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iURBAN CDSS

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Abstract

Central Decision Support System (CDSS) is the component of iURBAN platform dedicated to those stakeholders that are interested in the analysis of the data related to energy consumption and energy production, as energy providers, municipalities and third parties.

In this chapter, all the functionalities and the tools provided by CDSS will be discussed and presented to the reader, in order to give a complete overview of the capabilities of this component.

Keywords: CDSS, Energy management, Tariff, Chart, Map, Diagnostic, Tools, Demand response.

4.1 Introduction

Centralized decision support system (CDSS) aggregates data from all LDSSs to provide city-level decision support to authorities and energy service providers. The CDSS generates a number of parameters, including city-wide energy production and consumption forecasts. The CDSS component makes available, to different end users (as energy utilities, authorities, and municipalities), a large set of functionalities to monitor and plan the energy consumption/production.

Starting from the analysis of the data context and the users' needs, we have defined and describe a detailed set of functional requirements that are implemented by the CDSS platform:

- Get a continuous snapshot of city energy consumption and production;
- Provide a near real time regarding the situation of consumption/production of the city for every type of energy (electricity, heating, gas, hot water and cold water);
- Manage energy consumption and production data;
- CDSS HMI: the granularity is the building. The user, of CDSS HMI, can filter aggregated measures by city, district, building, energy type, and time period;
- Forecast of energy consumption data and per meter as well;
- Plan of new energy "producers" for the future needs of the city;
- Provide what-if scenario feature, offered by CDSS HMI (in collaboration with CDSS back end and virtual power plant (VPP));
- Support static and dynamic tariffs;
- Manage demand response (DR) programs;
- Manage technical losses;
- Visualize historical data with a chosen granularity and time period of consumption and production of energy and cold water.
- Detect meters in offline status;
- Provide geographical maps of building locations;
- Analyze International Performance Measurement and Verification Protocol (IPMVP) and key performance indicators (KPI) metrics;
- Make available weather forecasts.

In Figure 4.1, a general architecture of the whole CDSS is described, including the connections (regarding data exchanges) with the other iURBAN components:

As depicted in the above architecture schema, CDSS is composed of some sub-components.

In the following, the flow of the data managed by CDSS is described:

- Energy providers store real-time and historical measures to LDSS database (a component of Smart City Database (SCDB)) by suitable local decision support system (LDSS) Web services.
- CDSS (the processes of CDSS back end) retrieves the historical and real-time measures, by suitable LDSS Web services, from the LDSS database.
- CDSS GUI (the front end of CDSS) exchanges data with CDSS DB (by suitable CDSS Web services) in order to display measures in the graphical user interface (GUI) or to store data (for example, DR programs) to CDSS database.
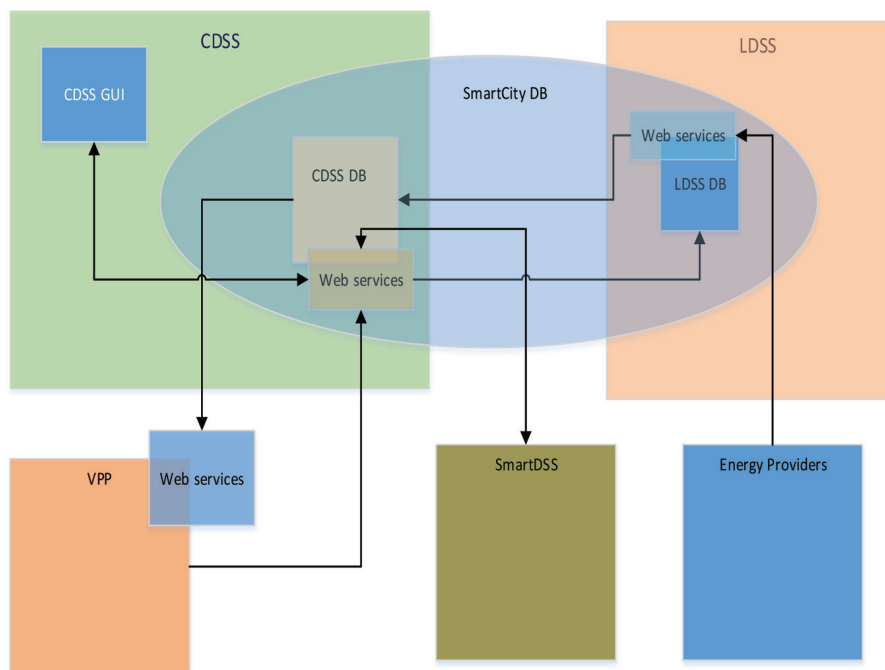
Figure 4.1 iURBAN logical view.

- CDSS exchanges data with the VPP in order to
  - VPP retrieves (from CDSS database by suitable Web services) the list of calculation (to do) related to what-if scenario.
  - VPP stores to CDSS database (by suitable Web services) the output result of calculation regarding the what-if scenarios.
- smartDSS exchanges data with CDSS in order to store data related to the following:
  - Calculated technical losses
  - Prediction algorithms
  - Advisor DR program
  - Consumption and production advice
  - Forecasting advice
  - Consumption and production rankings.
- smartDSS exchanges data with CDSS in order to retrieve data, from CDSS database, to calculate the following:

- Technical losses
- Advisor DR program
- Consumption and production advice
- Consumption and production rankings.

4.2 Graphical User Interface

The CDSS user interfaces are grouped by a suitable GUI that offers a set of functionalities to do the following:

- Check consumption and production with different granularity (city, district, building, installation) and filters that can be customized;
- Manage DR program management;
- Manage tariffs management;
- Visualize city map with involved buildings;
- Provide weather forecast;
- Offer meters diagnostic;
- Make GUI configuration.

4.3 Main GUI Functionalities in Detail

The main user functionalities, of the CDSS GUI, including the user authentication and the user roles (the user role indicates that the specified user can access only to a subset of user functionalities) are presented below.

4.3.1 User Login

The end users of the CDSS GUI are energy providers, local authorities, and municipalities but the login to the iURBAN system CDSS GUI is allowed to the following actors:

- **Super User**: They can view, create, and delete all data for every city and every energy type, but they cannot operate on CDSS DB data.
- **System Administrator**: They can view all data for every city and every energy type and can operate on CDSS DB data.
- **Decision Maker**: They can view all data for only one city and one energy type at all levels and cannot operate on CDSS DB data.
- **Provider**: They can view all data for only one city and only one energy type at all levels and cannot operate on CDSS DB data.
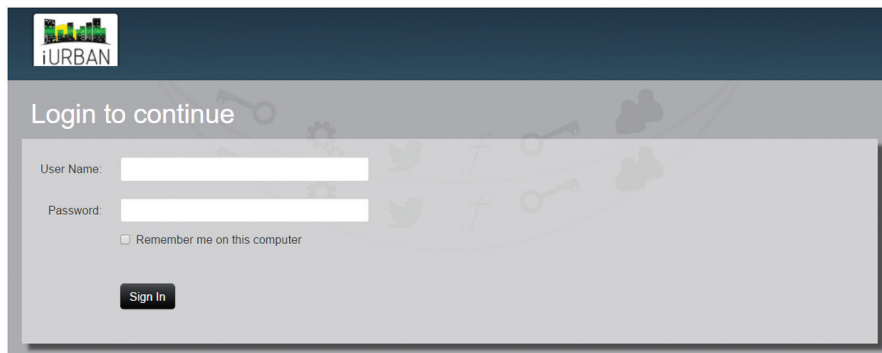
Figure 4.2 User login.

- **Municipalities, Local Authorities, Industry, and Similar Categories**: They can view all data for only one city and every energy type until city level; they cannot operate on CDSS DB data.
- **General User**: They can view all data for only one city and one energy type at city level and cannot operate on CDSS DB data.

The CDSS system manages the user profile and the authentication of the actors of iURBAN system CDSS GUI. The operator can interact with the system only through the features allowed by the assigned profile. The user reaches the GUI toolbar after an authentication consisting of the insertion of the user name and password in a dedicated pop-up presented before the access to the CDSS GUI (Figure 4.2).

4.3.2 Toolbar

Toolbar collects the macro functionalities of iURBAN interfaces. They are grouped taking into account the different kind of users (provider of energy, local authority and municipality, decision maker, etc.). The aim is to provide an easy and useful interface to allow the operator to manage data and information in an optimal way. From the toolbar, it is possible to open all the windows and the pop-up at the same time; this characteristic enables to view all data and to do comparison, analysis, and operations without information losses. The toolbar shows different views for each user profile, so the operator can interact with the system only through the features allowed by the assigned profile. The macro functionalities accessible from the toolbar are as follows:

- **Management**: It provides a cartographical representation of data and it shows a map of the city in 2D with districts, buildings, installations, meters using smart icons. Moreover, it manages objects (buildings, EV, DERs, etc.) like geometrical items to allow the creation of scenarios.
- **CityEnergyView**: It provides different views of energy consumption and production for different type (electricity, heating, water, etc.), at different level (city, district, building, etc.), and at different time (real time, last week, last month, last year, and custom range).
- **DR Management**: It provides interfaces in order to manage DR program (create, modify, view, cancel, etc.) and a list of possible peaks and tools to manage notifications to customers.
- **Tariff**: It provides interfaces for the tariff management and comparison.
- **Diagnostic**: It provides information about the status of the installations, whether they are offline and whether there are losses.
- **Weather Forecast**: It provides weather forecast information.
- **User**: It provides information about the current user login and manages its logout.
- **Configuration**: It provides interfaces to configure the console and the controls and allows the operator to check the system status (Figure 4.3).

4.3.3 Management

From *toolbar* by selecting *Management* button, it is possible to manage the city map according to the user profile.

Figure 4.3   CDSS GUI toolbar.

4.3.3.1 Map

User can view the city maps according to his profile. The *City Map* shows a 2D view of the monitored meter network, and each object is described with an appropriate icon.

On the left side of the screen, the user can access to some useful functionalities to work with the map:

- The tools to drag the map, to zoom in/out, and to calculate distances and areas;
- The legend of the icons used for the buildings on the map;
- The tool to filter the buildings by type and district (Figure 4.4).

Clicking on an icon showed on the map, the user obtains various detailed information on the chosen object (Figure 4.5).

User can click on the *Diagnostic* icon to check whether there are energy losses for that building, or on the *DataFlow Offline* icon. The *DataFlow Offline* informs that the building meter does not send data from more than 24 hours. In addition, the color of the icon suggests whether data are present or not:

- Green icon: No data are available.
- Red icon: Data are available (Figure 4.6).
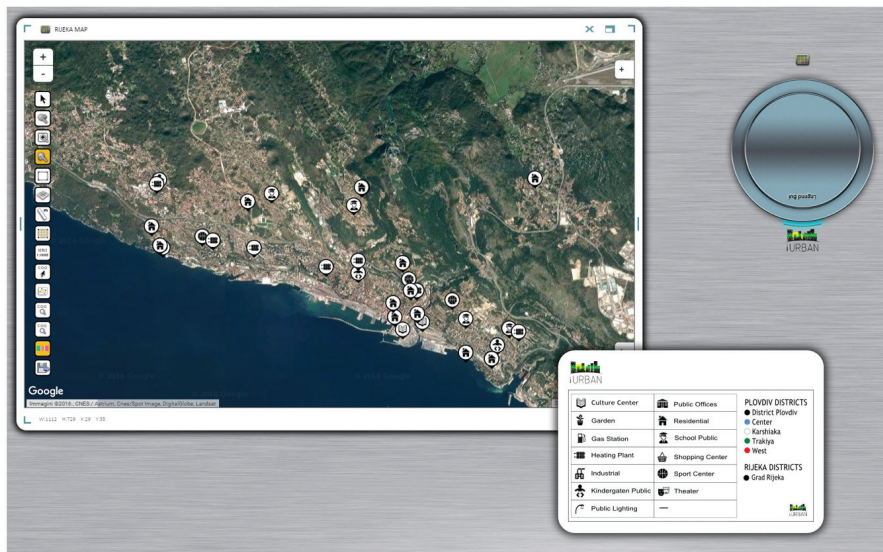
Figure 4.4   Management—map screenshot.
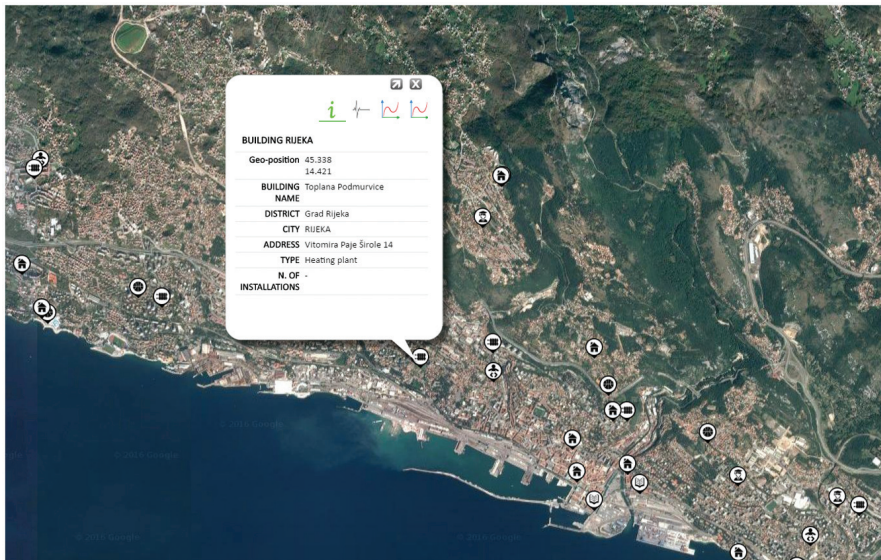
Figure 4.5   Management—map—building detailed information by clicking on the map on a specific icon.

Figure 4.6   Management—map—diagnostic losses and DataFlow Offline.

User can click on the *Graph* icon and a short report on the consumption related to the last 24 hours, 7 days, and 30 days is available. It is possible to open the *Graph Filter Maker* window to check whether there are energy consumption

and production data for that building, clicking on the *Chart Building* icon. This window is composed by three parts:

- *Filter Maker*
- *Graph Container*
- *Help Area*

The filters are already selected in order to show information related to the chosen object but the user can select filters according to his/hers profile:

- *Filter*
    - Energy type: electricity, heating, water, hot water, etc.
    - Level: city, district, building, installation (apartment), meters.
- *Time*
    - Daily, last week, last month, last year, and customizable range.
- *Chart*
    - EnergyView Consumption and EnergyView Production.

The *Graph Filter Maker* window provides the user a dashboard with different kinds of data aggregations relative to the energy consumption or production. The objective of this tool is to provide an overview of the energy management trend by several variables, as time, district, and energy type.

In particular, the dashboard is composed of the following charts:

- Monthly performance
- Average saving
- Quarters
- Week of month
- Total consumption (Figure 4.7).

4.3.4 CityEnergyView

From toolbar by selecting *CityEnergyView* button, it is possible to manage the *EnergyView* and *Consumption* 24H/7D/30D according to the user profile.

4.3.4.1 EnergyView
User can check the consumption and production energy data from *EnergyView*. User can select filter according to his/her profile. The system can show data at city, district, building, installation, and meter level and for different energy type (electricity, water, hot water, heating, etc.). Moreover, the user can select a period of time: daily, monthly, yearly, or a particular range of time.
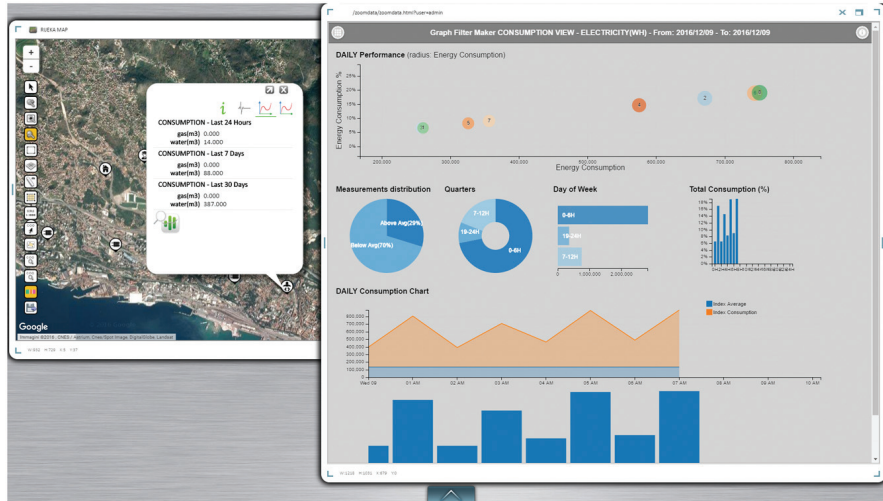
Figure 4.7   Graph filter maker window.

The *EnergyView* button opens a *Graph Filter Maker* window composed from three parts:

- Filter Maker
- Graph Container
- Help Area.

4.3.4.2 Filter Maker

This part allows the user to set the filters to use. The user can access it by clicking on the icon in the left upper corner. The *Filter Panel* is displayed and the user can choose the filters to apply between three buttons clicking on one of them:

- Filter
- Time
- Chart (Figure 4.8).

The *Filter* button allows the user to choose which cities, districts, buildings, installations, and/or meters and which energy type (electricity, water, heating, etc.) to select. After the filters choice, click *Apply* to create the charts (Figure 4.9).

The *Time* button allows the user to select temporal ranges. In this panel, the user can select from different default time ranges or a custom date. Once

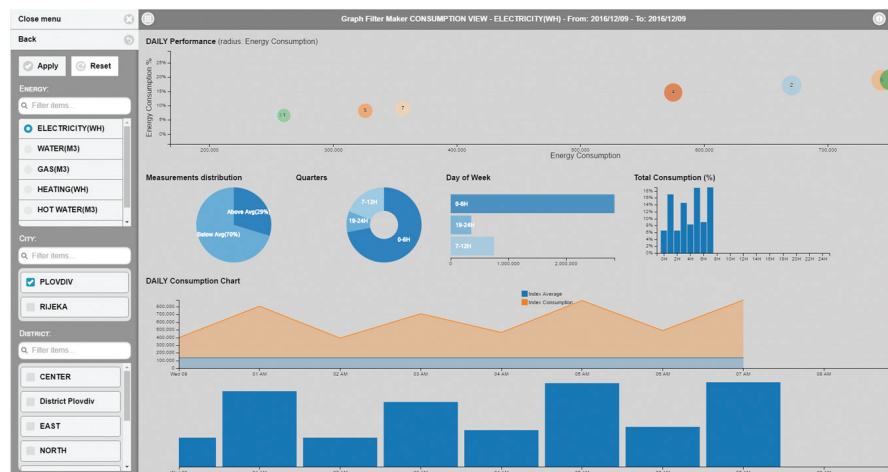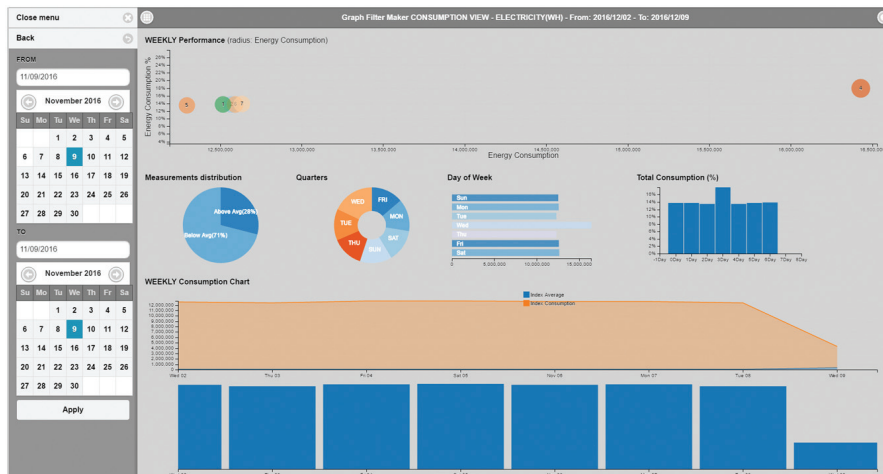**Figure 4.8** CityEnergyView—EnergyView—Filter Maker.

Figure 4.9 CityEnergyView—EnergyView—Filter button.

the time range is selected, the graphs will be showed into the *Graph Container* (Figure 4.10).

The *Chart* button allows the user to choose a chart view between EnergyView Consumption, EnergyView Production, and Energy Forecast (Figure 4.12).

Figure 4.10   CityEnergyView—EnergyView—Filter Maker—Time button.

Figure 4.11   CityEnergyView—EnergyView—Filter Maker—Time button customizable range.

The user can visualize the graphs related to the consumption data by selecting the radio button *EnergyView Consumption* (Figure 4.13).

The user can visualize the graphs related to the production data by selecting the radio button *EnergyView Production* (Figure 4.14).
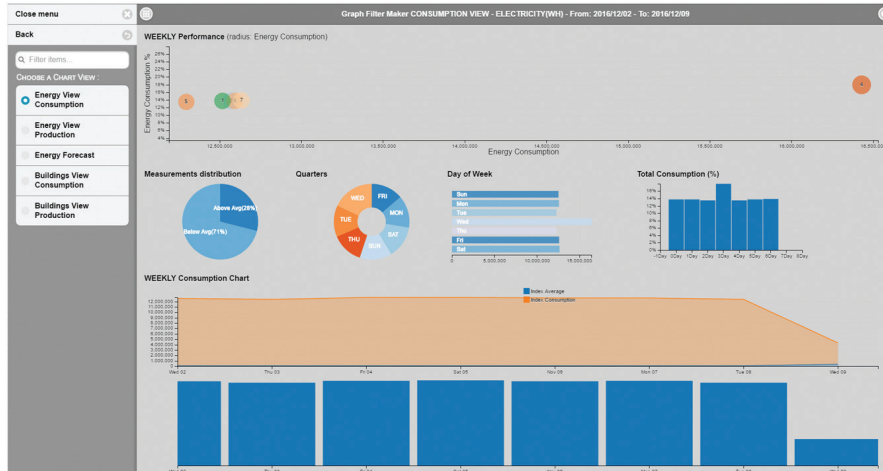
The user can visualize the graphs related to the forecast data by selecting the radio button *Energy Forecast* (Figure 4.15).

Figure 4.12 CityEnergyView—EnergyView—Chart button.
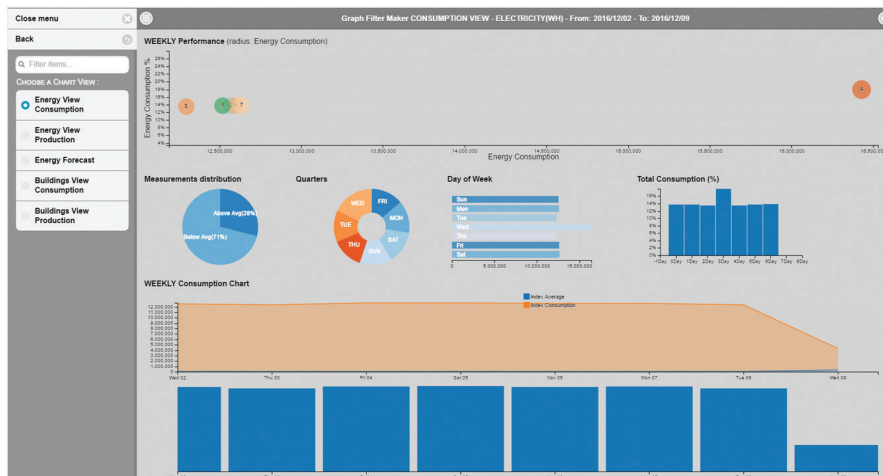
Figure 4.13 CityEnergyView—EnergyView—Filter Maker—Chart button: EnergyView consumption.

4.3.4.3 Graph Container
Graph Container is the hearth of the graphical component. It is in the middle of the page; here, six different charts, showing the filtered data, are presented:

- Bubble Chart
- Average Saving Chart

- Quarters Chart
- Quarters Horizontal Chart
- Total Bar Chart
- Line Chart.
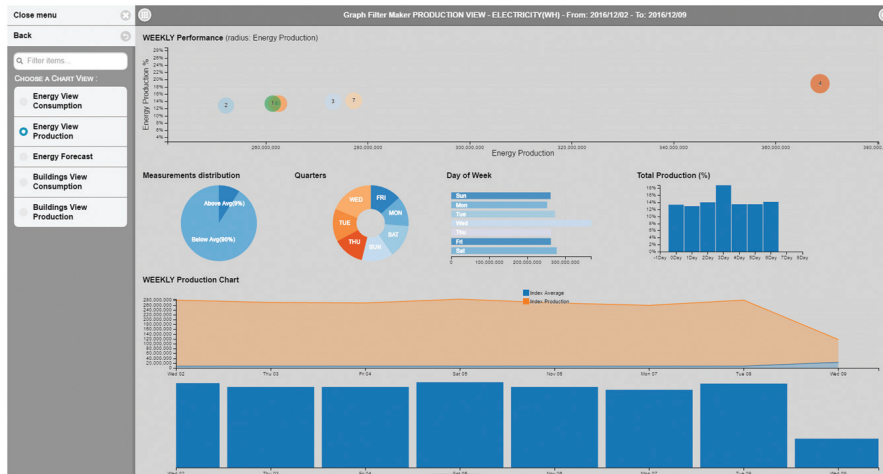
Figure 4.14   CityEnergyView—EnergyView—Filter Maker—Chart button: EnergyView production.

Figure 4.15   CityEnergyView—EnergyView—Filter Maker—Chart button: energy forecast.

The *Bubble Chart* is the first graph in the main container. It shows consumption and production as a percentage: the data are grouped in different time ranges. For example, by selecting "year" from the time filter, the graph view shows a representation of consumption or production grouped by month; instead, by selecting "month" from time filter, the graph view shows a representation of consumption or production grouped by week. Each radius bubble is the sum of values divided by the number of values in the list, and the result is multiplied by 100. Therefore, we can have the percentage of total consumption or production for each month. Months range is 1–12 (Figure 4.16).

The *Average Saving* Chart is a graph that shows energy savings or average of consumption and/or production in percentage.

For example, by selecting "Consumption" in to the "Chart filter," the saved percentage compared to the average value of consumption is presented. The consumption over the percentage provides consumption, and the consumption under the average gives a gap from average that representing savings (Figure 4.17).

The *Quarters* Chart is a graph that displays the production and consumption data of different time ranges in four parts (quarters, a quarter of month, a week, and a day). The value is expressed as a percentage.
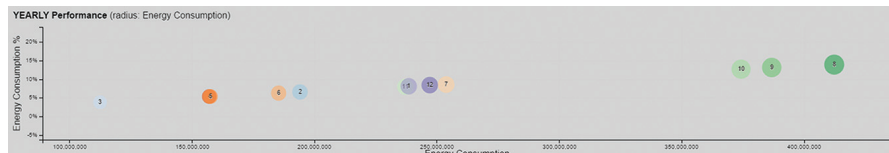

Figure 4.16 CityEnergyView—EnergyView—Graph Container—Bubble Chart.
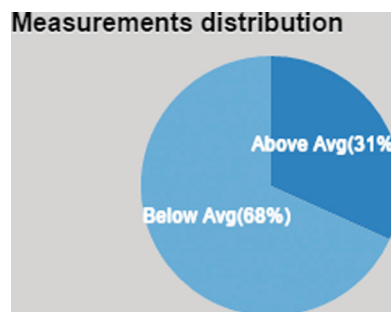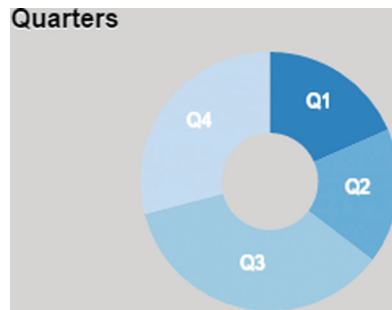

Figure 4.17 CityEnergyView—EnergyView—Graph Container—Measurements distribution.

For example, by selecting "year" from the time filter, the data are grouped by quarters. Each quarter is Q1 (January/February/March), Q2 (April/May/June), Q3 (July/August/September), and Q4 (October/November/December) (Figure 4.18).

The *Quarters Horizontal* Chart is a graph that is similar to the Pie Quarters Chart, but it shows the quarters in a horizontal way and represents values on the x-axis. For example, by selecting "year" from the time filter, the data are grouped by quarters. Each quarter is similar as above at the Quarters Chart (Figure 4.19).

The *Total Bar* Chart is a graph that displays the production and consumption data percentage in a stacked bar representation. For example, by selecting "year" from the time filter, the data are grouped by months. Each bar is a month identified by a number between 0 and 11 (Figure 4.20).

The *Line* Chart is at bottom of page, and it shows the production and consumption data line in the selected range.

Figure 4.18   CityEnergyView—EnergyView—Graph Container—Quarters Chart.
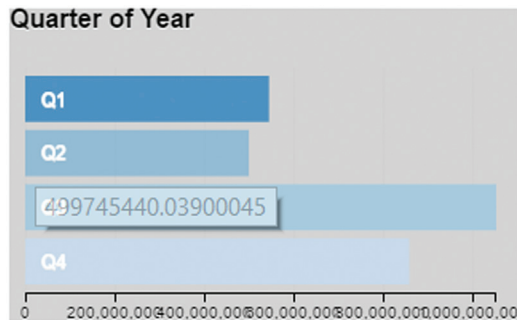
Figure 4.19   CityEnergyView—EnergyView—Graph Container—Quarters Horizontal Chart.
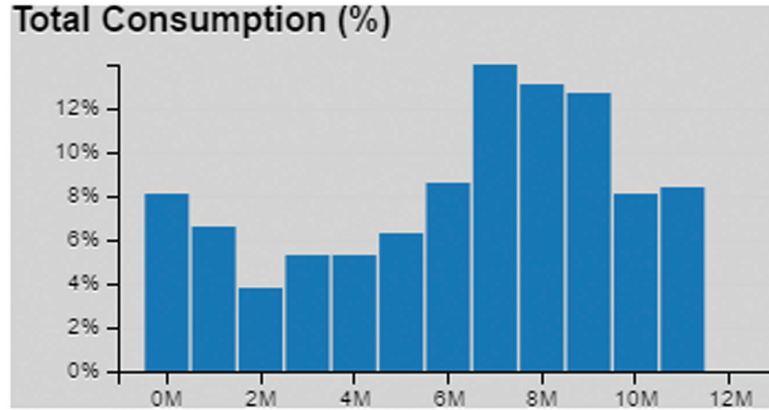
Figure 4.20 CityEnergyView—EnergyView—Graph Container—Total Bar Chart.

This graph has two lines: one for the average (blue) and one for the real data (orange). Beneath the x-axis, there is a bar chart that can elect a specific range. For example, by selecting "year" from the time filter, all values in a linear interpolation are showed (Figure 4.21).

4.3.4.4 Help Area

Help Area is on the upper right corner of display. This area helps the user with the *Help Pop-up* component. It provides a short description of each graph. This pop-up is ready to use when clicking on the icon in the upper right corner (Figure 4.22).

The Table 4.1 shows the relations between time filter and each grouping of graphs.

On the left column of the table, there are the "time" filters, and on the top row, there are the types of chart. For example, by selecting "Week" as time
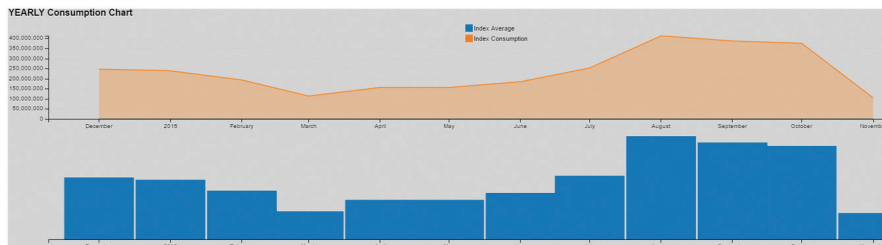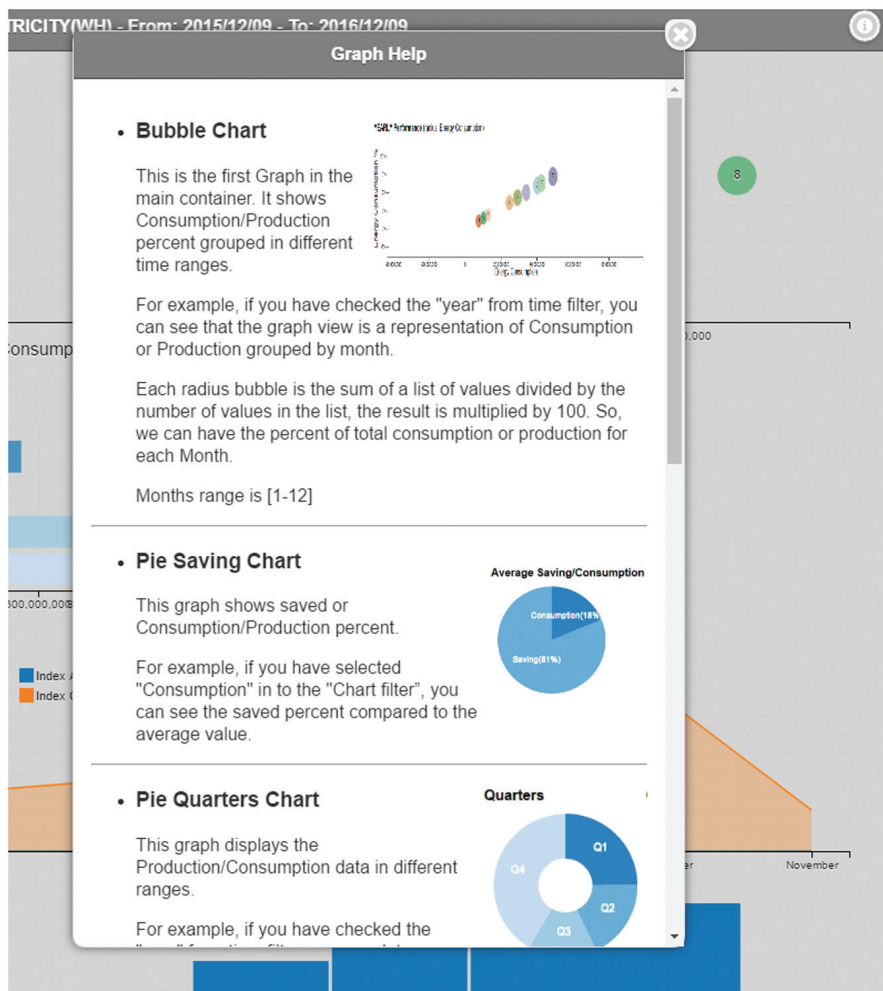

Figure 4.21 CityEnergyView—EnergyView—Graph Container—Line Chart.

Figure 4.22   CityEnergyView—EnergyView—Graph Container—Help pop-up.

range in the bubble graph, seven bubbles will be displayed; each of them is a day of the past week, numbered from zero to six.

4.3.4.5 Consumption 24H/7D/30D

According to his profile, user can check the consumption energy data of last 24 hours, 7 days, or 30 days. A list of energy consumptions for different energy type (electricity, water, hot water, heating, etc.) at building level is showed.

Table 4.1

Grouped By	Bubble	Quarter	Horizontal Quarter	Total Bar	Line
Today	Hours of day	0–6 H = 0–6 hours 7–12 H = 7–12 hours 13–18 H = 13–18 hours 19–24 H = 19–24 hours	0–6 H = 0–6 hours 7–12 H = 7–12 hours 13–18 H = 13–18 hours 19–24 H = 19–24 hours	Hours of day	Hours of day
Week	Days of week	Days of week	Days of week	Days of week	Days of week
Month	Weeks of month	Weeks of month	Weeks of month	Days of month	Days of month
Year	Months of year	Q1 = 0–2 months Q2 = 2–5 months Q3 = 5–8 months Q4 = 8–11 months	Q1 = 0–2 months Q2 = 2–5 months Q3 = 5–8 months Q4 = 8–11 months	Months of Year	Months of Year

Consumption 24H

Consumption 24H opens a window that shows a list of the consumption energy data of last 24 hours. Consumption 24H list shows the following data:

- City: city name, related to the showed consumptions
- District: district name, related to the showed consumptions
- Building name: building name, related to the showed consumptions
- Energy type: electricity, water, heating, etc.
- Total consumption: total energy consumption, related to the energy type.

XLS icon opens and/or prints the report of the Consumption 24H list (Figure 4.23).

Consumption 7D

Consumption 7D opens a window that shows a list of the consumption energy data of last 7 days. Consumption 7D list shows the following data:

- City: city name, related to the showed consumptions
- District: district name, related to the showed consumptions
- Building name: building name, related to the showed consumptions
- Energy type: electricity, water, heating, etc.
- Total consumption: total energy consumption, related to the energy type.

XLS icon opens and/or prints the report of the Consumption 7D list (Figure 4.24).

Figure 4.23   CityEnergyView—Consumption 24H.

Figure 4.24   CityEnergyView—Consumption 7D.

Consumption 30D

Consumption 30D opens a window that shows a list of the consumption energy data of last 30 days. Consumption 30D list shows the following data:

- City: city name, related to the showed consumptions
- District: district name, related to the showed consumptions
- Building name: building name, related to the showed consumptions
- Energy type: electricity, water, heating, etc.
- Total consumption: total energy consumption, related to the energy type.

XLS icon opens and/or prints the report of the Consumption 30D list (Figure 4.25).

4.3.5 Demand Response Management

From toolbar by selecting the *DR Management* button, it is possible to manage the DR program and the peaks monitoring according to the user profile. A DR program can be used to manage any consumption peaks related to any energy (two program kinds are managed: consumption and thermostat). It is composed

City	District	Building Name	Energy Type	Total Consumption
PLOVDIV	CENTER	6 SEPTEMVRI 224	electricity(Wh)	13298828.000
PLOVDIV	CENTER	Eliezer Kalev 12	electricity(Wh)	6061304.700
PLOVDIV	CENTER	GEN.DANAIL NIKOLAEV 94	electricity(Wh)	5221300.000
PLOVDIV	CENTER	HAN KUBRAT 8	electricity(Wh)	32029349.767
PLOVDIV	CENTER	KINDERGARTEN NEZABRAVKA	electricity(Wh)	1665192.000
PLOVDIV	CENTER	KINDERGARTEN PRIKAZEN SVIYAT	electricity(Wh)	3080806.000
PLOVDIV	CENTER	KINDERGARTEN PRIKAZEN SVIYAT	gas(m3)	0.000
PLOVDIV	CENTER	PENCHO SLAVEJKOV 38	electricity(Wh)	16221464.987
PLOVDIV	CENTER	PETKO D.PETKOV 57	electricity(Wh)	6169394.000
PLOVDIV	CENTER	TSCAR KALOYAN 13A	electricity(Wh)	6850116.000
PLOVDIV	CENTER	VESELA 33	electricity(Wh)	12008544.000
PLOVDIV	CENTER	Yanko Sakazov 2	electricity(Wh)	32276286.000
PLOVDIV	EAST	GEN. RADKO DIMITRIEV	electricity(Wh)	6708150.000
PLOVDIV	EAST	GEN. RADKO DIMITRIEV 21	electricity(Wh)	85707336.000

Figure 4.25 CityEnergyView—Consumption 30D.

of a number of actions to manage the demand of energy of the customer in response to the conditions proposed by the supplier, in order to reduce peak situations in the energy distribution grid. The system allows to manage a list of DR programs stored in the database and insert a new one. A DR program archive is designed in order to reuse a program for peaks of the same kind. From the DR program list (a detailed description is in the following "DR Program" paragraph), it is possible to create a DR program pressing the *New DR Program* button and filling the information required (a detailed description is in the following "DR Program" paragraph). A DR program is closely related to one or more actions that describe what the customer has to perform to fulfill the DR program that was sent. From the New DR program, it is possible to add one or more actions pressing the *Action* button and filling the information required (a detailed description is in the following "DR Program" paragraph).

Peaks monitoring manages the peak situations in the energy distribution grid identified by the system or manually inserted by the user. From peaks and DR monitoring (a detailed description is in the following "Peaks Monitoring" paragraph), it is possible to manually insert a peak pressing the *Add New Peak* button and filling the information required (a detailed description is in the following "Peaks Monitoring" paragraph). To reduce peak situations in the energy distribution grid, it is necessary to select a DR program to use, choosing among those previously entered, and link it to the peak from the peaks monitoring list (a detailed description is in the following "Peaks Monitoring" paragraph). When a peak was linked to a DR program, it is time to send the notifications to the customers. From peaks and DR monitoring, it is possible to send one or more notifications to the customers pressing the *Pencil* icon and filling the information required in the notification list (a detailed description is in the following "Peaks Monitoring" paragraph). Three buttons are proposed to the user in order to manage the notifications: create new notification, save new notification, and send notification to LDSS (a detailed description is in the following "Peaks Monitoring" paragraph). All notifications inserted that have not been sent by the user pressing the *Send Notification to LDSS* button will be sent anyway by the system at the scheduled time. When the action proposed to the customer is finished, the result related to the peak is presented in the notification list.

4.3.5.1 DR program

DR program opens a window that shows a list with the programs created from the system or from the user (Decision Maker, Supervisor). The DR program list shows the following data:

- DR program name: the name chosen for the DR program.
- Type: demand response type (thermostatdr or consumptiondr).
- Energy type: (electricity, water, heating, etc.).
- Tips: Suggestion should be followed by customer to achieve the goal required by DR program to improve the consumption or production.
- Reward: reward offered to entice the customer to change a behavior or habit.
- Creation date: creation date of the DR program.
- More icon opens a new pop-up that shows more information about DR program and related notifications.
- Delete icon shows whether a DR program can be deleted or not. The user can delete a DR program if there are not peaks or notification joined.

XLS icon opens and/or prints the report of the DR program list (Figure 4.26).

More icon shows the information related to the recommended user actions for a selected DR program. If no action is associated with a DR program, the Action Detail is empty.

In the upper rows of the pop-up is reported information related to the DR program, and in the lower rows, those related to the Action Detail.

The DR program presents the following fields:

- DR ID: demand response identifier.
- DR name: the name chosen for the DR program.

Figure 4.26 DR Management—DR Program.

- DR type: demand response type (thermostatdr or consumptiondr).
- Energy type: (electricity, water, heating, etc.).
- Creation date: creation date of the DR program.
- Tips: Suggestion should be followed by customer to achieve the goal required by DR program to improve the consumption or production.
- Reward: reward offered to entice the customer to change a behavior or habit.

The Action Detail presents the following fields:

- OfferID: It is the ID related to the offer.
- Action: It describes the behavior or the action to be taken by the user to get the reward.
- Action Operation: It indicates the value below or above the threshold that the user has to check. It is closely linked to Action Values.
- Action Value: Numeric value that indicates the threshold that the user has to check, in order to implement the right action. It is closely linked to Action Operation.
- Modify: Modify icon allows to change the action detail.
- Delete: Delete icon allows to delete the current action detail (Figure 4.27).

Figure 4.27   DR Management—DR Program—Action Detail.
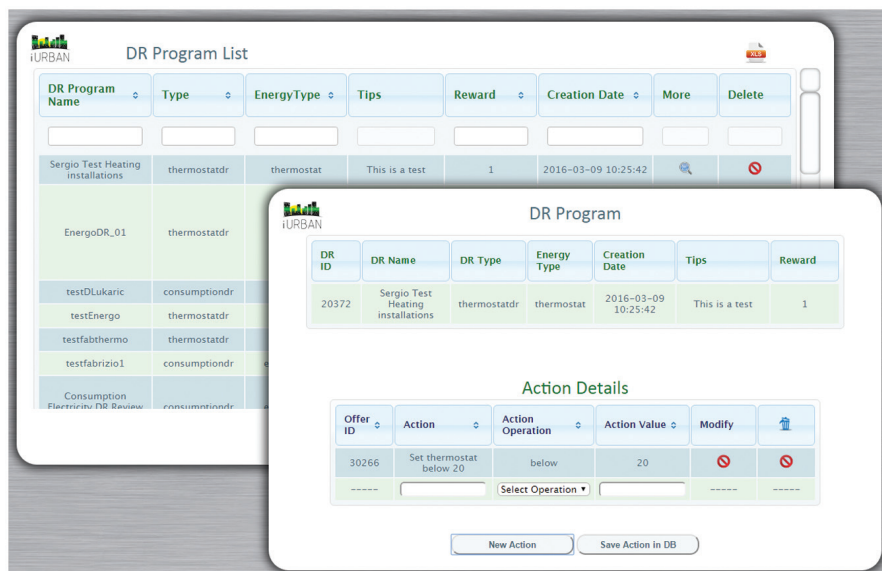
Figure 4.28 DR Management—DR Program—New Action.

New Action button presents a row under the current Action Detail in order to fill the fields to insert a new action.

Save Action in DB button saves in the CDSS DB the new action data inserted (Figure 4.28).

New DR Program button opens a pop-up where the user (Provider, Decision Maker, SuperUser) can insert a new DR program.

To insert, a DR program need the following fields:

- DR Program Name: mandatory
- DR Type: consumption, thermostat mandatory
- Energy Type: mandatory
- Reward: not mandatory
- Tips: not mandatory.

Action button opens a pop-up in order to insert economic offer related to the DR program created. Save button saves the new DR program (Figure 4.29).

With the *Action* button, the user (Provider, Decision Maker, SuperUser) can insert an action from this window filling the following fields:

- Action: action to be performed to get the benefit, mandatory.
- Action Operation: value action (below, above, etc.), mandatory.
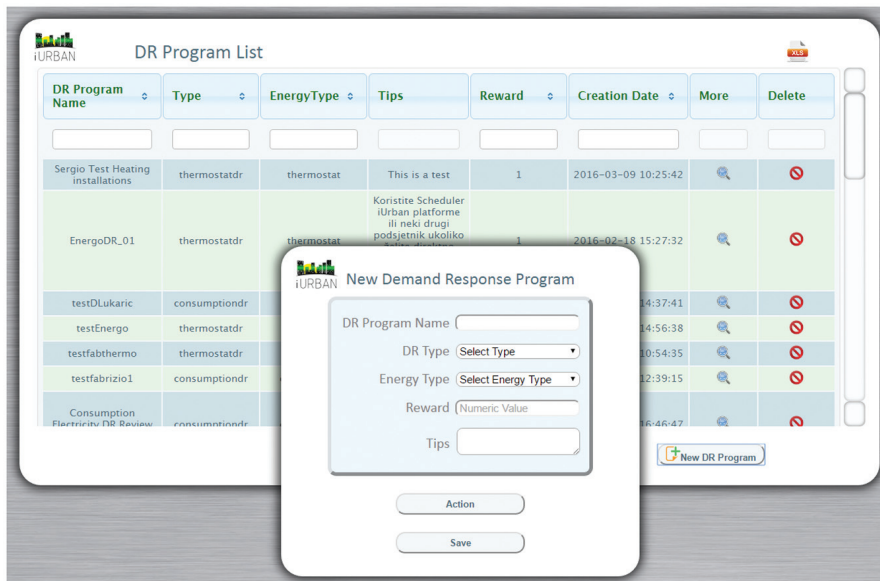
Figure 4.29 DR Management—DR Program—New DR Program button.

- Action Value: value of the action (numeric), mandatory.
- Delete: delete icon allows to delete the current action.

The *New Action* button adds a row to insert a new action. The *Save Action* button saves the new action inserted if the user saves the DR program (Figure 4.30).

4.3.5.2 Peaks monitoring

The peaks and DR monitoring allows the user to check the peaks generated if the energy production (response) is less than the energy consumption (demand). In this case, the user can try to resolve the problem using a suitable DR program. The peaks are calculated from the system or created manually from the user. It is possible to link a DR program with a peak. The fields showed in the "peaks and DR monitoring" list are the following:

- Type: user or system, inform the user whether the peak is manual or inserted by the system.
- City: city name where the peak should occur.
- Energy Type: kind of peak energy (electricity, water, heating, etc.).
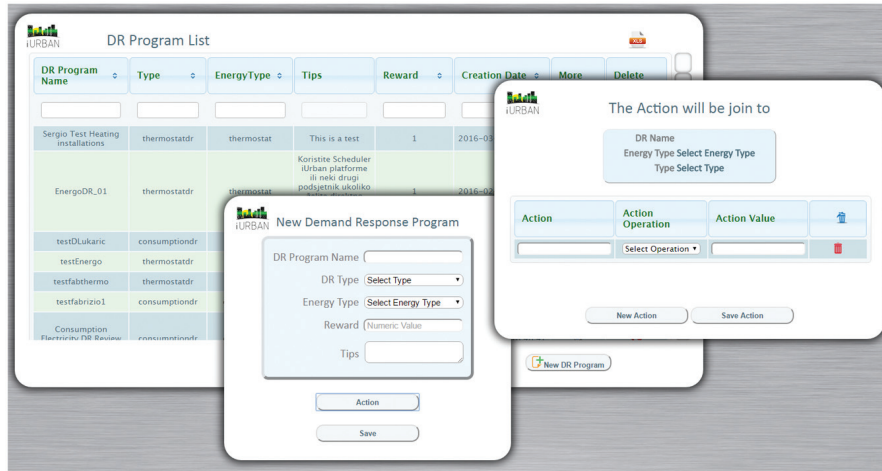- Start Time: start time of the peak.
- End Time: end time of the peak.

Figure 4.30 DR Management—DR Program—New DR Program—New Action.

- DR Program: It is the DR program linked to the peak. The field presents a list of DR program stored in the database, by the system or by the user, and related to the energy type of the peak.
- Status Icon: current peak status. It opens a pop-up with more information about peak status.
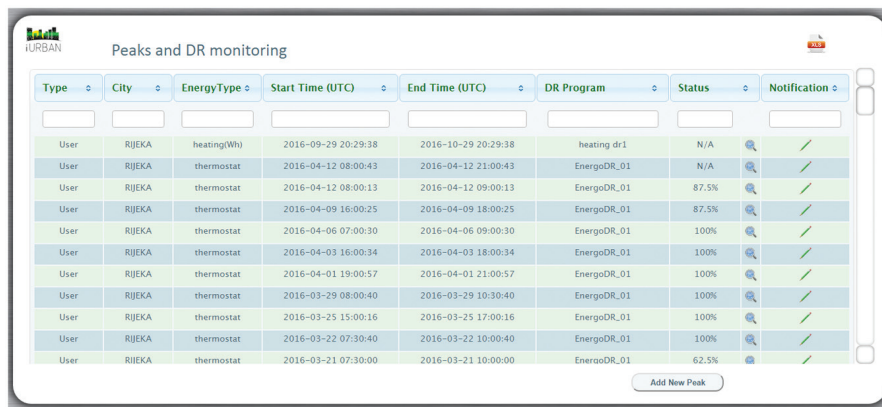- Notification Icon: It opens a window in order to create and manage the notifications to the customer for the DR program selected (Figure 4.31).

Figure 4.31 DR Management—Peaks and DR Monitoring.

Add New Peak button allows the user to insert a new peak (manual action) adding a row below the peak list (Figure 4.32).

   The fields showed in the "Status Detail" list are the following:

- Group: associated group.
- Start Time: start time of the peak.
- Expiration Time: expiration time of the peak.
- Action Value: value of the action (numeric).
- Action Operation: value action (below, above, etc.).
- Installation ID: installation identifier.
- Installation Name: name of the installation.
- Results: results obtained (Figure 4.33).

The fields showed in the "Notification List" are the following:

- Group: customers for which the notification is applied.
- Scheduled Time: scheduled time of the peak.
- Start Time: start time of the peak.
- Expiration Time: expiration time of the peak.
- Action: action to be performed to get the benefit.
- Action Value: value of the action (numeric).
- Action Operation: value action (below, above, etc.).
- Notification Status: status of the notification.
- Results: results obtained.

Create new notification button allows the user to insert a new notification adding a row below the notification list. *Save new notification* button allows
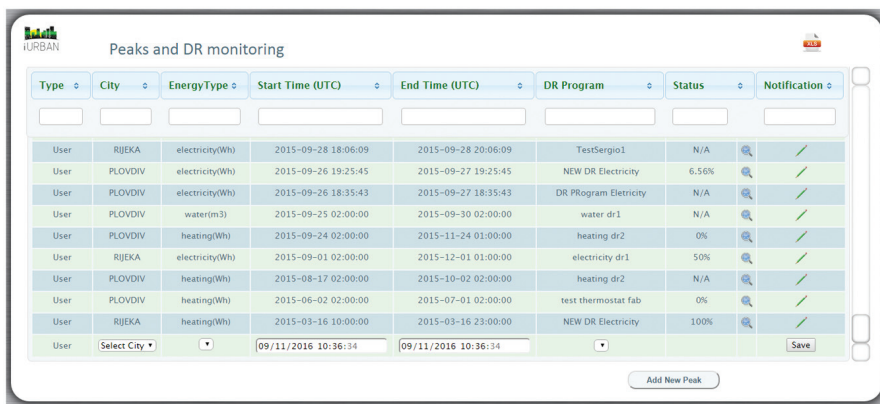
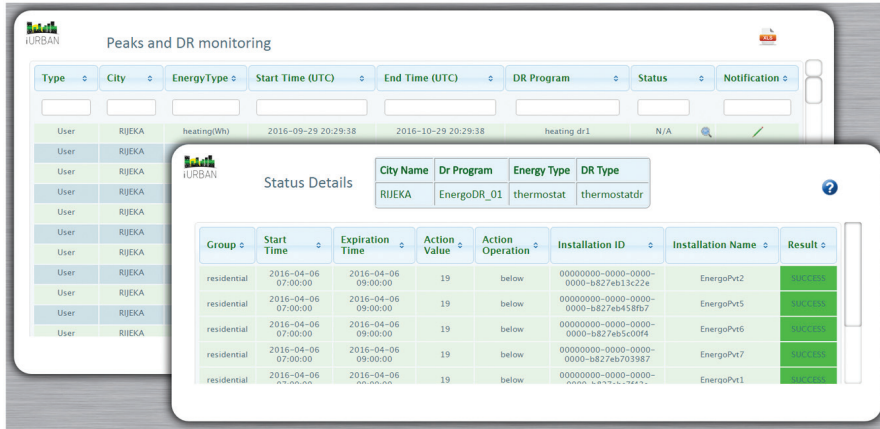**Figure 4.32**   DR Management—Peak and DR Monitoring—Add New Peak.

Figure 4.33   DR Management—Peaks and DR Monitoring—Status Detail.

the user to save the new notification. *Send notification to LDSS* button allows the user to send to LDSS one or more notifications previously selected in the checkbox on the left side of the list. If the user does not send the notification manually, it will be sent anyway at scheduled time by the system (Figure 4.34).

4.3.6 Tariff

From toolbar by selecting tariff button, it is possible to manage the tariff plans and the tariff comparison according to the user profile.
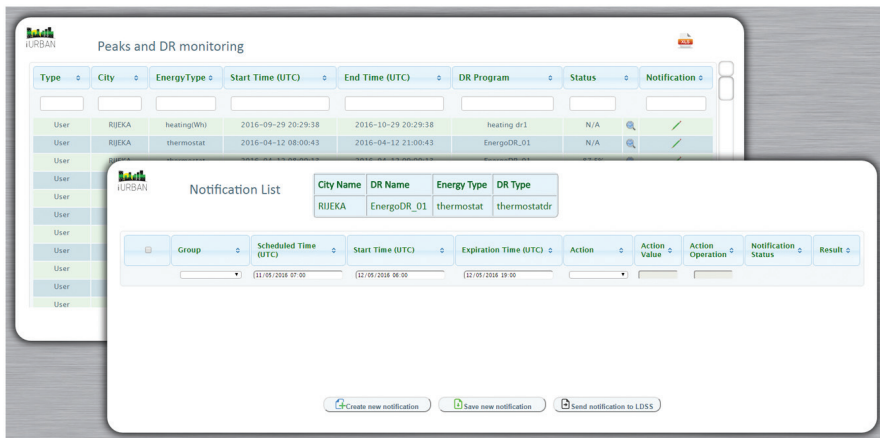
Figure 4.34   DR Management—Peaks and DR Monitoring—Notification List.

Figure 4.35   Tariff—Tariff Plans.

4.3.6.1 Tariff Plans

Tariffs Plans manage the tariffs applied to the customers. It is possible to insert new tariff and manage data related to the dynamic tariffs.

Tariffs Plans list presents the following information:

- City: city name where tariff is applied.
- Tariff Name: the name of the tariff.
- Energy Type: energy type related to the tariffs plans.
- Energy Unit: energy measure unit.
- Currency: currency applied.
- Group: customers for which the tariff is applied.
- Creation Date: start range for which the tariff plan is applied.
- Edit: the icon allows to change the tariff data.
- Delete: icon to delete the tariff.

XLS icon opens and/or prints the report of the tariff plan list.

The user can visualize the data applying a filter on each field (Figure 4.35).

New Tariff Plan button opens a pop-up where the user (Provider, Decision Maker, SuperUser) can insert a new tariff plan.

The mandatory fields are the following:

- City: the city name where apply the tariff.
- Tariff Name: the name of the tariff plan.
- Group: customer group to whom the tariff plan should be applied.

- Commodity: raw material.
- Unit: measure unit.
- Currency: the currency applied.

For each tariff, the user can create a tariff plan composed of one or more level (for the dynamic tariff for each level, it is possible to select a time of validity).

The fields to insert for each level are the following:

- ID level: level identifier.
- Level name: name of the level.
- Start: validity start date of the tariff plan (dd/mm/yy).
- End: validity end date of the tariff plan (dd/mm/yy).
- allDay: as an alternative to the start date and end date.
- Currency: the currency applied.
- Cost: cost for unit measurement.
- Edit icon: allows to change the tariff data.
- Delete icon: deletes the row.

The user can add new level click-on *Add Level* button that adds new line in the list. To save the tariff plan, the user can click-on *Save Tariff* button. XLS icon opens and/or prints the report of the tariff plan. On the base of the tariff applied, it will be possible to calculate the bill for each customer (Figure 4.36).
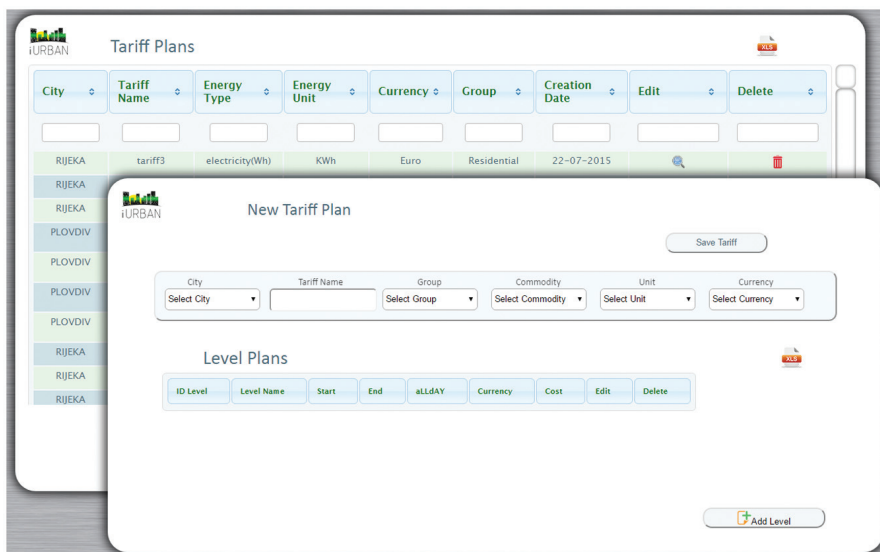
Figure 4.36 Tariff—Tariff Plans—New Tariff Button.

4.3.6.2 Tariff comparison

The tariff comparison shows a bar chart representing the comparison between some tariffs applied to the consumptions of the last year (Figure 4.37).

In the bar chart, the x-axis represents the months of the year and the y-axis represents the costs applied.

4.3.7 Diagnostic

From toolbar by selecting the *Diagnostic* button, it is possible to manage the DataFlow Offline and the technical losses according to the user profile.

4.3.7.1 DataFlow Offline

DataFlow Offline shows the list of meters (ID Meters) which do not send information to the system from more than 24 hours. That information can be useful in order to verify the status of the meters.

The DataFlow Offline shows the data for the cities and energy type related to the user profile.

Figure 4.37   Tariff—Tariff Comparison—Consumption/Price Curve.

Figure 4.38 Diagnostic—DataFlow Offline.

The DataFlow Offline table gives the following information:

- City: city name.
- Building Name: address of the building or indication of building type (e.g., school, CHP Plant).
- Installation Name: address of the building or indication of building type and floor or apartment number of the installation.
- ID Meter: Id alphanumeric of the meter.
- Data Last Measure: data of the last measure stored on the database.

The user can visualize the data applying a filter on each field.

XLS icon opens and/or prints the report of the DataFlow Offline list (Figure 4.38).

4.3.7.2 Hot Water Technical Losses

Hot Water Technical Losses is a loss of hot water in apartment buildings. It is the deviation calculated comparing the hot water provided to the entire building with hot water consumptions of each apartment of the building. The data of losses presented are described in the following:

- City: name of the city where the building is situated.
- District: name of the district where the building is situated.

Figure 4.39   Diagnostic—Technical Losses: Hot Water.

- Building name: name of the building where the loss occurs.
- Building address: address of the building where the loss occurs.
- Building type: kind of the building (sport center, public building, residential building, etc.).
- Date: date of the loss detection.
- Building consumption: total building consumption.
- Apartments consumption: total apartments consumption.
- Deviation: Deviation in percentage calculated by the system (Figure 4.39).

4.3.7.3 Heating Technical Losses
Heating Technical Losses is a loss of heating in apartment buildings. It is the deviation calculated comparing the heating provided to the entire building with heating consumptions of each apartment of the building.

The data of losses presented are described in the following:

- City: name of the city where the building is situated.
- District: name of the district where the building is situated.
- Building name: name of the building where the loss occurs.
- Building address: address of the building where the loss occurs.

- Building type: kind of the building (sport center, public building, residential building, etc.).
- Date: date of the loss detection.
- Building consumption: total building consumption.
- Apartments consumption: total apartments consumption.
- Deviation: deviation in percentage calculated by the system (Figure 4.40).

4.3.8 Weather Forecast

From the toolbar by selecting *Weather Forecast* button, it is possible to see the weather information related to the city of interest (Figure 4.41).

4.3.9 User

From the toolbar by selecting *User* button, it is possible to manage the user login and logout according to the user profile. A pop-up is shown containing all the information on the current user; it is possible to logout with the user, clicking on the icon on the upper right corner (Figure 4.42).

City	District	Building Name	Building Address	Building Type	Date	Building consumption	Apartments consumption	Deviation (%)
PLOVDIV	NORTH	Ilio Vojvoda 19	Ilio Vojvoda 19	Residential	06/04/2016	1.2	1.149	0.04
PLOVDIV	CENTER	Yanko Sakazov 2	Yanko Sakazov 2	Residential	06/04/2016	0.7	0.703	0.00
PLOVDIV	NORTH	Ilio Vojvoda 19	Ilio Vojvoda 19	Residential	05/04/2016	2.2	2.384	−0.08
PLOVDIV	CENTER	Yanko Sakazov 2	Yanko Sakazov 2	Residential	05/04/2016	1.7	1.841	−0.08
PLOVDIV	CENTER	TSCAR KALOYAN 13A	TSCAR KALOYAN 13A	Public offices	05/04/2016	5.1	5.113	0.00
PLOVDIV	NORTH	Ilio Vojvoda 19	Ilio Vojvoda 19	Residential	04/04/2016	5.1	5.076	0.00
PLOVDIV	CENTER	Yanko Sakazov 2	Yanko Sakazov 2	Residential	04/04/2016	13.4	13.379	0.00
PLOVDIV	CENTER	TSCAR KALOYAN 13A	TSCAR KALOYAN 13A	Public offices	04/04/2016	8.5	6.863	0.19
PLOVDIV	NORTH	Ilio Vojvoda 19	Ilio Vojvoda 19	Residential	03/04/2016	5.3	5.042	0.05
PLOVDIV	CENTER	TSCAR KALOYAN 13A	TSCAR KALOYAN 13A	Public offices	03/04/2016	15.9	13.084	0.18

Figure 4.40   Diagnostic—Technical Losses: Heating.

Figure 4.41   Weather Forecast.

Figure 4.42   User—User Information Pop-up.

4.3.10 Configuration

The *Configuration* button of the toolbar manages the console and the controls according to the user profile.

4.3.10.1 Console

The *Console* window manages the iURBAN console adding, modifying, or deleting a button on the toolbar (Figure 4.43).

Clicking on the *button name*, listed on the left of the window, all the information related to it will be showed on the right. It is possible to modify or delete it (Figure 4.44).

Selecting *New Button*, the fields to be filled to insert a new button will be presented on the right of the window (Figure 4.45).
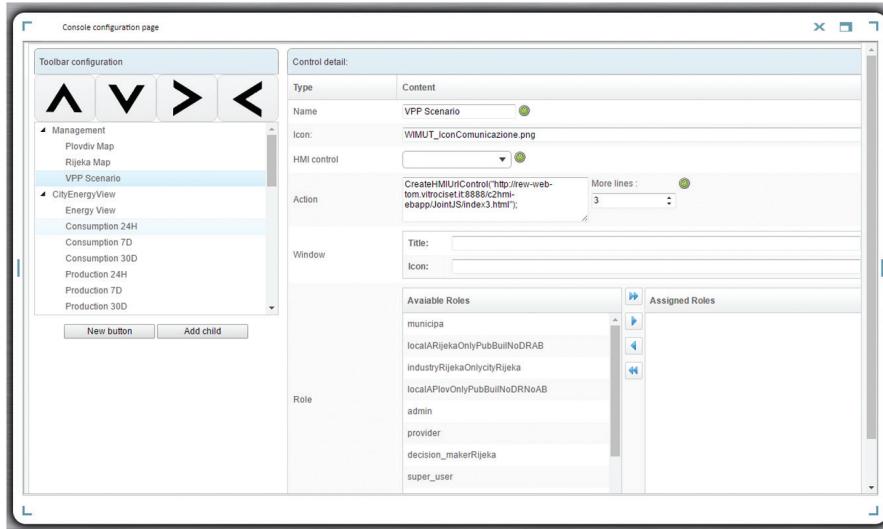
4.3.10.2 Controls

From the *Controls* window, it is possible to add, modify, or delete the iURBAN Controls (Figure 4.46).
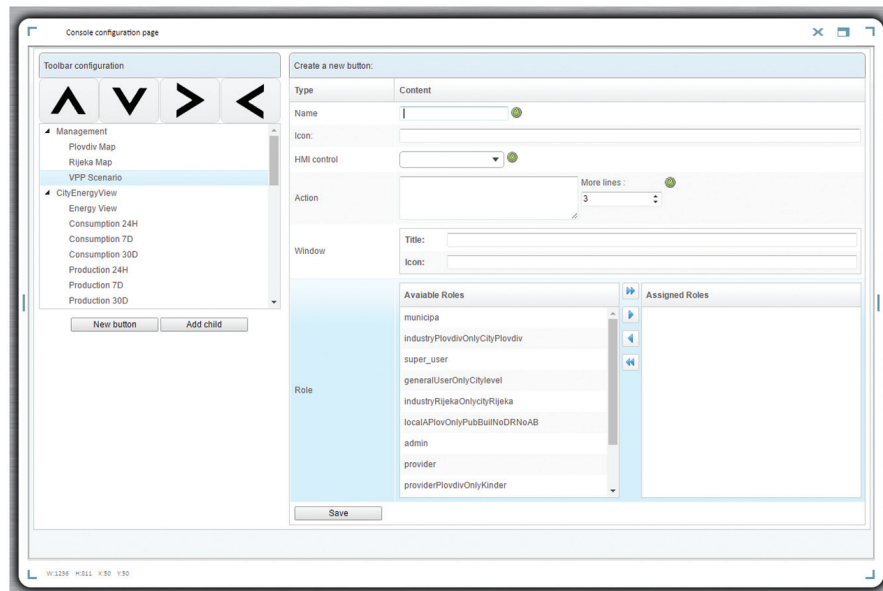
Clicking on the control name, listed on the left of the window, all the information related to it will be showed on the right (Figure 4.47).
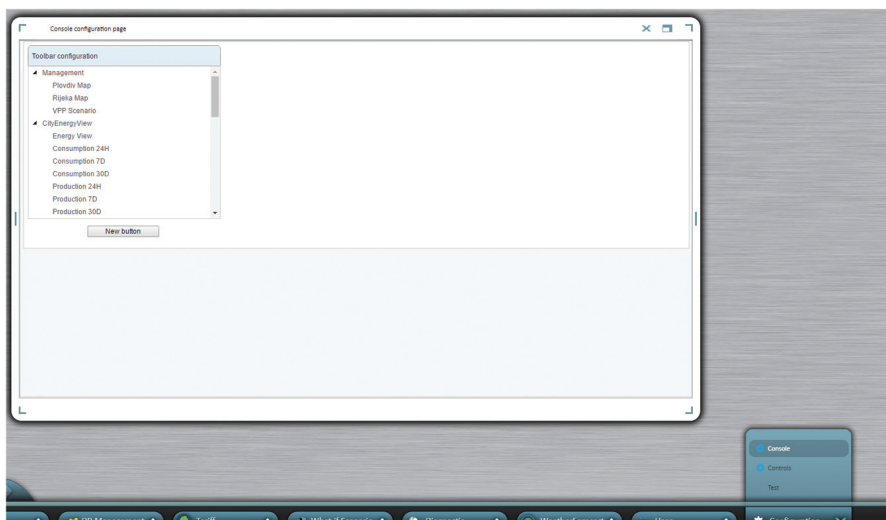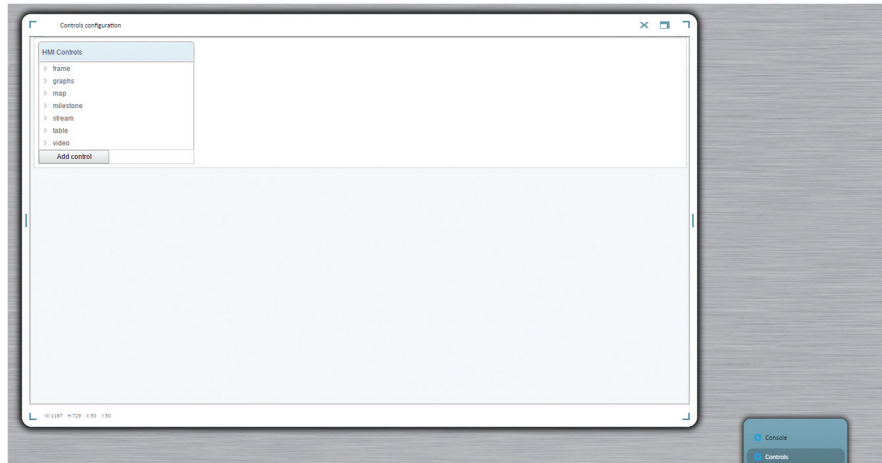

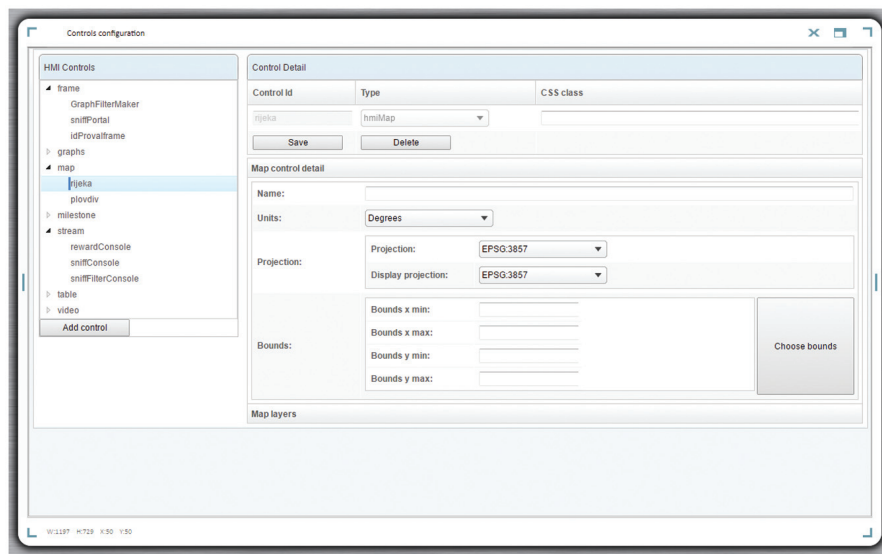**Figure 4.43** Configuration—Console.

Figure 4.44   Configuration—Console—Button Configuration.

Figure 4.45   Configuration—Console—New Button.

Figure 4.46 Configuration—Controls.

Figure 4.47 Configuration—Controls—Control Data.

4.4 Conclusion

The CDSS aggregates data from all LDSSs to provide city-level decision support to authorities and energy service providers. The CDSS generates a

number of parameters, including citywide energy production and consumption forecasts. CDSS allows the users to do the following:

- Get a continuous snapshot of city energy consumption and production;
- Manage energy consumption and production;
- Forecast energy consumption;
- Plan new energy "producers" for the future needs of the city;
- Visualize, analyze, and take decisions of all the end points that are consuming or producing energy in a city level, permitting them to forecast and planning renewable power generation available in the city, a real-time optimization and being perfectly scalable (meaning its ability to be enlarged to accommodate that growth of data).

Analyzing the results gathered in the two pilots of iURBAN project, we can say that the user interface and the interaction paradigm implemented for CDSS are really innovative compared with the systems that usually people from energy utilities and municipalities are used to work with. However, the functionalities and the data reports provided by CDSS must be improved in order to cover all the needs of the users from energy utilities and municipalities. The architecture of CDSS will allow us to easily extend it with new features following the new requirements indicated from the users.