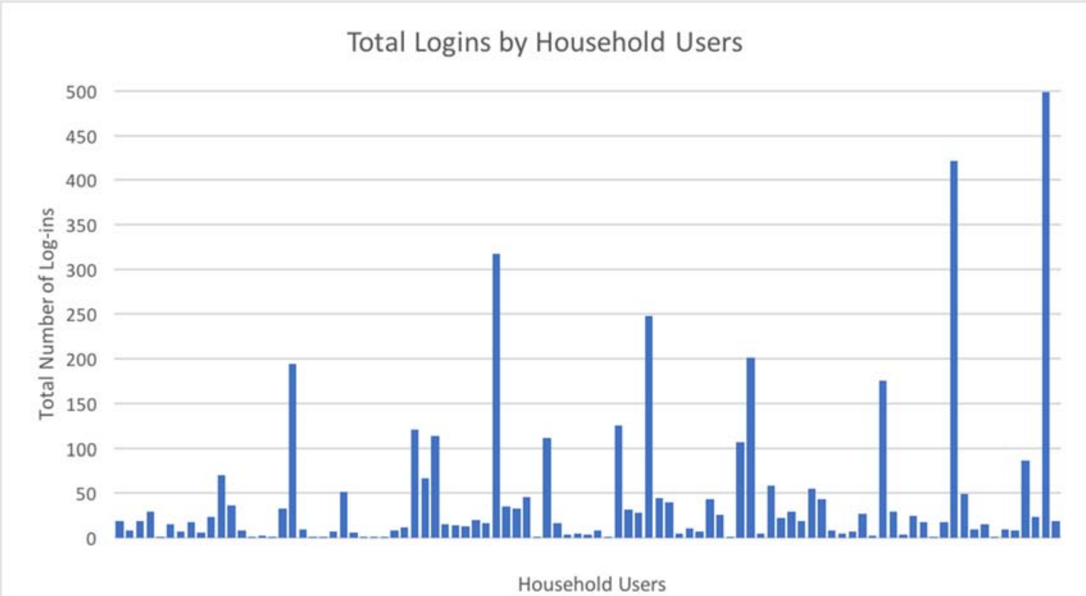
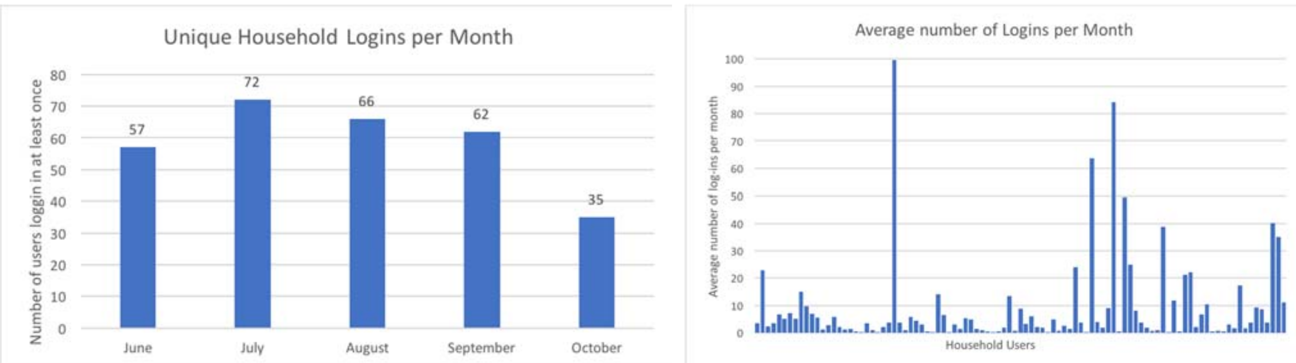


Figure 41: Total number of log-ins of German household users

Per month statistics of the frequency of user log-ins during the reporting period are displayed in Figure 42. First, in Figure 42 (a) is displayed the number of users logging in at least once to the application in each of the months during the reporting period. Out of the total 93 users registered for the pilot, the majority of the users are logging in at least once per month, with the highest number of unique log-ins in July 72 (*77% of the users*) and the lowest number of 57 (61%) unique log ins in June. Overall, the users in the German pilot have been logging in to the enCOMPASS app quite regularly during the reporting period. The lower values for June just indicate that the users needed a bit more time to start using the application.

Second, in Figure 42(b) the average number of logins per month is displayed. We see that the users *log in on average 8.8 times a month* with a standard deviation of 16.3. However, we can see that the 7 lead users, mentioned in the previous paragraph, logged in on average 30 times or more per month, which is much higher than the average. Overall, these usage patterns are quite common for the behavior change applications: we do not expect people to use them every day, but they should be used one or several times a week in order to help people adopt new behaviors.



(a) (b)

Figure 42: German households that have logged in per month in the App. (a) Shows how many unique users have logged-in in each month of the pilot so far. (b) The average number of logins per month per household

Page Visited

Figure 22 shows which pages the users accessed in the application. Figure 43 (a) shows the average number of accesses per page during the reported period. From the graph, we can see that the users are engaging with all the main pages of the app. The pages with the highest number of accesses are (in order of frequency of access): the *goal page with 43 average accesses*, the *achievement page with 36 average accesses*, and the *comfort page with 34 average accesses*. This result shows that the users are interested in setting and monitoring their energy savings goals, seeing how they performed and whether they could maintain their comfort while saving energy – thus allowing them to fulfil the main goals of the application. We can also see differences between the users when accessing the pages of the application: lead users accessing e.g. the *goal page over 200 times* during the course of the pilot. Interestingly, the users in the German pilot (20 average accesses) are not accessing the tips page as frequently as the users in the Swiss pilot (53 average accesses). We will try to shed some light on this result in the following sections. The pages with the lowest number of accesses are the profiling page and the rewards page, but as these pages are not essential to the functionality of the application, this result can be expected.

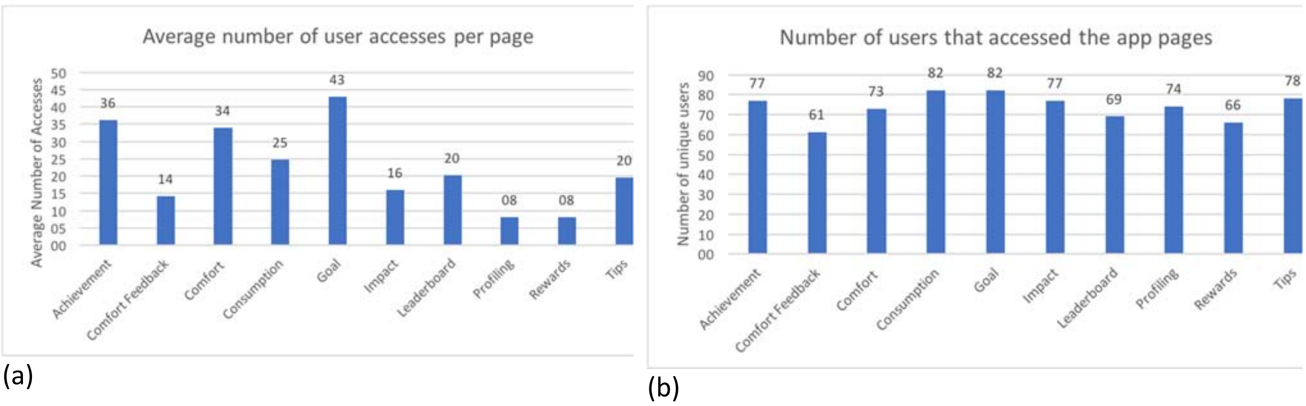


Figure 43: Pages accessed by German Household Users. (a) Average number of user accesses per page. (b) The number of users that have accessed the pages at least once.

Figure 43 (b) shows the number of users who have accessed the pages during the reported period to make sure that the page accesses reported in the previous paragraph are not done by a subset of active users. From the graph, we see that most users accessed all pages of the application, specifically: out of 93 users registered for the pilot, *82 (88%) users* accessed the goal page and the consumption page, *77 (83%)* accessed the achievement page, and *78 (84%)* accessed the tips page. In the previous paragraph we saw that the tips page is not as frequently accessed by German household users, however this graph reveals that they have been accessed by most of the users at least once. Even the profiling and the rewards pages – the least frequently visited pages of the application – were accessed by *74 (80%)* and *66 (71%)* of users, respectively. This shows that the majority of users have been able and interested to explore the main functionalities of the application.

Tips

Figure 44 displays the total number of tips read by household users in the German pilot during the reporting period. We see that the users read quite a lot of tips, specifically: *76 (82%)* users have read at least one tip. On average, users have read *63 tips*, with a standard deviation of 25.6. Here we see that the distribution is a bit more even as opposed to the frequency of use of the application and the page visits, showing the relatively high interest in reading tips among the users. We see that although the German household users visited the tips page less frequently on average, the average number of tips the users in the German pilot read is higher than in the Swiss pilot. This also indicates that users read more tips per session.

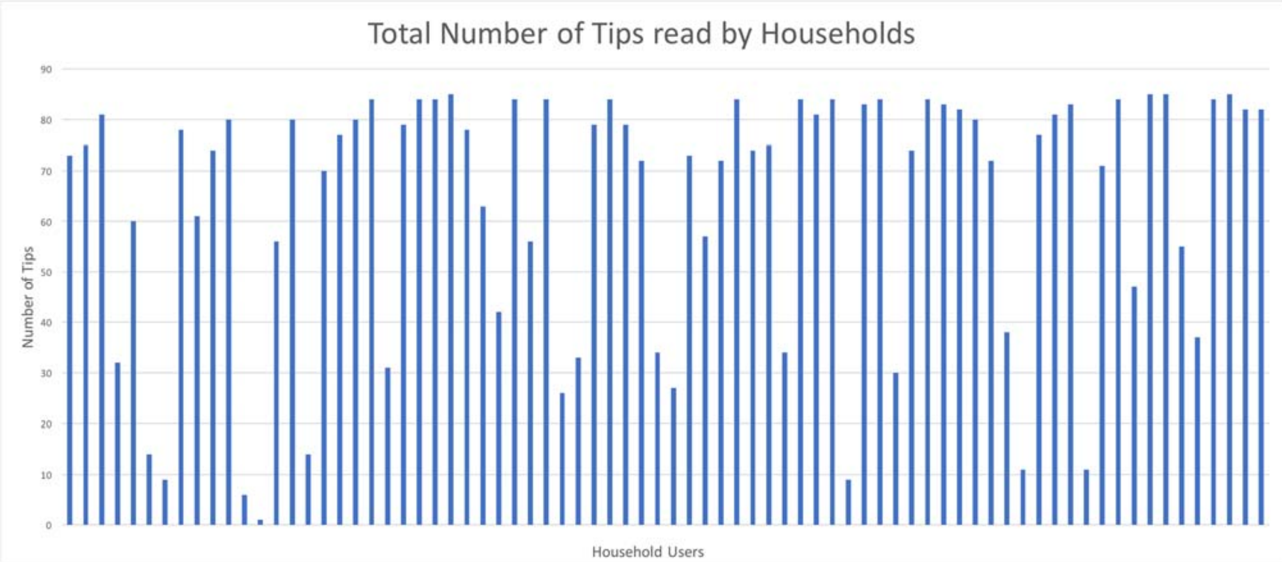


Figure 44: Total number of tips read by German Household users

Badges

Users receive badges as they collect points for the actions they perform in the application, such as accessing pages, reading tips, as well as in real life: such as saving energy. 92 (98%) users have received at least two badges. Figure 45 shows the number of badges awarded to the users: on average, the users were awarded with 4.9 badges. The distribution of the badges is quite even, with 83 (89%) users receiving between 2 and 7 badges, whereas the lead users receiving 10 badges or more.

The badges the users can receive are divided between 3 categories

- Learning
- Savings and
- Profiling.

Each is awarded for different actions in the app and real life. The badges allow the users to monitor how their knowledge and behavior with regards to energy saving is increasing. The distribution of the badges awarded in the application is depicted in Figure 46 which at the same time displays the number of users to whom these badges have been awarded, as a badge can be awarded to each user only once. What concerns learning badges (colored in yellow in the figure), most users or more specifically 59 (63%) have surpassed the level of trainee and 25 (27%) of the users are on the level of the apprentice. What concerns savings badges (colored green in the figure), most of the users, namely 79 (85%) have been awarded Starter energy saving badges and 62 (67%) of users – moderate energy savers, and even 35 (28%) of users reached the advanced stages in energy saving already. What concerns profiling, 86 (92%) of users are novices and 27 (29%) of users are engaged in this regard.

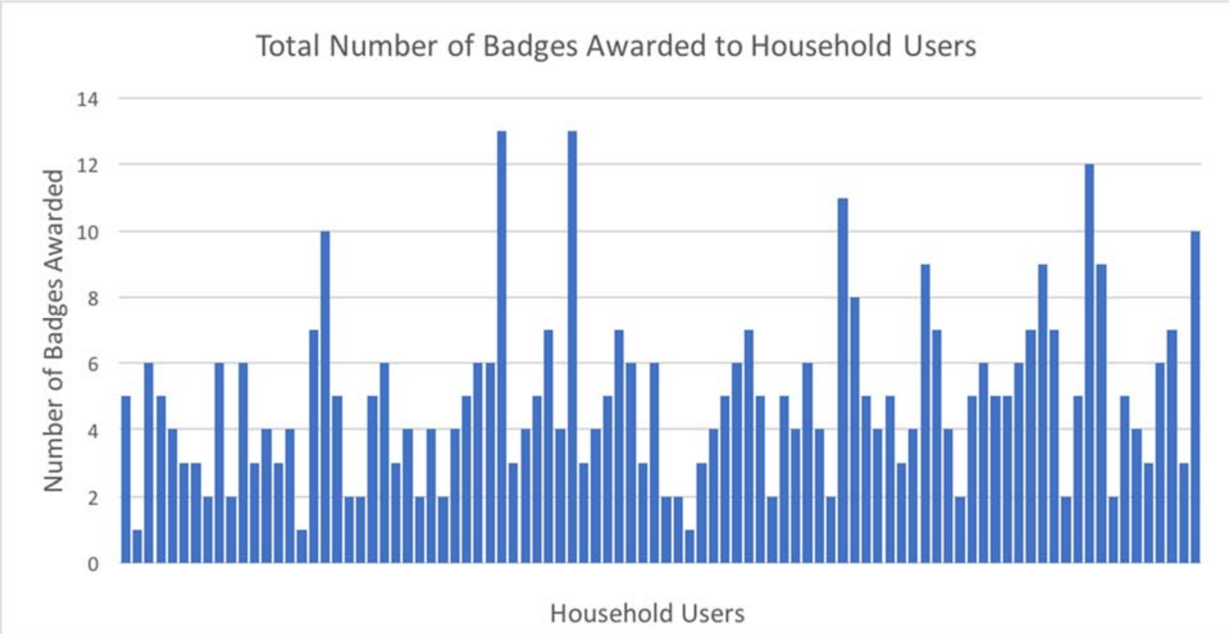


Figure 45: Total number of badges received by German household users

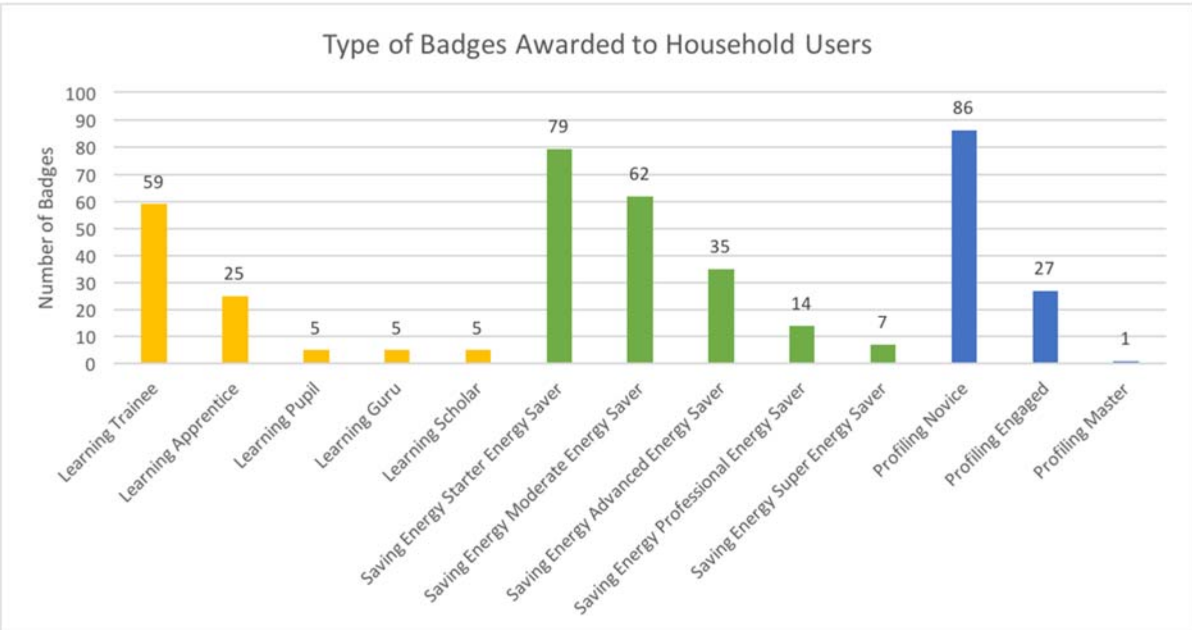


Figure 46: Type of Badges awarded to German Household users.

Notifications

In order to provide triggers to the users and remind them about using the application, the application sends out notifications about different actions that can be performed in the application. Once the users receive a notification, they can open it and it will redirect them to that part of the application which is mentioned in the notification. From the data we have, we see that only 31 (33%) users have opened at least one notification. Figure 47 displays the total number of notifications that these users opened (if they opened at least one). On average, the users have opened 3.4 notifications, with a standard deviation of 2.8. All users have notifications enabled for the application, so it is possible that even though they are not opening them, they might be still reading them.

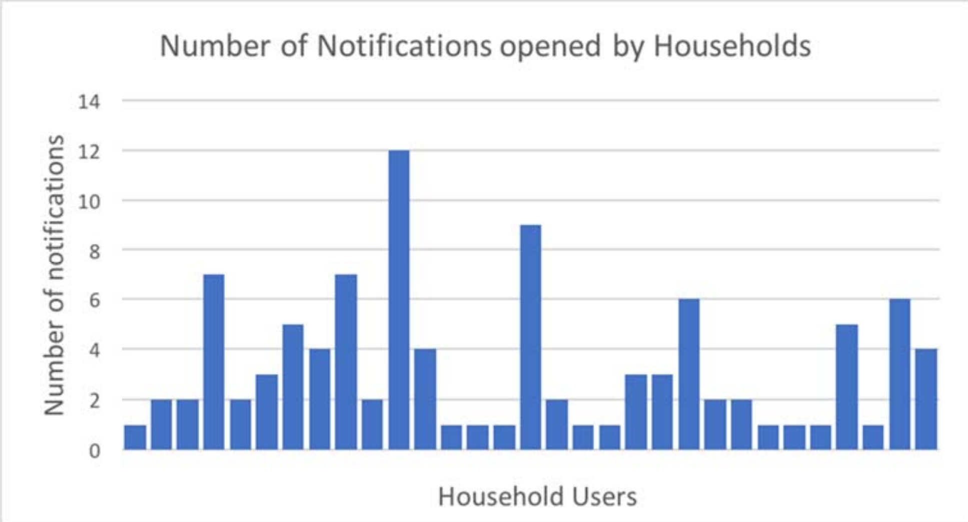


Figure 47: Total number of notifications the German household users opened (a subsample of those who have opened at least one)

3.2.3.2 Public Buildings

There are 3 teams for public buildings in the German pilot and each team consists of several members. The municipal building is on the first floor of Haßfurt's old city hall and the teams are organized according to the office separation, apart from the main part being a rather big open space, and therefore it has been split in two main areas. One area is West facing and it has been named the "Großraum 1" (in English: open space 1, number of members: 3). The other area is east facing and is has been named "Großraum 2" team (in English: open space 2, number of members: 3). The other team is called "Office 2" (number of members: 2) and located at the same floor. A detailed description can be found in D7.2. Therefore, the usage analysis and statistics presented below is done per team.

Login

Figure 48 displays the total number of log ins by public building users during the reporting period. We see that 2 out of 3 teams have logged in quite frequently to the enCOMPASS application, whereas team 3 has done considerably less so. Again, as in the Swiss pilot, we can explain this by the fact that some teams might have more motivation and more time to use the encompass application, whereas others might be constrained due to the nature of their work or other motivational factors.

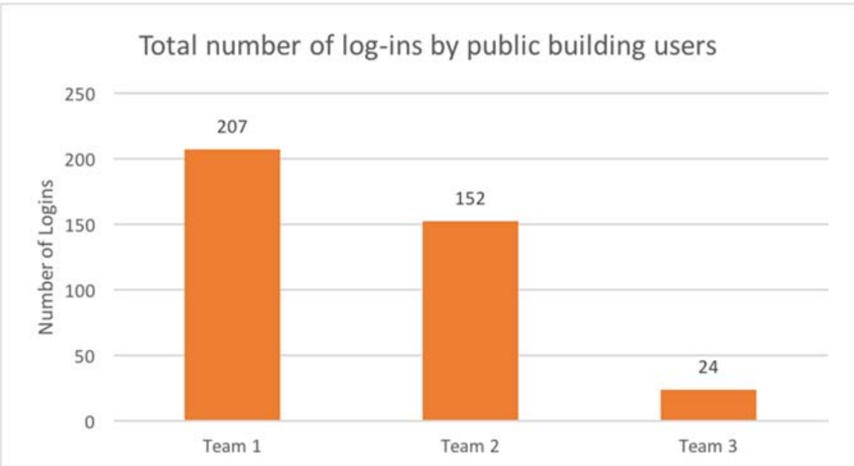


Figure 48: Number of logins by Swiss Public Building users.

Page Access

Figure 49 displays the average number of accesses per team of each page during the reported period. We can see that the pages that are accessed most are (in order of their frequency): comfort page with 44 average accesses and saving goal page with 34 accesses. Similarly, the household users, the public building users are mostly interested in setting and monitoring their energy saving goals, as well as viewing if they could maintain their comfort levels while saving energy. Compared to the Swiss public building users, the German users are less frequently accessing the achievements page. The pages with the lowest number of accesses by public buildings users are the profiling and the rewards. The distribution of page access among the teams is uneven: with the two more active teams accessing the pages more and the one less active team – less.

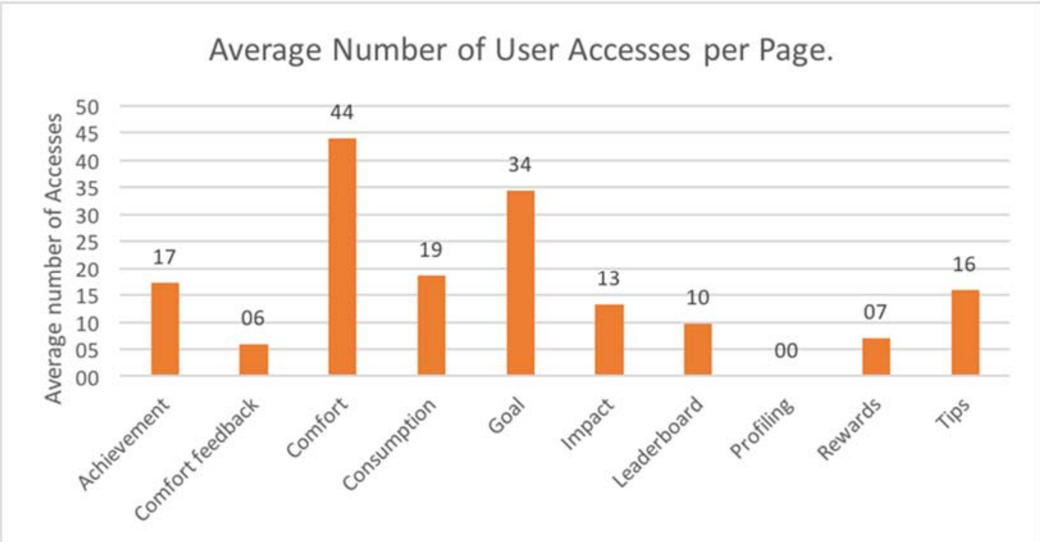


Figure 49: Average number of user accesses per page of the public building users

Tips

Figure 50 shows the number of tips read by the public building users. The users have read on average 30.6 tips, with team 1 being most active in reading tips, and team 3 – the least number of tips.

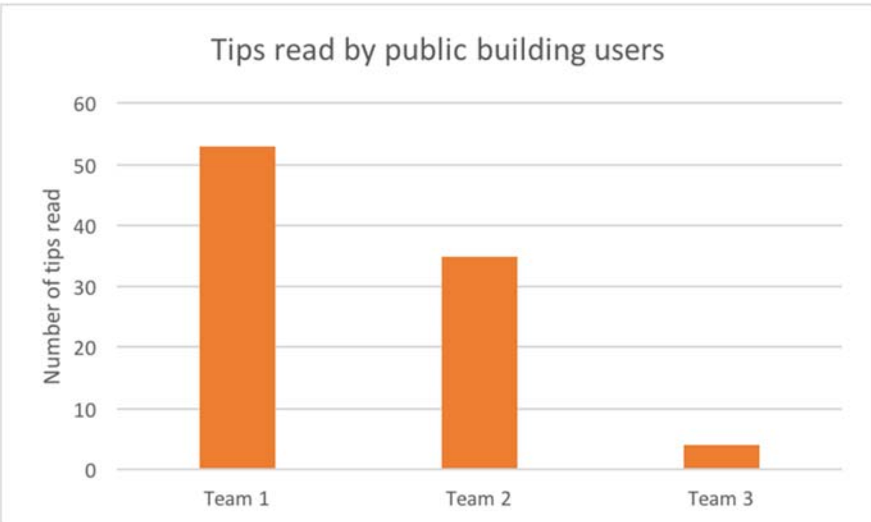


Figure 50: Total number of tips read by German public building users.

Badges

Figure 51 displays the number of badges awarded to the public building users. On average teams have received 4 badges, with a standard deviation of 1.3 badges.

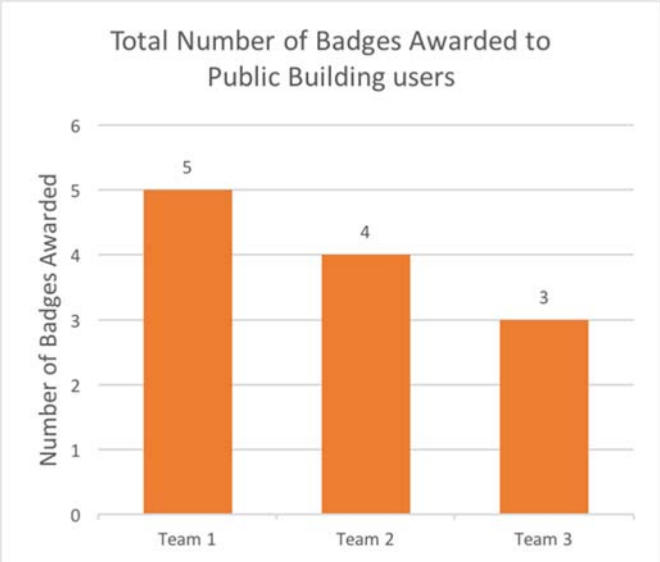


Figure 51: Number of badges awarded to German Public Building Users.

Figure 52 reveals the types of badges awarded to public building users. We see that all teams have received the Learning Trainee and the first two Energy Saving Badges, one team received also learning apprentice badge and two teams – profiling novice badges.

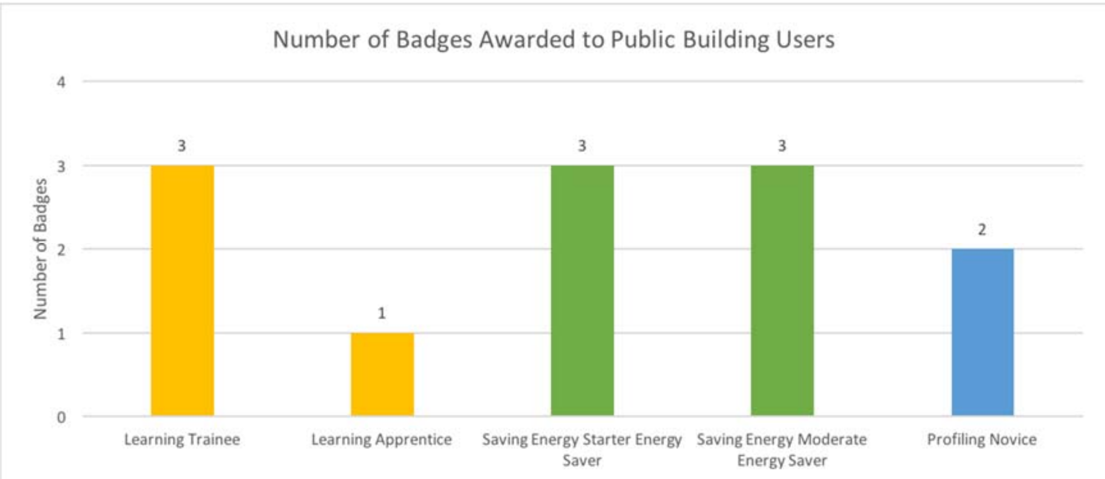


Figure 52: Types of badges awarded to German Public Building users.

Notifications

Only one notification has been opened by one Public Building User, therefore there is no more data to report here.

4 OUTCOME OF ENERGY SAVING ACTIONS: INTERIM EVALUATION

4.1 EVALUATION METHODOLOGY

The evaluation methodology has been described in detail in D7.1 and D7.2. The pilot baseline was presented and action plan was developed in D7.1 for all three pilots. According to that plan, we have first collected the baselines, recruited the intervention and the control groups, then installed the sensing equipment whereas the smart meters have been already installed, and finally the enCOMPASS App was launched.

The sample sizes and technical deployment plan were prepared for three pilot studies. The results from other work packages: D2.1, D2.2. D5.1 and D7.1 were used to prepare the D7.2 Validation methodology and action plan. The preliminary key performance indicators have been defined in D7.1 and refined in D7.2.

The design of the enCOMPASS validation approach was described in detail in the D7.2. This methodology is based on the eeMeasure methodology for the assessment of the impact on electricity consumption in schools, public buildings and households, and methodologies for assessment of the impact on awareness and user behaviour. Note that the control groups have been set up in the three pilots only for the households experiments, as for the schools and the public building the comparison will be made using a regression described in the eeMaasure methodology.

4.2 PRELIMINARY OUTCOMES OF ENERGY SAVING

We report a preliminary analysis of the energy savings achieved during the intervention period May-September 2018, in comparison to the baseline consumptions measured during the monitoring period May-September 2017.

Results are shown for households and public buildings, as the intervention period in schools starts in September 2018, for the Swiss and German pilots and in October 2018 for the Greek pilot.

4.2.1 Swiss Pilot

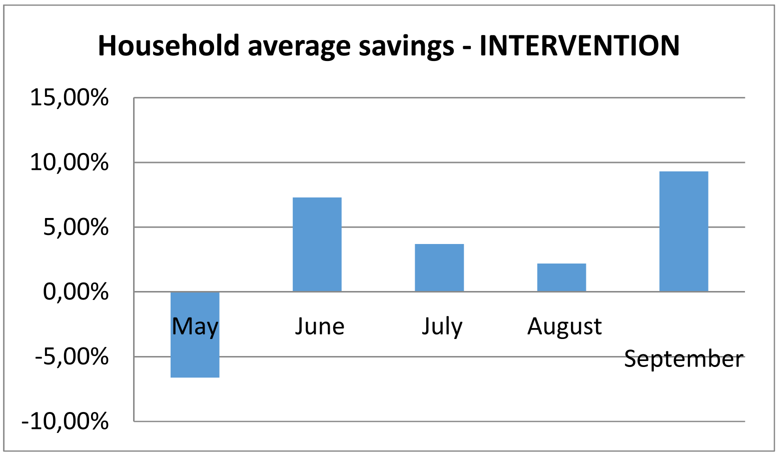


Figure 53: average energy savings in the Swiss pilot households (intervention group)

In Figure 53 we plot the average monthly savings achieved during the first five months of intervention, computed over a sample of 63 residential active users in Contone (3 users were excluded from the analysis due to missing or corrupted meter readings, other 9 users were excluded as they never logged-in nor used the enCOMPASS app). Though during the first month of intervention (May 2018) consumption raised by around 6%, in the next four months savings up to 9% have been observed.

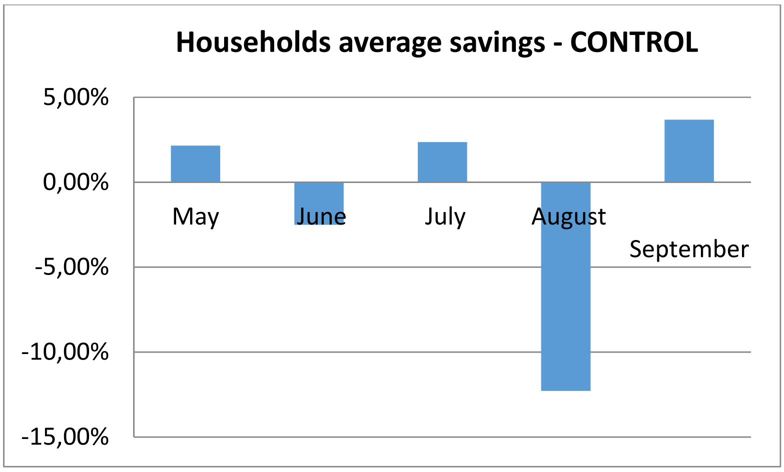


Figure 54: average energy savings in the Swiss pilot households (control group)

For the sake of completeness, in Figure 54 we plot the statistics computed over the control group composed by 45 households in Contone, not involved in the enCOMPASS activities. We notice that, starting from August, the savings achieved by the intervention group outperform those of the control group.

Moreover, in Table 6 we report aggregate consumption values, average and standard deviation values for both intervention and control groups.

Table 6: Energy consumption statistics in the Swiss pilot households

	Intervention group			control group		
	Total (kWh)	Average (kWh)	St. Dev.	Total (kWh)	Average (kWh)	St. Dev.
May 2017	25988.99	419.18	181.43	16354.34	481.01	342.70
June 2017	22179.51	357.73	179.85	12424.15	365.42	246.89
July 2017	22373.61	360.86	187.70	13121.87	385.94	251.48
August 2017	23200.47	374.20	190.58	11786.85	346.67	207.72
September 2017	26148.69	421.75	221.49	13806.92	406.09	289.55
May 2018	27708.83	446.92	343.86	16001.64	470.64	342.54
June 2018	20562.80	331.66	170.90	12736.14	374.59	257.75
July 2018	21545.93	347.51	173.62	12812.53	376.84	210.88
August 2018	22693.76	366.03	189.47	13235.26	389.27	244.64
September 2018	23714.17	382.49	206.95	13298.93	391.14	252.28

Figure 55 shows the consumption savings achieved in the municipality building of Gambarogno: here, remarkable savings were obtained during the first two months of intervention. However, these are unlikely to be due (for the most part) to behavioral changes in the office employees; moreover, the savings stop in June and in the next three months we observe an increase in consumption by up to 9% in the following three months. We cannot provide a clear explanation to this behaviour, and we have to investigate further with interviews with the building manager to understand whether some structural interventions on equipment were conducted with respect to the baseline.

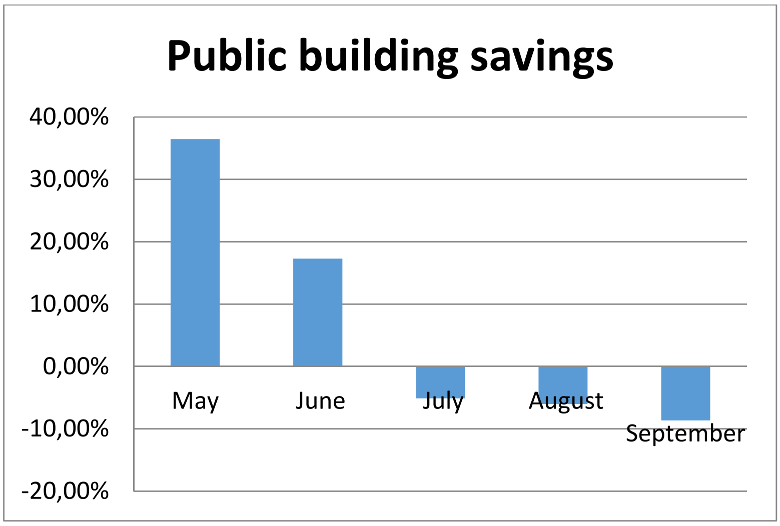


Figure 55: energy savings in the Swiss pilot public building

Moreover, in September 2018 the temperature in Gambarogno has been on average 18.8 C against 15.9 C in the same month in 2017. Given the rather high average temperature, we can assume that air conditioning might have played a role.

4.2.2 German Pilot

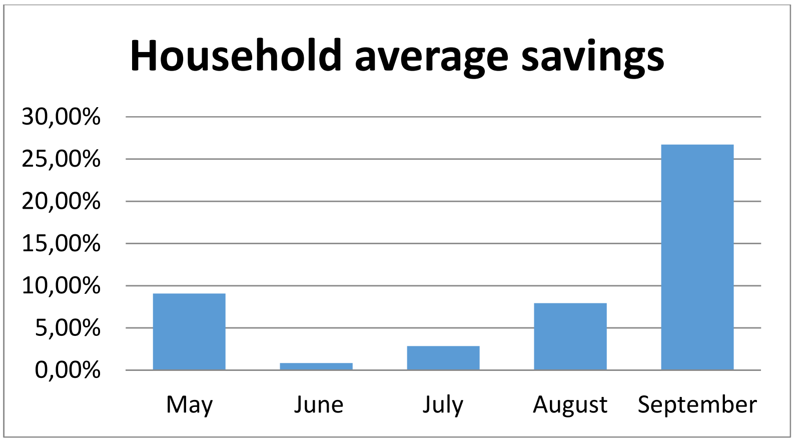


Figure 56: average energy savings in the German pilot households (intervention group)

Similarly to the analysis reported in the previous paragraph, Figure 56 plots the average monthly savings achieved during the first four months of intervention, computed over a sample of 79 active residential users in Hassfurt (in this case, 15 users were excluded from the analysis due to missing or corrupted meter readings and 18 additional users were excluded due to their total inactivity on the enCOMPASS app). In the first four months (May, July and August) savings up to 9% have been observed. September 2018 showed a remarkable consumption reduction (25%), motivated by the mild climate w.r.t. September 2017 (average external temperature in September 2018 was 18°C, whereas in September 2017 it was 15°C[13]).

In Figure 57 we also report the energy savings measured over the control group. It is compound by 21 households in Hassfurt, not involved in the enCOMPASS activities. For the analysis 17 households were ex-

[13] Source: https://www.worldweatheronline.com/hassfurt-weather-averages/bayern/de.aspx

cluded, because of lacking data quality. We notice that, starting from the beginning, the intervention group achieved savings every month. The control group shows an alternating behavior with respect to variations of energy consumption with respect to their baseline. In conclusion, the savings and the increasing in consumption cancel out, and, as expected, the control group does not show a definite trend in their behavioral change, apart from an increased consumption in August, which was rather warm. The small deviation in July might also be attributed to the fact that it is a typical holiday month in Germany, and therefore many users were only partially at home.

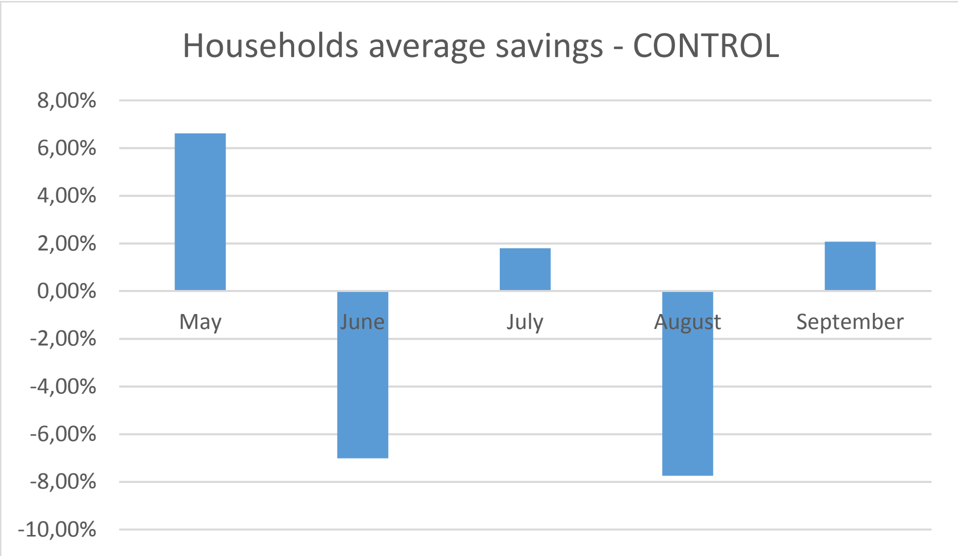


Figure 57: average energy consumption savings in the German pilot households (control group)

Again, in Table 6 we also report aggregate consumption values, average and standard deviation values for both intervention and control groups.

Table 7: Energy consumption statistics in the German pilot households

	Intervention group			control group		
	Total (kWh)	Average (kWh)	St. Dev.	Total (kWh)	Average (kWh)	St. Dev.
May 2017	19975.79	252.86	135.41	4741,31	225,78	103,74
June 2017	17586.79	222.62	126.53	4193,60	199,70	107,19
July 2017	18777.41	237.69	127.17	4731,60	225,31	100,94
August 2017	18461.13	233.69	126.60	4747,51	226,07	97,02
September 2017	19520.78	247.10	137.69	5004,41	238,31	119,04
May 2018	18163.43	229.92	112.02	4427,55	210,84	99,57
June 2018	17441.43	220.78	111.30	4487,83	213,71	106,67
July 2018	18244.32	230.94	114.91	4646,68	221,27	114,36
August 2018	16995.53	215.13	115.15	5115,33	243,59	116,81
September 2018	14307.81	181.11	91.74	4900,72	233,37	87,86

Figure 55 shows the consumption savings achieved in the public building of Hassfurt: savings were obtained during the first two months of intervention, whereas a slight increase appeared during July and August. September again exhibits a sharp consumption reduction motivated, as for the case of households, by the mild climate.

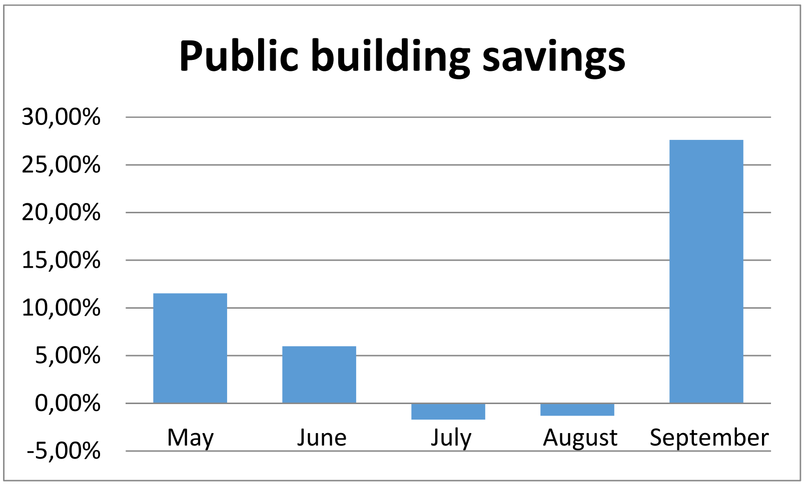


Figure 58: energy consumption savings in the German pilot public building

4.3 User Awareness Feedback from Baseline Questionnaire

4.3.1 Methodology

A questionnaire has been constructed that is comprised of the measurement instruments that have been outlined in *D7.2 Validation methodology and pilot action plan*.

A 10-minute effort was deemed the maximum amount of time users would be willing to invest in filling out the questionnaire. With this limitation in mind, the following constructs were selected as composite measures of awareness, which cover the KPI's outlined in the DoA and D7.2:

- Personal norms (derived from the Norm Activiation Model, Schwartz, 1977; 5 items derived from Steg et al., 2005; e.g. 'I feel morally obliged to save energy')
- Ascription of responsibility (derived from the Norm Activiation Model, Schwartz, 1977; 5 items derived from Steg et al., 2005; 'I feel jointly responsible for the exhaustion of energy sources ')
- Perceived behavioral control (3 items derived from [1]; e.g. 'I believe that I'm able to avoid all necessary electricity consumption in my home').
- Behavioral intention to save energy (3 items formulated cf. Theory of Planned Behavior, [2]; e.g. 'I plan to save a substantial amount of energy in the next 3 months')
- Self-reported knowledge of energy saving actions (5 items; e.g. 'I know how much energy my lamps consume')

Apart from these measures, the following data were collected as covariates for the analyses:

- Basic demographics (e.g. gender, age group, educational level, job category)
- Household composition (e.g. no. of adults, kids)
- Job category (as proxy for income)
- The user's biospheric (e.g. preserving nature), egoistic (e.g. wealth), hedonic (e.g. gratification for oneself), and altruistic values (e.g. helpful). Values were measured with 12 items derived from [3].
- Social comparison orientation (4 items derived from [4]; e.g. 'If I want to find out how well I have done something, I compare what I have done with how others have done')

Instruments are composed of multiple items, using Likert scales, or semantic differentials. Both household members and employees in public buildings have filled out the questionnaire.

The questionnaire for public buildings was adjusted to its context,

- ‘At work’ was added to the items on ascription of responsibility, and perceived behavioral control.
- The appliances that were assessed with the ‘knowledge about energy saving actions’ items were adjusted to the work setting (e.g. laptops, air conditioning, heating, lights).
- Subjective norm items were added, to assess the influence of superiors, co-workers and people in the private life on the intention to save energy, following Lo et al. (2014).

4.3.2 Data quality

First, internal consistency of the used scales was assessed using the Cronbach’s alpha model. Results are displayed in Table 8.

Table 8. Internal consistency of awareness scales.

Construct	α
Norm activation model	
Ascription of responsibility	.90
Personal norms	.88
Perceived behavioral control	.80
Behavioral intention	.93
Social orientation	.84
Energy knowledge	.93
Values	
Egoistic*Values*	.78
AltruisticEgoistic	.87.78
BiosphericAltruistic	.96.87
HedonicBiospheric	.93.96
Hedonic	.93

The alpha levels demonstrate good internal consistency between the items, suggesting that the translation of the standardized questionnaire items into the different languages of the pilot has not disrupted the coherence of the scales.

4.3.3 German pilot

4.3.3.1 Households

In Table 9 the number of questionnaire respondents is displayed for the control group and for the treatment group (i.e. enCOMPASS users), showing that in total 121 participants responded to the baseline questionnaire in the German pilot

Table 9. Baseline questionnaire respondents.

Condition	**No. of participants**
Control group	31

Treatment group (en-COMPASS)	90
Total	121

The age distribution is displayed in Figure 59.

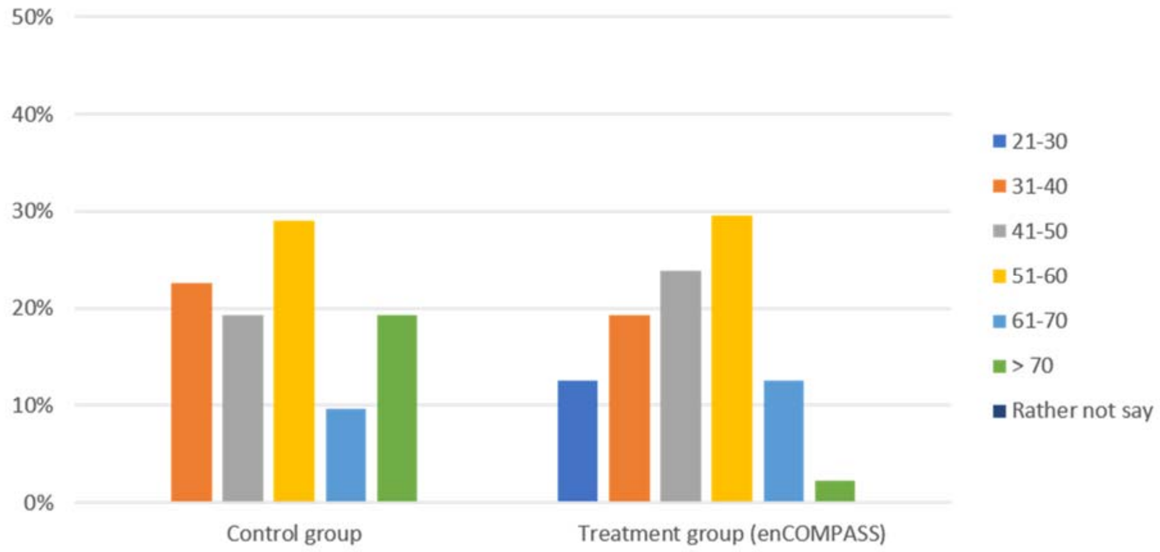


Figure 59. Age distribution (Germany).

The results demonstrate that the age group from 51-60 is most present in the sample, followed by users between 41 and 50. In contrast, a relatively small share of participants is younger than 30 years of age.

The distribution of gender indicates that more men than women participated in the questionnaire, as can be seen from Figure 60.

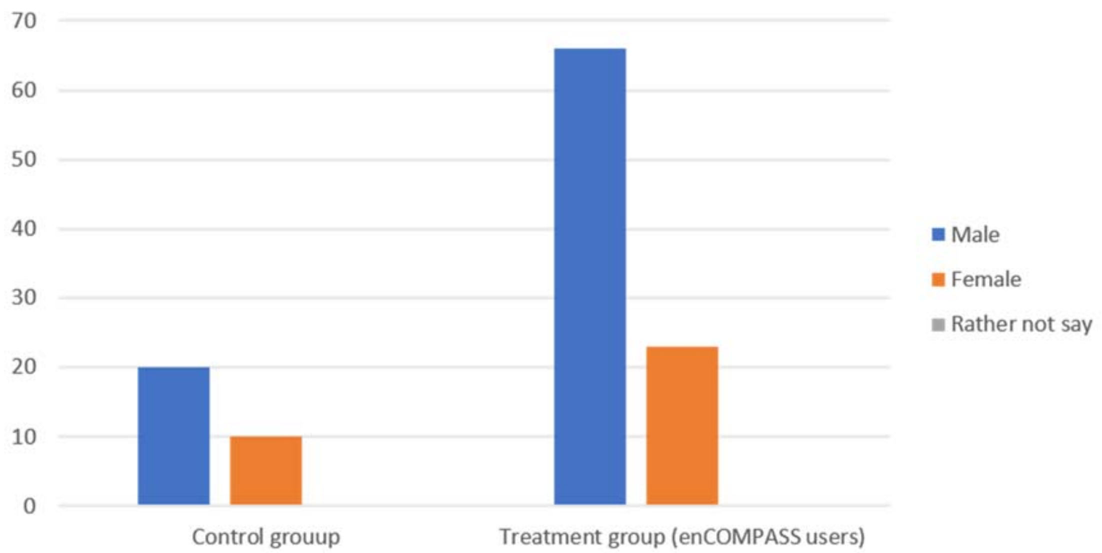


Figure 60. Gender distribution (Germany).

As a first step in our analysis, we assessed the values of the participants in both the control group and the treatment group, using Steg et al. (2014)'s instrument, which distinguishes between hedonic, biospheric, altruistic and egoistic values. Values were measured on a nine-point scale, ranging from ‘opposed to your principles’ (1) to ‘of supreme importance’ (9). Results are depicted in Figure 61.

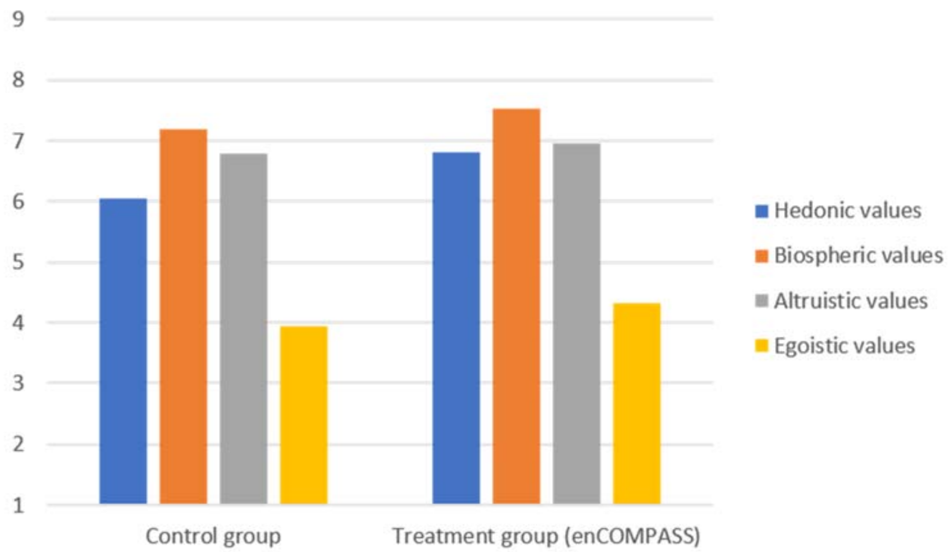


Figure 61. Results regarding the respondents’ values (German pilot).

The results show that the values are relatively comparable between both conditions, save from the hedonic values. Participants in the treatment group have significantly stronger hedonic values than participants in the control group (t(50,74)=-2.38; p=.02). For the other values, differences between conditions were not significant (-1.60 < t(118) < -1.08).

The results for social comparison orientation (Gibbons & Buunk, 1999) were assessed, comparing the control group against the treatment group with enCOMPASS users. Results are depicted in Figure 62.

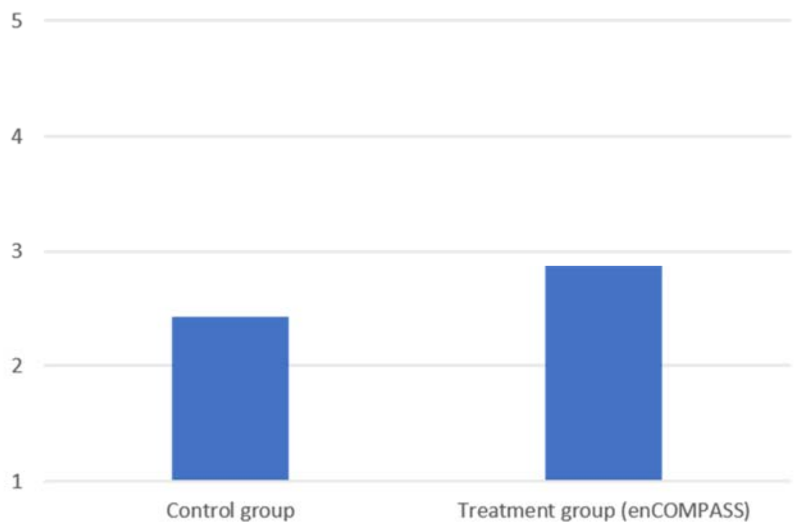


Figure 62. Social comparison orientation (German pilot).

Results demonstrate that users in the treatment group deem the opinion of significant others as slightly more important than users in the control group. This difference was significant (t(116)=-2.83; p=.005).

Subsequently we assessed the predictors of energy saving. In Figure 63 ascription of responsibility and the participants' knowledge of energy consumption are displayed, while in Figure 64 the personal norms, perceived behavioral control, and behavioral intention are shown.

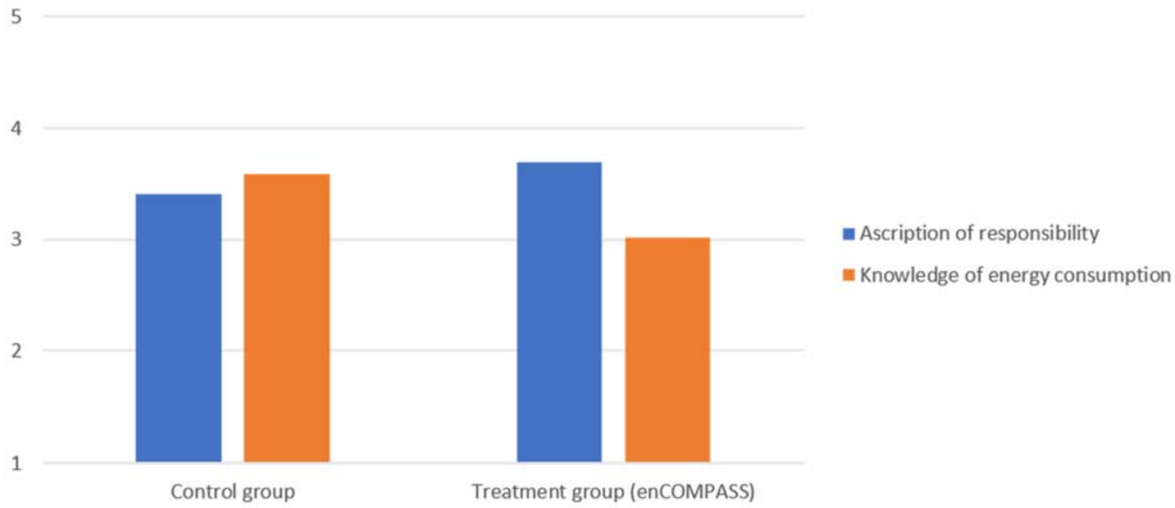


Figure 63. Ascription of responsibility and knowledge about energy (Germany)

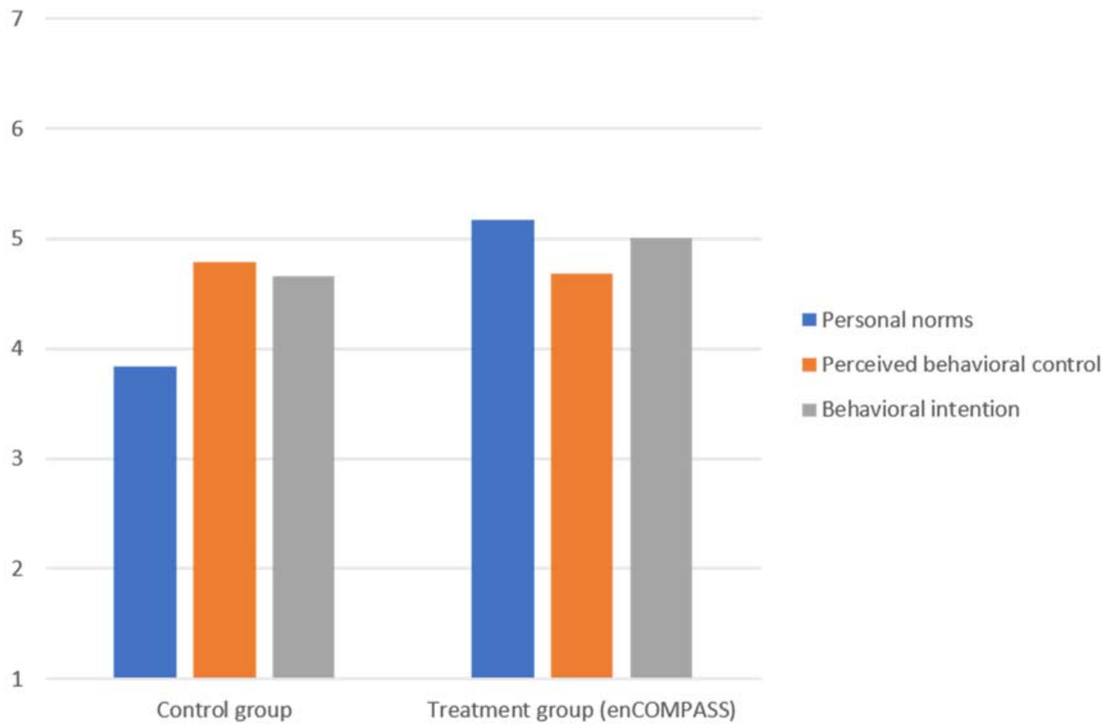


Figure 64. Personal norms, perceived behavioral control, and behavioral intention.

The moderate average values on the awareness measures suggest that the use of enCOMPASS could potentially increase their values. Such a more fine-grained measurement of awareness using well-known measures from environmental psychology enables a detailed assessment of the impact of enCOMPASS on specific determinants of energy consumption behavior.

Independent samples t-tests were run to assess if there are systematic differences between the control group and the treatment group. No such differences were found regarding ascription of responsibility ($t(119)=-1.47$; $p=.15$), perceived behavioral control ($t(119)=.49$; $p=.63$), and behavioral intention to save energy (t(118)=-1.58; p=.12). In contrast, personal norms (t(86.48)=-9.25; p=.000) were higher and behavioral intention was stronger (t(118)=-1.58; p=.12) for participants in the treatment group than in the control group.

4.3.3.2 Public buildings

8 participants responded to the baseline questionnaire concerning the public buildings in the German pilot. These are all the participants taking part in the pilot in the public building in Germany. As is evident from Figure 65 unlike the other German samples, this sample contained more women than men.

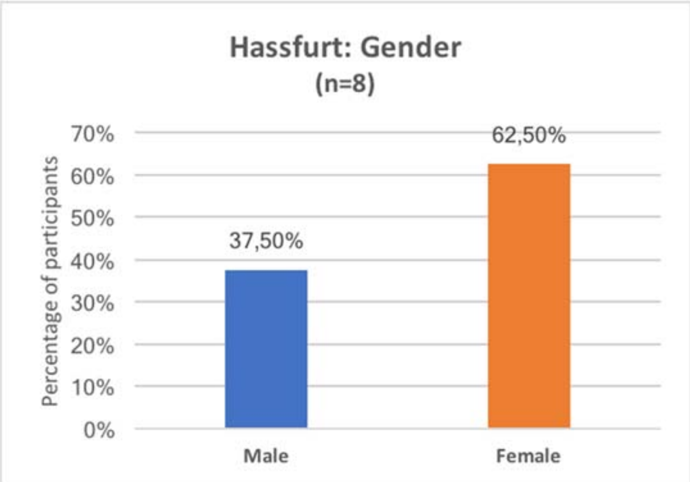


Figure 65 Distribution of gender for public buildings participants (Germany, n=8)

As Figure 66 shows, the majority of participants chose not to disclose their educational level. One quarter of the respondents stated that their highest level of education was post-secondary non-college education, a smaller number of the group had completed upper secondary education. None of the participants in the sample reported to have a University degree (Bachelor's, Master's, Doctoral or equivalent level).

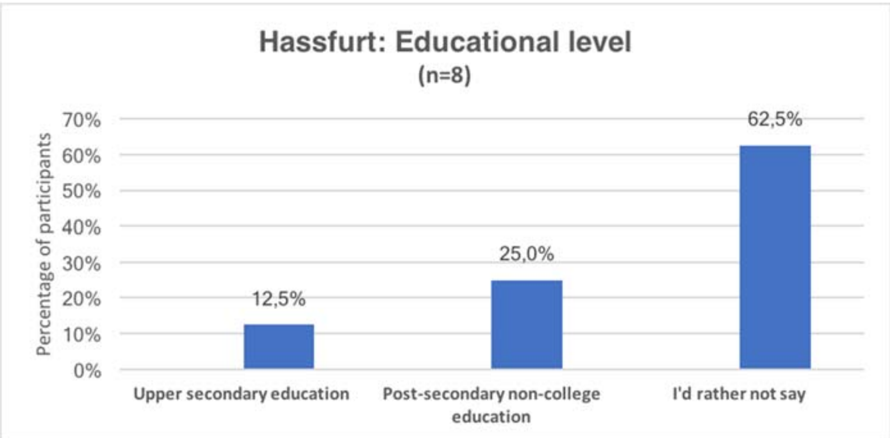


Figure 66 Distribution of educational level for public buildings participants (Germany, n=8)

Figure 67 demonstrates that the age group from 31-40 is most present in the sample, followed by users between 41 and 50. One quarter of the participants is older than 50 years. In contrast, a relatively small share of participants is younger than 20 years of age and there were no participants in the age group from 21-30 years.

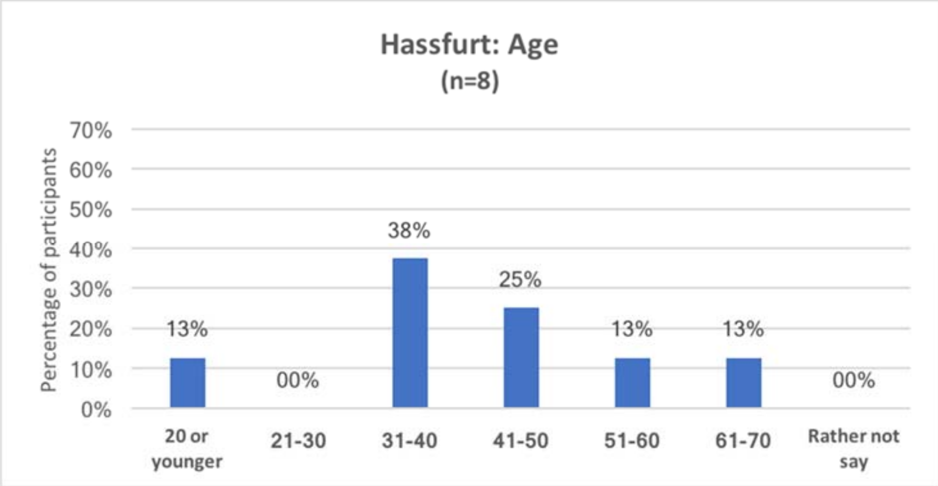


Figure 67 Distribution of age for public buildings participants (Germany, n=8)

As shown in Figure 68, respondents feel moderately responsible to save energy (3,6 average on a 1-5 point Likert scale, with answer options ranging from 'fully disagree' (1) to 'fully agree' (5)). At the same time, the knowledge of energy consumption is very low with 2,36 average on the 1-5 scale, which is clearly below the neutral point of 3. This is an interesting finding which provides a good starting point for the use of our behavioural change application the main aim of which is to allow users to increase their knowledge about energy saving.

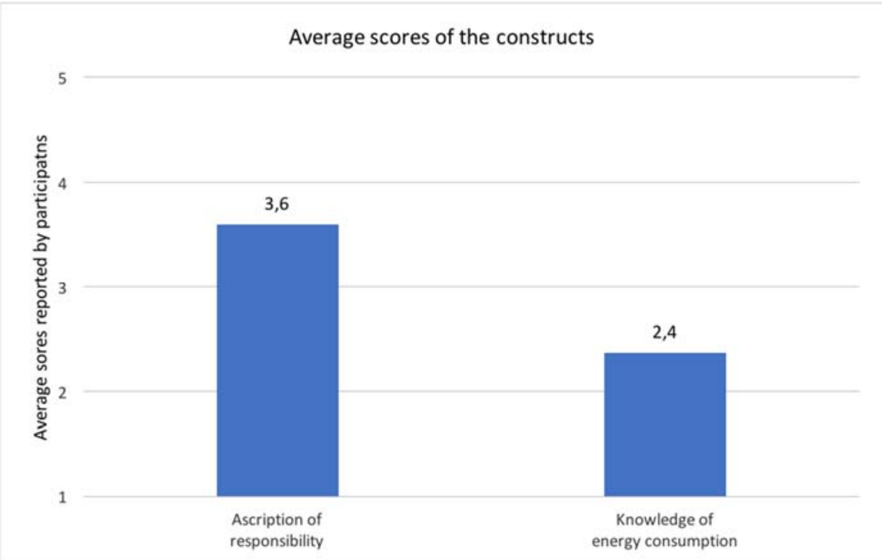


Figure 68. Ascription of responsibility and knowledge of energy consumption (Germany, n=8).

Figure 69 displays the results of the participants' average scores on perceived behavioural control, personal norms, subjective norm, and behavioural intention. The results indicate that public building users in the German pilot feel morally obliged to save energy (personal norms) to a moderate degree with a score of 4,8 on a 1-7 scale, they are not really confident about whether they are able to do so (perceived behavioural control) with a score of 2,9 on the 1-7 scale, and have a moderate intention to save energy (behavioural intention) with a score of 4,6 on a 1-7 scale. This is an interesting finding as it reveals that although people feel that they should save energy, they do not believe in their abilities to do so. As such, the enCOMPASS application is a good starting point to allow them to change their attitudes and behaviours as it provides them with tips on how to actually save energy.

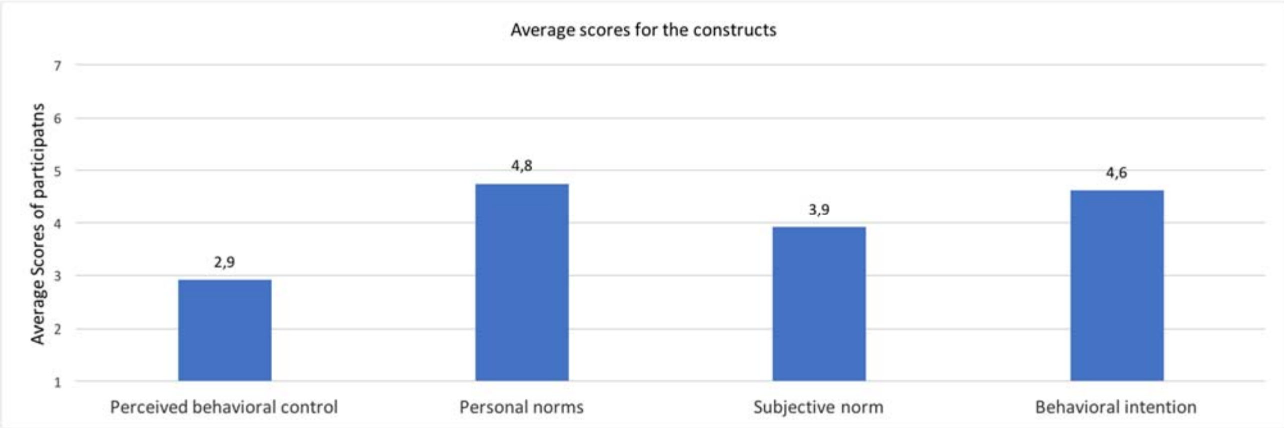


Figure 69. Perceived behavioural control, personal norms, subjective norm and behavioural intention (German public buildings pilot).

Considerable variation has been found with regard to the subjective norm: the influence of superiors, co-workers, and people in the employees' private life. On average, the respondents felt moderately under the influence of their social circle with a score of 3.9 on the 1-7 scale. The standard deviation was very high at 1.9. This is due to the fact that some of the respondents indicated very high agreement with all the statements tested in the construct, while others indicated consistently low agreement to the items tested. This shows that respondents either seem to perceive a very strong social expectation in their private as well as professional life to save energy or they perceive very little pressure by their work and family environment to do so.

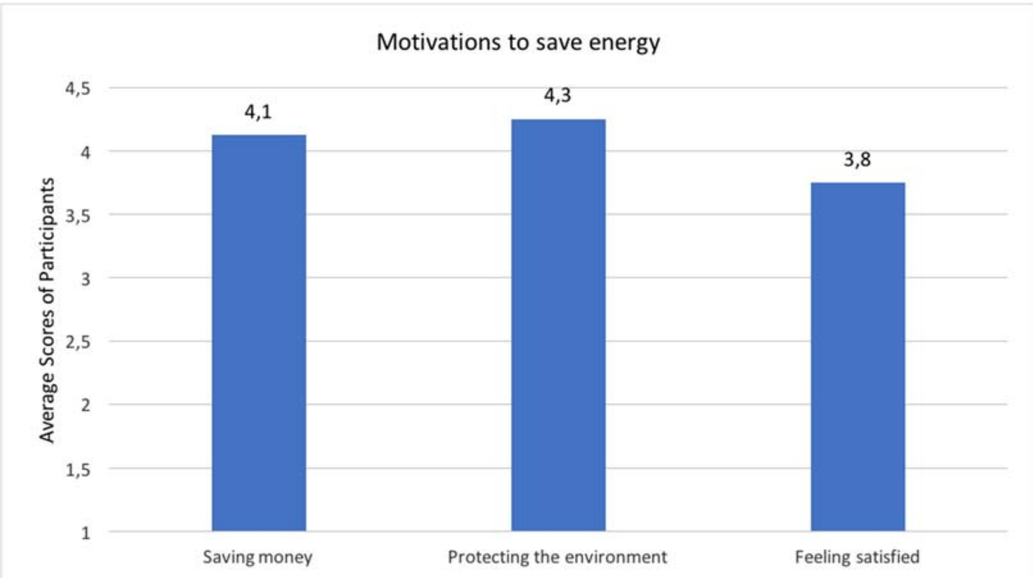


Figure 70. Motivation to save energy (German public buildings pilot).

When it comes to the values that motivate the German public building respondents to save energy, as Figure 70 shows, protecting the environment is the strongest motivator, closely followed by saving money. The construct was measured with a 1-5 point Likert scale, with 1 = "very unimportant" and 5 = "very important". The averages for both items are clearly above 4, which shows the high importance that is given to both values in general. Feeling satisfied was still relatively important to the respondents, but with an average below 4, it was clearly less important than the other two.

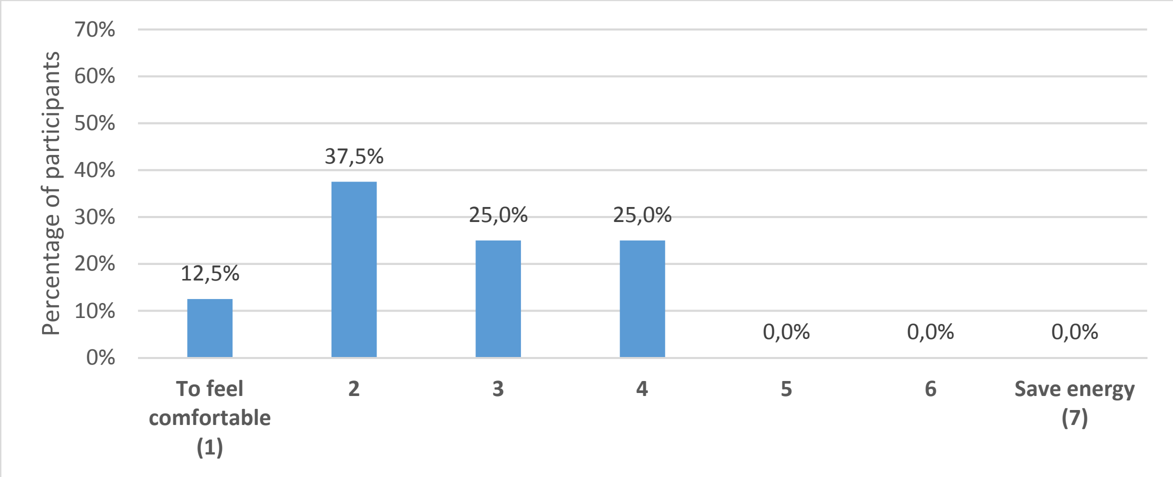


Figure 71. Trade-off between comfort and energy saving (German public buildings pilot).

Despite the high value that is being placed on protecting the environment and saving money, Figure 71 shows that comfort is still the decisive factor when it comes to the trade-off between feeling comfortable and saving energy. The overall average of 2,6 clearly highlights this inclination. Three quarters of the respondents indicated a strong to moderate tendency towards "feeling comfortable", which means that for the majority of the respondents saving energy comes secondary to their comfort. None of the respondents indicated a number higher than 5, which would have indicated that the respondent would have been willing to be less comfortable for the sake of saving energy.

4.3.4 Swiss pilot

4.3.4.1 Households

As Table 10 shows, in the Swiss pilot 101 participants filled out the baseline questionnaire, of which 56 in the treatment group and 45 in the control group.

Table 10. Baseline questionnaire respondents in the Swiss pilot.

Condition	Swiss pilot
Control group	45
Treatment group (enCOMPASS)	56
Total	101

In Figure 72, the age distribution is displayed for the Swiss pilot. The distribution is comparable to the German pilot, save from a smaller representation of the age group between 51-60 in the treatment group. Similar to the German pilot, in the Swiss pilot the share of participants below the age of 30 is relatively low. In contrast, the majority of the participants are between the age of 41 and 60.

In Figure 73, the gender distribution is displayed for the Swiss pilot. Similar to the German pilot, these results show that more men than women participate in the pilot.

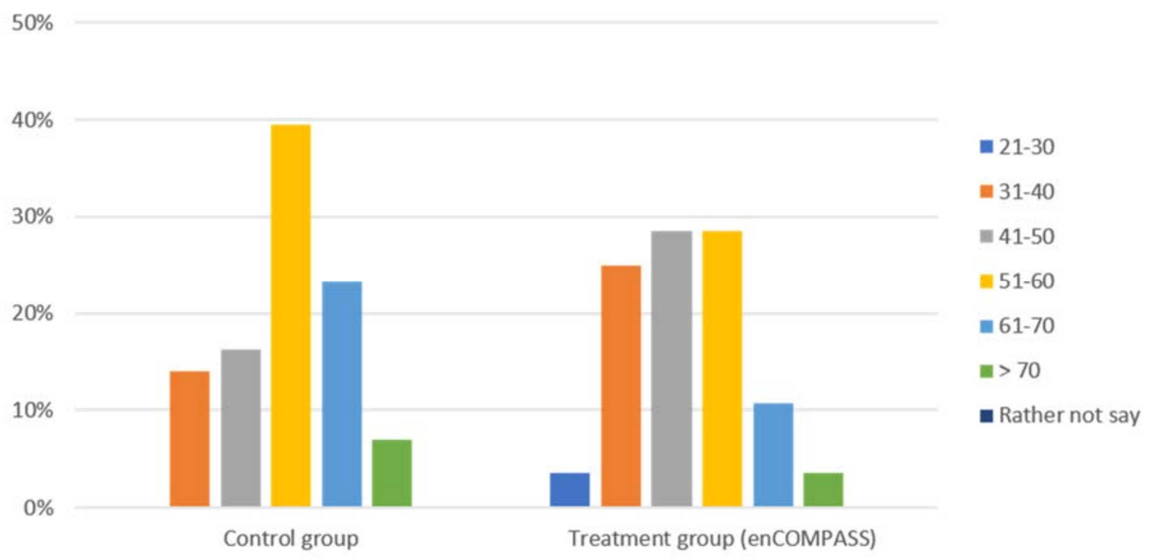


Figure 72. Age distribution (Switzerland).

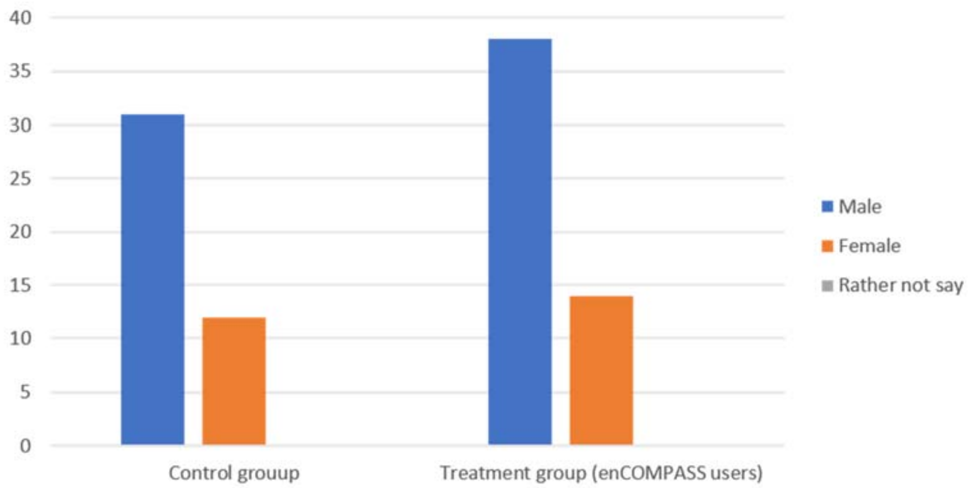


Figure 73. Distribution of gender (Switzerland).

Next, we assessed the participants' hedonic, biospheric, egoistic, and altruistic values. The results are displayed in Figure 74. A score of 1 indicates that the value is opposed to one value, whereas a value of 9 denotes that the value is of supreme importance for the respondent.

Independent samples t-tests show that the bioshperic values are significantly stronger in the control group and the treatment group (t(24.09)=2.63; p=.02), while for the other types of values there were no systematic differences between the treatment and control group (-.45 > t(63) > 1.04; n.s.).

In Figure 75, social comparison orientation is displayed. Items were measured on a five-point Likert scale. No significant differences were found between the control group and the treatment group (t(98)=.12; p=.90), suggesting that participants in the control group were equally inclined to compare themselves with significant others than participants in the treatment group.

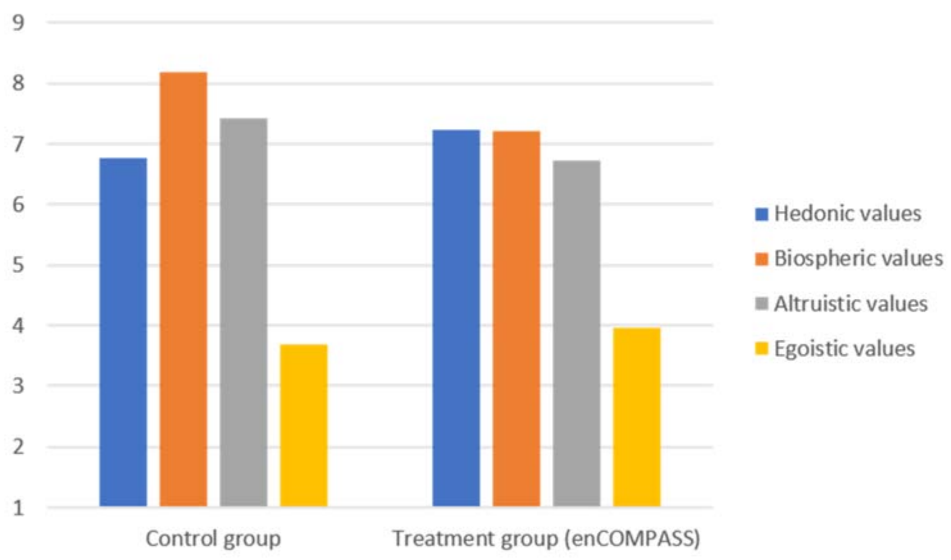


Figure 74. Results regarding the respondents' values (Swiss pilot)

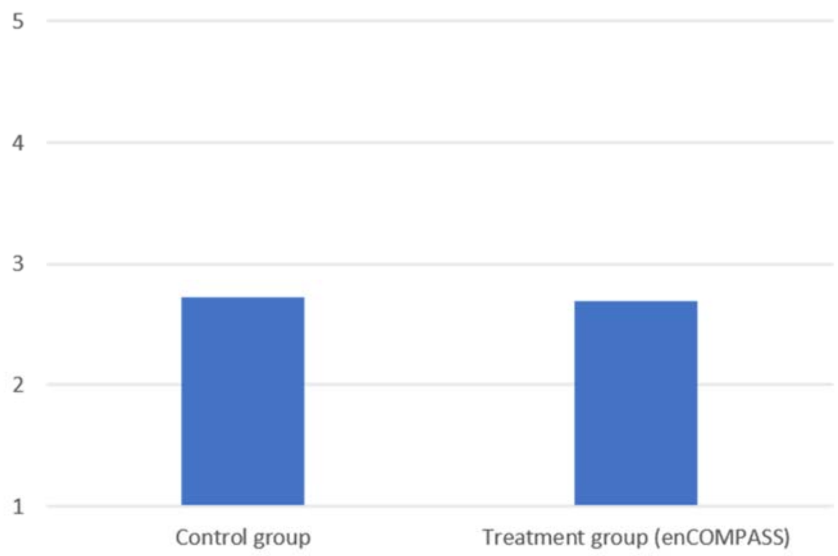


Figure 75. Social comparison orientation (Switzerland)

Figure 76 and Figure 77 display the results for the behavioral predictors of energy saving. The results show similar, moderate values across all measures. No differences were found between the control group and the enCOMPASS users for ascription of responsibility (t(99)=.49; p=.62), personal norms (t(98)=1.49; p=.14), and behavioral intention (t(99)=-1.51; p=.14). In contrast, knowledge about energy consumption (t(93)=3.41;p=.001) and perceived behavioral control (t(99)=3.33; p=.001) were significantly higher for the control group.

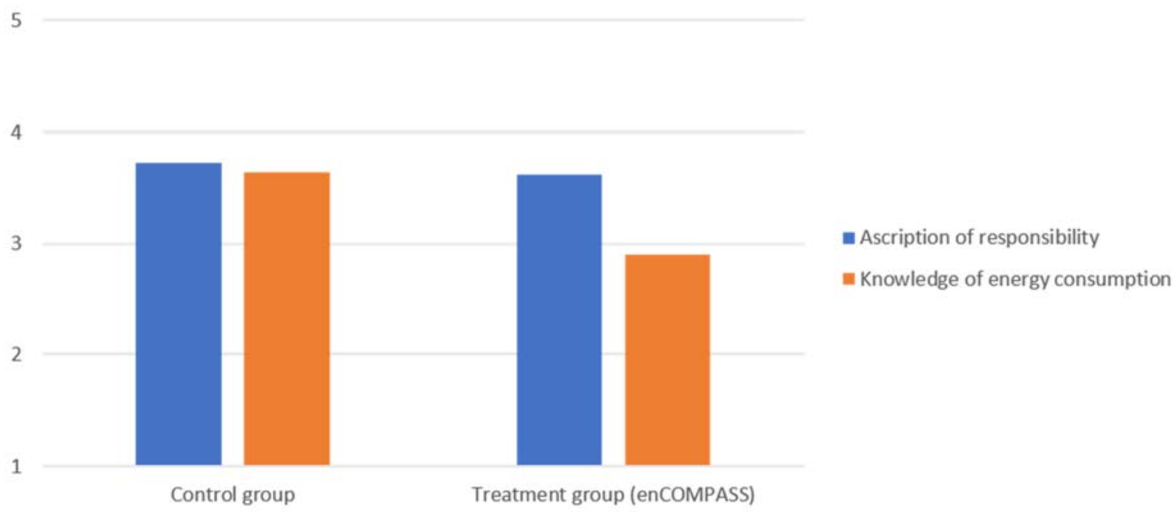


Figure 76. Ascription of responsibility and knowledge of energy consumption (Switzerland).

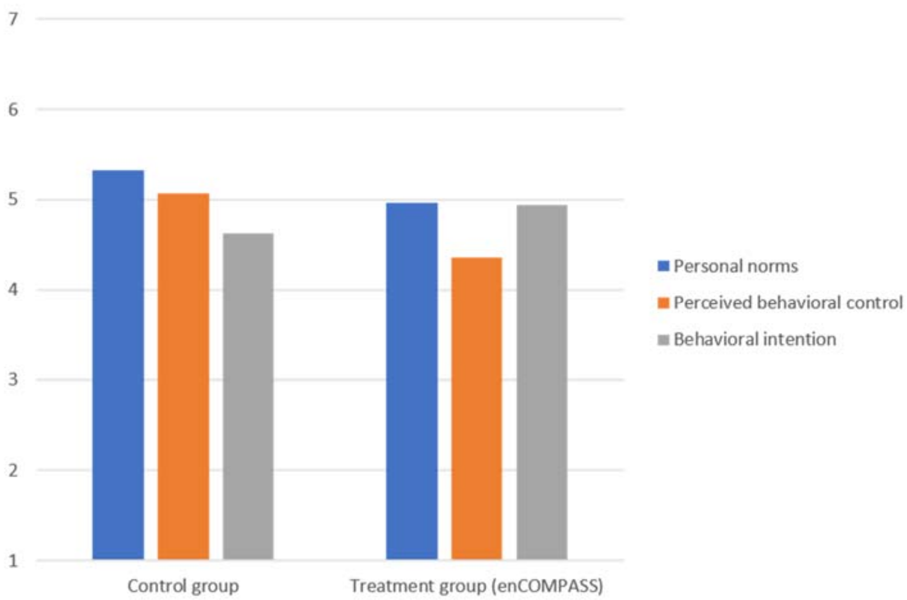


Figure 77. Personal norms, perceived behavioral control, and behavioral intention (Switzerland).

4.3.4.2 Public buildings

15 respondents have filled out the baseline questionnaire for the public buildings in Switzerland.

Figure 78 shows the gender distribution of the sample. The distribution is similar to sample for the German public buildings, with a larger percentage of women answering the survey than men.

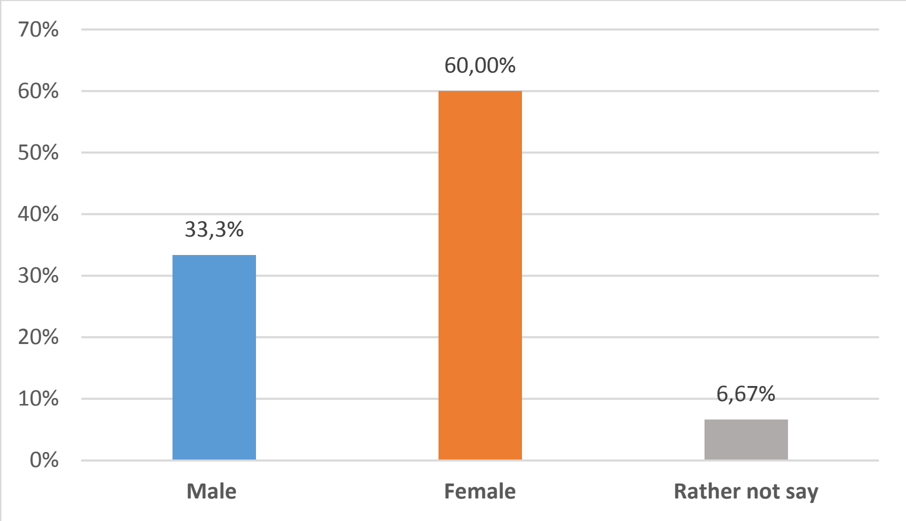


Figure 78. Distribution of gender for public buildings participants (Switzerland, n=15).

As shown in Figure 79, none of the respondents reported an educational level below upper secondary education, which is the same as in the German sample. The largest group has finished a post-secondary non-college education. More than one quarter of the public building respondents reported a University degree.

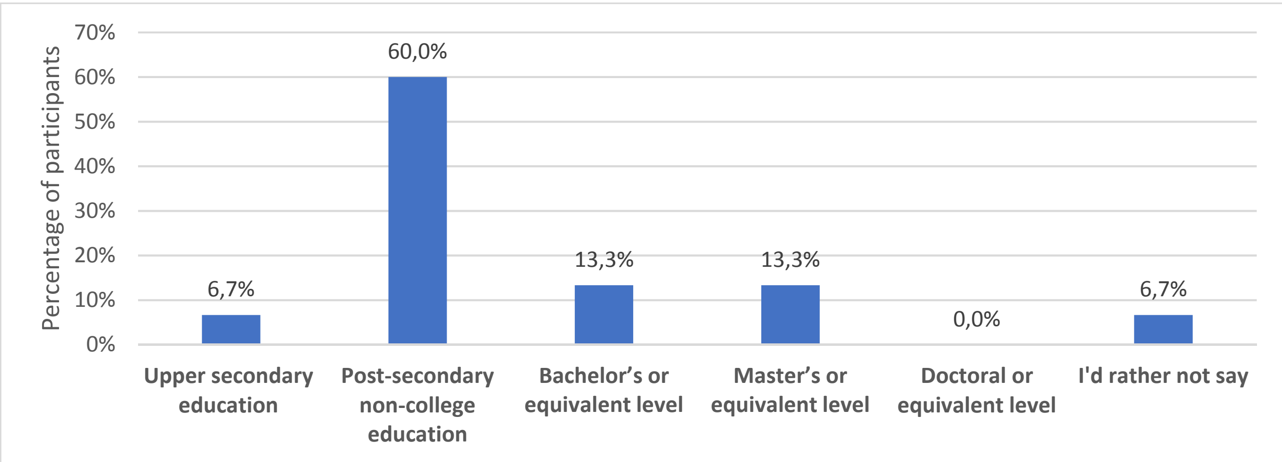


Figure 79. Distribution of educational level for public buildings participants (Switzerland, n=15).

Figure 80 shows the age distribution of the sample. Almost half of the users in this sample are 51-60 years old, a quarter is 31-40 years old. There are no participants who are younger than 20 and only 13% are between 21-30 years of age. Overall, we can say that the sample is rather mature.

Figure 81 shows that the respondents feel a strong responsibility to save energy (average score of 4,2 on the 1-5 scale). They also report a moderately high level of knowledge around their energy consumption (3,7 on the 1-5 scale), which is different to the German sample where the knowledge level is lower. In the Swiss sample, the gap between perceived responsibility to save energy and knowing how to do so is a lot smaller than in the German sample.

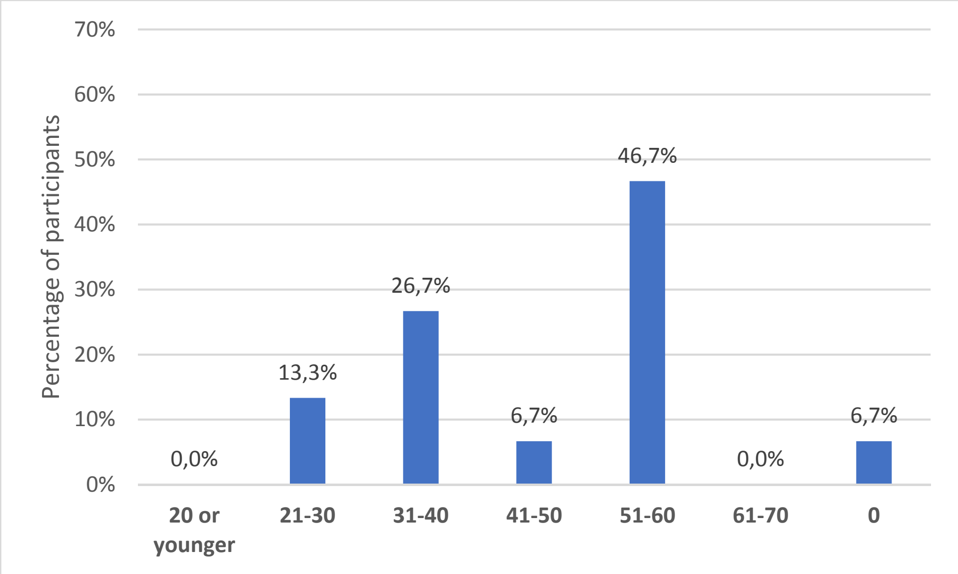


Figure 80. Distribution of age for public buildings participants (Switzerland, n=15).

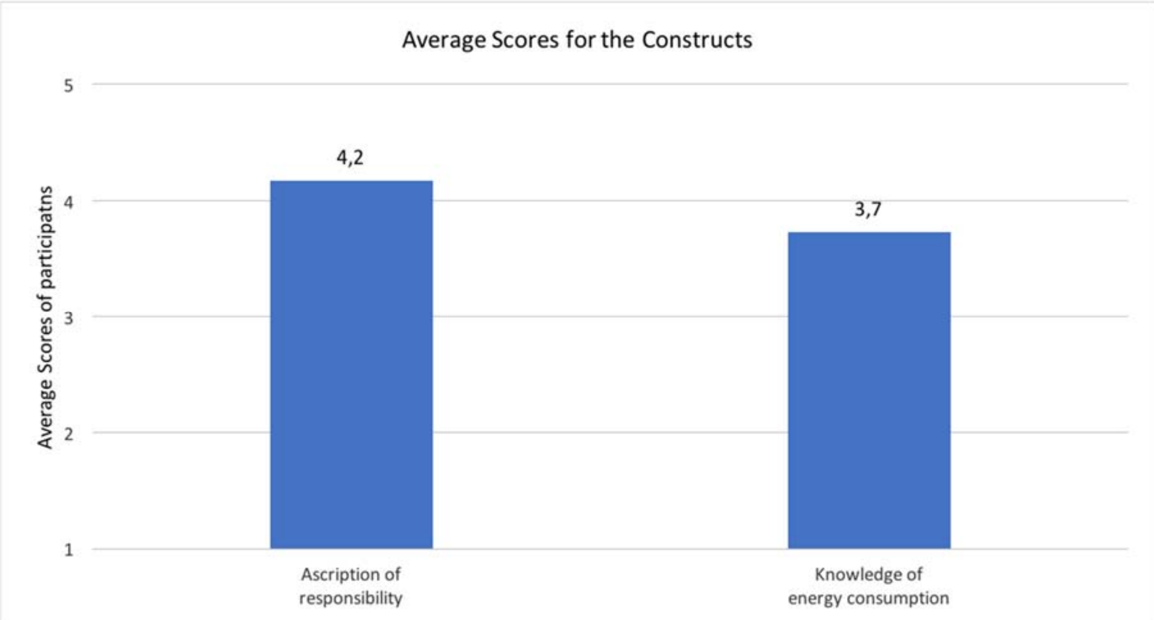


Figure 81. Ascription of responsibility and knowledge about energy (Swiss public buildings pilot).

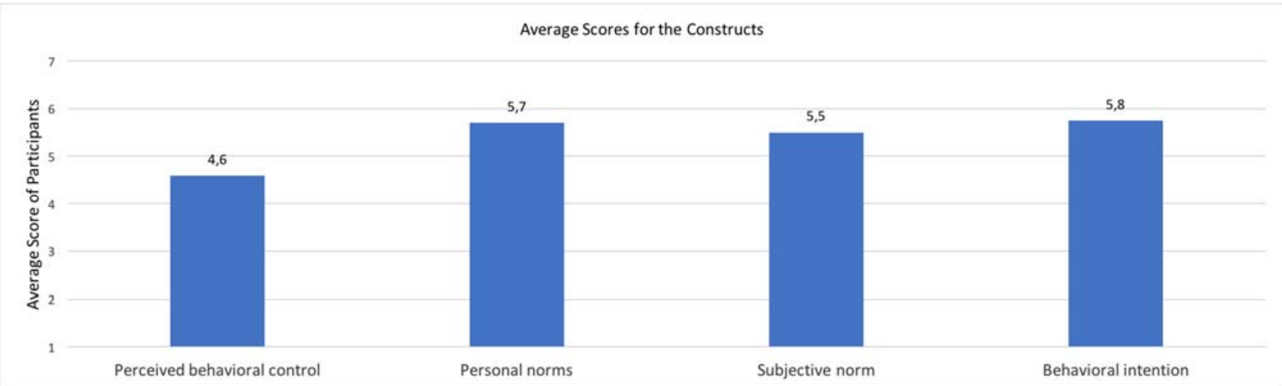


Figure 82. Perceived behavioral control, personal norms, subjective norm, and behavioral intention (Swiss public buildings pilot).

Figure 82 shows that Swiss public building users feel quite a strong moral obligation to save energy (personal norms) with an average score of 5.7 on the 1-7 scale and have a relatively strong intention to do so (behavioural intention) with a score of 5.8 on the 1-7 scale. They also perceive a high social expectation from their work and family environment to save energy (subjective norm) with a score of 5.5 on the 1-7 scale. At the same time, their perceived behavioural control (confidence about being able to save energy is lower at 4.6 on the 1-7 scale, which is a similar finding to the one with the German public building users. Considerable variation has been found with regard to the perceived behavioural control: the standard deviation was high at 1.8.

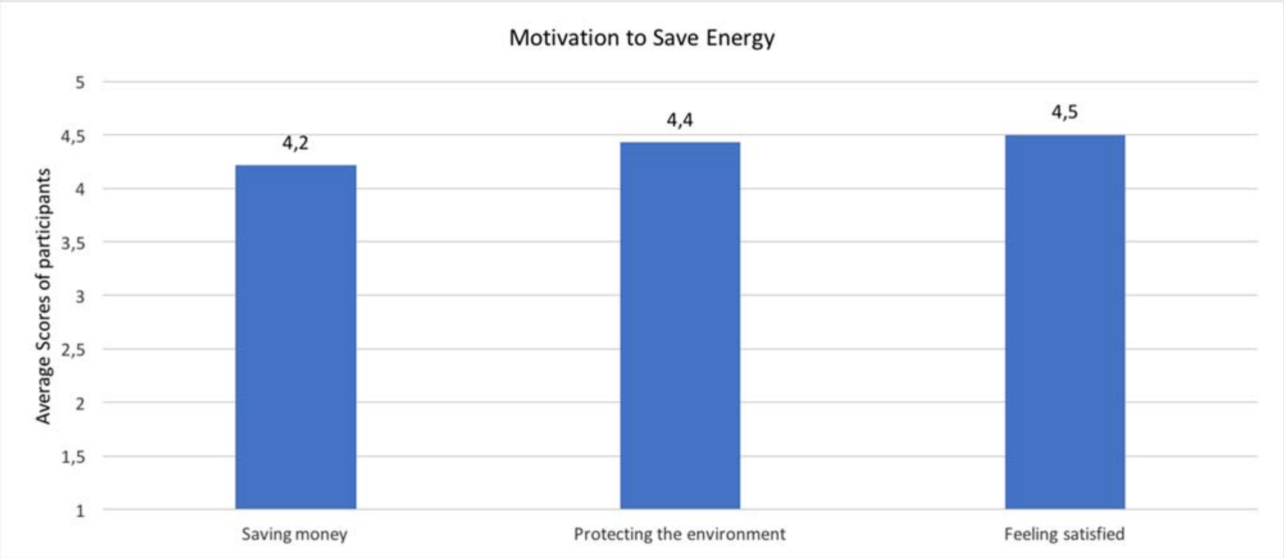


Figure 83. Motivation to save energy (Swiss public buildings pilot).

Figure 83 shows that the Swiss public building respondents found personal satisfaction (4.5 on the 1-5 scale) and the protection of the environment (4.4 on the 1-5 scale) the strongest motivators to save energy. Saving money was still very important (4.2 on the 1-5 scale), but relatively less so than the other two factors.

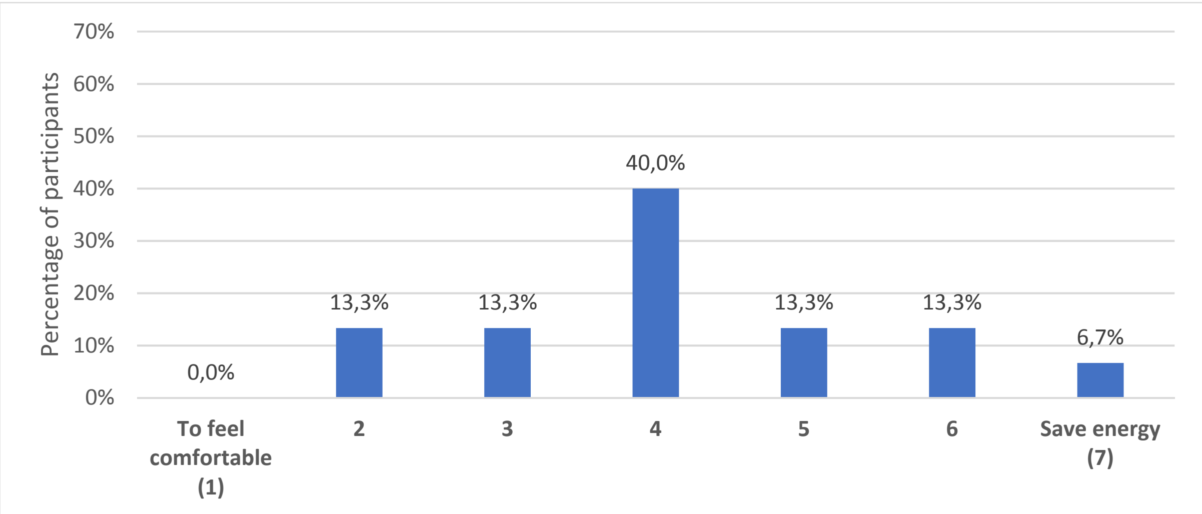


Figure 84. Trade-off between comfort and energy saving (Swiss public buildings pilot).

Figure 84 indicates that the Swiss public building respondents have a higher inclination to forego personal comfort in order to save energy than their German counterparts. The average of 4.53 shows a clear tendency towards energy saving, with to nearly three quarters of the respondents indicating the number 4 or higher in the scale. Only a little more than one quarter clearly favoured their comfort over the aim of saving energy.

4.3.5 Greek pilot

4.3.5.1 Households

In the Greek pilot, 66 households have completed the baseline questionnaire. The distribution of responses is displayed among the treatment group (i.e. enCOMPASS users) and the control group is displayed in Table 12.

Table 11. Distribution of respondents across building types (Greek pilot).

Condition	
Control group	48
Treatment group	18
Total	66

Given the recent launch of the pilot and the ongoing onboarding of the Greek enCOMPASS users, the number of enCOMPASS users will steadily increase during the upcoming period. Results below reflect the responses to the questionnaire until October 29th.

As a first step in the analysis, the gender distribution among the pilot users was examined for both the control group and the enCOMPASS users. The results are displayed in Figure 85.

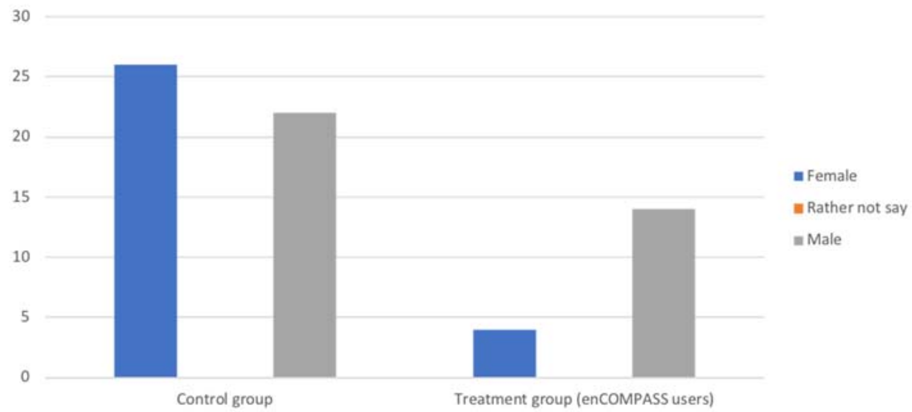


Figure 85. Gender distribution among Greek household respondents.

The results display a relatively even distribution within the control group, while – similar to the German and Swiss pilot – in the treatment group more men than women have filled out the questionnaire.

Subsequently, the results were analysed regarding the age distribution between and within the conditions. In Figure 86 the results are displayed.

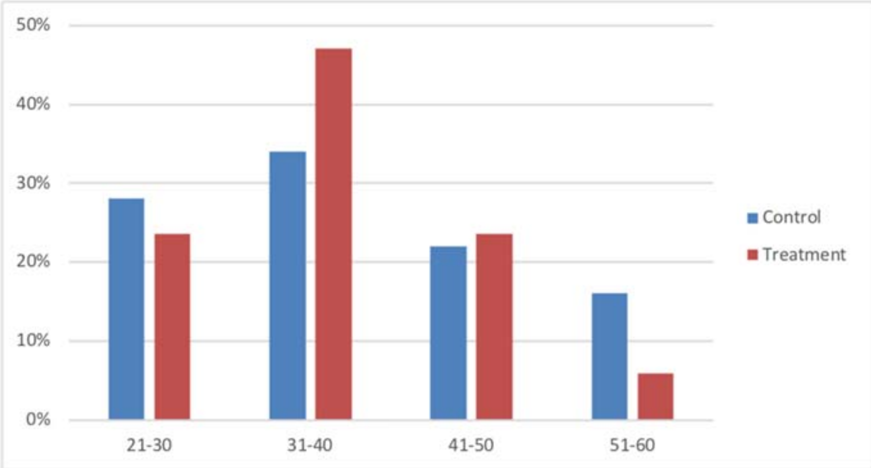


Figure 86. Age distribution among Greek household respondents.

Results demonstrate that in both conditions the age group from 31 to 40 is the largest. Additionally, users over 60 and younger than 21 did not participate in the questionnaire. Finally, the results show that participants between 51 and 60 are more present in the control group than in the treatment group, while the reverse is true for the group between 31 and 40. The age group between 41 is equally represented in both conditions.

In Figure 87 the hedonic, biospheric, altruistic, and egoistic values of the Greek participants are displayed.

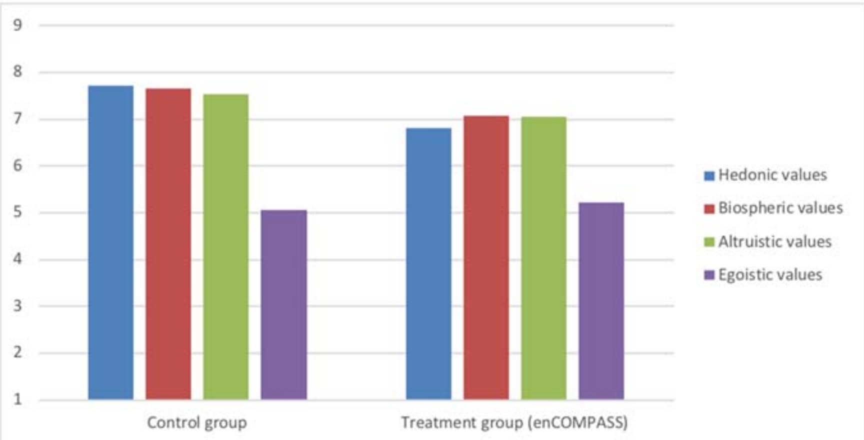


Figure 87. Values of the Greek household respondents.

Participants in both conditions have strong hedonic, biospheric, and altruistic values, with small differences between the types of values, suggesting that their values are balanced. In line with goal-framing theory [9] that values compete for focal attention, the outcome of which is dependent on the context.

Independent samples t-tests were run to assess potential differences between the control group and the treatment group. For all value types, the differences between the pilots proved to be non-significant for egoistic (t(66)=-.34; p=.74), altruistic (t(66)=1.20; p=.24), and biospheric values (t(66)=1.31; p=.20). However, hedonic values were stronger for participants in the control group than for the experimental group (t(66)=2.08; p=.04).

Figure 88 summarizes the importance of social comparison for questionnaire respondents.

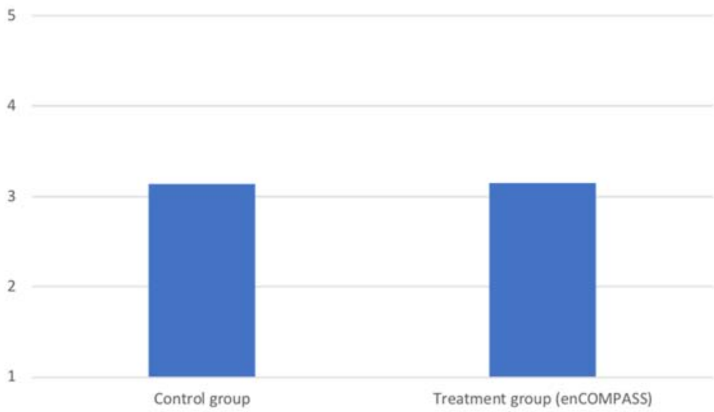


Figure 88. Social comparison orientation among Greek household respondents.

The results show moderate levels around the scale average for both the control group and the treatment group. Statistical testing confirms that there is no systematic difference between the two groups regarding the respondents' social comparison orientation (t(66)=-0.65; p=.95).

Comparable to the German and Swiss pilot, energy consumption awareness was operationalized into several constructs. In Figure 89, ascription of responsibility and knowledge of energy consumption are displayed, which were measured using multiple item five-point Likert scales.

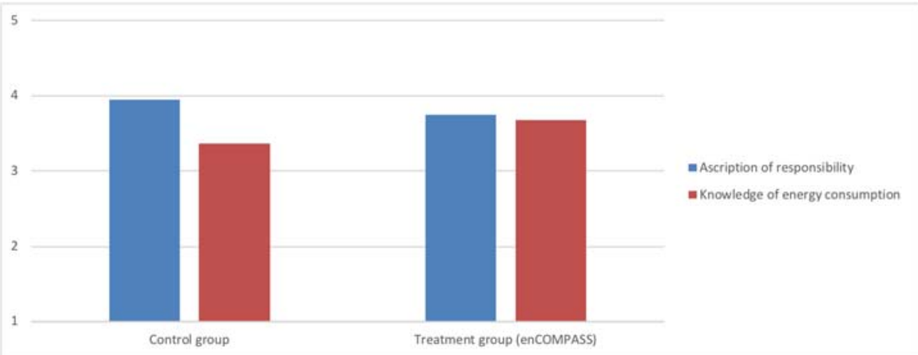


Figure 89. Ascription of responsibility and consumption knowledge among Greek household respondents.

Ascription of responsibility was slightly lower for the treatment group (3.8) than for the control group (4.0). However, this difference was not significant (t(66)=.79; p=.43). In contrast, the knowledge about energy consumption proved to be higher in the treatment group (3.7) than in the control group (3.4), but again this difference was non-significant (t(66)=-.95; p=.34). The moderate scores for knowledge of energy consumption imply that there is room for improvement, which could be achieved by exposure to incentives from the enCOMPASS application.

In Figure 90 the personal norms, perceived behavioral control, and behavioral intention are displayed.

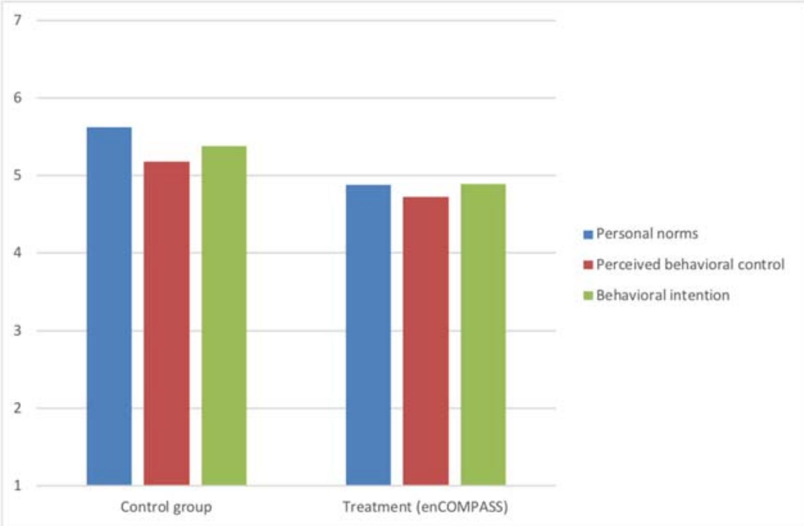


Figure 90. Personal norms, perceived behavioral control, and behavioral intention among Greek household respondents.

Across conditions, averages were found that were somewhat above the neutral point of the seven-point scale, with values in the treatment group being slightly lower than in the control group. Independent samples t-tests were run to test whether the differences were significant. Only the difference in personal norms was significant: personal norms (e.g. the perceived moral obligation to save energy) was stronger in the control group than in the treatment group ($t(66)=2.21$; $p=.03$). Differences between the conditions regarding perceived behavioral control and behavioral intention were non-significant ($t(66)=1.35$; $p=.18$ and $t(66)=1.41$; $p=.16$ respectively).

Perceived behavioral control scores were lower than the other predictors of energy consumption behavior, even though scores are still above the scale average. The results suggest that perceived behavioral control can be improved by educating users how to save energy. The use of the reading static tips and context-aware recommendations in enCOMPASS have the potential to increase perceived behavioral control in the treatment group.

4.3.5.2 Public buildings

In the Greek pilot, in total 46 participants have completed the baseline questionnaire, divided by the different public buildings in the pilot. The distribution of responses is displayed in Table 12.

Table 12. Distribution of respondents across building types (Greek pilot).

Building	No. of respondents
National Documentation Center	18
Watt&Volt Headquarters	17
Watt&Volt Retail Store	11
Total	46

In Figure 91 the gender distribution of the Greek public buildings participants is shown.

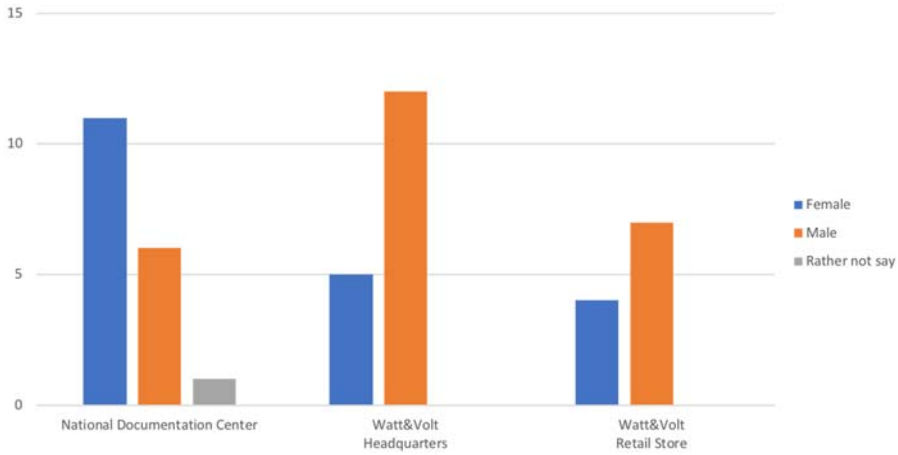


Figure 91. Gender distribution of public buildings participants (Greek pilot)

The results indicate that in the Watt&Volt buildings more men than women responded to the questionnaire, while this result is reversed for the National Documentation Center.

In Figure 92 the educational level of participants in the Greek public buildings pilot is displayed, divided by the three buildings.

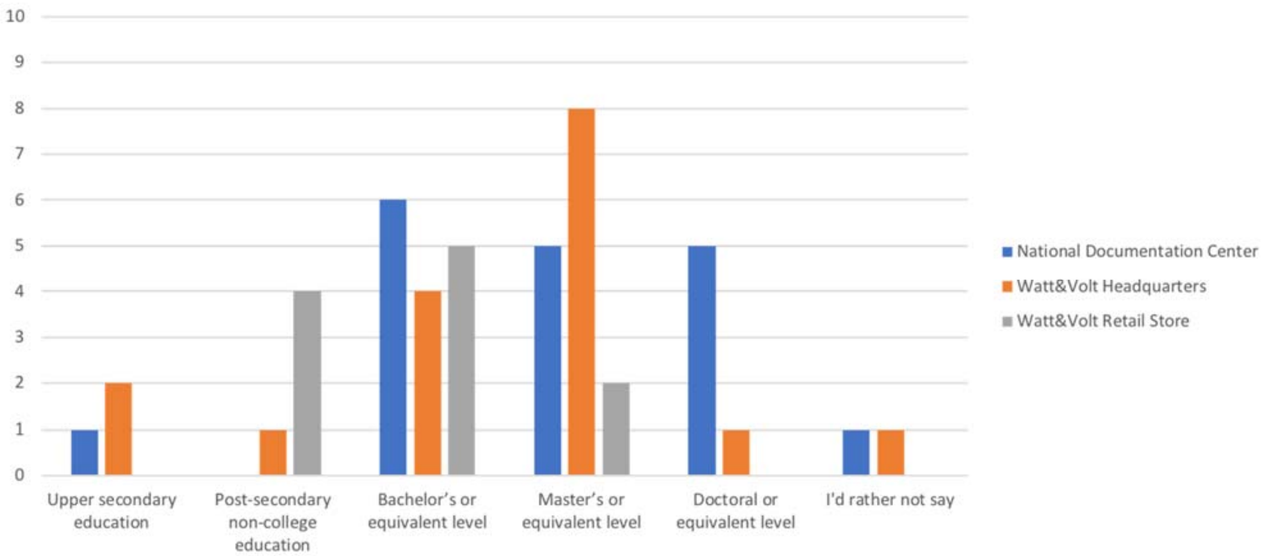


Figure 92. Distribution of educational level for public buildings participants (Greek pilot)

The results show that overall the educational level of the participants across buildings is relatively high, particularly for the National Documentation Centre. This could be expected given the nature of the building.

The age distribution is displayed in Figure 93.

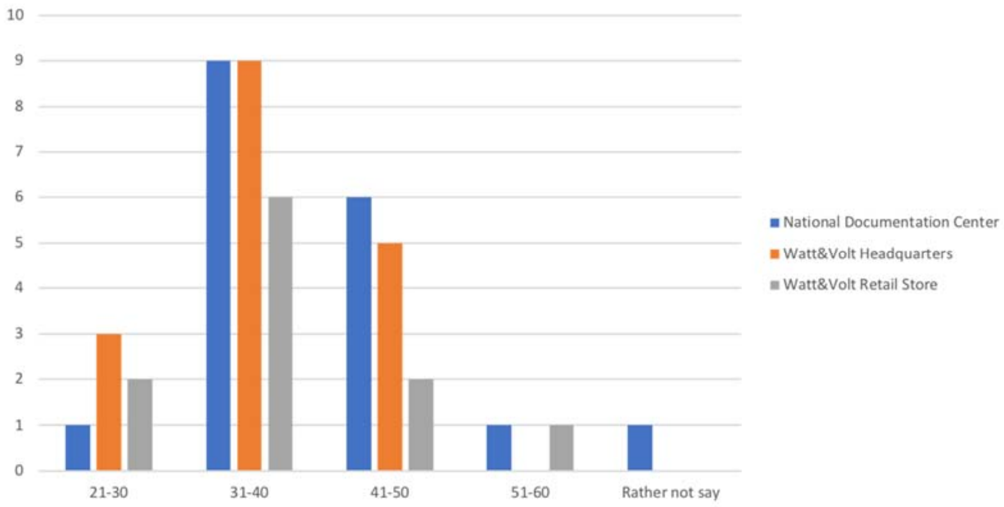


Figure 93. Age distribution (Greek public buildings pilot)

As can be seen from the diagram, the largest share of the participants are between the age of 31 and 40, followed by the age range 41-50. In contrast, relatively few participants below the age of 30 and above the age of 50 have responded to the questionnaire. The age distribution is comparable between building types.

In Figure 94, the average scores for ascription of responsibility and knowledge about energy consumption are depicted. Questions were asked as Likert-scale questions, ranging from 'fully disagree' (1) to 'fully agree' (5).

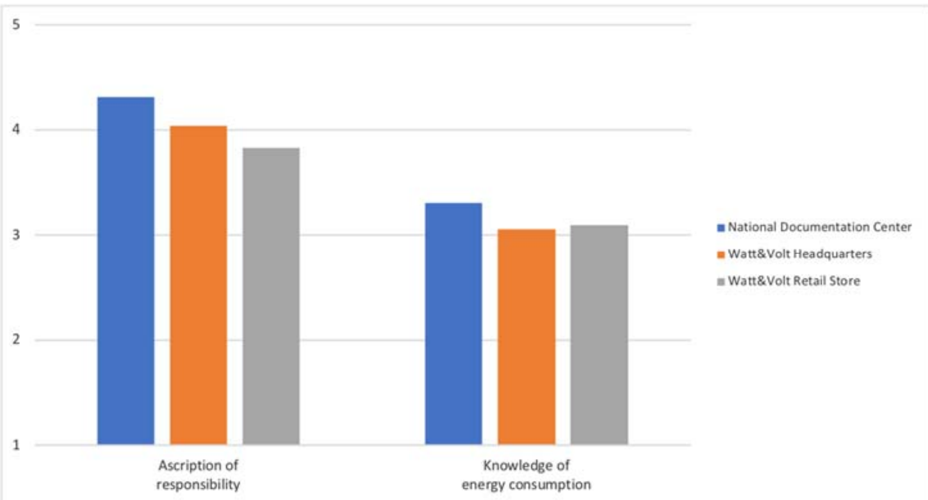


Figure 94. Ascription of responsibility and knowledge about energy (Greek public buildings pilot)

The results demonstrate that employees in the different public buildings have a relatively high sense of responsibility for their energy consumption at work with averages around 4 (on a five-point scale). In contrast, their self-reported knowledge level about consumption of the main devices at work is close to the neutral point of the scale, which suggests that there is room for improvement by the use of the enCOMPASS application.

Figure 95 displays the results of the participants' average scores on perceived behavioral control, personal norms, subjective norm, and behavioral intention.

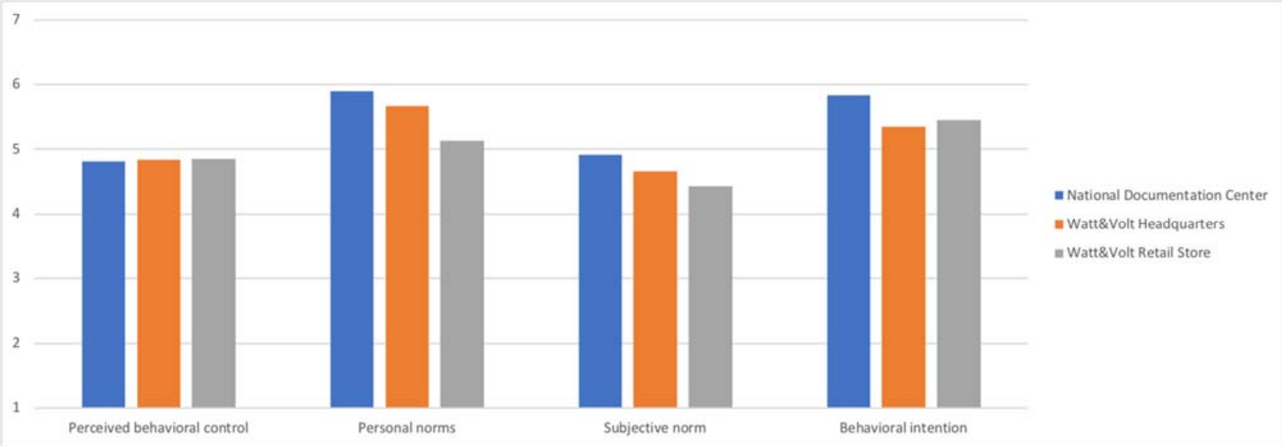


Figure 95. Perceived behavioral control, personal norms, subjective norm, and behavioral intention (Greek public buildings pilot).

The results indicate that public building users in the Greek pilot feel above average morally obliged to save energy (personal norms), that they feel moderately confident about whether they can do so (perceived behavioral control), and have a relatively strong intention to save energy (behavioral intention).

Considerable variation has been found with regard to the subjective norm: the influence of superiors, co-workers, and people in the employees' private life. On the one hand, a relatively large share of the participants in the National Documentation Centre did not know the answer to the question about whether their superiors (6 out of 18), or co-workers (5 out of 18) want them to save energy. On the other hand, the standard deviation was relatively high at 1.4.

In Figure 96 we depict the values of the participants, in terms of the importance they attach to save money, to protect the environment, and to feel satisfied (i.e. comfortable).

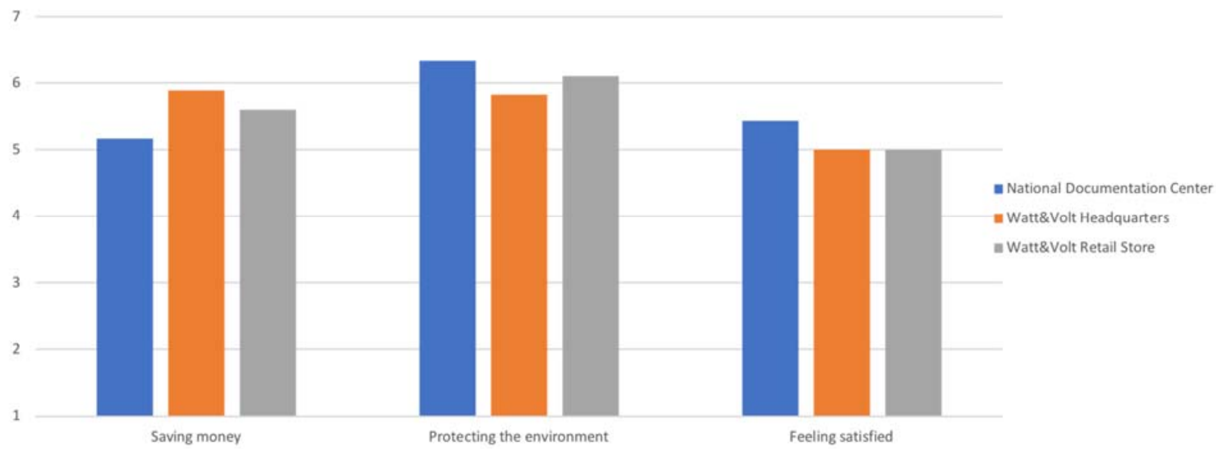


Figure 96. Values (Greek public buildings pilot).

The distribution of the values indicates that protecting the environment was more important than saving money or feeling satisfied. This was the case for all building types. The results also indicate that the difference participants attach to these values is relatively small across the buildings (at the most .7 on a seven-point scale).

However, there is a potential conflict between the values of saving energy and feeling satisfied. We explicitly asked the respondents to mark their position on this trade-off on a seven-point scale. Results were coded with a value between 1 (feeling comfortable is most important), and 7 (saving energy is most important). The averages for the public buildings in the Greek pilot are displayed in Figure 97.

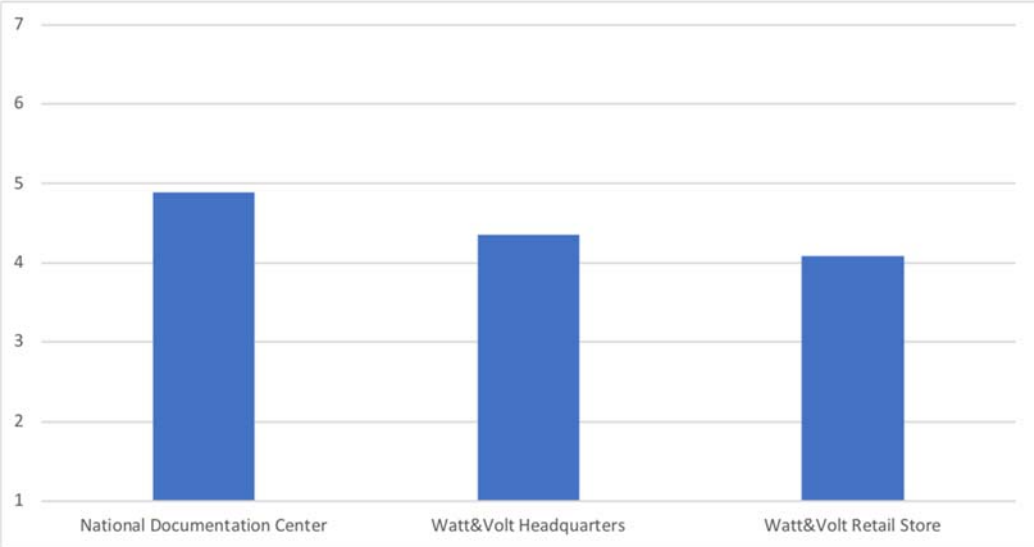


Figure 97. Trade-off between comfort and energy saving (Greek public buildings pilot).

With an average of 4.1, employees in the Watt&Volt Retail store found saving energy and feeling comfortable equally important. In the Watt&Volt Headquarters (average: 4.4), and the National Documentation Centre (Average: 4.9) the balance shifted towards saving energy. These results suggest that the comfort level is important to users when they consider putting effort into energy saving. The enCOMPASS application provides insight into this trade-off. By analyzing the position of this trade-off before and after the pilots, we can observe whether the position of this trade-off has changed due to exposure to the enCOMPASS application.

4.4 Overall Interim Evaluation of Impact KPIs

In this section, the impact on previous defined KPIs is measured and explained. The KPIs were defined in D7.2 Validation methodology and pilot action plan. In that deliverable it was stated that the KPIs would be measuring the following items:

1. *KPIs related to energy consumption and CO2 emissions;*
2. *KPIs related to energy consumption awareness, knowledge, and intention to save energy;*
3. *KPIs related to usability and comprehension of energy consumption information, comfort level and recommendations for actions;*
4. *KPIs related to exploitation.*

A note must be made with respect to KPIs related to exploitation. These KPIs will be closely monitored as part of the exploitation work in WP8. Results will be documented in the exploitation plan deliverables, most notably D8.6.

Here we discuss the first three groups of KPIs.

Energy savings have been already presented in Section 4.2. The preliminary results are encouraging for the households, but the trend needs to be confirmed in the next months, especially after the release of the new version of the enCOMPASS App and when more data from the Greek pilot will be available. In Figure 98 we report the average savings (in kWh) measured across the two pilots which have been running from May until September. The figures include savings produced by public buildings and households.

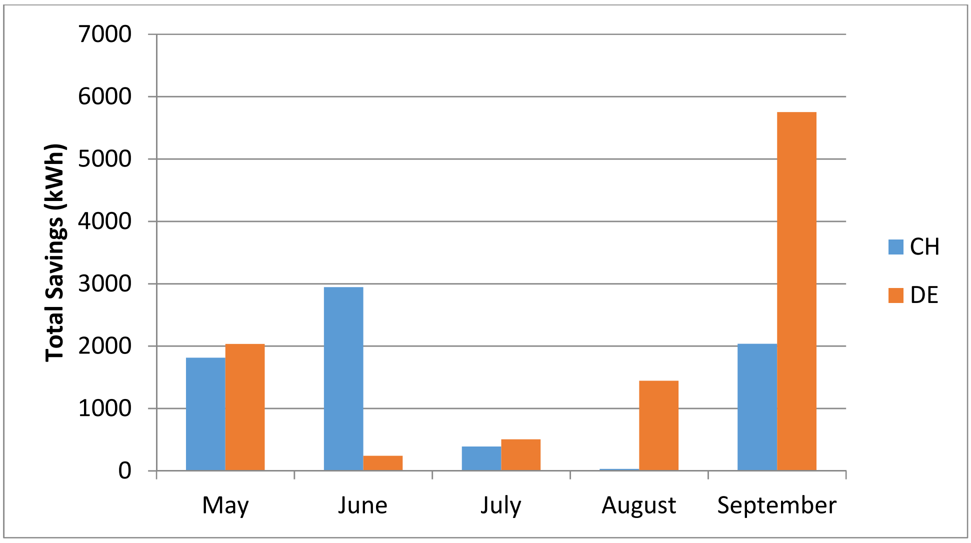


Figure 98. Average savings in kWh in the two running pilots.

Concerning **CO_2 emissions savings**, results reported in Figure 99 have been computed for the Swiss and German pilots, considering carbon intensity values of 0.0044 and 0.4639 $kgCO_2/kWh$, respectively [5]. Savings are much more remarkable in the German pilot, due to the two orders of magnitude higher conversion coefficient.

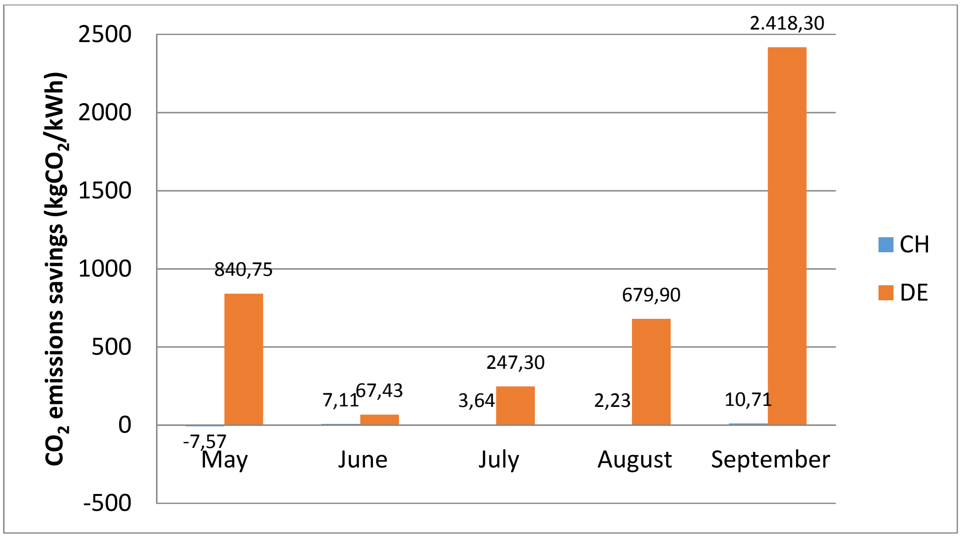


Figure 99: CO_2 emission savings in the Swiss and German pilots

With respect to the **user-awareness and usability** KPIs at this moment in time only the baseline awareness results are available and have been reported in previous sections. What can be said at this stage is that the good psychometric properties of the user awareness measures give the impression that these measures are capable of capturing the effect of the use of enCOMPASS on the awareness regarding energy consumption.

At the time of writing of this deliverable, the first monitoring period, as defined in D7.2, is ending (end of October). The first interim evaluation of the user responses (through a questionnaire) is due to be performed at M24 and this data will thus be available only after this deliverable. A questionnaire has been issued to the users, which will yield initial data concerning the KPI's regarding user awareness and knowledge:

- User awareness of energy consumption:
- User knowledge of energy saving actions.

Because these KPI's have been formulated relative to the baseline (e.g. a 1-point increase on a five-point scale), they cannot yet be measured with baseline data only, and thus depend on the results of the R1 evaluation questionnaire issued prior to the second release.

At the same time, the R1 evaluation questionnaire will yield data for an initial assessment of the KPI's concerning user feedback on the technology acceptance of the system, its motivational impact, and its impact on comfort. Accordingly, the obtained results on these KPIs will be reported in the next evaluation deliverable D7.4.

5 CONCLUSIONS

Real-world deployment and validation of the enCOMPASS approach is a crucial part of the project. This deliverable has detailed the deployment of the hardware and enCOMPASS app in the Swiss, German and Greek case study, their associated promotion campaigns, and the first validation results: the preliminary outcomes of energy saving, awareness feedback from baseline questionnaires distributed to the users, as well as the interim evaluation of impact on KPIs for all case studies in the first 17 weeks after the start of the pilot studies.

With the start of the first monitoring period in June 2018, it can be recorded that the deployment of the meter- and sensor infrastructure in all the pilots was accomplished successfully. Even though every location has its own infrastructure and cannot be compared among each other, the integration of data in the enCOMPASS database system did work for all three utility companies. Meanwhile several issues in the process of data collection occurred but could be dealt with. For release 2 of the enCOMPASS app data handling procedures will be improved.

With respect to all three pilots, the preliminary usage data suggests that the users positively received the first release of the enCOMPASS app, as well as on the level of individual features, while tentative evidence for a reduced consumption of electricity in the German and Swiss case points out the potential impact of the enCOMPASS platform. These first results suggest that the KPI's and target levels that have been defined in *D7.2 Validation methodology and pilot action* plan are feasible to achieve. However, the duration of the data collection and some technical discrepancies in the Greek pilot do not allow us yet to draw final conclusions.

The first evaluation period is about to end in October 2018 and the intermediate evaluation questionnaires are being finalized and submitted to the users as this deliverable is being written, in line with the work plan. The questionnaire will consider the technology acceptance of the system, its motivational impact, and its impact on comfort of the users.

The results of the intermediate user questionnaires and further findings of the second monitoring period will thus be reported in the next evaluation deliverable *D7.4 Final overall validation and impact report* in month 36 of the project. The here reported trend of possibilities to achieve energy savings with sustainable changes in user energy consumption patterns without compromising comfort levels, will be observed during the next months of the pilot monitoring and evaluated.

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