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iURBAN LDSS

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Abstract

This chapter provides an overview of the iURBAN graphical user interface developed targeting households. Provides a summary of functions supported and its corresponding interface.

Keywords: Smart home, Graphical user interface, Energy management, Energy visualization, Demand response, Notifications, Messaging, iOS, Android.

5.1 Introduction

The local decision support system component of iURBAN, called LDSS, is responsible to deliver a set of functions to households. It is composed by a back end and front end based on Web and mobile phone-based GUI. Figure 5.1 shows the component in relation to the Smart City Database (SCDB) and the centralized decision support system (CDSS).

LDSS main goal is to engage consumers and prosumers on the efficient use of energy. The engagement is based on data, captured in near real-time, related to their energy consumption, as well as energy production from their installed distributed energy resources (DER). The engagement is target throughout a user-friendly interface using every-day-use devices such as smartphones, tablets, and PCs. The LDSS is the main tool connecting households with their energy footprint and energy services. LDSS is built on the goal to offer a complete set of smart home functionalities grouped in four main blocks:

- Comfort
    - Climate control

  - Comfort levels (temperature, humidity, and luminance)
  - Air quality
- Energy management
- Security
  - Smoke, carbon oxide (CO), flood detection
  - Movement detectors
  - Magnetic detectors (for doors, windows)
  - Arm and disarm function
- Automation
  - Lights
  - Smart plugs
  - Thermostats

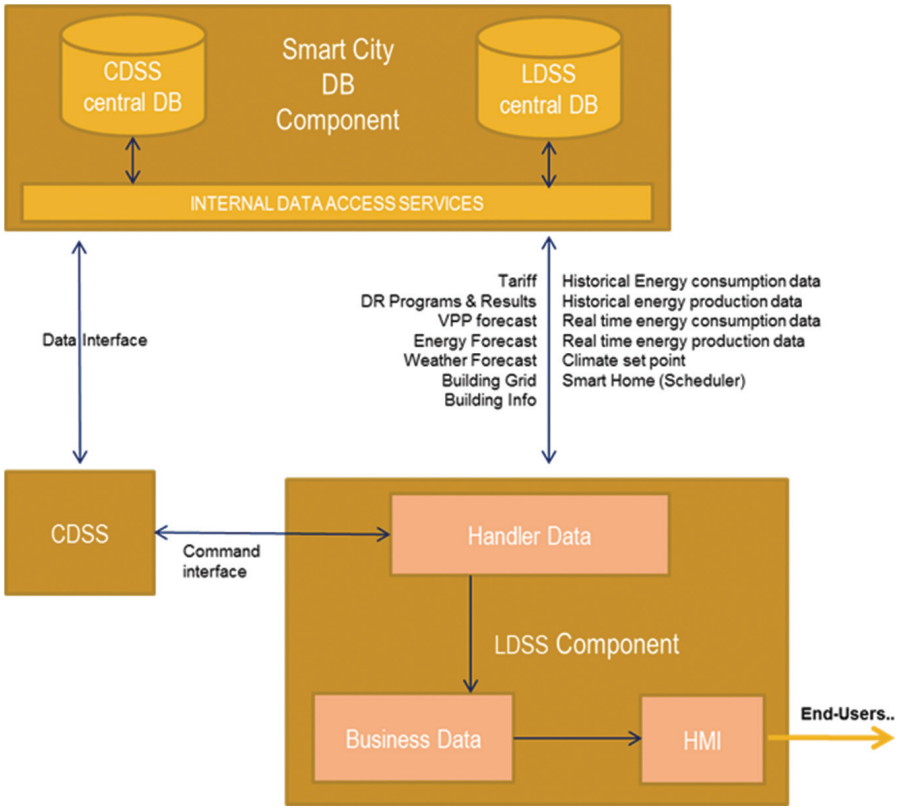


Figure 5.1 LDSS component and its relations.

iURBAN LDSS user installations provide data through a set of sensors and actuators based on Z-wave and wireless MBUS pulse reader off-the-shelve products and/or smart meters. The interface can be configured so the user can jump directly to energy information in case they do not have installed other devices than the smart meter (i.e., they do not have smart home enabled functionalities).With regard to energy management, the following features are offered:

- Visualization and exploration of energy consumed and produced
    - Historical data
    - Real-time data
    - Comparison
    - Export
- Visualization of energy consumption and production prediction
- Energy visualized
    - Electricity, gas, water, and heating
- Categorization of electricity consumption by means of retrofitting
- User engagement
    - Tips
    - Energy consumption/production comparison with neighborhood.
    - Personalized messages
    - Rewards
- Weather forecast
- Demand response
    - Heating
    - Electricity

5.2 Graphical User Interface

As the main tool to engage households on energy efficiency, LDSS is responsible for combining energy consumption and production visualization with user engagement.

The graphical design took into account different user levels of interest in relation with energy consumption/production and energy efficiency. At outer level, the tool visualizes information using a simple red/yellow/green color scheme. Red color is used when over consumption or inefficient consumption is detected by the artificial intelligence modules of iURBAN; on the opposite,

green color is used to inform users' good efficiency on energy consumption if achieved at their home.

From the outer level, the user can dig down on to obtain detailed information about the consumptions/production and forecast, for instance, is able to plot energy consumption/production per hour/day/week/month basis, or even raw data captured by smart meters. The rich set of features associated with energy exploration makes the LDSS a powerful tool to explore and understand the reasons of the energy consumed/produced at home.

LDSS has been also developed taking into account needs of service providers (utilities, energy retailers, telecommunication companies, security companies, facility managers, etc.). LDSS brings a powerful mechanism for them to communicate with clients. Initially target to issue tips to improve energy efficiency, however the mechanism can be extended to send personalized messages to each client. This communication mechanism helps service provider to keep customer loyalty.

Enabling the development of new energy services is easy through the infrastructure provided by iURBAN and the LDSS. LDSS provides an example of new energy services as a way to prove it. The service that has been implemented is demand response programs for climate control and electricity consumption.

LDSS, through different means of communication channels such as SMS, e-mail, and push notifications to iOS and Android devices, allows service provider to notify demand response actions to their customers. Upon reception, LDSS user can modify thermostat settings and energy consumption to achieve the requests. Current LDSS version does not support automatic settings of smart plugs nor climate controllers, due to the context of execution of the pilots; however, automatization at this level can be achieved with extremely low effort. Specific user interfaces have been developing providing users about the benefits of achievement of the demand response as well as how to achieve it.

LDSS has been designed targeting Web and smartphone access. In case of Web interface, LDSS has been designed using the following:

- ASP.NET MVC.[1] The Web server has been deployed in Azure Web Sites.[2]

In case of smartphone, LDSS has been designed for the following:

- Android API version 16 or above.
- iOS 7.0 or above.

[1] http://www.asp.net/mvc.

[2] https://msdn.microsoft.com/en-us/magazine/jj883953.aspx.

5.2.1 Main Graphical User Interface Functionalities

Within this section, the LDSS graphical user interface is explained. The next figures are based on the Web interface, but the reader should take into account that the same principles apply for iOS and Android apps, so the user is finding the same functions and visualizations in the entire ecosystem of visualization.

The service is accessible at https://ServiceURL/Account/Login as shown in Figure 5.2.

The graphical user interface has been designed to be very simple and friendly. Special effort has been done to represent energy consumption (and production when available) to LDSS users.

Energy information is shown divided into three periods of time by default: (i) day, (ii) week, and (iii) month as shown in Figure 5.3(b). If user is interested in other means of energy exploration, the interface allows them to select different periods of time.

Energy information is shown for the four types of energy being provided by iURBAN utilities and energy agencies: (i) electricity, (ii) heating, (iii) gas, and (iv) water as shown in Figure 5.3(a).

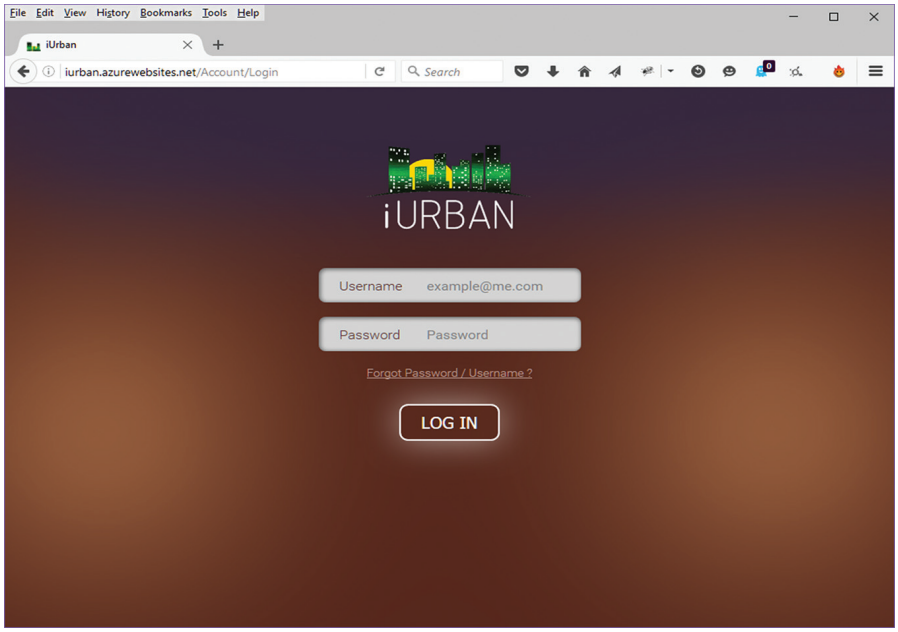
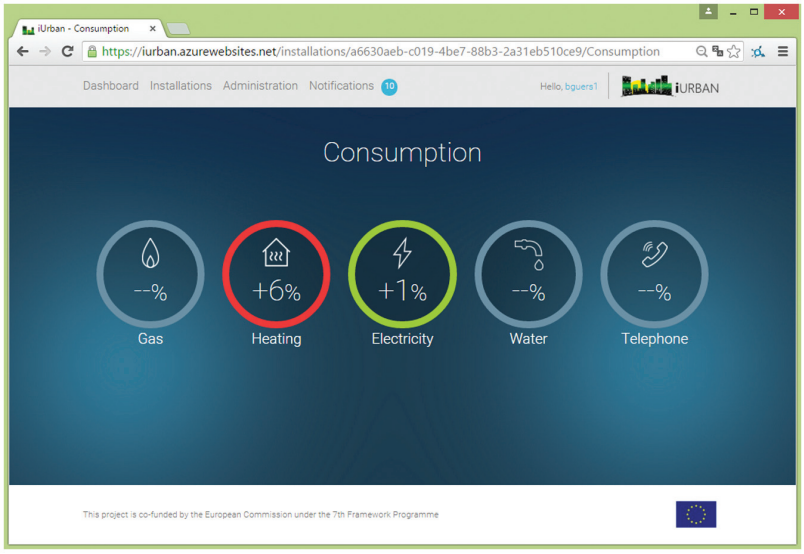


Figure 5.2 Access to LDSS GUI.



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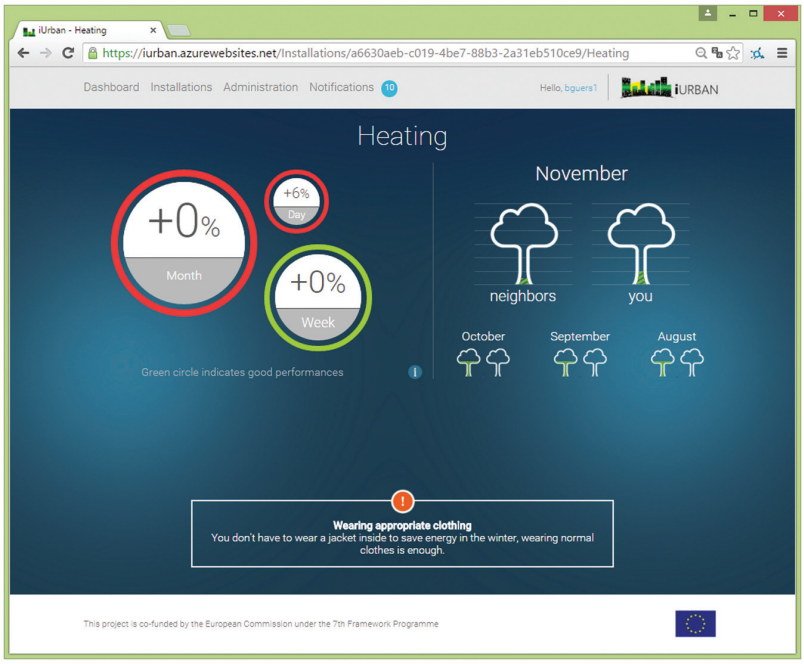


(b)

Figure 5.3 Energy visualization in iURBAN—(a) types and (b) default periods.

Concepts of user engagement have been introduced in the GUI, as shown in Figure 5.3(b), where energy tips and energy consumption efficiency based on trees achieved is shown.

Personalized messages can be sent every time the operator wishes, or can be scheduled over a period of time. Messages can be persistent or can be shown only during a few seconds. This provides a really powerful tool for communication between utility and their customers. Figure 5.4 shows an example.

The comparison between LDSS users will be performed using a concept called *Green Rewards*, represented with a tree. An average of the *Green Rewards* in all the installations included in the iURBAN pilots is performed to show LDSS end users how close are they with regard to the average (in the GUI named *neighbors*). User can know which day the tree was awarded by clicking a tree as shown in Figure 5.5.

Energy consumption and production predictions (for gas, water, and heating) have been also integrated into the user interface. This information is shown to users at the same level of real smart meter data as shown in Figure 5.6, where (a) shows the prediction of electricity consumption at the end of the day, while (b) and (c) provide the prediction of consumption by hours and days, respectively, superimposed with real consumption.

Users producing energy will be able to visualize the production in the same view as is shown energy consumption. So they will find production and consumption summary in a single view as shown in Figure 5.7.

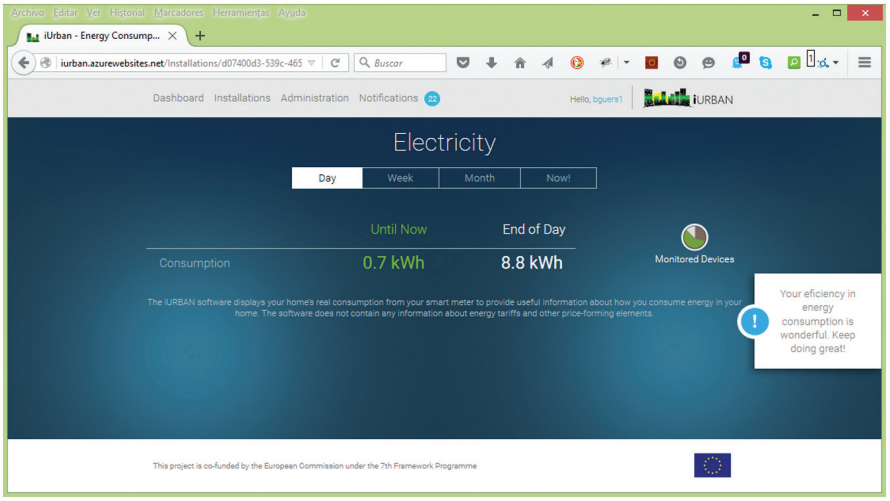


Figure 5.4 Personalized message.

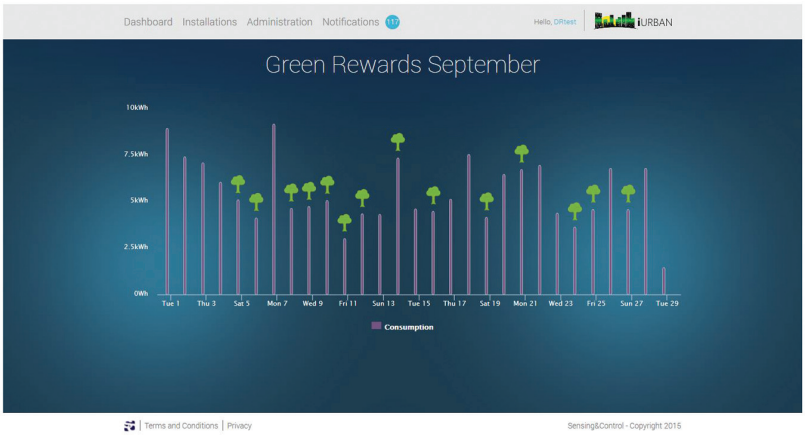
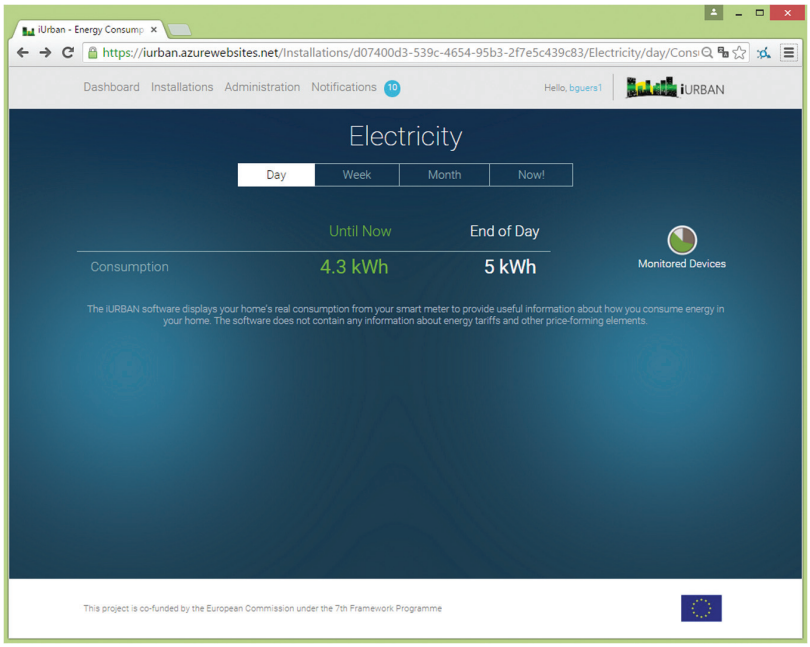


Figure 5.5 Tree award by day.

As previously commented, iURBAN deals with different types of energy besides electricity; Figure 5.8 shows screen captures for heating and water consumption.



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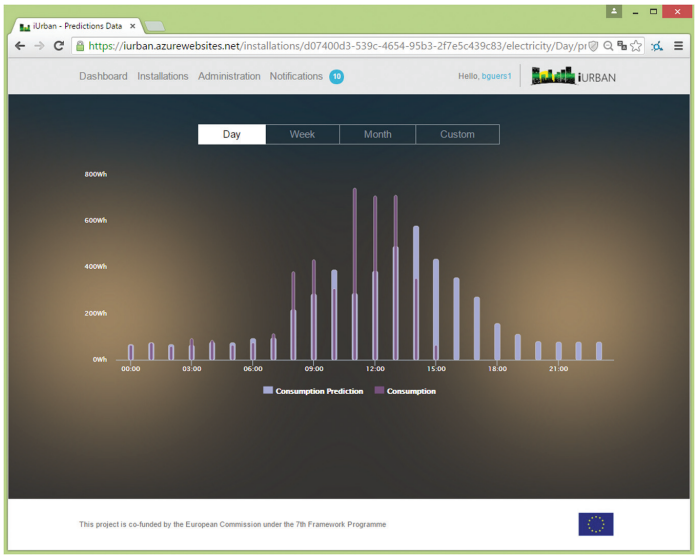

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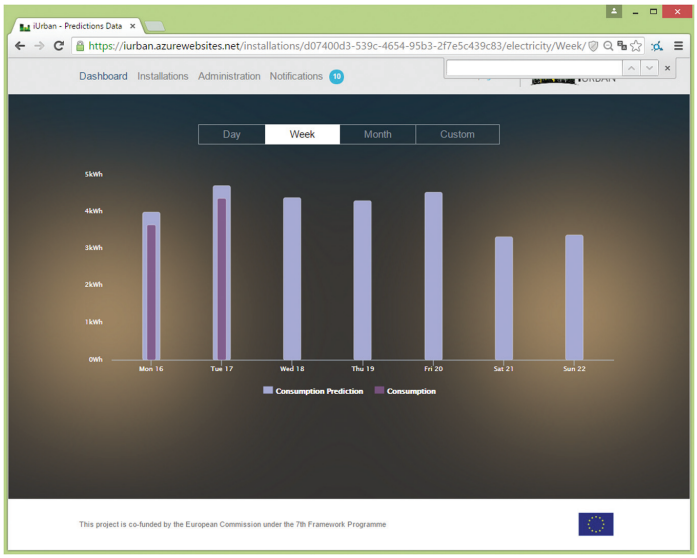
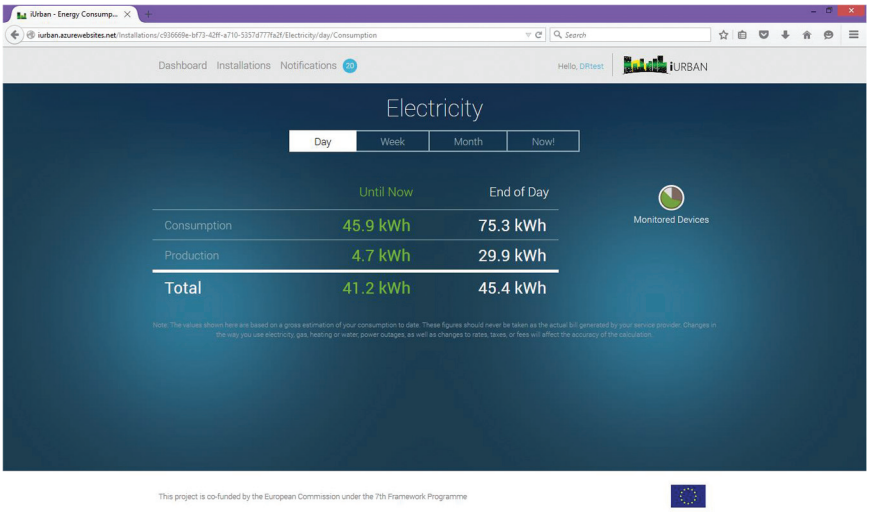


(c)

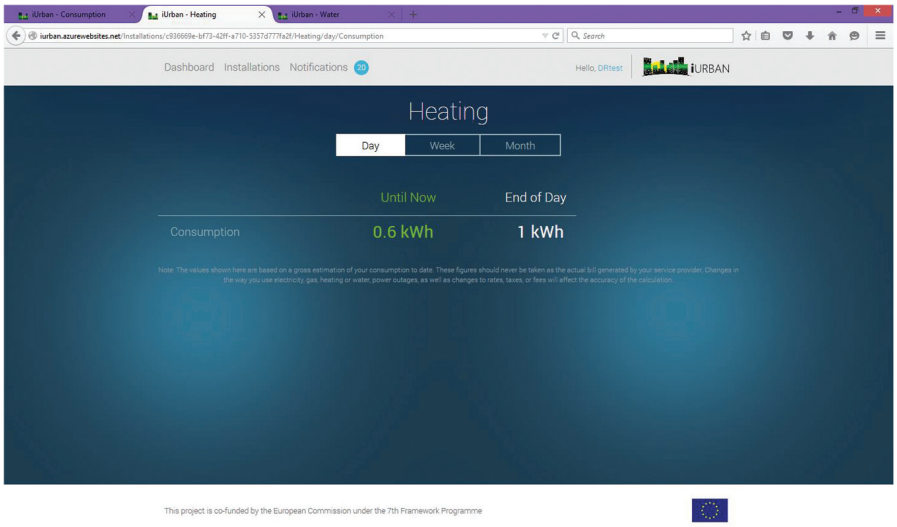
Figure 5.6 Energy visualization of energy consumption and energy prediction in iURBAN—(a) consumption up to given time of the day, and prediction for the end of the day, (b) detail of electricity consumption and prediction by hours, and (c) detail of electricity consumption and production by days.



(a)

(b)

Figure 5.7 Energy visualization of energy consumption and energy prediction in iURBAN—(a) consumption and production summary, including predictions, (b) graphical view of week day.



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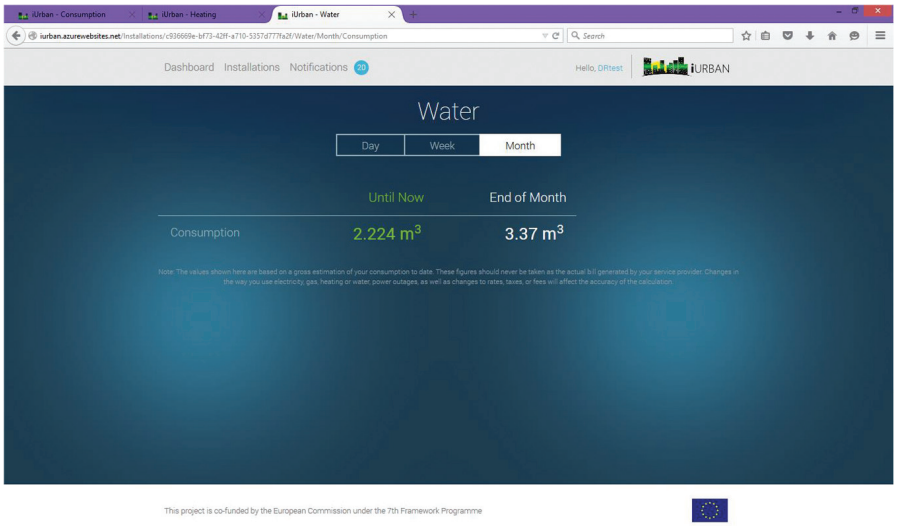
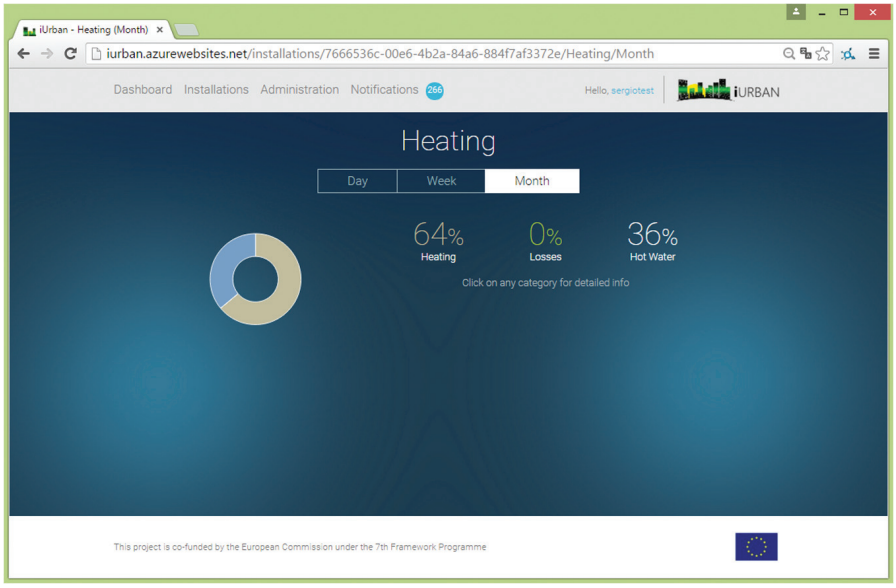


(b)

Figure 5.8 (a) Heating and (b) water consumption visualization in iURBAN.



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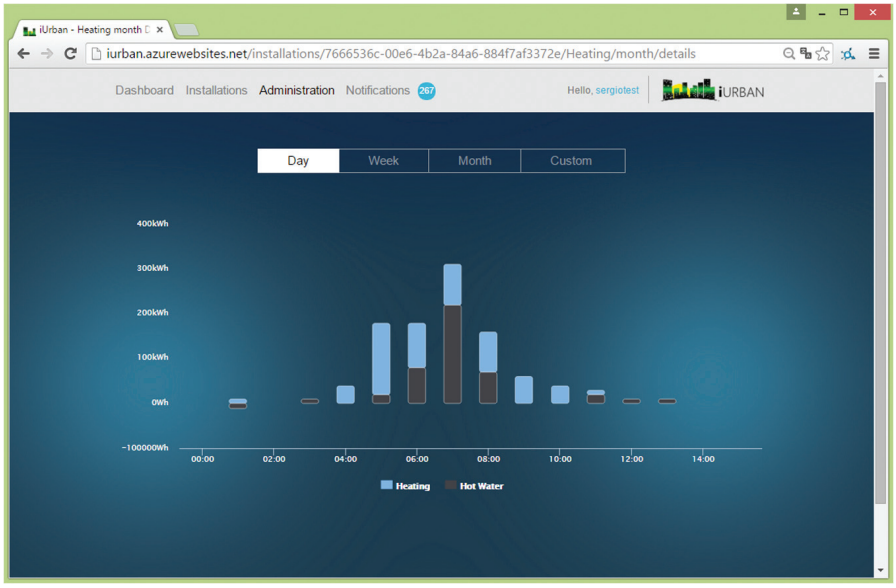


(b)

Figure 5.9 District heating energy consumption view.

In Plovdiv, some buildings use district heating as main source of heat to keep the living place warm during winter. For the households within these buildings, the LDSS has incorporated a representation of the energy consumed which is associated with district heating: (i) heat energy, (ii) hot water, and (iii) losses, in order to enable consumption analysis by the owners of the installations. Figure 5.9 provides an example of an installation.

The demand response has been introduced in the LDSS by means of two different views: (i) notifications (electricity and heating) and (ii) demand response action request.

The notification arrives each time CDSS sent a demand response action to a given installation. It provides information about the type of demand response and a link of the information related to it. Figure 5.10 shows demand response notification for the electricity and heating.

From notifications view, the user can get further information about the demand response requests. Figure 5.10 shows screen captures for the two types. While consumption DR is informative, the thermostat demand response action needs agreement by end user in order to allow LDSS to modify thermostat settings.

Thermostat DR is enabled through the smart home using Z-WAVE thermostats. Upon agreement from customer, the settings to the thermostat

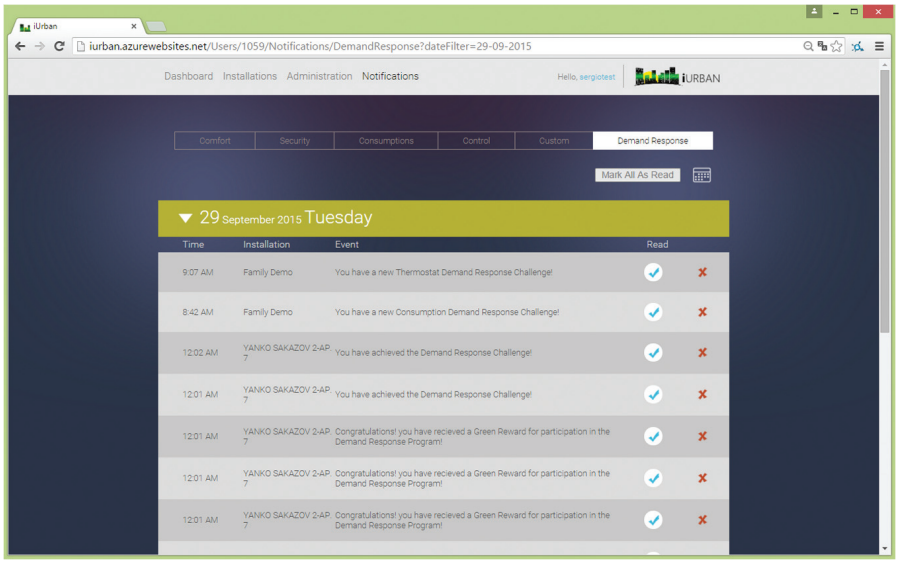
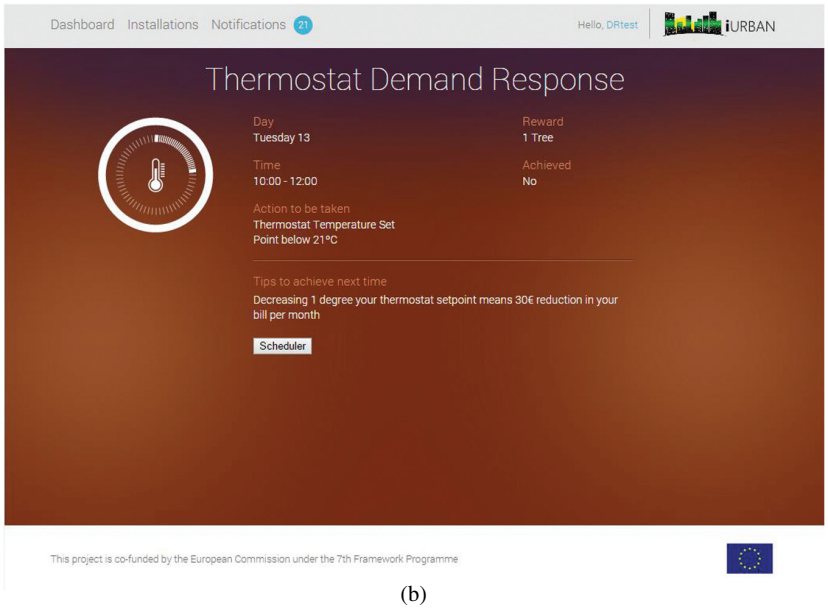


Figure 5.10 Demand response notifications view.

(a)



(b)

Figure 5.11 Demand response information for (a) consumption demand response and (b) thermostat demand response.

are set (i.e., fix thermostat target temperature) by means of scheduled action at a given time.

When a DR action is achieved, the user is informed by means of a notification. At any time, the user can review its achievements (coin icon in Figure 5.11), in comparison with the energy consumed and the trees awarded. The user can review the historical achievements as shown in Figure 5.12.

LDSS provides tools to end users to manage Z-wave devices at home. A graphical management interface has been developed in order to provide easy understanding process. Users are able to manage their installation, such as adding new devices to smart home, configuring them, and knowing its status just to provide few examples as shown in Figure 5.13.

As pointed out before, LDSS is also provided by means of Android and iOS app. The app comes with same functionalities as in the Web interface, with the exception of administration functions, which are not included. One of the main complements with respect to the Web interface is the real-time notifications by using the push channels of the smartphones, thus making more usable by the end users, especially for the purpose of demand response.

Figures 5.14 show a screen capture from iPhone.

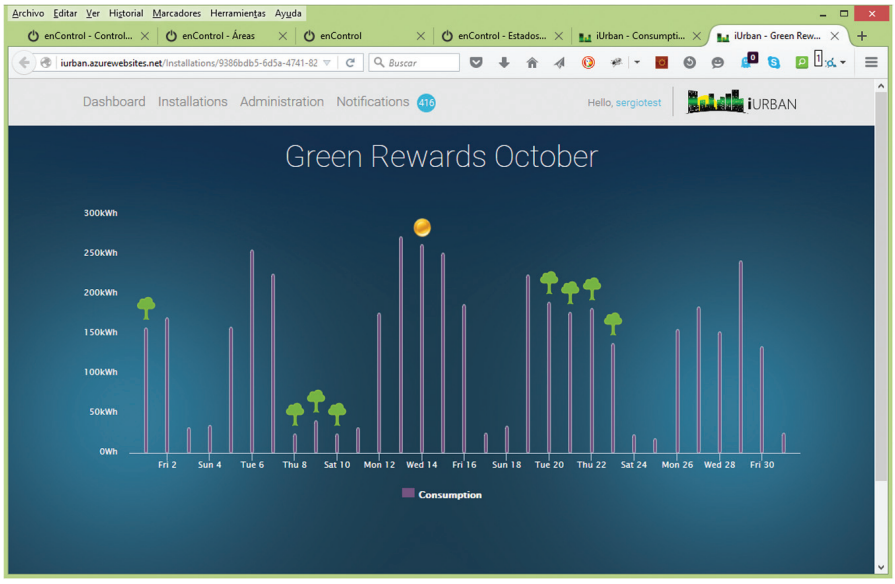
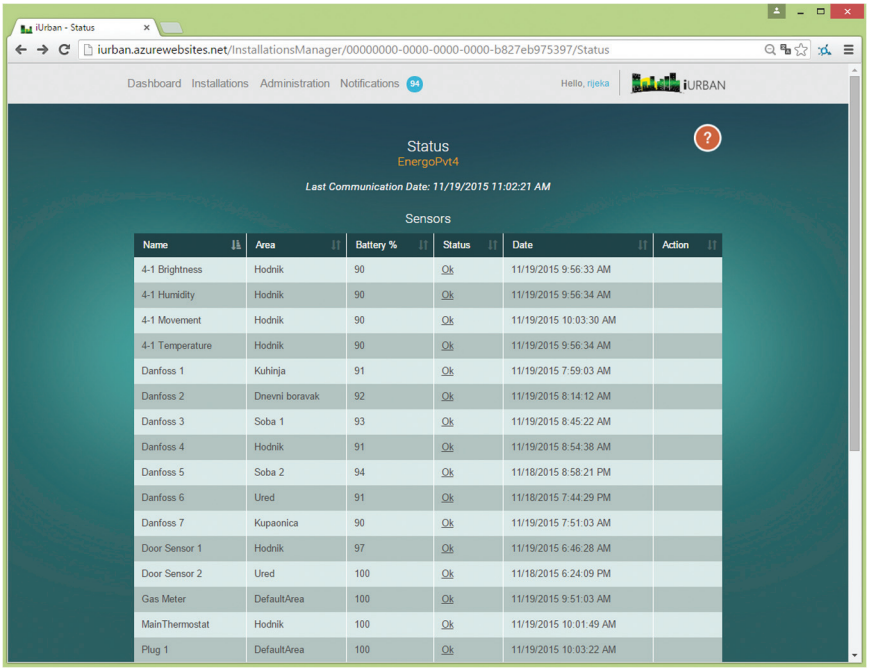


Figure 5.12 Demand response achievements.



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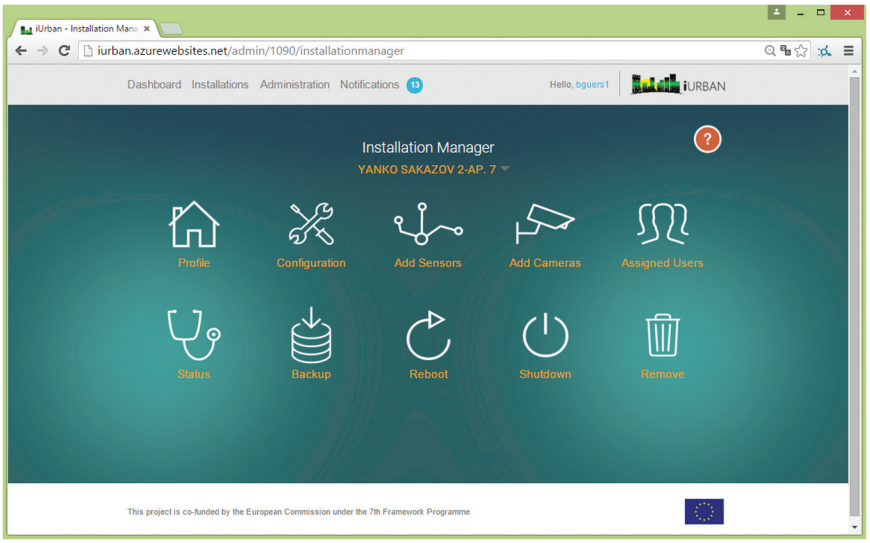

(b)

Figure 5.13 Z-wave devices management and status views—(b) general control, (a) device status, and (c) security device status.

(a) (b)

(c)

Figure 5.14 Captures from iPhone interface.

5.3 Conclusion

LDSS is a tool target to households and embraces visualization of energy data and engagement functions to foster knowledge on the way energy is consumed and promote energy aware habits.

It has been designed with the help of end users, as they have taken active part during the development of the graphical user interface. We believe this exercise increased the chances to succeed in the acceptance of the final solution by end users, particularly to understand what it is important for them and what is not.

LDSS has been designed as Web interface, but Android and iOS apps have also been developed; in particular, the push notifications offered by the smartphones were extremely useful to drive demand response programs and communication with users more friendly.

The combination of energy information (from the utilities) and the capabilities of smart home of the LDSS have been reported as key for end users to install in their homes, especially the security and remote control of home heating system.