The SIT4Energy project has received funding from the German Federal Ministry of Education and Research (BMBF) and the Greek General Secretariat for Research and Technology (GSRT) in the context of the Greek-German Call for Proposals on Bilateral Research and Innovation Cooperation, 2016

Project Acronym:	**SIT4Energy**
Project Full Title:	**Smart IT for Energy Efficiency and Integrated Demand Management**
Project Duration:	**36 months (01/03/2018 – 28/02/2021)**

DELIVERABLE 1.3.1
User Information Model

Work Package	**WP1 – Consumer Requirements Analysis**
Task	**T1.3 – User Information Model**
Document Status:	**Final**
Due Date:	**28.02.2018**
Submission Date:	**28.02.2018**
Lead Beneficiary:	**HOST**

Dissemination Level	
Public	X

Co-financed by Greece and the European Union

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Executive Summary

This deliverable D1.3.1 "*User Information Model"* provides the first results on the identification of user information needs to inform the design of the SIT4Energy applications. The derivation of the model comprises an analysis of literature to inform the understanding of the end users and the application context from related work. Furthermore, user workshops in form of focus groups were performed to support the identification of user information needs from the specific application context focused on the actual SIT4Energy pilots and their target groups.

The deliverable is structured as follows:

Section 2 presents an overview on the methodology for the development of the model which consisted of two main activities: the literature review and the user workshops with the SIT4Energy target groups.

Section 3 involves the literature review which establishes an overall understanding of the user information needs from related work. The results cover different aspects regarding energy optimisation, energy consumption and the decision-making process. In addition, the analysis of existing work in the development of technological tools to support similar application scenarios allowed to gather additional insights for the design of the SIT4Energy applications.

Section 4 describes the methodology and the implementation of the user workshops to complement the literature analysis. In this case, three user workshops were performed in Germany and Greece, focused on the SIT4Energy target groups in the project pilots. User feedback was collected based on the presentation and discussion of mock-ups that were developed to illustrate the main ideas of the SIT4Energy project and envisaged applications. The results were integrated into different categories of information that provide a better understanding of the user information needs, including detailed information about the context and main activities that could be supported by the SIT4Energy applications.

Section 5 presents the derived "User Information Model", which was generated by integrating the findings obtained from the literature review and the user workshops. The information model is defined for each target group and presented from a user-centered perspective, structuring different types of information needs and the related context information that can inform the design of the SIT4Energy system.

Section 6 presents the conclusions of the deliverable.

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List of Acronyms and Abbreviations

Term	Description
EE	Energy Efficiency
EMS	Energy Management Service
EU	European Union
HUA	Harokopio University of Athens

1. Introduction

The goal of the SIT4Energy project is to demonstrate how integrated energy management for prosumers can be realised through smart IT solutions supporting the identification of efficiency potentials in local energy production and consumption. The project includes the development of a Smart Energy Dashboard for helping prosumers and utilities to optimize energy production and consumption and an intelligent mobile recommendation service for energy saving in university settings.

The development of SIT4Energy applications addresses different target groups. This deliverable identifies the user information needs for the different target groups in order to inform the design process. The identified information needs are presented in form of a User Information Model structured in a descriptive way from a user-centered perspective. This distinguishes it from the SIT4Energy data model that will be defined from a system perspective in a more formalized way within work package 4.

1.1 Scope and objectives of the deliverable

This deliverable presents results obtained in the identification of the user information needs for different SIT4Energy target groups in order to inform the design of the SIT4Energy applications. In order to cover a broader understanding on the user information needs, the information needs have been derived from general information from the literature review and from the user workshops with the SIT4Energy target groups. At the end, the findings were integrated into a User Information Model for each target group, and presented from a user-centered perspective, structuring different types of information needs and the related context information that can inform the design of SIT4Energy applications.

The objective of this deliverable is to:

- Provide an overview of the user information needs from the literature review of relevance for guiding the development of the User Information Model,
- Present the results from the user workshops performed with the SIT4Energy target groups in order to obtain insights about more specific information needs of the SIT4Energy target groups in the project pilots,
- Identify user information needs to inform the design of SIT4Energy applications.

1.2 Structure of the deliverable

This deliverable D1.3.1 "*User Information Model*" is structured in 5 sections. Section 1 introduces the deliverable. Section 2 describes the methodology followed for the definition of the model. Section 3 addresses the literature review to identify user information needs corresponding to the SIT4Energy target groups. Section 4 comprises the implementation of the user workshops as well as the results gained. Section 5 presents the resulting User Information Model presenting the identified information needs for each target group. Section 6 presents the conclusions of this deliverable.

1.3 Relation to other tasks and deliverables

This deliverable covers the identification of user information needs for informing the design of SIT4Energy applications. Understanding end-user needs by involving them since the early stages in the design process allows better informed development of technological artefacts. For that reason, the results presented in this deliverable represent important insights for the development of SIT4Energy modules and applications, in particular for the Smart Energy Dashboard (D3.5) and the Mobile Recommendation System (D3.2).

2. Methodology for deriving the User Information Model

The development process for the User Information Model focuses on identifying the user information needs to inform the design of end-users applications of the SIT4Energy system. This process is divided into two stages: 1) literature review and 2) workshops with end-users, described below. The User Information Model was then defined by integrating the findings from the literature review and the user workshops, resulting in one model for each target group (defined in D1.1) in order to cover individual needs of the target groups. Each User Information Model has been described following the same structure and focusing on the user-centered description of information needs for each target group. .

This literature review stage consisted of gathering and selecting relevant journal and conference articles from scientific databases such as ACM digital library, IEEE, Elsevier, Springer etc. The search was conducted through keywords such as prosumers, energy management, visual analytics, utility, building managers and related terms. The selection focused on contributions relevant for the SIT4Energy target groups. The results present the user information needs grouped into categories easing the follow-up and synthesis of the User Information Model for each target group.

The user workshops in form of focus groups were performed to complement the initial findings from literature. The central purpose was to present the participants with first mock-ups of envisaged SIT4Energy applications in order to get feedback about the different elements considered and in this way to identify more specific information needs. In line with the user-centred methodology, involving users on in early design stages represents multiple benefits in the development of successful technological products [1][2].

Designing the mock-ups presented in the workshops was inspired by previous user profile research from the literature review and a survey performed in task 1.1 (see D1.1), resulting in different mock-ups intended to cover the potential target groups´ needs in the workshop sessions (Table 1). The details about the target groups and their characteristics have been given in the deliverable D1.1.

Table 1. Performed user workshops

	Workshop	Place	Mock-up presented
Germany	TG1: Prosumers (Customers)	Stadtwerk Haßfurt	Smart Energy Dashboard
	TG2: Utilities (Employees)	Stadtwerk, Haßfurt	Smart Energy Dashboard
Greece	TG3: University end-users (Academic staff)	University of Harokopio, Athenas	Mobile Recommendation System

3. Literature review for the identification of user information needs

3.1 Overview

The threat of global climate change encourages the government, institutions and end-users to change their behaviour with respect to energy production and consumption. For instance, several associations have defined goals to meet ecological and economic demand [3][4]. Furthermore, the energy market has become more flexible by allowing end-users to produce their own energy. As such, the end-users can not only produce energy to cover their energy needs, but also sell the excess of energy to the national or local grid [5], establishing the new concept of "prosumer" [3][6]. The rise of prosumers contributes to the creation of new business models and electricity markets [7][8].

To support the changing energy landscape, new tehcnological innovations are needed, to enable monitoring and analysis of the new types of data, and assisting the end-users as well as utilities and other institutions in making smarter consumption and production decisions. Some tools such as those supporting investment decisions, exploring various cenarios, power systems analysis and similar have already been implemented [9]; however a lot more is still needed to keep pace with the constantly changing energy landscape. To make these tools efficiently serve the purposes for their customers, some challenges still need to be solved. For example, the various stakeholders on the energy market might be motivated by different needs and require different kinds of information to make decisions effectively. Therefore, identification of the needs of the different parties involved, such as the utilities, the end-users and instittutions, is critical in order to support efficeint collaboration between them and thus ensure the properly functioning energy market. In the following sections we introduce the target groups in the SIT4Energy project and identify their information needs to support the development of activities related to energy management.

3.2 Prosumers

3.2.1 Prosumer definition

The "prosumer" is a very broad concept which may refer not only to individuals but also concern devices, buildings, or larger social communities (Figure 1). Understanding the breadth of the prosumer concept is important for the identification of the variety of needs that these groups might have and their impact for the development of support tools [10][11]. In our context, a prosumer is a consumer with a production device (human-focused view).

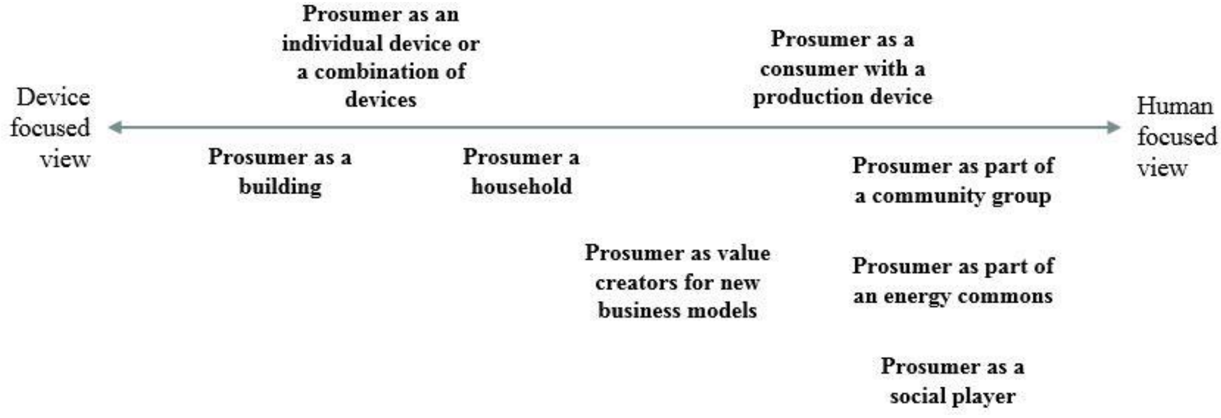


Figure 1: The concept of the "prosumer" (image adapted from [11])

The defined end-user group "Prosumers", however, might have a different set of needs and motivations which can be used to create new value propositions for them. The classification available in the literature [12] presented in Figure 2 identifies the following types of prosumer motivations, which can be later used to identify prosumer needs:

- ***Money saving***: Prosumers are motivated by price and want to reduce their energy bill. This is usually the main motivation of a user to become Prosumer.
- ***Time-saving***: Prosumers require set-it-and-forget-it solutions for managing their energy needs (e.g. automated configurations of when to store energy and when to sell it to the grid).
- ***Energy Stalwarts***: Prosumer is motivated to be one of the first on the market to use the new technology [11].
- ***Buyer/supplier***: Prosumers purchase energy from the utilities when their production is not enough. Further, they sell the excess energy they produce to the public grid.
- ***Pragmatic users***: The prosumer is willing to face risks connected with using the technology for energy purposes, e.g. confidential information.
- ***Environmentally conscious***: Prosumer is interested in eco-friendly and efficient alternatives.
- ***Passive users***: The prosumer requires consistent no-frills service without any surprise on the bills; and therefore is interested in timely feedback.

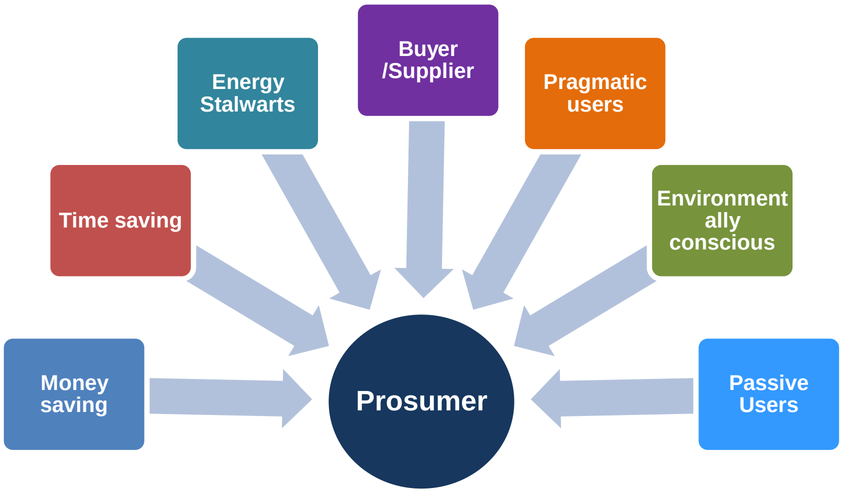


Figure 2: Prosumers value proposition (image adapted from [12])

3.2.2 Activities related to energy management

Prosumers play an essential role in the renewable energy market by owning a variety of renewable devices such as PV systems complemented with smart meters. Usually, the utilities obtain the consumption measurement from those devices to generate a monthly electricity bill. However, often these reports are not very detailed; making it difficult for prosumers to analyze their consumption and production throughout the day [13], and resulting in being unable to adjust their consumption and production accordingly [14].

Although storage of energy is still expensive, few prosumers invested in batteries to be able to store excess energy and use it at a later time or feed it back to the grid when needed. In this respect, they are interested to optimise their enregy balance [15][16], as well as to benefit from selling their excesses at dynamic prices during peak hours to increase their returns [14].

3.2.3 Motivations and needs

Recent research in renewable energy has been trying to understand why people become prosumers. First, the prosumers are motivated financially to reduce their electricity bills as well as by environmental concerns [6]. Financial concerns often prevail, however, as prosumers expect to be rewarded if they contribute to the public grid [4].

Second, being a prosumer allows them to be more competitive and productive because they feel responsible for energy production [6]. To increase their motivation in this regard, it is essential to provide them with examples of behaviors from other similar prosumers, e.g. households with the same number of residents [4]. Furthermore, people living in rural areas are more susceptible to become prosumers, as well as those who live in buildings built after 2009 [17]. By using novel technology such as smart meters, prosumers´ interest in monitoring consumption and production increases [4].

Third, the prosumers are motivated by social motivations such as co-production of energy and contributing to the public grid [11]. Therefore, it is important to consider their needs within the entire process.

3.2.4 Tools to support the energy activities for prosumers

One of the main concerns related to renewable energy is the development of technology that supports the new energy market. This includes not only the installation of renewable systems per se, but also providing the customers with monitoring and supporting tools [18][19].The implementation of renewable energy systems leads to the increase in the amount of data from different sources (e.g. smart meters, forecasting services for weather etc.) that needs to be considered for decision making. For that reason, understanding the information needed in the decision-making process is essential to develop tools that support monitoring and analysis of energy consumption and production [15].

For example, the implementation of an interactive web-based visual analytics system includes three primary capabilities: a) the information regarding the energy network, b) on-demand consumption and production information; and c) post-hoc and predictive analytics of consumption and production [20]. Furthermore, providing users with several layouts of the same information can be novel and relevant for them; however, the various representations should have a similar point of reference to prevent losing the visualization value [20]; [21].

Forecasting energy consumption as one of the focal points of interest, requires consideration of different factors such as historical consumption, occupancy profile, a day of the week, a month of the year and temperature [22]. Some authors propose designing scenarios in order to define the necessary variables for such calculation. For example, Yan et al.[15] proposed to include temperature, solar radiation, humidity, air pressure and wind speed as primary factors. This information is then presented using charts, e.g. pie and bar charts to illustrate the forecasted energy demand [15]. Other authors propose to include economic and cultural factors as covariates for forecasting the energy demand [23]. In this way, the users can get a more personalised prediction based on their consumption preferences, e.g. low, medium or high consumption as well as storage device types and capacity.

The design of a visual analytics dashboard to support the decision-making process has gained attention on the part of researchers and developers [24]. The critical factors for the design of such a dashboard include the availability and completeness of data, its structuring, quantification and exploration to produce meaningful graphs that avoid misinterpretation [25]. The analysis of the necessary information to include in the dashboard is therefore of paramount importance. For example, one dashboard explored by authors [26] to evaluate energy related activities included the following features: a) electrical power consumption monitoring using real-time systems b) comparative information and c) educational information. The authors observed positive impact of using the dashboard for the utility managers which included attitudinal changes such as increase in awareness, desire to learn more, and motivation to save energy [26].

3.2.5 Defining prosumer information needs

Researchers conclude that the identification of prosumer information needs regarding energy management is a significant challenge [24]. For example, the tools that support optimisation of energy consumption/production should integrate personalised goals and needs [25] in order to be effective for the end-users. However, there are very few tools that consider this. In order to understand user's information needs, we categorize the users by profile and identify the needs specifically pertinent to them [12]. For example, Table 2 shows various interests/needs of the employees in the context of municipal finance management,, depending on their role [24]. From the table we see, that depending on their profile (role), users have a very different need profile.

Table 2: Examples of identification of energy information interest by profile [24]

Profile	Interest / Need
Communal secretary	Evolution of the annual expenses related to energy manage municipal finances
Head of the department of energy	Financial statements of charges related to electricity and budgeting
Counsellor	Annual retail energy accounting to define and communicate energy policies
Delegate to the energy	Consumption of energy resources to identify priorities for actions and detect abnormal consumption.
Manager	To get alerts for abnormal consumption
Expert in energy	Overview of energy consumption to monitor de energy policy of the municipality

The needs have to be identified on two different levels: a) the strategic level which describes the resources required; and b) the operational level which refers to the identification of measures by the users [24]. Overall, to support the all-encompassing nature of the energy dashboard, such aspects as financial data (e.g. prices), and the ability to compare with previous periods, (e.g. last year) should be considered in the dashboard. Two types of variables are of paramount importance for the dashboard.

First, as meteorological conditions are crucial to determine the amount of generated energy, these values in conjunction with additional parameters such as prices and building occupancy could represent fundamental information to estimate energy demand and supply. Recommendations regarding the weather forecast could benefit the planning of energy related activities [27]. Weather forecasting can be classified into four categories according to the source where the information was obtained 1) arbitrary, the2) historical 3) local forecast and 4) external forecast. Each type has implications for supporting energy planning for prosumers. However, most relevant parameters are the strength of wind and the number of sun hours [27].

Second, dynamic prices are another relevant variable for prosumers to make decisions with regards to energy consumption and production. On the energy market, energy price changes during the day due to the balance requirements of the real-time energy production system [28]. However, consumer-behaviour is important when taking advantages of the dynamic electricity prices. If they are unable to reduce consumption during expensive peak times, bills could increase [29]. Therefore, it is important to encourage them saving energy, by providing timely information.

A further concern is how the information should be presented in the dashboard. According to Park et al. [20], presenting the information in different layers creates dynamic interaction for

end-users and can thus ease their processing requirements enabling faster understanding. Additionally, the dashboard can be enriched by implementation of “what if-scenarios” to provide help with complex calculations to estimate the measurements selected by the user e.g. (demand estimation, cumulative cost, etc.).
Using the information presented above, below we summarize the prosumer information needs by grouping them into four categories. Additionally, in Table 3 we provide specific examples of the necessary information for each of the categories. Overall information needs can be defined in terms of:

- **User definition**: classifying users by interests, including goals and motivations, e.g. a prosumer who wants to save energy is considered “*the prosumer saver profile*”; he is concerned about opportunities to save money by optimising energy production/consumption.
- **Technology**: The prosumer holds one or more renewable energy artefacts such as PV, wind turbines, etc.
- **External services**: weather forecast services to review factors such as wind speed, sun hours. This information could help the prosumer to understand patterns about consumption/production related to specific weather conditions. Another example is an external recommendation system to provide tips to help the user to achieve objectives.
- **Layers**: make consumption/production information more specific by adding additional details, e.g. filtering some data by a particular time span or comparing the consumption with a similar household.

Table 3: Examples in the classification of prosumer information needs

User definition	Technology	External services	Layers
- Consumption limit - Consumption reduction (%) - AVG consumption similar households	- Type of device (PV, wind turbine, etc.) - The capacity of storage devices	- Weather forecast service - Recommendation systems (tips) - Stock market prices	- Date - Type of contract - Level of consumption - Consumption or production - Payment or profits - Grid (if they belong to more than one network)

3.3 Utilities

3.3.1 Utility definition

Due to the exacerbation of the environmental problems, there is a growing need for renewable energy which, in turn, leads to an essential change in the electricity sector. The role of the utility is transformed by incorporating prosumers into the market as part of “*the energy transition”* [30]. The increase in green energy sources led to a decrease in energy demand and thus reduction of revenue for the utilities [31]. For that reason, utilities had to offer new business services such as installation and maintenance of domestic power plants [30]. As a result, the utilities have taken on the role of guiding new members, especially prosumers into the energy market.

3.3.2 Activities related to energy management

Due to the changes in the power generation market, the operations performed by the utilities have been extended with activities such as planning the energy production or purchasing it from third parties [32]. This leads to the necessity to put data analysis in the forefront. At the same time, real-time pricing has emerged as one of the main factors impacting the energy supply, especially during peak-times [33][34]. As such, the utilities have to anticipate the changes in the energy consumption associated with dynamic prices [35].

Additionally, due to the abundance of “green energy sources” weather is another main factor that determines energy generation (solar, wind, geothermal, biomass and so on) [36]. Integrating green sources into the energy market allows to schedule the operation of power plants to dispatch energy on demand [27], therefore, it is important to provide accurate inputs, e.g. weather forecast.

Integrating the green sources of energy into the energy market has helped to mitigate climate change; hence, forecast errors in this regard should be avoided, as they might lead to scheduling the operation of power plants to dispatch energy on demand

To provide better services, the utilities continuously monitor and test the performance of the technological infrastructure [27]. Some tests are based on forecasting conditions (electricity prices, building occupancy) to predict energy demand [37]; however, the results are often unreliable [27].

Being at the forefront of the innovative technology, some utilities have acquired energy storage systems [38]. Energy storage is an efficient solution to the imbalance of the electricity grid, allowing to store the excesses produced for later use. Therefore, monitoring the proper operation of those devices is of paramount importance for the utilities. Knowing the features of the different devices is crucial in ensuring their flawless operation [39].

3.3.3 Motivations and needs

As a result of introduction of new business models on the enegy market, utilities are concerned with increasing their sales and profits [31]. For that reason, the adoption of new regulations to improve the efficiency in the energy supply process is crucial, which includes the reinforcement of standards and renewable energy certificates to continuously improve the operations of the new technological equipment and cope with the new challenges.

Another characteristic of the utilities is the strengthening of the relationship with their customers by offering quality services. Usually, the customers receive the electricity bill; however often it does not provide detailed information about consumption throughout the day and also has difficulties with the integration of renewable energy players, e.g. prosumers [32].The ability of the utility to incorporate this information might increase the satisfaction of the customers and thus improve their relationship.

Additionally, the ability of prosumers to store energy in their domestic renewable systems strengthens customer demand-side, however it makes the energy-demand prediction by the utilities more difficult. In periods of high production, prosumers supply their energy demand and inject the excess into the grid [3]. The utilities will have to forecast how much the prosumers can produce and at which times as well as how much they will consume themselves and how much they will sell to the grid [37]. For that reason, for the utilities it is essential to know detailed information about the capacity of the prosumer’s storage devices and continuosuly monitor their behaivor to identify patterns. For example, dynamic pricing available on the market can help forecast the behavior of the customers: they will be more likely to sell when the price of energy is high.

3.3.4 Tools to support the energy supply activities for the utilities

The integration of alternative energy resources into the energy market has encouraged the development of tools to help with monitoring consumption and production. Some tools focus on prediction of energy demand to support the planning activities for the utilities [35]. These include development of algorithms to forecast different conditions such as building temperature, solar radiation, and gas emission and in this way contribute to the identification of patterns in the prediction of energy demand.

Forecasting energy consumption is a complex process which involves identifying multiple variables that together comprise energy demand. In the example in Figure 3 a methodology is shown that visualizes the relationship between the various factors involved in forecasting energy demand [35]: it includes weather inputs, consumption in the different networks as well as consumption by the customers. The outputs of the forecasting algorithms are presented to the users with the help of charts for the various time periods (monthly, seasonally and yearly) and training parameters (historical information about consumption) [35].

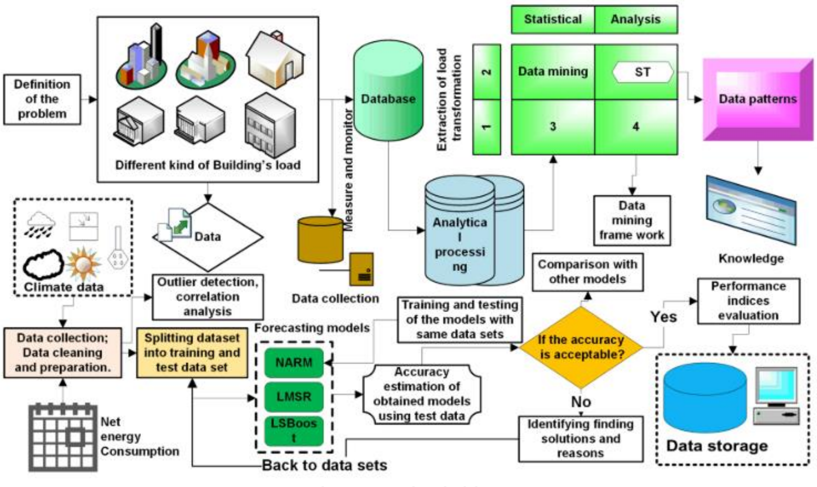


Figure 3: Example of a forecasting methodology for utilities proposed by [35]

Another simulation tool compares different parameters and offers recommendations for the use of variables to obtain more precise calculations [40]. The authors identified a variation in the peak-demand by various energy supply companies. Further, the inclusion of weather was necessary as the tool was tested in different regions. In this case, the climate was classified by clustering similar conditions that facilitated learning about specific situations, e.g. sunny days [41].

Having identified the proper operation of storage devices as an important factor for the utilities, some efforts have focused on the development of applications to facilitate the monitoring of those devices. In this way, the utilities can guarantee a suitable operation and improve their planning capability [42]. One of the tools developed in this area considered the following information: the number of equivalence cycles (obtained from the total discharged energy in a month divided by the rated capacity), the scheduled maintenance, peak power time and the charts illustrating the storage measure for the different sources (wind, thermal, geothermal) [39].

Finally, tools that enable communication between the energy storage battery and the PV system [42] are essential to ensure their smooth integration into the energy grid. An example of a control centre application visualises the connection between the battery and the PV system. In the output, charts showing the PV-Generation and the battery power measures [42] are presented to the user.

3.3.5 *Defining utility information needs*

With the transition to renewable energies, the utilities have implemented strategies to suit the new changes they were facing. Based on the information provided in the previous sections, we identified some considerations which served as a base to determine the utility´s information needs.

On the one hand, in order to motivate the customers to optimise the use of renewable resources and gradually become part of the energy market system, behavioral change is necessary [34]. On the other hand, utilities have to provide better services based on the consumption patterns identified from the customer data [27]. For this, utilities require information from the customers, such as consumption, peak-demand hours etc [9]. Additionally, some efforts have focused on proposing methods to estimate energy demand [27] to be able to serve the customers in a timely manner. For that reason, the weather and some characteristics about the devices could be essential to improve accuracy in the execution of these methodologies, and to help users facilitate the decision-making process [23][24].

The technological infrastructure is the base for the successful operation of the utilities; therefore, monitoring devices are essential to guarantee the provision of quality services, and help the correctly operate the devices [42]. For this, such information as the capacity of devices, performance and detection of failures are the most relevant.

Finally, dynamic prices are important to the utilities because the variations can significantly affect the sales and the demand for energy from the customers. Therefore, the information about the changes in the price and the peak-hours consumption is important to them [43].

Using the information presented above, below we summarize the information needs of the utilities. Additionally, in Table 4 we provide specific examples of the necessary information for each of the categories we identified. Overall information needs of the utility can be defined in terms of:

- **Key points:** objectives pursued by the utilities; presented as KPIs to measure progress of achieving goals over a period, e.g. increase sales per month.
- **Forecasting services:** forecasting information such as –weather forecasting services as well as outputs from algorithms to predict the energy demand.
- **Monitoring:** Information about the operation and performance of the devices in the company, e.g. storage batteries, power plants. Additionally, information about storage device of the customers can provide vital insights to estimate their energy demand.
- **Business:** information about energy sales and purchases from prosumers as well as energy providers. Additionally, information regarding dynamic prices can facilitate the identification of consumption patterns, especially during peak-time prices.
- **Layers:** users can filter the data to create a personalised visualisation. This feature can help them to identify similar situations or create comparisons between specific intervals.

Table 4 presents examples of variables to be applied to the categories defined above.

Table 4: Examples in the classification of utility´s information needs

Key points	Forecasting services	Monitoring	Business	Layers
- Target sales - Target	- Forecasting weather	- Power plants - Battery storage	- Sales - Purchases from	- Date - Time

consumption - Performance of storage devices	- Forecasting consumption - Forecasting production - Forecasting purchase	- Smart meters - Additional devices	other providers - Purchases from the prosumers - Profits - Losses - Dynamic prices	- Type of purchase (prosumer, third parties).

3.4 University end-users

3.4.1 University users definition

According to research in Canada and China, public buildings contribute 20-40% of the world´s energy consumption [44][45]; however, it is alarming that sometimes their consumption is higher than necessary [46][47]. The cost of energy at the workplace is of little relevance to most employees; so they are rarely motivated to save energy. Usually, offices are occupied in the working days during a fixed time, e.g., from 9 am to 5 pm [48]. Some zones are equipped with equipment for heating, cooling, and artificial light and so on. Most of this equipment is automatically controlled without involvement of people. Therefore, the amount of energy spent often remains unnoticed by the employees and the management and is reflected only in the bills they receive. This invisibility does not positively contribute to the desire of the employees to save energy at work.

Their attitudes can be changed, however, through organisational policies or through the influence of social norms and increasing sense of community. Group dynamics are common to all workplace settings and creating an energy aware group which is concerned about climate change can help in achieving significant energy savings for the public buildings. At the same time, the change in attitudes and motivating employees to save energy can be promoted by the management. The attitudes of the managers towards energy saving can motivate the employees to save energy as well. Additionally, when it comes to tenanted buildings, building owners can play a role to increase sustainable behaviour through the requirements they place on their tenants [50].

3.4.2 Motivations and needs

The development of renewable energy systems has led to reducing energy consumption in public buildings [48]. However, the majority of these technologies are programmed to operate automatically optimising the use of resources (e.g. water, electricity). Furthermore, some researchers have proposed to involve end-users to help reduce energy consumption [51]. Although there is quite some research exploring the factors impacting the reduction of energy consumption in the household setting [55], very few studies deal with encouraging energy consumption at the workplace [56].

Usually, employees share the facilities at the workplace and try to adapt them to their needs regarding comfortable temperature and luminance. There is a positive relationship between comfort conditions and productivity; however sometimes the employees do not use the equipment efficiently (e.g. turn on the heating and open the window) which leads to an increase in energy consumption [48]. It is difficult to motivate them to take actions in saving energy. First, energy consumption is often invisible to the employees [51]. Second, although reducing energy bills could be a motivation for households; it would not work for the employees as they are not the ones paying the energy bills. Therefore, other ways need to be found to motivate them to save energy at the workplace.

Studies show that in order to motivate employees to save energy, it is necessary to provide them with access to information about consumption of the building, change their awareness and attitudes regarding the impact of energy on the environment as well as instill a sense of control that their actions can indeed have an impact on the energy consumption of the whole building [52]. Most energy monitoring systems can be used in the different environments, such as manufacturing, schools, or companies [53]. Therefore, it is necessary to consider the possibility to design them in such a way that they can be used by a variety of users, e.g. to provide smart meter applications designed for end-users.

Overall, developing tools to reduce energy consumption in public buildings is a challenging, but not impossible task. Any such system should consider a wide range of motivational, social, organisational and technical issues [55].

3.4.3 Tools to promote energy optimisation in public buildings

Several efforts have been made to motivate employees to reduce energy consumption at the workplace. Odom et al. [57] analysed the effects of persuading students living in accommodation residences to minimise water and electricity consumption through the implementation of an eco-visualisation. As a result, they proposed to focus on the following aspects:

a) ***Concrete consequences***: use of figures or numbers to provide meaningful information.
b) ***Abstract quantities***: provide information on consumption based on a personal profile to make users understand the impact created by their actions.
c) ***Numbers and statics are not motivating***: Use visualisation or dynamic elements to provide more meaningful information and engage the users
d) ***Relevant instructive information***: provide information or suggestions to perform their behaviors in an energy-saving way.

Another tool to increase awareness about energy efficiency proposed by Trombley et al. [58] dealt with an implementation of a visual dashboard in a school. Through the dashboard, students and teachers received real-time information about energy consumption of the school. As a result, the students were more interested in learning about reducing energy consumption; as well as learned how to adjust more consciously the temperature and ventilation in the classrooms.

A further study by Tran [59] presented a mobile system to motivate the employees to conserve energy through social mechanisms. The main persuasive elements used were:

a) ***Using social network to bring energy-related feedback to new users***: the strategy was to challenge friends to provide information about energy consumption and start a competition. The competition would motivate them to reduce energy use to get better performance and subsequently compare their results to others in several ways (self-comparison, social one-to-one, ranking, etc.).
b) ***Notifications and suggestions***: awareness about the positive and negative impact of their actions could lead the users to identify patterns (Figure 4). Information about the energy consumption of others could help them to optimise their own energy use.

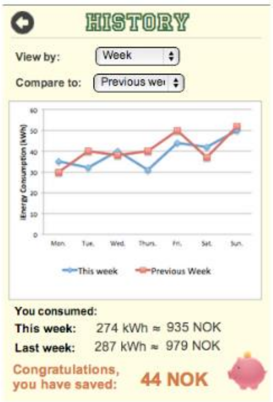


Figure 4: Mobile interface design proposed by Tran [59]

3.4.4 Defining end-users information needs in public buildings

The first step in the involvement of employees to actively participate in the energy saving efforts of the public building is to provide relevant information about their consumption [53]. Presenting energy consumption can be done as KPIs such as the kilowatt hour consumed and/or the emissions of CO_2. Further, presenting the information which uncovers the correlation between the actions they undertake and the energy which was consumed, e.g. the times when the lights or the heating was on. Additionally, to motivate employees to optimise their energy consumption, it is necessary to provide them with recommendations or tips to save energy [52]. According to Foster et al. [55], all organisational energy interventions require the following three primary aspects:

- ***Visualisation***: Using visual elements to facilitate the interaction with relevant information, e.g., consumption per day. It could also motivate the employees to meet saving goals, e.g., reducing consumption by 2% compared with the previous day (indicate the measurement target).
- ***Incentives***: In contrast to domestic energy saving applications, participants need extra motivation to maintain interest and participate, e.g., incentives by groups, areas or even individually at different intervals, such as monthly, weekly, etc.
- ***Engagement***: Provide timely feedback on progress, to allow the participants to monitor how they perform. Recognize achievements by scaling up actions that promote good practices. Finally, organize competitions with other departments in the organisation.

Using the information presented above, below we summarize the information needs of the employees in the public buildings. Additionally, in Table 5 we provide specific examples of the necessary information for each of the categories we identified. Overall information needs of the employees can be defined in terms of:

Key points: information about consumption at any specific time, department, area, etc.; organisational objectives, e.g. target consumption for the next month.
Engagement: Information to keep the participants interested in using the app and contributing to energy saving. It could include specific incentives defined by the institution that could inspire individual or group achievements. This information could be presented in ranking tables to inform about achievements in different areas.
Recommendations: Information to support the employees performing actions to optimise energy consumption. This information could be helpful to identify patterns in different scenarios inside the workplace.
Layers: employees can access information about historical consumption of individual, group, etc. Real-time information could be important to compare the performance throughout the day; users can review a specific time frame to track progress.

Table 5: Examples in the classification of user information needs in public buildings

Key points	Engagement	Recommendations	Layers
- Consumption - Target consumption	- Ranking consumption (by person, areas, etc). - Individual consumption and achievements.	- Provide tips to minimise consumption in the workplace. -	- Date - Time - Areas, department or individual

3.5 Building managers

3.5.1 Building managers definition

In the transition from traditional energy system to renewable and sustainable infrastructure, the role of owners and building managers has been changed significantly. In order to meet the governmental requirements to be considered as energy efficient buildings, they need to apply for certificates from third parties which require the adoption of renewable and sustainable technologies [60]. Furthermore, green energy buildings differ from non-green buildings in such factors as occupancy, operational hours (for commercial buildings), different types of tenants [60]. Therefore, building managers face different challenges as part of the energy transition.

3.5.2 Activities related to energy management

As the growing trend for installing renewable energy systems continues, building managers are responsible for monitoring the operation of different devices implemented throughout the buildings [60]. In addition, they may manage several buildings, which multiples the complexity and implies attending to different situations such as monitoring devices to analyse energy consumption, energy costs, etc., based on certain factors (e.g. internal/external temperature, humidity, illumination, etc.) [61]. Further, they are concerned with unanticipated situations such as technology degradation, unsuccessful usage of green technologies and so on [60]. However, the awareness of these aspects allows to identify the needs of this type of users and to develop tools that cater these needs.

3.5.3 Motivation and needs

For the installed renewable energy systems, it is necessary to provide the building managers with accurate and relevant information about the operation of the infrastructure in the buildings. In addition, the decision to switch to green energy implies the acquisition of expensive technological infrastructure as the energy efficiency investment [60]. Therefore, the information about potential energy savings incurred by these systems is important to estimate the return of the investments [62] and also to motivate the building managers to continue promoting energy optimization.

According to Liang et al. [60], energy management for building managers consists of several improtant factors (Figure 5). The engineering factors refer to the operation of the technological infrastructure, including determinants such as building attributes, weather conditions and urban micro-climate which can influence the energy performance. Behavioural factors are the most relevant because the occupants´ preferences significantly impact the efficiency and performance of the building. Usual actions such as opening the windows to ventilate or illuminate a room, can provide a significant impact on energy saving. This behaviour often cannot be predicted by energy estimation procedures, and thus makes it difficult to optimize and consider in the planning process. Organisational factors include the communication between tenants and landlords which could aid significantly in terms of optimizing bills and contract conditions for both parties. This, in turn, can bring in multiple benefits for both, e.g. reducing electricity bills and promoting caring for the facilities and the energy infrastructure.

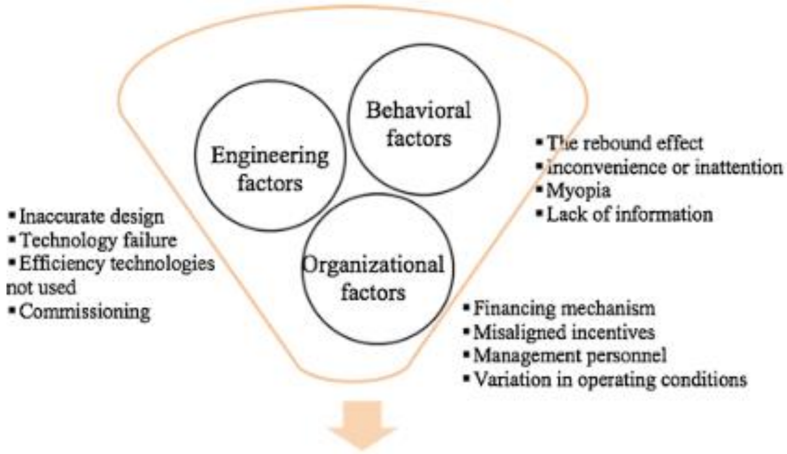


Figure 5: Factors involved in the energy performance gap (image taken from [60])

3.5.4 Tools to support energy management activities

The penetration of green energy systems has led to the development of tools to predict energy saving through simulation models such as eQUEST, EnergyPlus and similar [60]. Furthermore, several efforts have been made to develop IT-solutions to manage the energy behavior of the whole building [61], gather real-time information and consolidate it into visual analytics dashboards [63] support the building energy management.

3.5.5 Defining building managers information needs

Below we summarize the information needs of the building managers identified from literature. In Table 6 we also provide specific examples of information for each identified category. Overall information needs of the building managers can be defined in terms of:

- **Key points**: This category comprises relevant information related to the main concerns for building managers to aid the resource management process.
- **Infrastructure**: Monitoring the performance of technological devices could facilitate the identification of failures and thus provide better services to their tenants.
- **Recommendations**: building managers could receive some tips or recommendations about more efficient use of the devices that they can apply to reduce energy use in the building. In this way, they could share information with their tenants as a part of the lease agreement.
- **Layers**: This category intends to facilitate the interaction with dynamic information. There will be functionality that allows the building managers to create personalised information views to carry out specific analysis.

Table 6: Examples in the classification of building managers´ information needs

Key points	Infrastructure	Recommendations	Layers
- Energy consumption. - Energy savings (costs) - Illumination - Humidity	- Status in the performance of devices.	- Provide tips optimise energy consumption by exploiting technological infrastructure.	- Date - Time - Building - Technological device

4. User workshops for identification of user information needs

4.1 German pilot

4.1.1 Prosumers

Methodology and participants

On Thursday, 10th January 2019 a two-hour workshop was held from 5-7pm at the Stadtwerk Haßfurt (SHF) premises in Haßfurt, Germany. The aim was to bring together prosumer-clients of the utility and the project managers of the SHF and the researchers from European Institute for Participatory Media (EIPCM) in Berlin who are supporting SHF in the work on the prosumer-oriented part of the Smart Energy Dashboard. SHF hosted the workshop. In total, six prosumers attended the workshop (Figure 6): 1 female and 5 male.

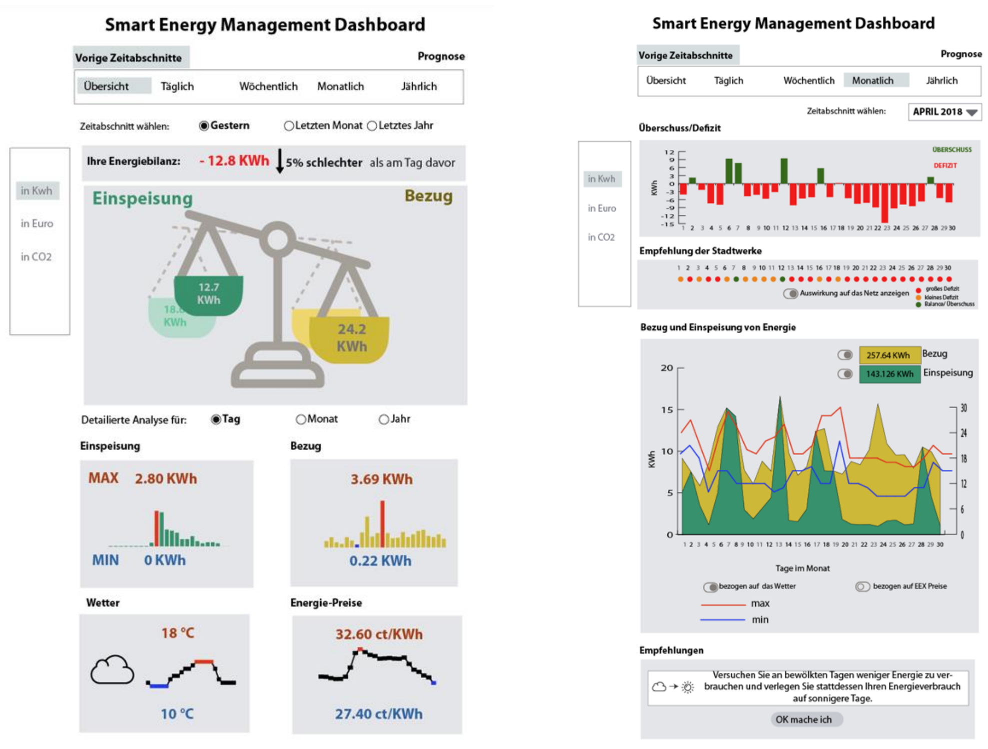
After the welcome, a brief introduction to the SIT4Energy project was given, followed by a general overview of the workshop agenda, starting with the definition of prosumers and a classification of their different types, as well as their role in Germany's energy transformation. Participants were then asked what type of prosumer they currently were and why they had chosen to become a prosumer. Then the participants were asked what type of information they used in order to decide about their energy production and consumption, and if this information was sufficient. They were then shown the mock-ups of the smart energy dashboard and asked for detailed feedback about it. They were then asked what their specific needs were regarding the dashboard functionalities, and if any specific functionalities were missing. Overall, the workshop was semi-structured, so that the prosumers were asked questions, but also given sufficient freedom to express their needs in a natural conversation .

Figure 6: Participants attending the prosumer workshop in Haßfurt

Smart Energy Dashboard Mock-up

The participants were presented with the developed mock-ups of the dashboard. The main idea of the dashboard presented in Figure 7 and Figure 8 is that it visualizes the energy balance achieved by prosumers: the energy they produced (fed back to the grid) and the energy they consumed (the energy they procured from the grid)[1], during the various time segments, such as: daily, weekly, monthly or yearly. In the dashboard, the consumers are presented with their historical information, as well as with forecasted values. By analysing this information, users can adjust their consumption and production in the future.

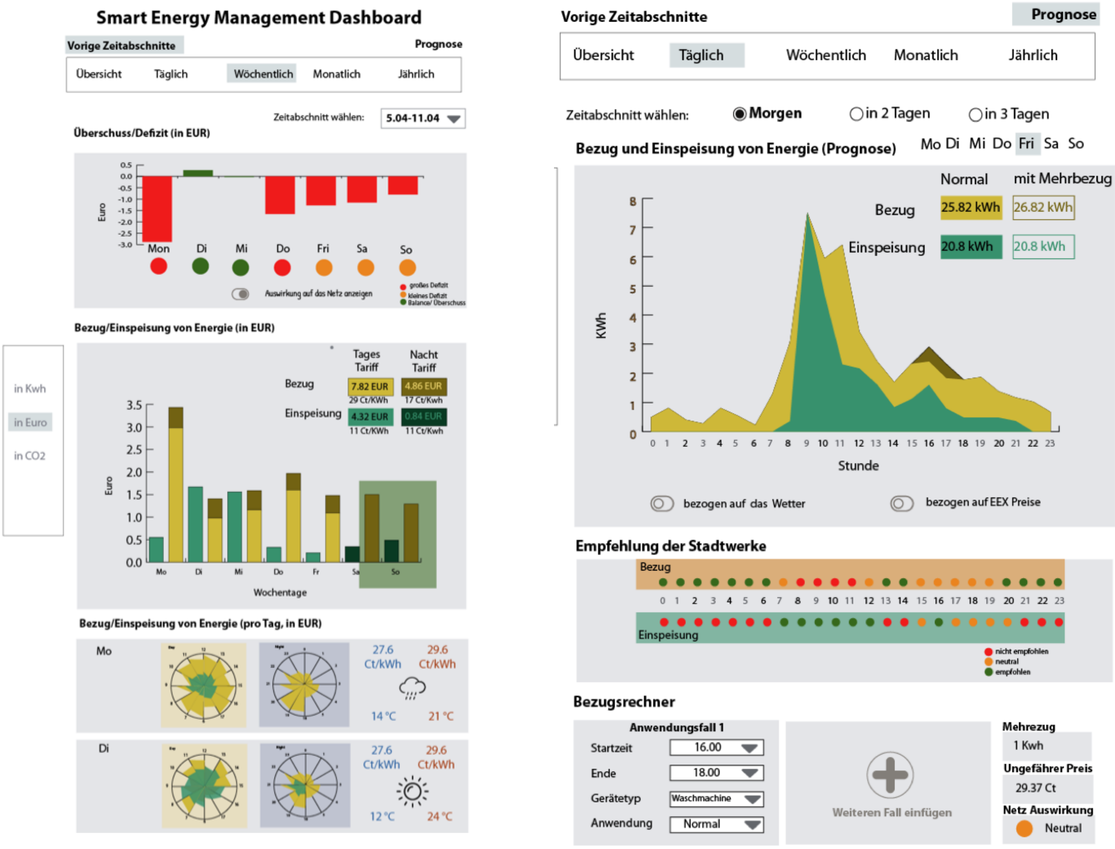
[1] Depending on the type of prosumer, for some prosumers the data of consumption/production is available, whereas for others, only the amount they fed back or extracted from the grid is available.



(a) (b)

Figure 7: Mock-ups of the Smart Energy Management Dashboard: (a) start screen of the dashboard; (b) the monthly view of the dashboard

Visualisation of consumption and production was done in several ways, ranging from a rather metaphorical representation in Figure 8 (a), an area graph in Figure 8 (b) or bar diagrams in Figure 8 (a). The idea was to check which of these representations are most appealing and understandable for prosumers. One of the main features of the dashboard is that in all of the visualisations, additional information was included that might help prosumers understand factors driving their energy balance better, such as the highest and the lowest temperature, the overcast, or the energy prices. Prosumers themselves can visually inspect this information or they can rely on the explicit recommendations provided by the system. These recommendations are based on their past behaviour, e.g. if it was cold and cloudy, the prosumers would be advised to reduce their consumption to match the low production output (or shift it to a later time point when more sun is available). Additionally, in the dashboard, the users can translate the KWh values into EUR and Co2 (via an approximation). In this way, the prosumers can easily see what impact their production and consumption has in monetary and environmental terms – which might be more important for some kinds of prosumers focused either more on material or social values.



(a) (b)

Figure 8: Mock-ups of the Smart Energy Management Dashboard: (a) weekly view of the dashboard; (b) the forecast view of the dashboard.

Apart from historical values for the various periods, the prosumers will be presented with the forecast values for their energy production and consumption during the next day (week/month), which are based on their historical consumption/production in the same period as well as the forecasted weather and energy prices. As presented in Figure 8 (b) prosumers can see their forecasted consumption and production on the area chart (or another type of visualisation of choice), over the next 24 hours. Additionally, they are provided with a recommendation of the utility for each hour, which is based on the overall amount of available energy, whether they are encouraged or discouraged to produce/consume at this time. Furthermore, they can use the consumption calculator, which, after inserting the time and the type of consumption, gives an additional estimate of how much energy they would consume and visually displays that amount on the area chart. In this way, prosumers can visually see what impact the additional consumption has on their energy balance and make more informed consumption decisions accordingly. Overall, the forecasted values will allow giving some planning security to the prosumers with regards their energy balance in the future.

Workshop results

The workshop results are summarised in Table 7 below and explained in more detail in the text below the table.

Table 7. Workshop results for prosumers

Questions	Description
Who	Prosumers – the energy consumers who produce their energy. Most of the prosumers have photovoltaic systems (PV systems) of different generations. Some of the prosumers feed all the produced energy directly back to the grid and then consume energy directly from the grid, whereas others consume what they have produced and feed only the residuals to the grid. Few prosumers also have batteries for energy storage.
What	Main prosumer motivations are financial concerns, environmental reasons and personal or professional interest in the subject (the technical affinity and motivation to use the most innovative technology available on the market). Overall prosumers were highly interested in optimising their consumption and production and getting the most benefits out of their installed power plants.
Why	The following needs were identified: - Planning certainty for the future - One-stop platform for relevant energy-related information - Monitoring and optimisation of energy production and consumption - What if scenarios to experiment with finding the most optimal energy balance - The business case for investing in new technologies (such as storage)
How	Currently, prosumers use the information from their PV plants to monitor their energy consumption and production. If they are interested in additional information, they usually look it up using different websites or freeware apps, for example, weather apps or other available software on energy monitoring. However, in these sources they can only find scattered information; they have no source which displays all of the necessary information to make optimal consumption/production decisions.
Information required	- Consumption and production (in the same chart). - Energy bought and sold to the grid. - Weather (number of sun hours). - Energy prices (current and forecasted). - Reference values to comparable profiles (PV systems, other consumers). - Recommendations about more optimal consumption and production, especially in relation to low energy prices. - Display of consumption/production in monetary, kWh and CO2 terms. - Daily, weekly, monthly and yearly information. - Reference values (e.g. in KilowattPeak). - Quick and simple overview with a possibility to have detailed information on request.

All of the participants in the workshop were prosumers. Most participants reported that they had photovoltaic systems (PV systems) of different generations. One prosumer also had a combined heat and power plant and was thinking about the acquisition of two small wind turbines. Another participant used a variety of different equipment including a PV system, a battery storage device and a fuel cell for heating. Mainly the prosumers are motivated by financial concerns such as saving energy-related costs, the profitability of state-subsidized investments, later amortisation of their investment, and cost reduction at retirement age. The participants that stated ecological reasons mentioned the reduction of CO2 emissions and supporting the transition towards a more sustainable energy system. A few participants were not only driven by financial and environmental motives alone but also had a personal or professional interest in the subject. Among these participants, some were technically affine pioneers, equipped with a range of different systems for power production and storage, as well as combined heating and water systems.

When asked what type of information they used in order to decide about their energy production and consumption, and if this information was sufficient, most prosumers replied that they were using the information from their PV plants to monitor their energy consumption and production. If they were interested in additional information, they usually looked it up using different websites or freeware apps, for example, weather apps. The information that workshop participants were mainly interested in was to know their *consumption and production*, as well as information on the *weather* (e.g. sun hours) and *energy prices* (e.g. current and forecasted energy prices on the stock market). *Reference values* in order to monitor and compare their own consumption/production with that of others were also mentioned.

When asked what their specific needs were regarding the dashboard functionalities, prosumers alluded to wanting a certain amount of *planning certainty* concerning the next day. A central need for them was the *ability to assess how optimal their past production and consumption behaviour* had been and how they could continue to behave optimally in the future. Participants also reported that they are interested in receiving *recommendations* about more optimal consumption and production possibilities. Given their strong interest in energy prices, they would like to receive notifications alerting them with a price prognosis for the following day. For example: “Prices will be lower between X and Y pm tomorrow, but they will be higher in the evening. We advise doing your washing between X and Y Pm”. In order to strategically assess their efficiency, they were also interested in *“what if” - scenarios*, that would enable them to calculate their energy balance in different scenarios, for example regarding the upgrading of their system with a storage unit. Prosumers would like to be able to run a potential analysis and calculate financial implications of various options, e.g., “Your current consumption/production balance is X. If you had a storage capacity, it could be improved to Y. This would save you Z€ per period.”

The participants were then invited to give their feedback to the first mock-ups of the “Smart Energy-Dashboard“. In general, the mock-ups were well-liked by the workshop participants. Participants stated that they find it valuable to see their *demand and supply at the same time*. They wanted to view the details of their consumption and production, and they were also interested to know what was *sold and bought from the grid*. They would like a *quick and simple* overview of their overall consumption at first glance. They generally liked the ability to have access to the more detailed information in a second step, but this should only be visible on demand.

It also became obvious, that participants did not have a specific preference as to the way of visualising information (metaphorical, area or bar charts). Some participants preferred more quantitative data, whereas others were more attracted to the metaphorical view. They also liked the possibility to display information in the three ways: *monetary, kWh and CO2 emission*s. As many still do not link their energy consumption to CO2 emissions, they found this information to be especially useful and interesting. Prosumers also appreciated having *daily, weekly and monthly* overviews, as well as they, desired to see their *total consumption in the year*.

Further suggestions included *reference values* shown in KilowattPeak (kWP) in order to support the monitoring of their PV plants. There was a suggestion for the dashboard to include a *forecast* of the *energy stock exchange prices* and give recommendations about when to expect a lower price in the near future. For example: „Happy hour is tomorrow between 8 and 10 am. Prices are low, it's a good moment to consume.“ These requests directly relate to the prosumers’ need for optimisation.

Overall, prosumers’ main needs were to achieve a certain amount of *planning security* for the next day as well as to have strategic analysis tools that would allow them to *monitor and continuously optimise* their energy production and consumption. Concerning to the mock-ups of the dashboard, the main points of interest to the prosumers were consumption overviews presenting historical data and information on weather and energy prices (historical and prognosis), as well as “what if scenario” calculations. In summary, prosumers were interested in using a *platform* that would combine the various types of *energy-related information* which could help them make more optimal consumption and production decisions. It can thus be concluded that there is a need for the smart energy dashboard and that it would be a useful tool for the prosumers to help them achieve their planning and optimization needs.

4.1.2 Utilities

Methodology and participants

The workshop with utility employees was held in Stadwerk Haßfurt and lasted about two hours. The primary objective was to identify some initial insights into the development of a Smart Energy Dashboard for utilities that should facilitate the analysis of data regarding energy consumption and production of their customers for better planning and integrated demand management. Currently, the company does not have a job position responsible for the data analysis; therefore, five employees who perform activities as technical supervisors and decision-makers in the energy production attended the session.

In the beginning, participants signed a consent form which explained the confidentiality in the treatment of information obtained during the event. Then, a round of open questions was held to get a background about the activities they perform in the company as part of their work, as well as regarding the handling of information from their customers. Subsequently, the mock-up was presented to illustrate some initial ideas about the design of the Smart Energy Dashboard for utilities; after explaining the mock-ups, the participants answered open questions to give feedback to the proposal. Finally, the moderators summarised the main ideas/feedback in the form of conclusions.

Smart Energy Dashboard mock-up

As part of the electricity supply contract, the installation infrastructure usually includes the use of smart meters which send the consumption measurement per hour to the utility. The company provides the information to their customers through a customer service portal which includes additional features, e.g. pricing, payments among others.

The mock-up design was based on information provided by the smart meters to the utility, such as consumption (see Figure 9 – a) and additional information such as total sales (see Figure 9 – b) and information regarding weather (see Figure 9 – c). Finally, the prototype included two charts to illustrating an intent to combine data on energy consumption and data on user behaviour from interaction with the portal (see Figure 9 –d). See Annex B for detailed information.

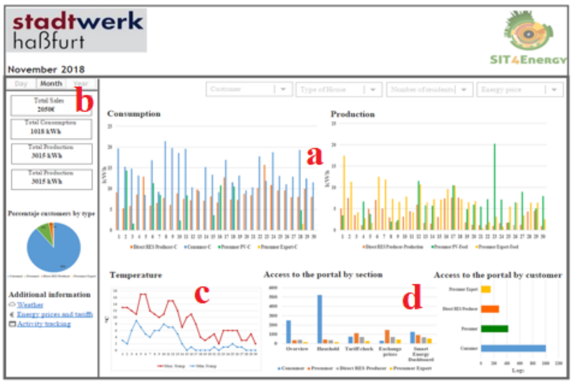


Figure 9: Main elements in the Smart Energy Dashboard for the utilities

The prototype included a variety of filters to allow the users selecting some criteria to generate a dynamic visualisation (Figure 10). In this version, the mock-up consisted of the filters like temperature, energy consumption and production, type of customer among others. Selecting ranges facilitated the creation of customised visualisations.

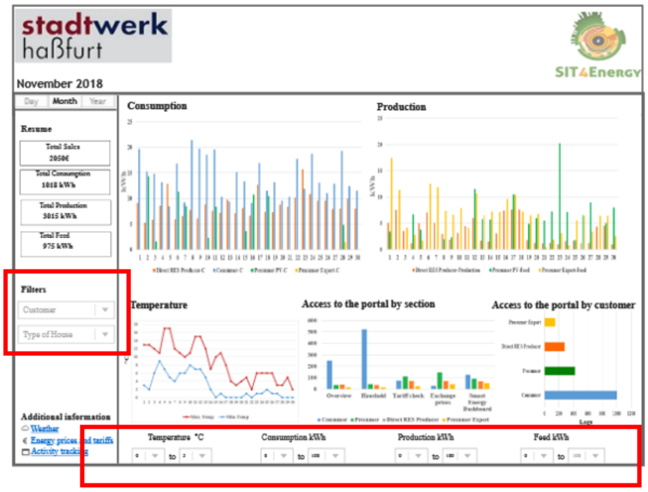


Figure 10: Customisable filters in the viewing of information for the utility

Finally, the mock-up design included additional features to facilitate analysing data, e.g. applying different filters as well as creating reports (see Annex B), these features were explained in detail to the participants.

During the workshop, the voice feedback was recorded while the moderators were observing and taking notes from of the participants' comments and feedback to the prototype. Subsequently, the notes and the audio recording were analysed to identify relevant findings. Table 8 summarises the preliminary results which were structured in the form of questions to provide detailed information about the utility information needs.

Workshop results

Table 8. Workshop results for the utilities

Questions	Description
Who	The participants roles in the company include that of a technical supervisor and decision-makers regarding energy production. As part of their work, they analyse previous data as well as the consumption per day to manage

	the activation of power stations in the company.
What	The technical supervisor currently conducts manually the analysis of relevant data for planning the energy production for the next day. However, the participants also monitor the consumption throughout the day, especially during peak-hours to determine the duration and the estimated time for the activation of the power stations in the company. When the energy demand exceeds the production, the utility purchases energy from other suppliers. The utility supplys energy primarily to private consumers. In contrast, most prosumers generate their own energy and store it or sell the excess to the company. However, in periods of shortage, they become consumers too.
Why	The company does not have any job position regarding the analysis of information; however, it will be useful to them to have a tool to support the analysis of information as well asthe monitoring the energy consumption. That could help them to estimate the amount of energy to be produced in order to meet the demand. The prosumers have different storage devices, e.g. batteries that are not always used at their maximum capacity, especially during high energy production (e.g. sunny days). In this case, the utility is interested in supporting their customers to exploit the capacity of those devices fully; if the prosumers allow the company to operate the devices for storing their energy, the utility could have an extra amount of energy stored in the customers´ devices. In return, the customers could be rewarded with incentives, e.g. lower prices during low energy generation season.
How	Currently, they do not have any tool or software to support the analysis of information. They use data from the smart meter usually from the previous day as well as the weather forecast to manage the energy supply. However, they cannot analyse scenarios for specific situations and take the most favourable decisions.
Information required	Based on the analysis carried out after the workshop, the following categories have been identified: -Stadtwerk Haßfurt goals: • To have a tool to aid the estimation of day-ahead energy consumption through the analysis of previous information. • To identify different scenarios of energy consumption & production from previous data to prevent peaks in the energy consumption and to support the decision-making process for the company, e.g. the activation of the power stations or the purchasing of energy from third parties. • To analyse the capacity of storage devices of their customers to help them to exploit the excess storage capacity for the electricity generated by the utility. • To analyse the customers´ behavioural change in energy consumption regarding the dynamic energy prices. • As a long-time goal: to operate independently avoiding the supply through third parties. -Information needs: • Weather forecast for sun hours, wind and temperature filtered by day-ahead, week-ahead. • Historical information on energy consumption/production, including the following filters:

	a) Intervals during the day, e.g. 13:00 – 16:00 b) Prices, e.g. day and night rate c) Type of customer, e.g. consumer, prosumer expert, etc. d) Filtered by the different grids in the company. Use the heatmap visualisation to show consumption or production to present the information for all the networks. e) Positive, negative or both • Sales and purchases of energy a) Intervals during the day, e.g. 13:00 – 16:00 b) Prices, e.g. day and night rate c) Type of customer, e.g. consumer, prosumer expert, etc. d) Filtered by the different grids in the company. Use the heatmap visualisation to show consumption or production to present the information for all the networks; in this way, they could see possibilities for transfering electricity from one grid to another. e) Positive, negative or both • Energy prices in the stock market by a specific day and filtered by an hour.

4.2 Greek pilot

4.2.1 University end-users

Methodology and participants

The SIT4Energy workshop named “Modelling the end-users’ needs” was held at ITML’s premises in Athens (Greece) on 21/12/2018. The event was aiming to get the first insights in the information needs for designing the Mobile recommender app for use in university settings. The target group is the academic staff and students from the Harokopio University of Athens (HUA) at the Athens campus as energy end-users in a university setting (SIT4Energy target group 3 described in D1.1). Around ten representatives of academic staff from the HUA campus were attending the event (Figure 11). The participants signed a consent form at the beginning of the workshop in which they were assured that their data were treated confidentially.

Figure 11: Participants in the university end-user workshop

The main objective of the event was to present to the participants the initial mock-up of the mobile app to be developed for the HUA campus and to get feedback from them as the potential end-users. The event has started by briefly presenting the SIT4Energy project (the scope, objectives and expected outcome) and followed by illustrating the important insights as an outcome of SIT4Energy survey already performed at the beginning of the project (documented in D1.1). After that, the initial mock-ups of the mobile app were demonstrated to the attendees. The participants had the opportunity to gather and exchange their ideas during the presentation that was split into short intervals to allow the participants to express their ideas or comments, to generate feedback and to make notes (Figure 12).

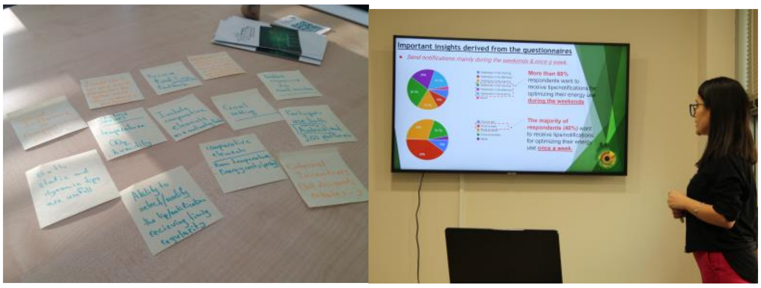
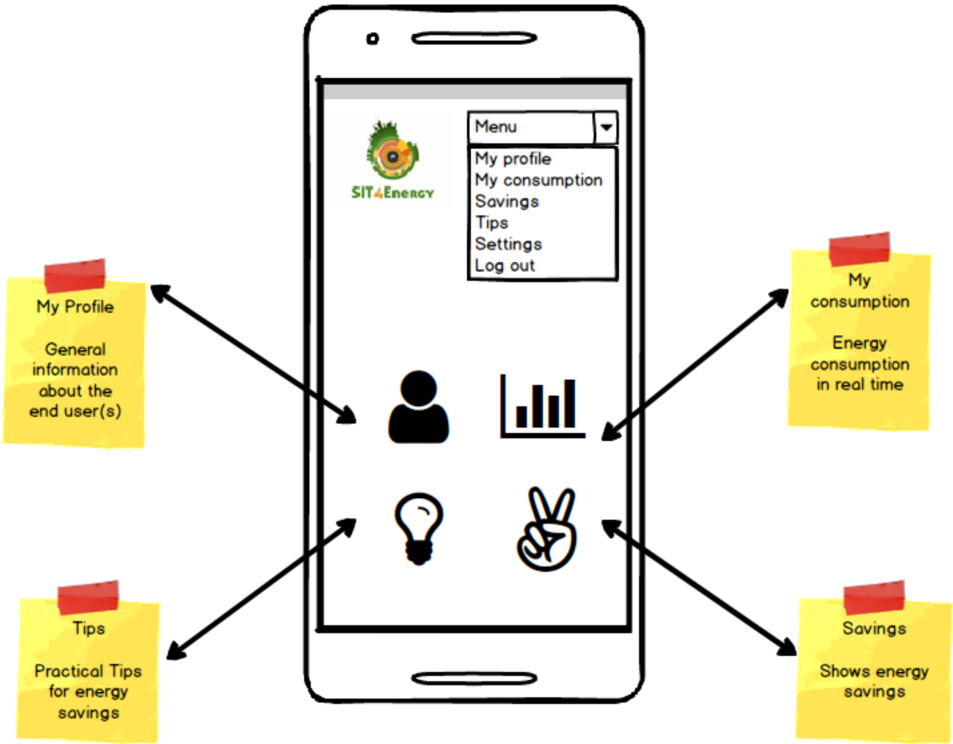


Figure 12: University end-user workshop procedure

Mobile App mock-up

The presented initial mock-up of the mobile app consisted of the following components: My profile, My consumption, My Savings, Tips & notifications and Settings as presented in the figure below:



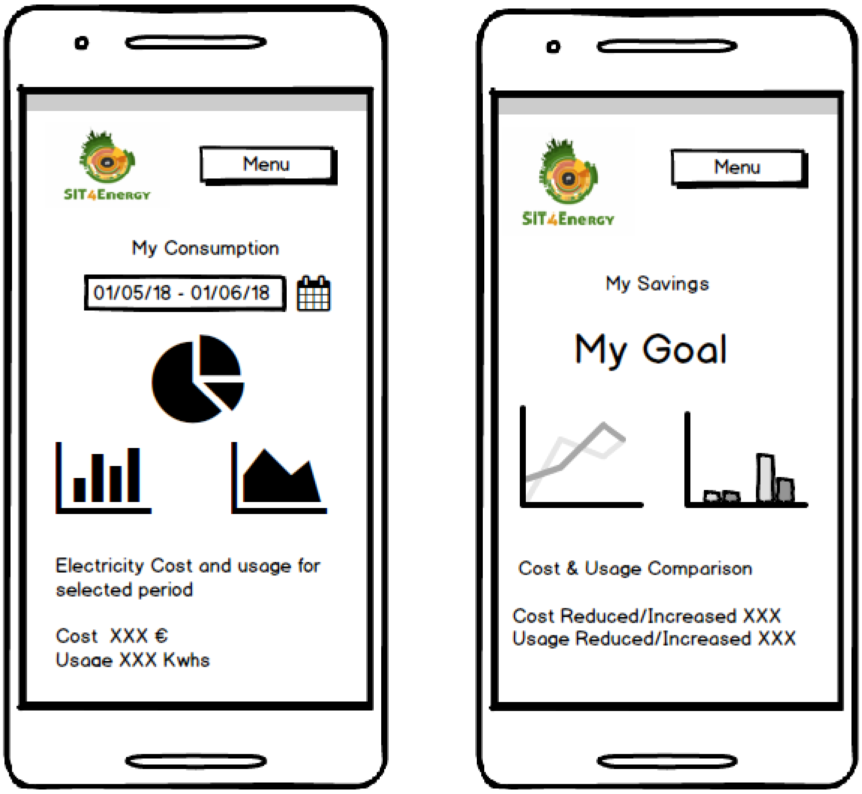


Figure 13: University end-user mobile app mock-up

Table 9. Workshop results for end-users

Questions	Description
Who	Representatives from HUA campus (2 students, 3 researchers, 1 research assistant, 3 faculty members)
What	The users are energy consumers. None of them performs any energy management activities due to lack of relevant information, economic aspects, issues related to security and privacy, lack of trust and lack of tools to do so.
Why	Almost all participants are not satisfied with the information received about their energy consumption. The given information is not complete, and the majority of participants desire to get more insights about their energy consumption, billing system as well as to be able to control their energy consumption. The users are highly motivated to start using energy management related tools and services are aiming to reduce both energy consumption and energy bills.
How	Currently, they are not using any energy management tools, they are not developing any actions right now neither at home nor at their workplaces.
Information required in household	- Receive information (tips & notifications) to be able to reduce bills. - Billing and usage monitoring and controlling: • Access to current energy usage and billing information • Receiving tips/notifications to reduce their current energy usage/bills and to control this process (i.e. keep the achieved energy saving or bill saving constant).

	- Real-time consumption to have a better budget estimation - Using my saving functionality. My saving functionality represents a screen with a) a graph with two curves illustrating the consumers' current energy usage vs target energy usage (in kWh) and b) a centrally placed horizontal bar chart with two bars illustrating the consumers' current energy consumption cost vs target energy consumption cost (in Euro). For the participants, the important feature was to set a specific plan (my goal or my target) for a certain period of time based on the current energy usage/cost and try to reach to that goal/target.
Information required in the work space	The mobile recommendation system deployment in the HUA campus would be useful for the occupants (academic staff, students) if it can help to change their everyday working space activities related to energy consumption. Most of the participants agree that if by receiving tips & notifications they gain knowledge about their current energy consumption habits, they would be willing to change them in order to save energy. With regard to energy consumption reduction in their working space, participants consider the most important parameters to be indoor temperature, windows/doors status and electricity consumption for lighting.

5. SIT4Energy User Information Model

5.1 Overview

This section presents the results of analysing information needs from the SIT4Energy target groups: prosumers, utilities, university end-users and building managers. The first step was the literature review to define the initial set of user information needs, later complemented with the analysis of insights obtained from the user workshops.

The user information model in this deliverable is intended as a formulation of user information needs from a user-centered design perspective [64] that can inform the design of the SIT4Energy system (the technically-oriented data model for the SIT4Energy system is subject of work package 4). Therefore, the information needs are presented in a contextualised way that is defined by the four main categories as follows:

User definition: it comprises the overall description of activities carried out by the user regarding the SIT4Energy framework, both personal and work-related, where relevant. Besides, it includes user types to provide a richer context defining the information needs.

Intentions: this refers to user motivations and needs in the development of activities related to energy optimisation within home, school or workspace; the main focus is on the possibilities for development of tools to support those needs.

Information type: includes a set of identified types of information corresponding to specific needs of a given target user group.

Information layers: variables to allow the creation of personalised filters to provide dynamic interaction with the information presented in the SIT4Energy end-user applications.

This provides a user-centred context for making the information needs better understandable with respect to the specific target users and the intended context of use. The individual User Information Models for each of the target groups are presented in the following sections.

5.2 Prosumers

The Prosumer Information Model refers to the information needs that can inform the design of a Smart Energy Dashboard to support prosumer activities regarding optimisation of their energy consumption and production. Detailed information is presented in Table 10.

Table 10: Prosumers Information Model

Category	Description
Prosumer activities	The German utility Stadtwerk Haßfurt offers electricity services to different types of prosumers belonging to the following categories: a) Type I: they produce and consume energy separately. They pay for energy consumption and sell the energy produced to the company. b) Type II: they produce energy to meet their demand, selling the surplus into the grid and consuming energy from the grid when they need it. c) Type III: they produce energy to cover their demand and also to store it in their batteries, selling surplus into the grid and buying energy when they need it (as consumption or to fill their storage devices when energy is cheap).
Intentions	The prosumers could benefit from having a tool to support the following actions: - Reduce energy bills. - Planning certainty for consumption and production - Optimise energy consumption to benefit from the dynamic prices. - Using energy production efficiently through the household or injecting it into the grid. - Have detailed information about energy payment and reimbursement. - Contribute to environmental care by using green energy. - What if scenarios to experiment with finding the best optimal energy balance
Information type	The design of the Smart Energy Dashboard for prosumers could consider the following types of information: - Energy consumption from the grid. - Energy production and storage. - Energy dynamic prices - Tips or recommendations to reduce consumption and optimise production. - Tips or recommendations by using dynamic prices efficiently.
Information layers	Dynamic information could be provided by allowing users to select parameters or filters to personalise the information presented. The proposed filters are shown below: - Time (months, weeks, days, hours). - Weather conditions such as sun hours, wind speed, etc. - Dynamic prices. - Amount of energy consumed/produced (if available) - Amount of energy bought/sold from the grid - Information about KWh, EUR, CO2.

5.3 Utility

The Utility Information Model refers to the information needs that can inform the design of a Smart Energy Dashboard to support activities of utility employees in the energy demand and supply planning. The goal is in particular to support the identification of optimization potentials through a better understanding and integrated management of local production and consumption. Detailed information is presented in Table 11.

Table 11: Utility Information Model

Category	Description
Utility employee activities	Employees of the German utility Stadtwerk Haßfurt responsible for planning the production and purchase of energy mainly perform the following activities: a) Energy production/consumption analysis from previous data records. b) Energy distribution planning through different electrical grids in the company. c) Planning the energy purchase from third parties.
Intentions	The utility employees could benefit from having a tool to support the following activities: - Dynamic visualisation of energy consumption and production by analysing information from previous records. - Analysis of the storage devices management, both from the company and prosumers. - Energy management through the electrical grids in the company to facilitate the decision-making process. - Analysis of weather conditions to estimate the energy production. - Visualisation of purchases and sales of energy to prosumers. - Using different variables, such as weather conditions, energy consumption/production in the definition of what-if scenarios to analyse or simulate specific conditions and facilitate the decision-making process. - Provide accurate and detailed information to their customers. - Analyse the relationships between forecasting weather and energy consumption/production
Information type	In order to meet the user information needs, the design of the SIT4Energy Management Dashboard could consider the following types of information and analysis: - Historical energy consumption/production. - Storage devices status (for the company and for prosumers). - Forecasting weather. - Status for the electricity networks in the company. - Energy sales and purchases from prosumers as well as third parties. - Key points defined for the company in the form of objectives (e.g. target sales in a month).

	- Dynamic electricity prices.
Information layers	Dynamic information could be provided by allowing users to select parameters or filters to personalise the information presented. The proposed filters are: - Time (months, weeks, days, hours). - Different electricity networks in the company. - Types of customers. - Weather conditions such as sun hours and wind speed. - Dynamic prices.

5.4 University end-users

The University End-users Information Model aims to inform the design of a mobile recommendation system for energy saving for university staff and students. The mobile app should allow them to access information on how they can reduce electricity consumption on the campus. However, the scope of the application could also be extended to actions that these users could perform in the household as well. Detailed information is presented in Table 12.

Table 12: University end-users information model

Category	Description
University end-users activities	Representatives from Harokopio University of Athens (HUA) including students, researchers, research assistants. They are not directly responsible for optimising energy consumption on the campus. However, they would interact with information regarding energy consumption behaviour alternatives by using smart energy services. The information could be useful not just in the workspace but also in their household.
Intentions	The university end-user can play different roles according to the place where they are. Therefore, intentions have been divided into two categories: University: - Saving energy by using appliances and electronic devices efficiently. - Encourage energy savings in the academic and student community. - Get real-time information on energy consumption. - To have adequate thermal conditions in the work/study place. Household: - Reducing electricity bills. - Get real-time information on energy consumption. - To save energy by using appliances efficiently. - To receive recommendations for energy saving.
Information type	In order to meet the user information needs, the design of the tools to support the energy optimisation could consider the following types of

	information: University: - Provide real-time information on energy consumption. - Provide tips to save energy. - Engage users by promoting individual and collective competence. - Reward individual and collective achievements (based on energy optimisation). Household: - Provide real-time information on energy consumption - Provide detailed information about consumption. - Provide tips to reduce energy consumption, especially during peak-time.
Information layers	Using filters to facilitate access to the information could include the following filters: University: - Time (months, weeks, days, hours). - Area/team/group/room. Household: - Time (months, weeks, days, hours). - Energy price.

5.5 Building managers

The Building Managers Information Model describes the information needs relevant for supporting mainly the energy monitoring and maintenance of their buildings, but which could also lead to offering better services to the tenants and optimising resources and the use of investments into renewable energy systems. This can inform the design of a tool for building managers that could be tested in the university setting of the Greek pilot. Detailed description of the model is presented in Table 13.

Table 13: Building managers information model

Category	Description
Building managers´ activities	The building managers perform the following activities of relevance for the project: a) Energy consumption analysis from previous records. b) Budget planning for covering energy expenses of the buildings. c) Supporting the tenants when they face issues regarding the technological infrastructure that could affect the energy services provided.
Intentions	Building managers could benefit from having a tool to support the following activities: - Monitoring of energy consumption for the different buildings. - Analysis of the status and performance of different devices installed in their buildings.

	- Overseeing and ensuring optimal operation of energy-related technological infrastructure in their buildings. - Providing quality services to their tenants based on the prompt identification of failures and malfunction of devices belonging to the energy-related technological infrastructure.
Information type	The design of a SIT4Energy tool for building managers could consider the following types of information: - Visualisation of energy consumption. - Visualisation of energy savings compared with traditional energy systems. - Visualisation of the operation status of the different devices in their buildings. - Recommendations or tips to optimise energy consumption and also to exploit the use of their technological infrastructure.
Information layers	Dynamic information could be provided by allowing users to select parameters or filters to personalise the information presented, as follows: - Time (months, weeks, days, hours). - Different building (type of house, type or tenant). - Technological device.

6. **Conclusions**

This deliverable presented the development of the "*User Information Model"* that was derived from a literature review on the user information needs and user workshops with the SIT4Energy target groups in the project pilots.

The primary objective of the literature review was to set the initial findings to identify potential user information needs. In order to provide a better understanding, the outcomes were presented into five categories: 1) user definition, 2) activities related to energy management, 3) motivation and needs, 4) tools to support the development of activities (household, workspace) and 5) defining the user information needs. The categories provided a general overview of different aspects concerned with the energy information needs for the different user groups.

This was followed by user workshops with SIT4Energy target groups in the project pilots that were performed to elicit their specific information needs and gather feedback to mock-ups of initial ideas for the design of the SIT4Energy applications. The initial mock-ups for were informed by the literature analysis and the workshops were performed in Germany, with prosumer customers and utility employees from the Stadtwerk Haßfurt and in Greece, with university staff and students from the Harokopio University of Athens. For both the workshops in Germany and in Greece the partners form both countries cooperated in their design and preparation.

Through the progress of both stages, the research process combined general (literature review) and particular (user workshops) evidence. Based on the obtained results from the two stages, the User Information Model was described for each target group from a user-centered perspective. Each User Information Model provides insights into the identified user information needs for each target group in a structured and contextualised way (user definition, intentions, information type, information layers) that can inform the design of the planned SIT4Energy end-user applications.

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Annex A: Smart Energy Dashboard Mock-up for prosumers

Figure A1: The start screen of the Energy Prosumer Dashboard

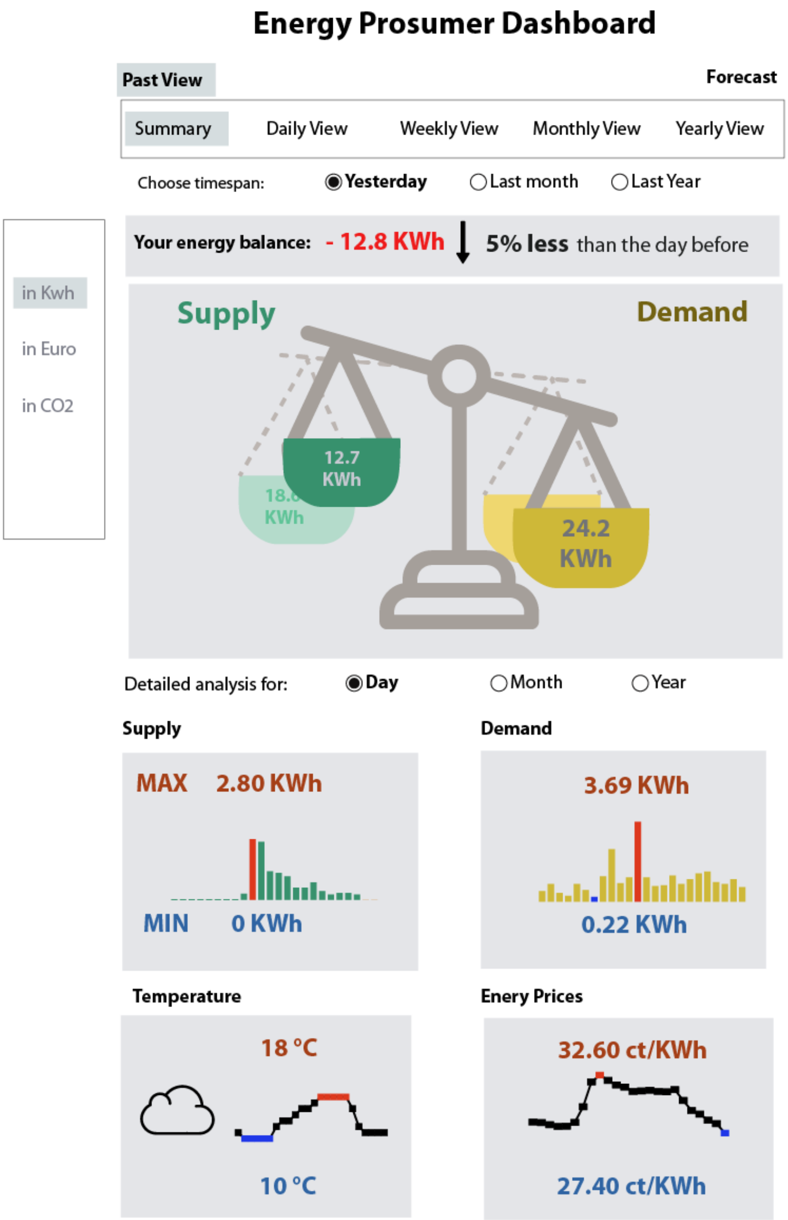


Figure A2: The daily view of the Energy Prosumer Dashboard

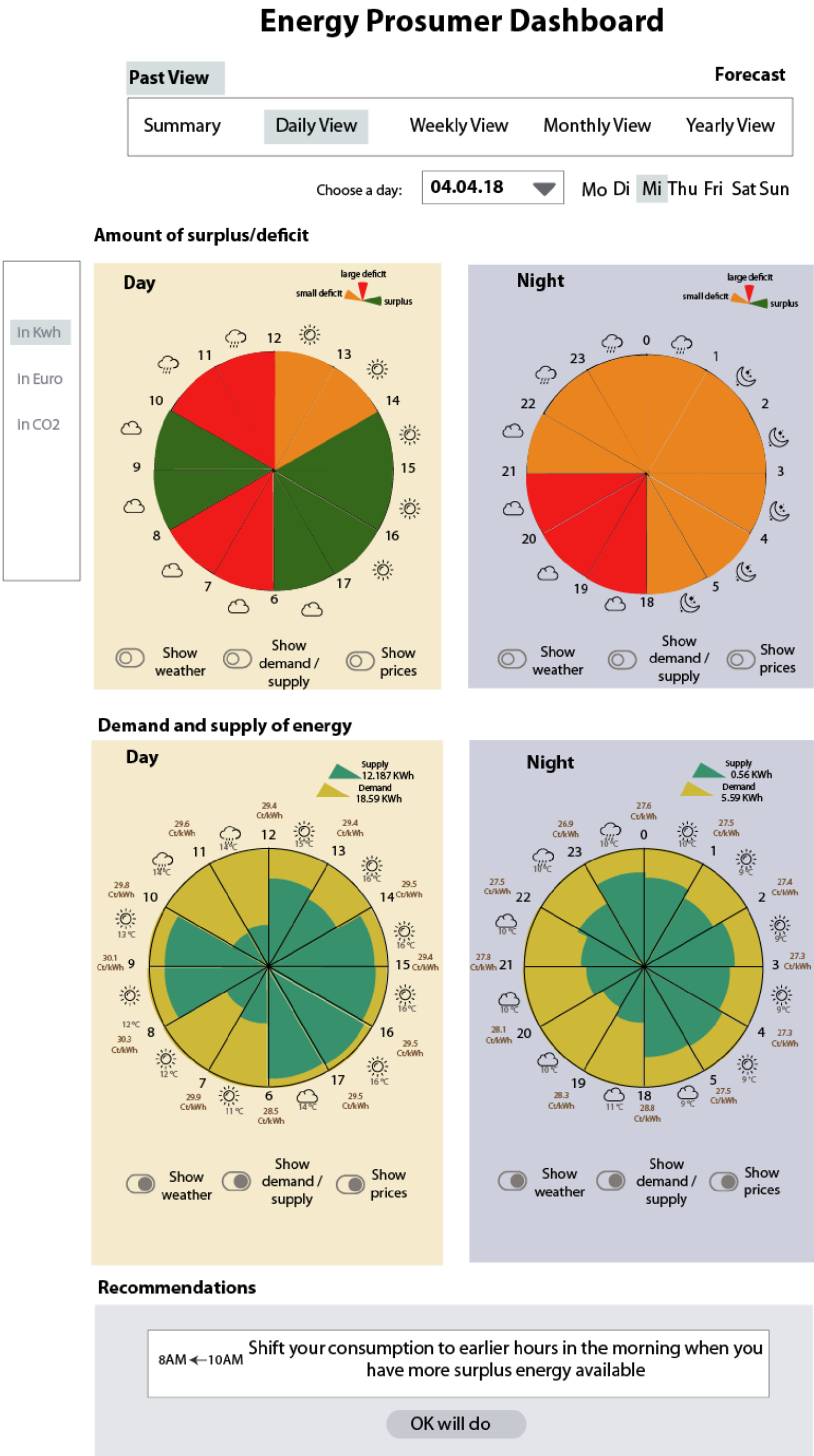


Figure A3: The weekly view of the Energy Prosumer Dashboard

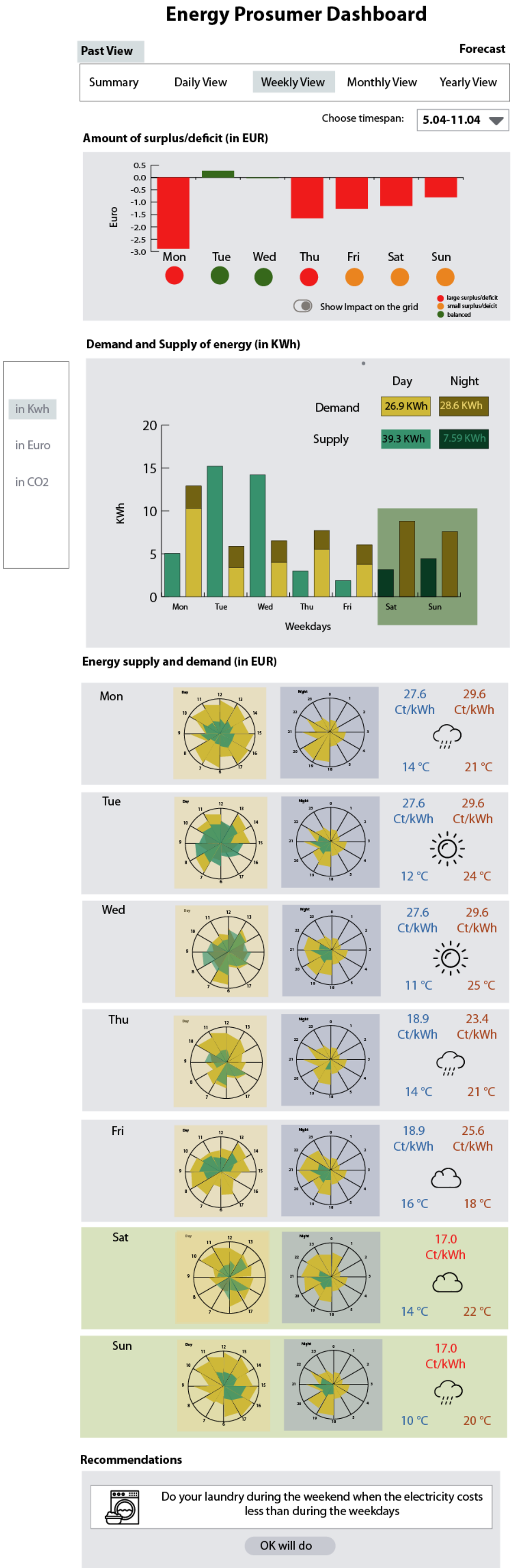


Figure A4: The monthly view of the Energy Prosumer Dashboard

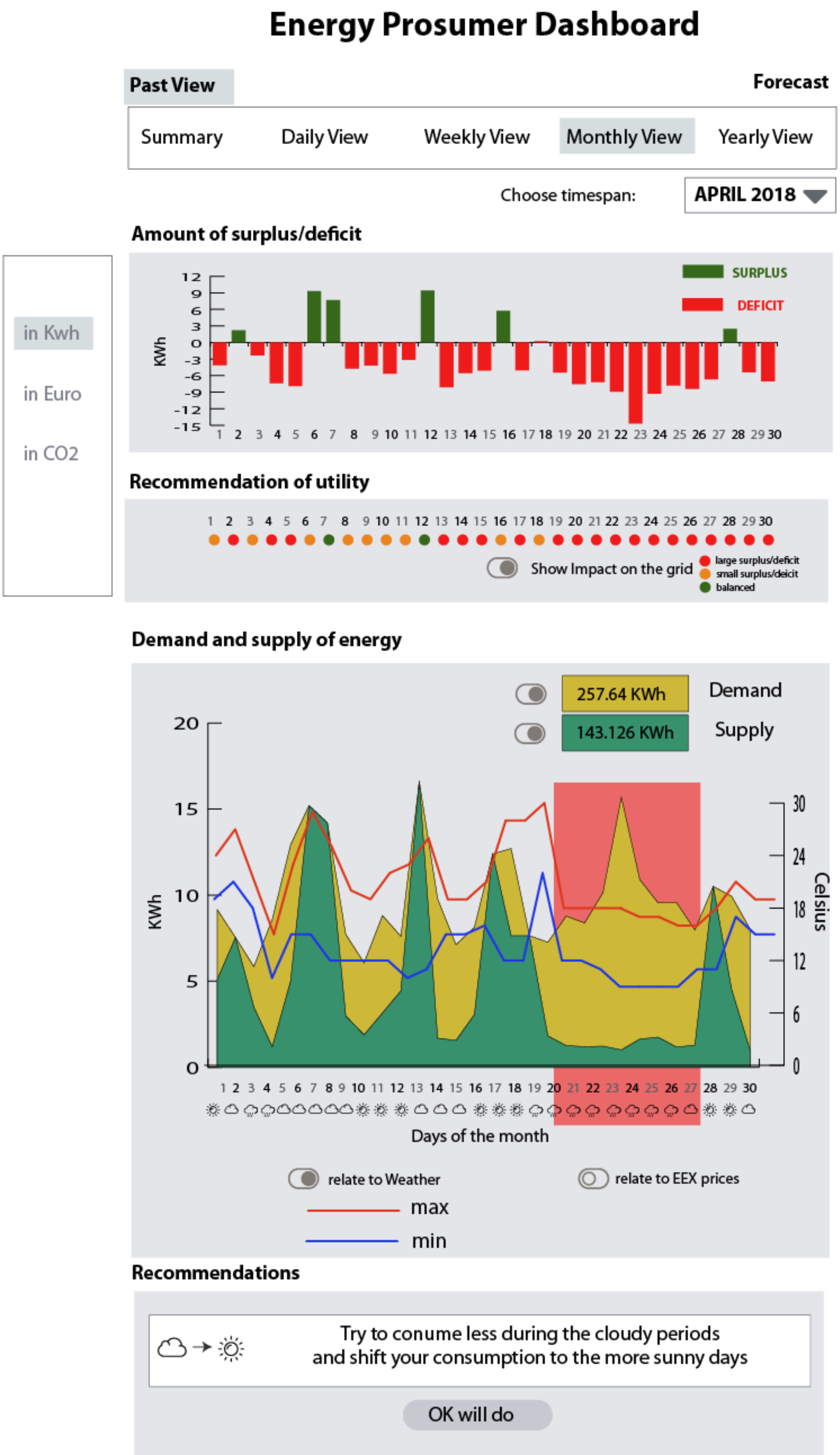
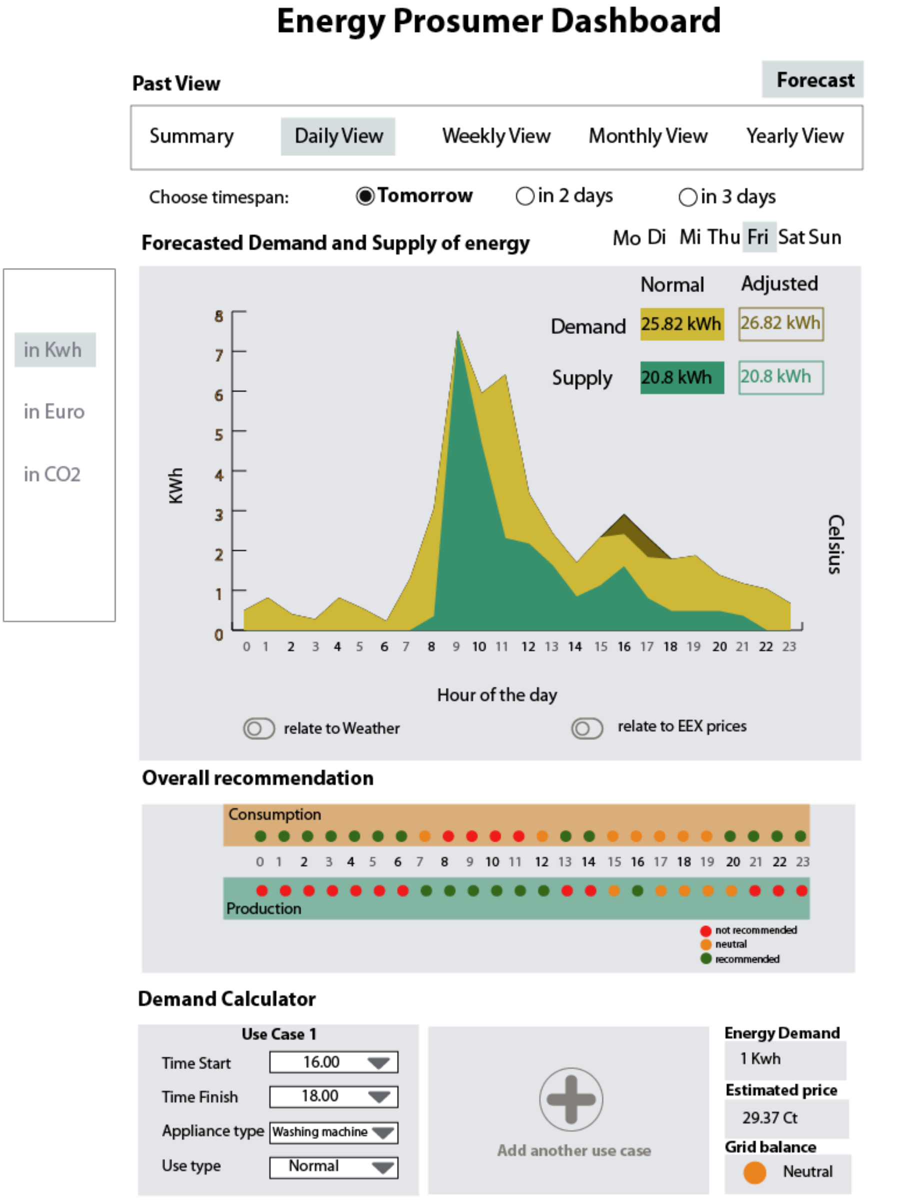


Figure A5: The forecast view of the Energy Prosumer Dashboard



Annex B: Smart Energy Dashboard Mock-up for the utility

Figure B1: Consumption and production by type of customer (November 2018)

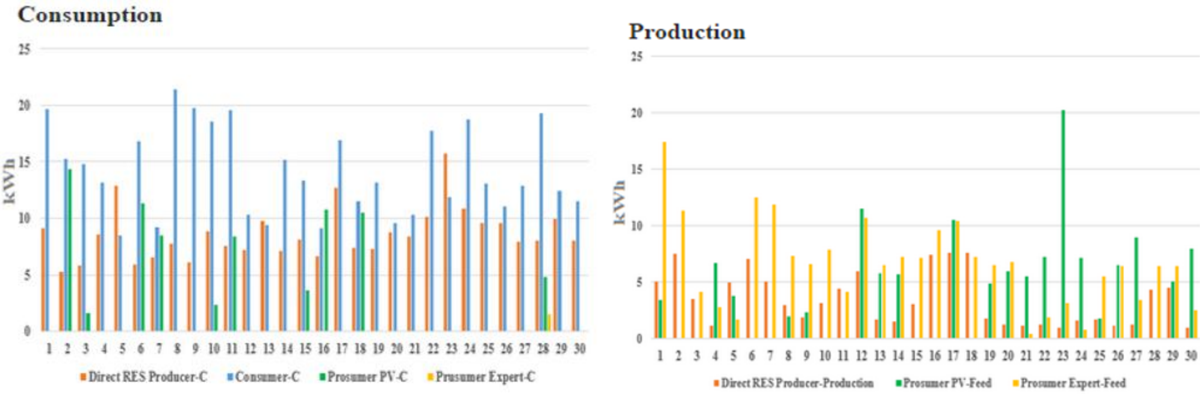


Figure B2: Maximum and minimum temperature (November 2018)

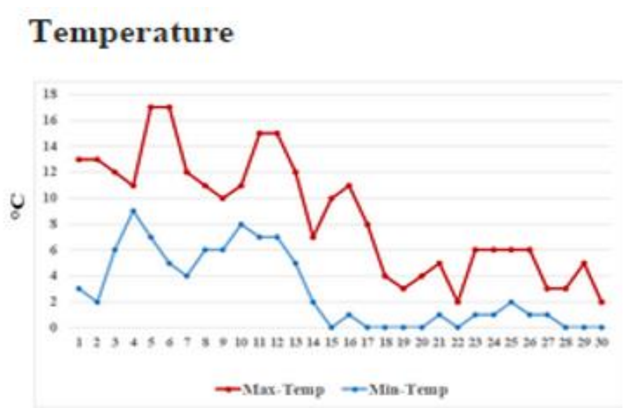


Figure B3: User behavioural change regarding the visualisation of information in the portal web

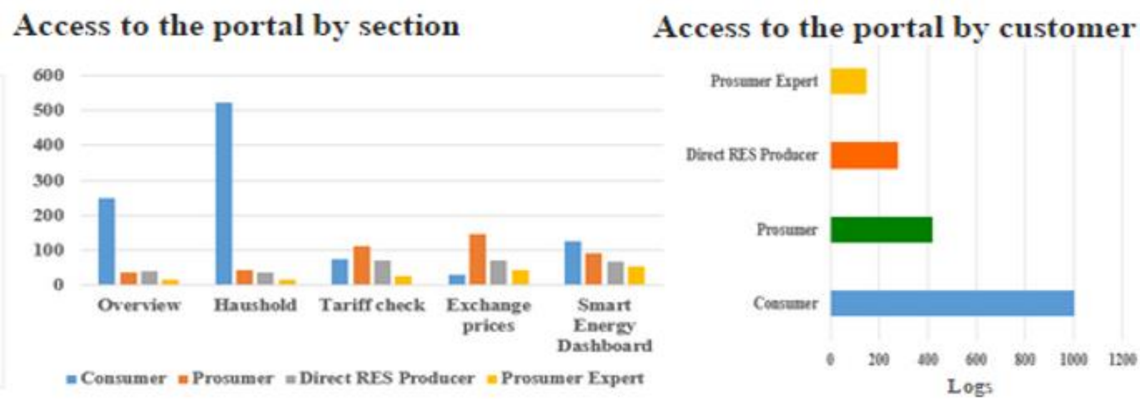


Figure B4: Filters used to provide a dynamic visualisation of the information presented in the charts

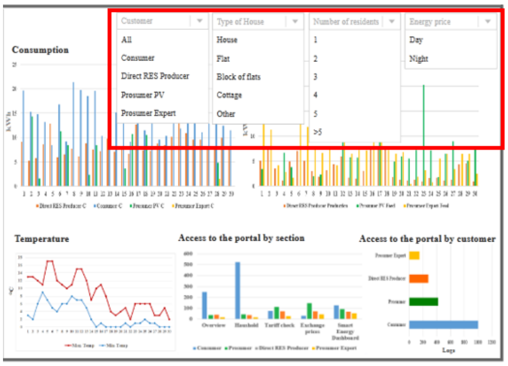


Figure B5: Consumption and sales presented by daytime and night rate (November 2018)