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Deliverable D6.5

Final Integrated NRG4CAST Toolkit (Final Prototype)

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Executive Summary

Deliverable D6.5 has focused on the rollout of the Final Integrated NRG4CAST Toolkit as an integrated Decision Support System. This process included the integration of software components developed in the 3rd year of the project with the building blocks of the previous version of the Toolkit which have been enhanced according to the requirements of the pilot scenarios.

One of the main challenges faced was the design and implementation of seamless Authentication & Authorization of the users to the individual components in an integrated way, according to well-defined roles relevant to the pilot requirements. In this context, the Central Authentication Service Single Sign On solution is used by all the software components in order to authenticate the users against a specially designed and deployed User & Role database. Each component handles authorization autonomously through the use of an appropriate REST API for User & Role information retrieval.

Furthermore, much work has been also done on the update and refinement of the pilot scenarios supported by the Toolkit. Many hundreds of new sensors pertaining to a plethora of NRG4CAST energy consumption objects residing in the consumption centres of the different pilots have been integrated for the final rollout. Reporting and forecasting functionalities have been further specified and upgraded.

Last but not least, the Final Integrated NRG4CAST Toolkit supports the definition and configuration of virtual consumption centres which group together objects and their sensors from different pilot context in order to support the integrated city scenario.

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Abbreviations

API – Application Programming Interface

CAS – Central Authentication Service

FTP – File Transfer Protocol

GUI – Graphical user interface

JSON – JavaScript Object Notation

MDB - Monitoring database

REST – Representational State Transfer

SQL – Structured Query Language

SSO – Single Sign On

1 Introduction

This deliverable report presents work done in the final integration phase of the NRG4CAST Toolkit. Specifically Deliverable D6.5 was focused on the integration of several new software components, i.e. User & Role Management as well as the components developed as a result of work packages WP4 and WP5 (Situational Awareness, Knowledge Formalization, Knowledge-driven Planning & Optimization components). Also, significant effort has been made to provide a unified way to the users to access and be authorized to the several components of the NRG4CAST Toolkit (Single Sign On & Role-based Access Control).

The Sensor Registry & Consumption Centre Configuration / Report Management & Real-time Visualization components have been implemented following a modular UI Toolkit approach enabling fast prototyping and integration of new pilots, objects and reporting functionalities. Summaries of the information stream are easily provided by the Monitoring database which provides a Generic SQL API available to the Monitoring GUI already from the 2nd year prototype of the NRG4CAST Toolkit.

Further, more work has been done on the specification and refinement of the several pilot contexts (Miren, FIR, Turin, NTUA and IREN), with regard to the reporting and forecasting functionalities. Last but not least, the Sensor Registry & Consumption Centre configuration component has been enhanced with the functionality to create Virtual Consumption Centres in the context of a virtual pilot which corresponds to the integrated city scenario which incorporates and combines consumption data from different NRG4CAST objects (buildings, lamps, charging stations, traffic sensors, etc.).

The structure of the remainder of this deliverable report is organized as follows:

Section 2 presents an updated view of the NRG4CAST Toolkit Architecture presenting a high-level view of all the components, their position and interaction.

Section 3 describes the solution followed in order to provide a unified Single Sign On and Role-based Access Control functionality to the users of the Toolkit.

Sections 4, 5, 6, 7, 8, 9 and 10 present the software components of the NRG4CAST Toolkit. In the sections new components are described on a high level (Section 4: User & Role Management, Section 7: Knowledge Formalization, Section 9: Knowledge-driven planning & optimization, Section 10: Situational Awareness). In the case of components formerly developed (Sections 5, 6, 8), information presented pertains to new and updated functionalities.

Section 11 presents updated descriptions with regard to the different pilot scenarios supported by the NRG4CAST Toolkit with focus on the goals for the 3rd year of the project. The virtual integrated city scenario approach is also briefly presented.

Section 12 concludes the deliverable report with a brief summary of its achievements.

2 NRG4CAST Toolkit Architecture

The architectural diagram presented in Figure 1 is an update and refinement of the architecture specification presented in Deliverables D5.1 and D6.4 [1],[2]. The new architectural diagram contains components developed during the 3rd year of the project such as User & Role Management, Knowledge Formalization and Situational Awareness components, their position and interactions with the other components of the system.

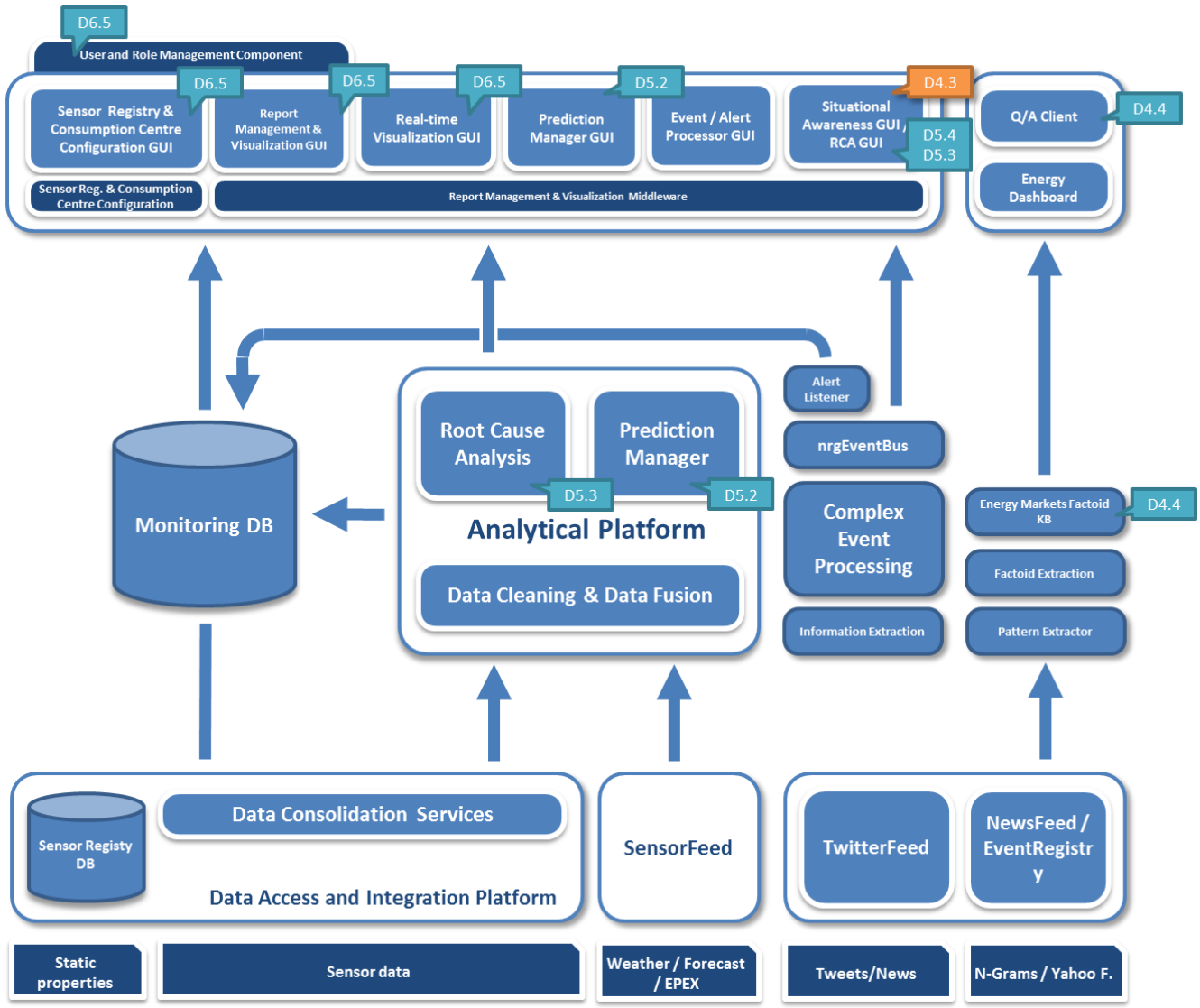

Figure 1. NRG4CAST Toolkit Architecture [1]

Figure 1 marks existing components which were enhanced for the Final Integrated NRG4CAST Toolkit in Deliverable D6.5 as well as all the new components which were developed in various deliverables of the 3rd year (D4.3, D4.4, D5.2, D5.3, D5.4) and have been integrated into the Toolkit.

3 Single Sign-On and Role-based Access Control

3.1 Single Sign On

The users of the NRG4CAST Toolkit should access the multiple components in a unified way providing credentials only once. In order to do that a Single Sign On mechanism has been implemented.

In order to implement the Single Sign On mechanism we have reviewed and evaluated a number of Open Source Single Sign On frameworks:

- WSO2 Identity Server
- OpenSSO
- JOSSO
- Central Authentication Service

We finally selected the Central Authentication Service (CAS) solution according to the following criteria:

1. Ease of use
2. Wide usage
3. Good support and documentation
4. Cross-platform client support: Java, .NET, PHP, Perl, Python, Ruby, etc
5. Direct industrialization (Apache license)

From the criteria presented above the most important one have been 4 (Cross-platform support) and 5 (Apache License) due to the fact that the NRG4CAST components have been developed in different platforms and the need to easily commercialize the NRG4CAST prototype.

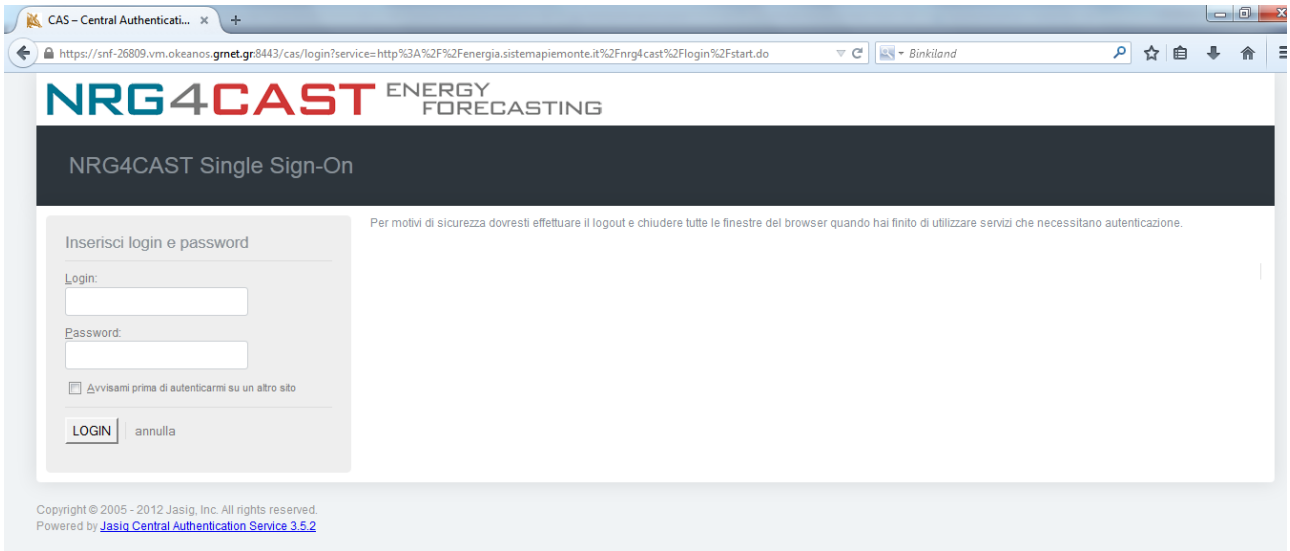

Figure 2. NRG4CAST Single Sign On Web Page

3.1.1 Central Authentication Service

Figure 3 presents the authentication flow of a User to a component web front-end.

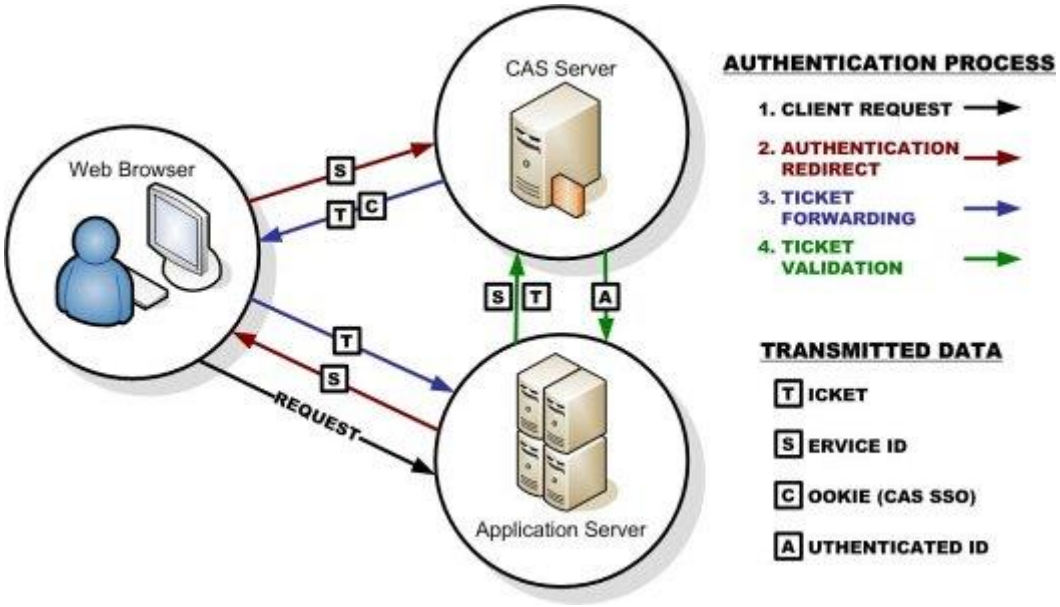

Figure 3. CAS Authentication flow (adopted from CAS documentation)

1. The user attempts to access the NRG4CAST component's Web Server.
2. The component redirects it to CAS. CAS validates the user's authenticity by checking his/her username and password against the User/Role database (Figure 4)
3. If the authentication succeeds, CAS returns the user to the NRG4CAST component, passing along a security ticket.
4. The component then validates the ticket by contacting CAS over a secure connection and providing its own service identifier and the ticket. CAS then gives the component trusted information about whether a particular user has successfully authenticated.

3.2 Role-based Access Control

After a user accesses a component he must be presented with the appropriate User Interface and acquire authorization to specific services and functionalities according to his/her role in the NRG4CAST Toolkit.

The CAS service is only responsible for authentication. Role-based access control is performed internally by each separate component due to divergent deployment platforms. Each component retrieves the security ticket concerning the authenticated username and provides or rejects access to relevant functionalities **autonomously.**

Access control to the functionalities of each component proceeds with the retrieval of the role of the user and its authorization with regard to certain tasks and the relevant role menu. This information is retrieved by the User/Role database through a REST Application Programming Interface implemented for this purpose which fetches relevant data.

3.2.1 User/Role Database

The User/Role database has been implemented in a Postgres database server at 83.212.107.133:5432. Figure 4 presents the schema of the User/Role database.

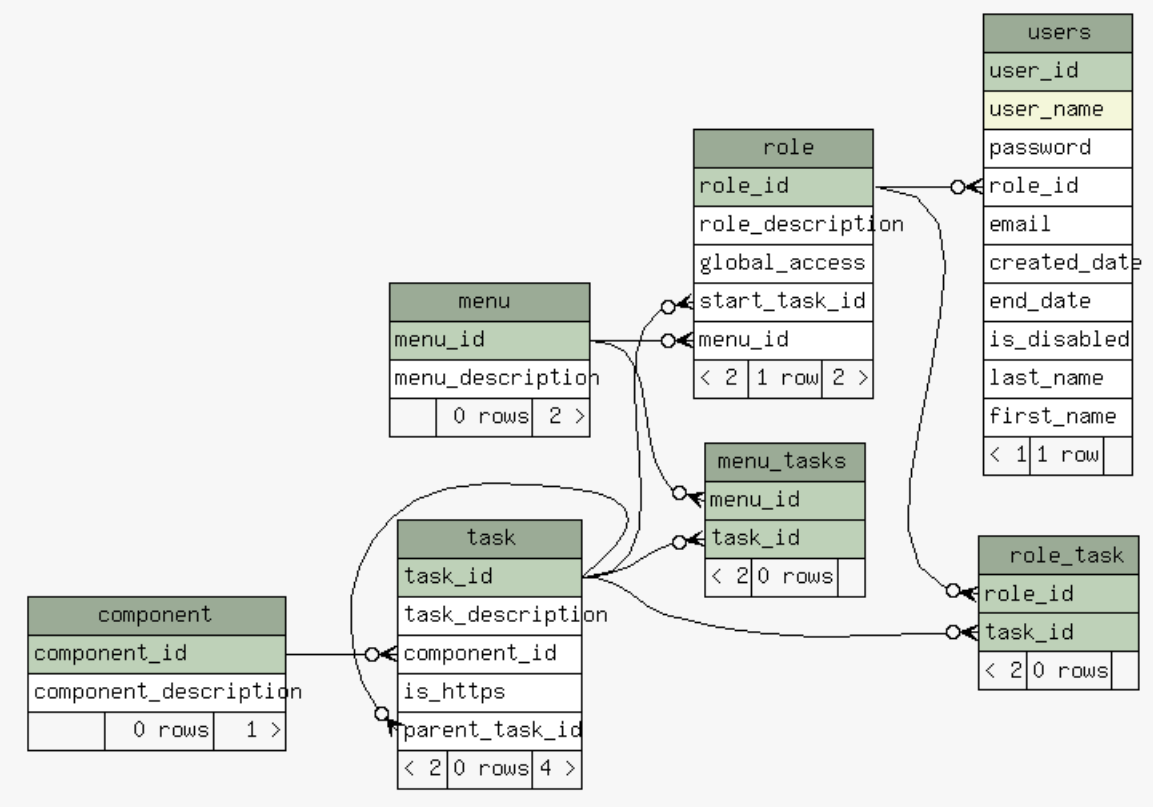

Figure 4. User/Role Database

According to the schema above a user has one exclusive role in the NRG4CAST Toolkit. Each role is connected with a specific menu and a set of tasks. Each task belongs to a specific component. When the User selects a menu the contents of the menu_tasks table are retrieved and displayed. Any task which is not accessible to the user according to his/her role and the data in role_tasks table can be filtered out.

Further, a role can have the flag global_access turned on in order to have a Global Administrator role.

The design of the database conforms to the National Institute of Standards and Technology (NIST) Role-based Access Control standard. (http://csrc.nist.gov/groups/SNS/rbac/).

3.2.2 Role REST API

The REST API for the retrieval of roles is available in: http://snf-26809.vm.okeanos.grnet.gr:9080/nrg-user-auth/v1/users/


```
[{"userId":"admin","username":"admin","email":"admin@
nrg4cast.org","lastName":"Admin","firstName":"Admin",
"role":{"roleId":"admin","roleDescription":"Global
administrator
role","globalAccess":true,"menu":null,"startTask":{"t
askId":"admin_viewmap","taskDescription":"View
map","component":{"componentId":"nrg_admin_tool","com
ponentDescription":"NRG4CAST web administration
tool"},"children":[],"https":null},"tasks":[{"taskId"
:"admin_viewmap","taskDescription":"View
map","component":{"componentId":"nrg_admin_tool","com
ponentDescription":"NRG4CAST web administration
tool"},"children":[],"https":null}]},"disabled":null}
]
```


Figure 5. Role REST API JSON response

Figure 5 depicts the response of the REST API when only one user (admin) and role (Global administrator) exist in the database.

3.2.3 Single Sign On to the NRG4CAST monitoring web front-end

The front end web application of the NRG4CAST project uses the Central Authentication Service (CAS), a single sign-on protocol for the web. It allows user to access a multiple applications providing user id and password just once. Once authenticated by any of the NRG4CAST Toolkit components, the user will have access to other system components secured with this permission.

Any access to the Report Management & Visualization and Real time Visualization Components GUI should be made only by authenticated users. Non-authenticated users are redirected to the NRG4CAST CAS web application requesting authentication. CAS validates the user authenticity by checking a username and password against a database. If login is successful, the user will be automatically redirected to the NRG4CAST welcome page. All the applications associated to this certain user id, role id and task id are listed under the "Available applications" menu (Figure 6). After choosing the application from the list, the user will be redirected to the Report Management & Visualization and Real time Visualization Components GUI.

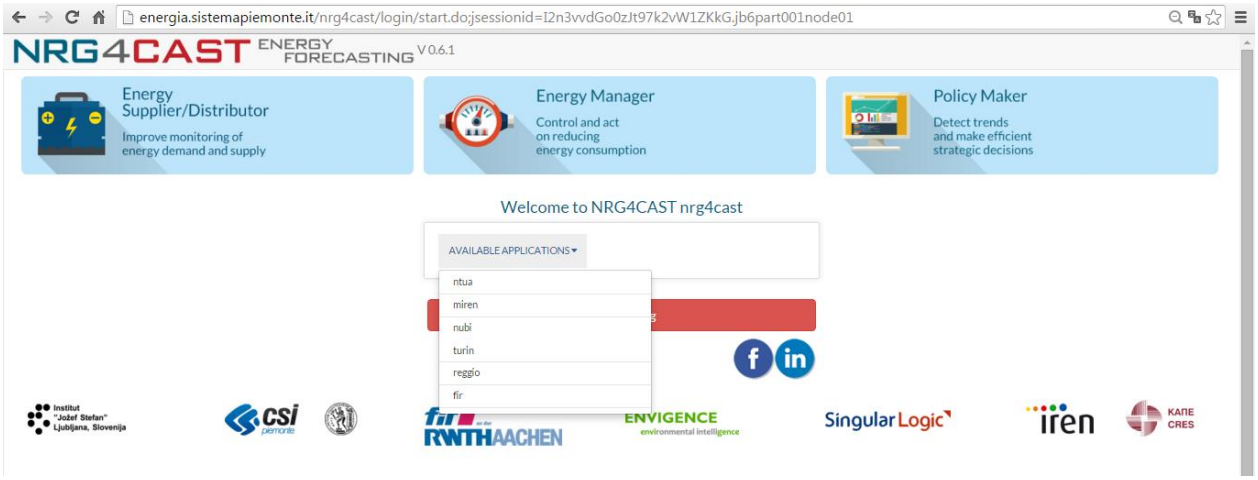

Figure 6. NRG4CAST Toolkit welcome page, available applications for the "super user" profile

NRG4CAST Toolkit manages a number of user profiles with different levels of permissions through the unique service. CAS then gives the Report Management & Visualization and Real time Visualization GUI trusted information about whether a particular user has successfully authenticated and what are the roles associated with this particular user. Based on the roles, the web application allows or doesn't allow certain functions.

In particular, basic and advanced users and associated roles have been created for each pilot as following:

- reggio-manager, reggio-guest
- ntua-manager, ntua-guest
- turin-manager, turin-guest
- miren-manager, miren-guest
- fir-manager, fir-guest (Figure 7)
- nubi-manager, nubi-guest.

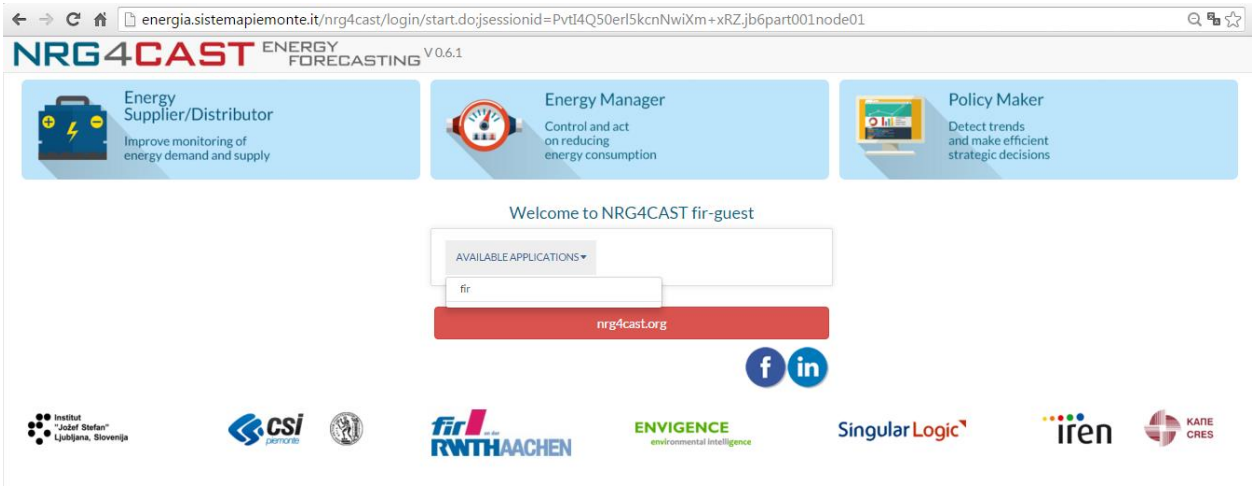

Figure 7. NRG4CAST Toolkit welcome page, available application for the fir-guest profile

Basic user (guest) provides users with the rights necessary to operate all the GUI functions except for an Advanced Search (Figure 8). Furthermore, *Advanced user* (manager) has an access for all the basic and advanced GUI functionalities including Advanced Search and SQL query tool. Both base and advanced users are allowed to operate only within the pilot of competence.

The "super user" profile has been created to allow the system tests and developments. This system administrator user has all the advanced user rights and operates within all the NRG4CAST pilots.

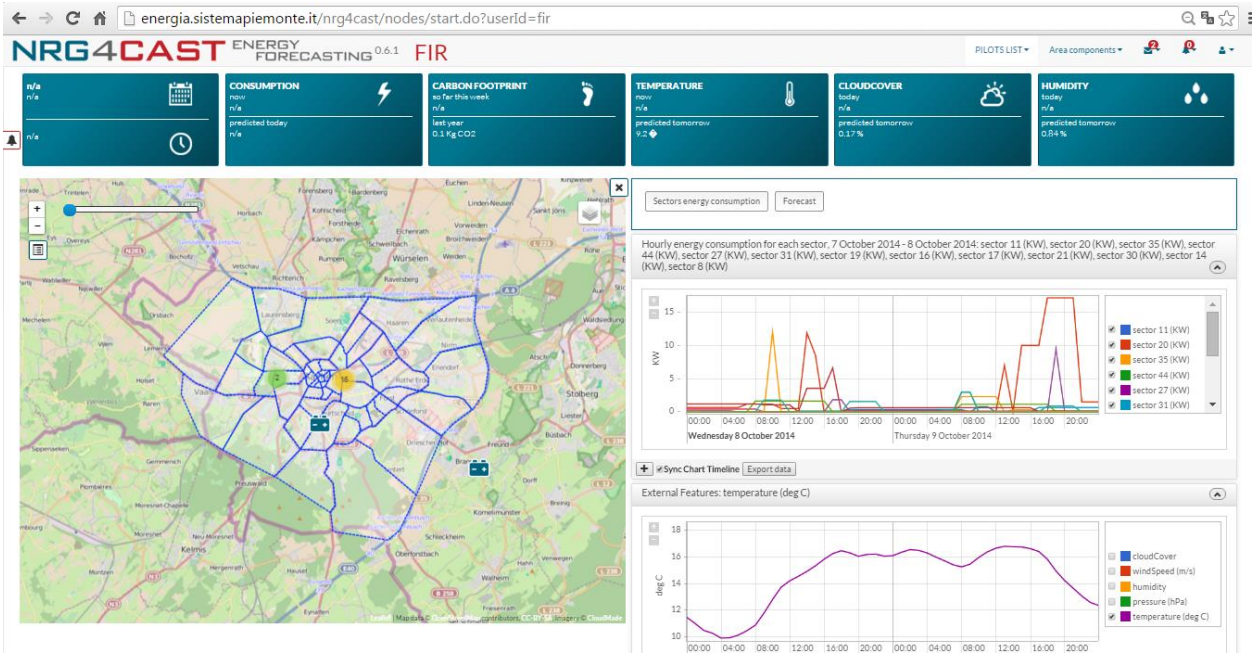

Figure 8. Report Management & Visualization and Real time Visualization GUI, basic user fir-guest (all the GUI functions except for the Advanced Search and SQL query tool

4 User & Role Management Component

The User & Role Management component is responsible for the management of users and roles within the NRG4CAST Toolkit. The User & Role Management component consists of the User & Role database which was presented in Section 3.2.1, the Role REST API which was presented in Section 3.2.2, as well as the User & Role Management GUI.

Figure 9 presents the Graphical User Interface for the User & Role Management component.

Figure 9. User & Role Management GUI

The User & Role Management GUI is accessible through: http://snf-26809.vm.okeanos.grnet.gr:9080/ with credentials: vb /vb (username/password).

The User & Role administrator can insert/update/delete users, roles, components, tasks, menus.

5 Sensor Registry / Consumption Centre Configuration Component

The Sensor Registry & Consumption Centre Configuration component has been presented in Deliverable D6.4 [2]. In this section, we summarize updates and enhancements implemented in the 3rd year.

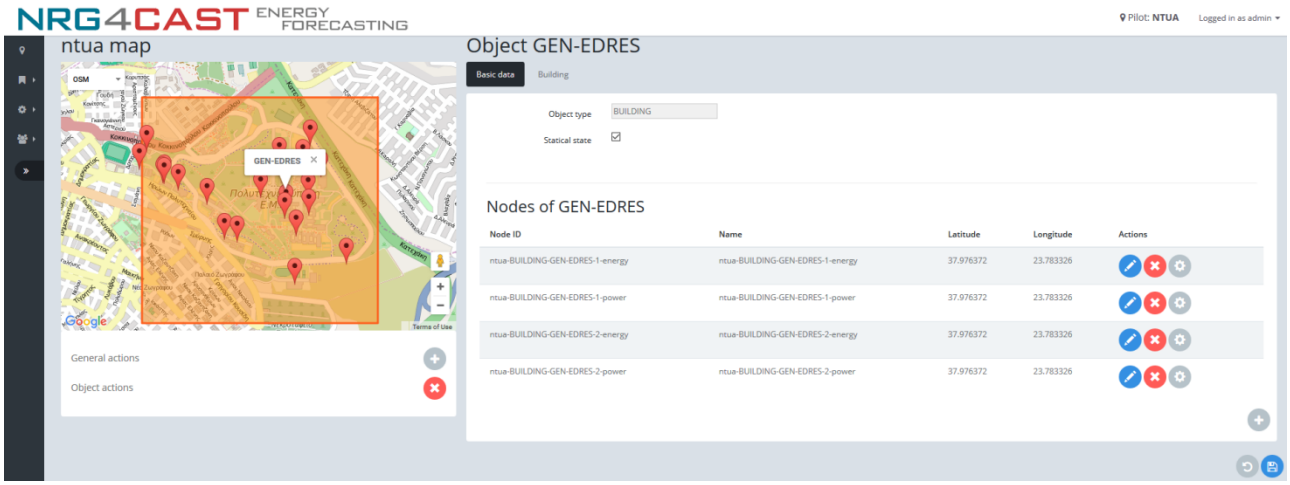

Figure 10. Sensor Registry & Consumption Centre Configuration Component

A REST API has been implemented for the configuration of the consumption centre / object / node / sensor hierarchy in the monitoring database performing:

- Allocation of consumption centres per pilot
- Setup of object hierarchy, including buildings, building parts, lamps, production plants, substations, and other objects per consumption centre
- Assignment of location information for each object
- Setup of data sources per node / sensor & sensor type allowing information to be gathered from disparate sources.

Further, a generic streaming mechanism has been implemented replacing the ad hoc streaming mechanism developed in the first 2 years of the project which supports:

- Arbitrary scheduling of data collection per each node
- Retrieval of input from various sources via extensible modular architecture
- Currently implemented sources:
    - CSV files from remote FTP, customizable with regards to column definitions and timestamp format,
    - Custom Excel files from remote FTP
    - Web service invocation, including dynamic variables assignment
- Tracking of all scheduled streaming jobs and differential data retrieval, as long as this is supported by the data source
- Batching allows scalable retrieval, no matter how large the source dataset is

Last but not least, a UI Toolkit implemented using the angular.js framework is implemented according to the requirements of the DOW:

- Multi-tenant implementation, to support multiple pilots in one instance of the web administration tool,

- View and edit consumption centre hierarchy on the map view,
- Browse and select from the “tree-view” of the pilot hierarchy,
- Setup all types of objects supported,
- Component-based architecture which allows easy extension of view & edit capabilities with new object types,
- Streaming configuration via configuration templates with support for multiple streaming implementations.

Through the component many hundreds of new sensors have been integrated for the FIR, NTUA and TURIN pilots.

6 Report Management & Visualization / Real-time Visualization components

The Report Management & Visualization and Real-time Visualization Components have been described in detail in the Deliverable D6.4 [2]. These two NRG4CAST Components are tasked with visualization of historical and real-time data coming from different sensors and visualization of real time information and forecasts related to NRG4CAST objects, consumption centres, nodes and sensors, metadata, and data related to external features.

During the 3rd year of the project functionalities of the Report Management & Visualization Component and Real-time Visualization Component were refined. The viewer and the reports became more complex. This Chapter describes the development and integration carried out during the last year of the project.

The real time alerting is now available within the Real-Time Visualization GUI (Figure 11). The NRG4CAST alarms were classified as follows:

- technical alerts (broken sensors, no data etc.)
- economic alerts
- environmental alerts
- energy alerts.

Moreover an alarm level concept has been introduced to classify alerts as a notice, warning, or alarm. Each alert is referred to a certain object. All the alerts are geo-referenced and are visualised on the map in real time (Figure 12).

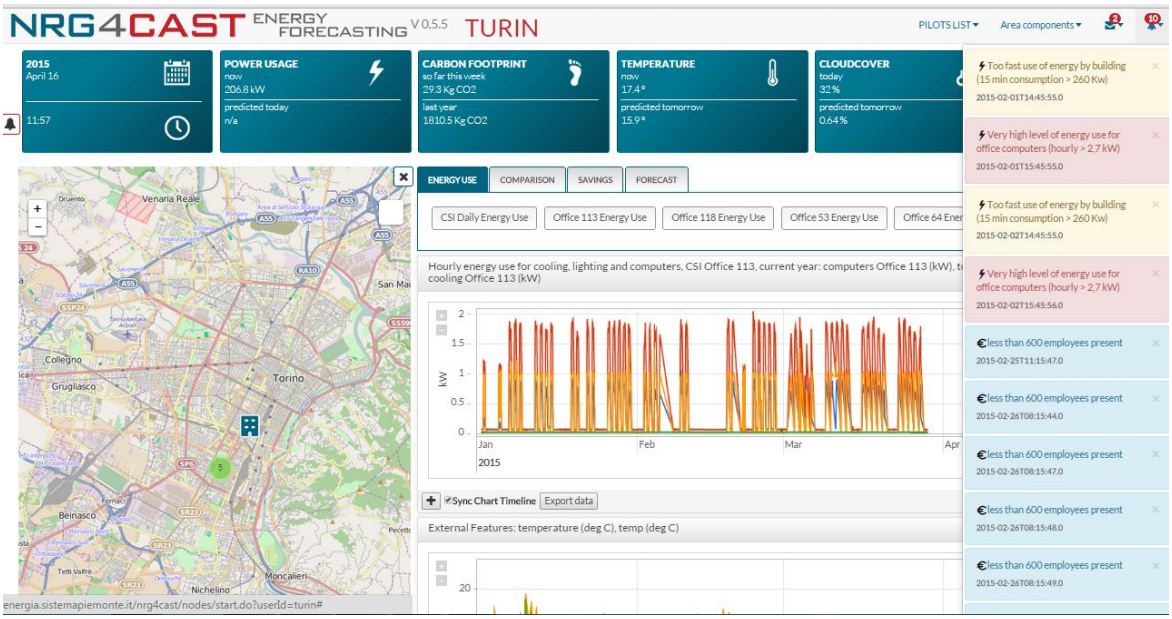

Figure 11. Visualisation of alerts in real time, Turin pilot

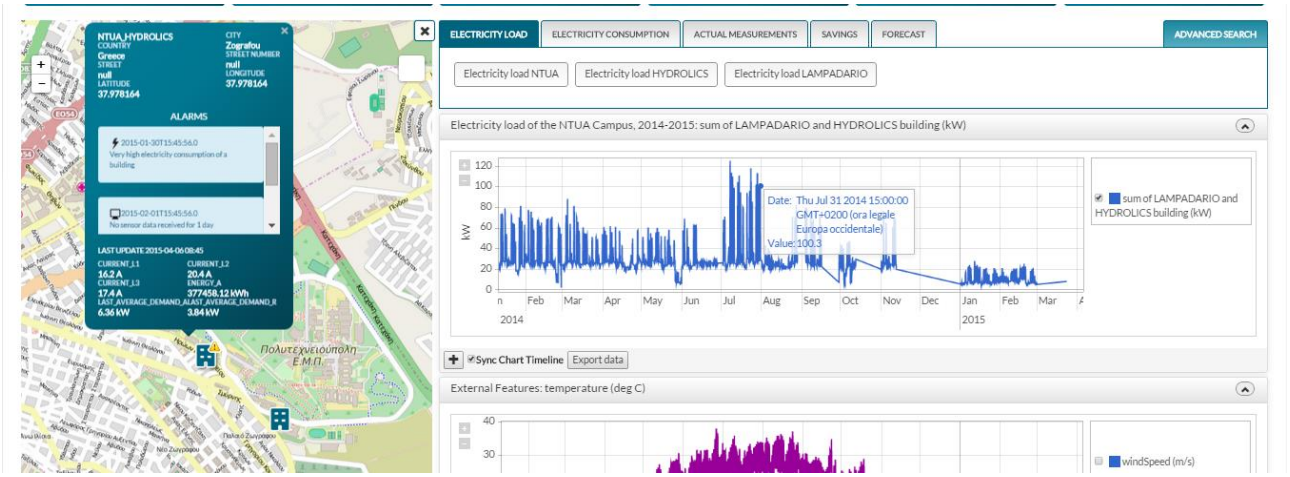

Figure 12. Georeferenced alerts in real time, NTUA pilot example

It is possible to view the system historical alerts within the left corner of the GUI (Figure 13).

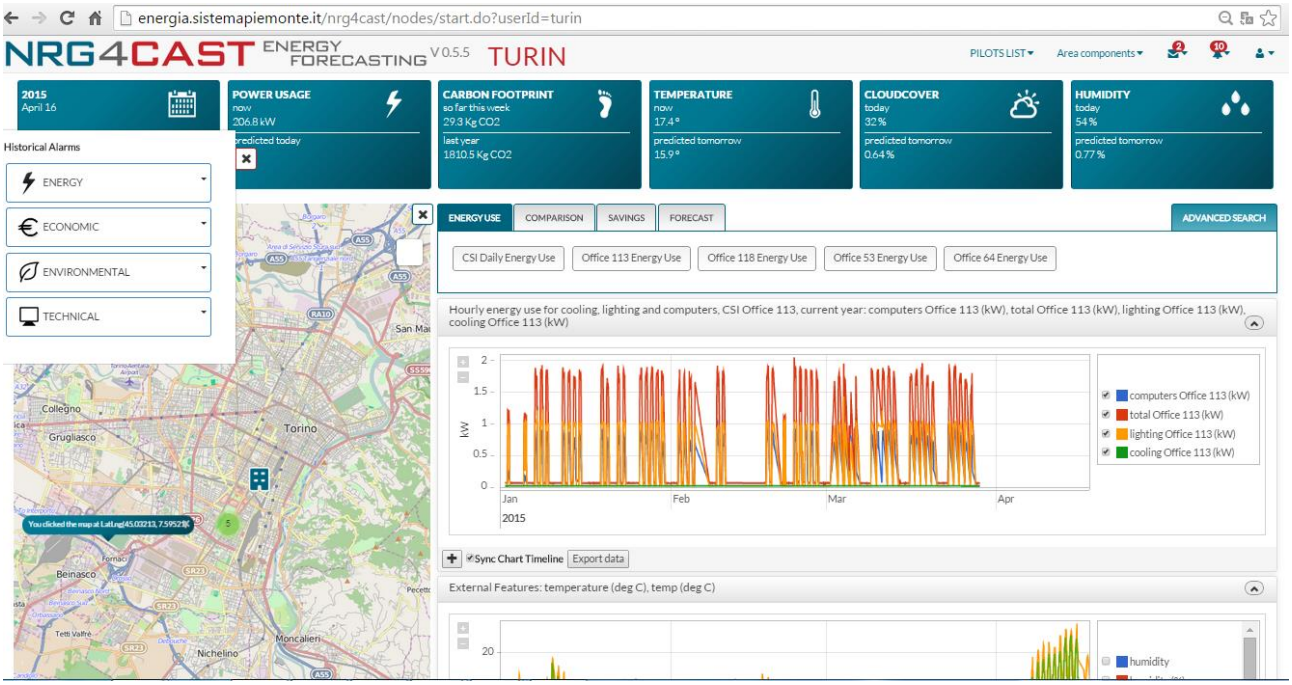

Figure 13. NRG4CAST Toolkit, Turin Pilot, visualisation of historical alerts

Furthermore, the situational awareness GUI has been integrated within the Report Management & Visualization and Real-Time Visualization GUI (please refer to the Chapter 10 for details).

The NRG4CAST Toolkit is now protected by an authentication system (please refer to the Chapter 3 for details). Any access to the Report Management & Visualization and Real time Visualization Components GUI can be made only by authenticated users.

During the 3rd year of the project a significant number of new sensors were integrated within the pilots' context (Figure 14).

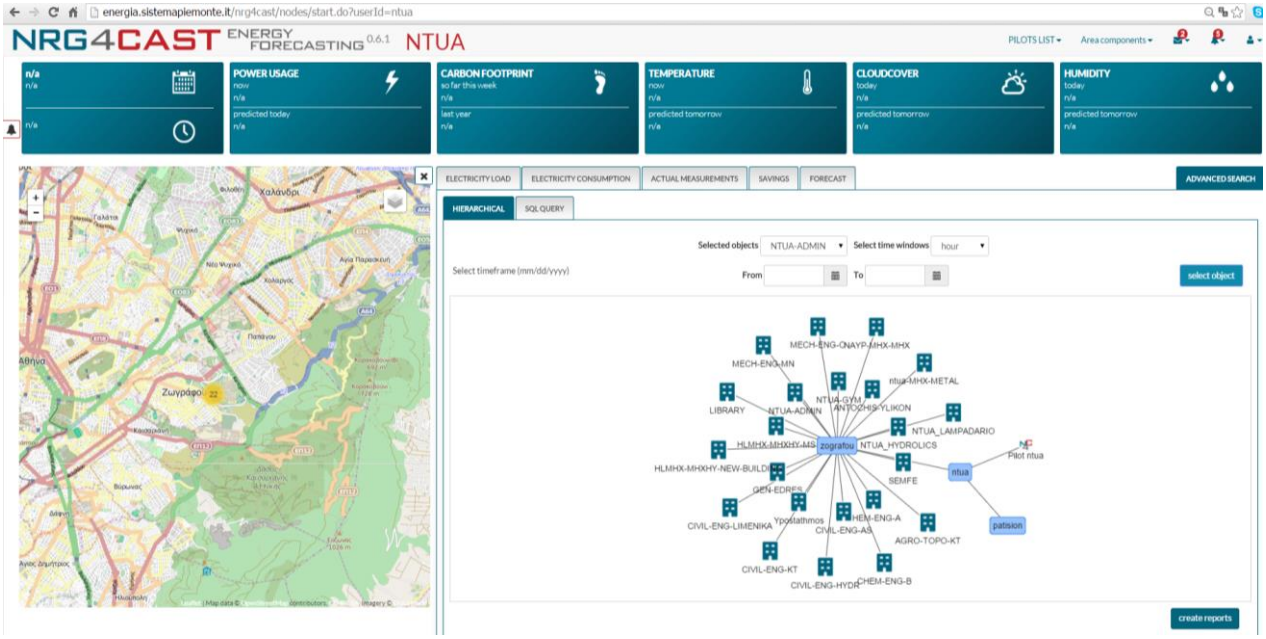

Figure 14. Hierarchical search tool, NTUA pilot example, objects visualisation

Figure 15. Georeferenced objects visualised on the map, NTUA pilot example

Furthermore, an SQL query tool has been added within the Advanced Search tool of the Report Management and Visualization Component (Figure 16). The central data repository integrating all the data residing in the NRG4CAST Toolkit is the Monitoring database. The Monitoring database is queried by the Monitoring component either in the case of pre-defined reports or in the case of the creation of on-the-fly complex SQL queries which can yield very useful results. For example, the total consumption of all the objects in a consumption centre or in a pilot may be calculated and presented on a time series through the appropriate SQL command.

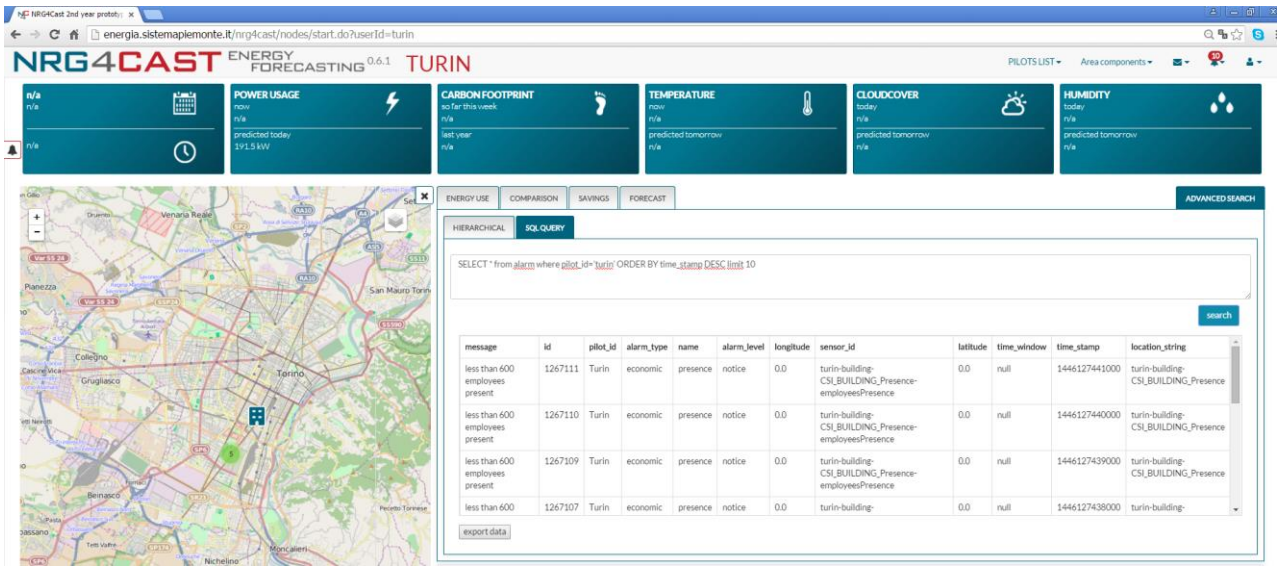

Figure 16. Advanced search SQL query tool, direct connection with the NRG4CAST monitoring database

Moreover, all the pilots were refined during the 3rd year of the project and FIR pilot functionalities were integrated within the NRG4CAST Toolkit.

7 Knowledge Formalization component

The Knowledge Formalization Component has been described in detail in Deliverable D4.4 [3]. The component has been evaluated in the work, reported in Deliverable D5.2 [4]. Evaluation has not shown any promising modelling/prediction results with the extraction of additional modelling features of textual data. The prototypes are running separately and should be used as a basis for further research.

Further research should focus on:

- refining the set of textual data sources
- improving the methods for evaluation of suitability of extracted features for modelling

The process has been coined with the term *nowcasting* and it is still an active research topic, with only partial results, that can be used for production purposes.

8 Prediction Manager

The Prediction Manager has been described in detail in Deliverables D3.1 [5] and D5.2 [4]. Models for all the use cases have been constructed, analysed, and pushed to production. Predictions are being generated in almost real time and are pushed (integrated) into Monitoring database for visualization and further analysis through different components of NRG4CAST GUI.

The work has been driven by the data approach from the beginning. An independent module that is able to process multivariate heterogeneous streaming data has been developed within the project. Results have been evaluated by expert users and the module is already scheduled to be reused by other projects.

9 Knowledge-driven Planning & Optimization component

The Knowledge-driven Planning and Optimization component has been started in Deliverable D4.3 [6] and was rewritten and finished within work reported in Deliverable D5.3 [7]. It represents a novel approach with potential for becoming a valuable tool for energy system analysis. However some pioneering work has been completed within the NRG4CAST project and therefore potential usability value has not yet been reached.

The system is integrated into the platform via a SSO approach and is running as an independent instance for each of the selected use cases.

10 Situational Awareness component

Situational Awareness component has been described in detail in Deliverable D5.4 – Situational Awareness Services [8].

NRG4CAST team has implemented situational awareness services for a number of project pilots and use-case scenarios. This component is based on the user context and provides related information about the environment to be used in the reasoning process. The NRG4CAST Toolkit utilizes general domain knowledge in order to produce explanations with regard to the results of the reasoning process. Further, personalized rules and user input constitute the basis for the NRG4CAST Toolkit situational awareness services.

In particular, the NRG4CAST situational awareness services have been designed on the baseline of the monitoring and alerting services. The situation is assessed by the NRG4CAST Toolkit through the utilization of sensor information about the environment. The assessment process entails the comparison of an individual user context with the environmental sensory information. Sensory data are inputted to the model which interprets them with regard to an individual user context. The future state of the environment is then anticipated by the model.

The situational awareness services are built on top of the monitoring and alerting services and are closely connected to basic real-time decision support and reasoning environment of the project. The situational awareness GUI allows for anomaly awareness, shows “monetary” savings, and highlights high energy consumption and anomalously high temperatures. It is possible to analyse the energy consumption of an overall complex consumption centre, such as an University Campus, a city, and a municipality area. The situational awareness GUI has been integrated within the Report Management & Visualization and Real-time Visualization Components GUI.

11 NRG4CAST Final Integrated Prototype Pilot Contexts

11.1 Miren pilot

We tested the NRG4CAST components with street classification features. Depending of the circulation of the vehicles on the selected street, we try to calculate the impact of the dynamic road classification. The information about the street classification would be sent back to street light backend every 15 minutes, if changes occur. System reacts automatically every 15 minutes with the intervention on the dimming profile of the desired light or group of lights. Today street light systems don't have such automatic control and it is not possible to control if street lights all of the time reach the regulations values.

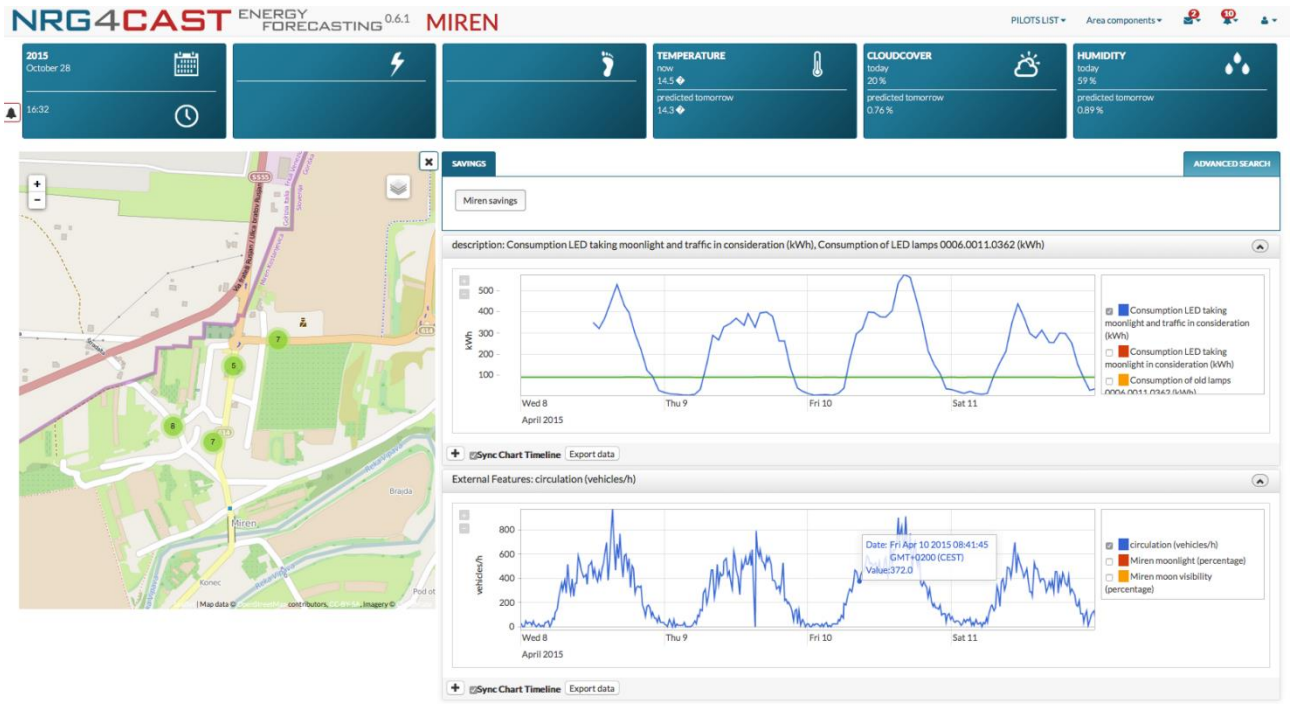

Figure 17. NRG4CAST web front-end – Miren case, showing the realtime consumption and comparable to real time traffic

We use the same data from the street lights as in the 1st prototype, which are the following:

- ELCN Report No
- ELCN Report Summa Value
- ELCN Report Average Value, total / samples
- ELCN Samples Since Last Report,
- ELCN Max Value, The max reading value during the measurement period
- ELCN Min Value, The min reading value during the measurement period
- ELCN Dim Level Ch1, DIm level for Ch1 (only ch1 used at the moment)
- ELCN Dim Level Ch2, not used
- ELCN Calculated Consumption
- HopCounter,
- SequenceNo,
- Measured Consumption

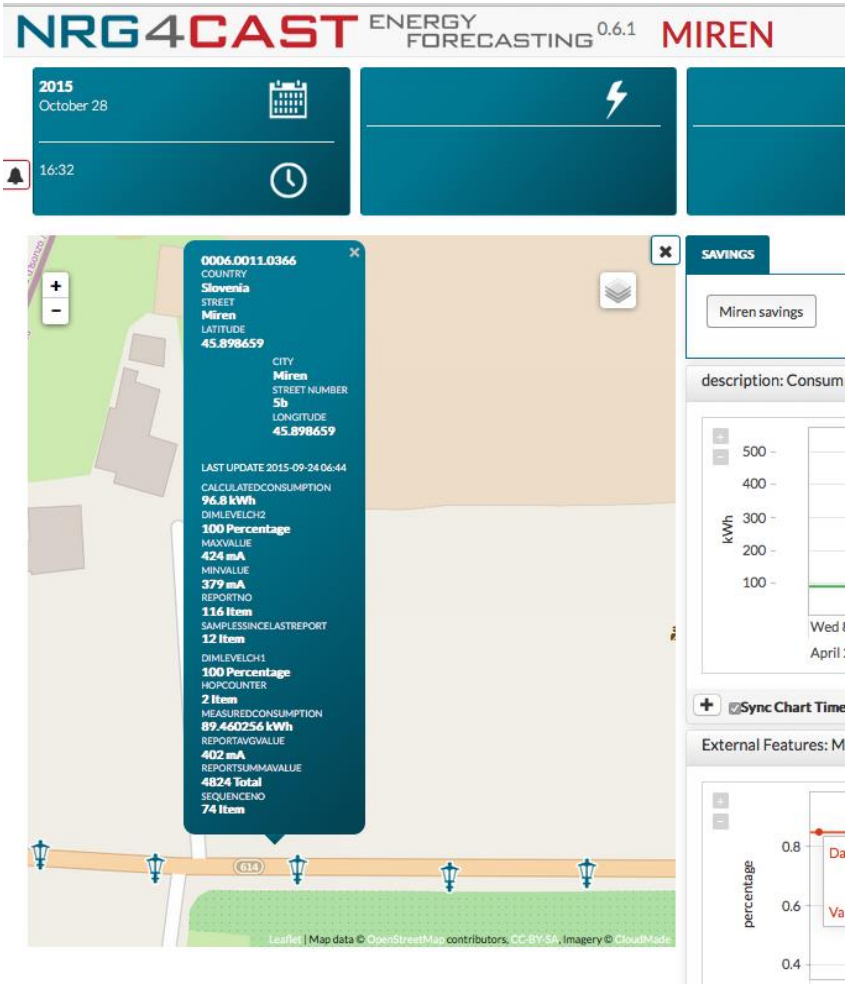

Figure 18. NRG4CAST web front-end – Miren case, showing the last data from the street light sensors

We add additional data:

- traffic circulation, which is calculated every 15 minutes from the traffic sensor
- weather forecast from the external source
- moon phase depending on the geographical data

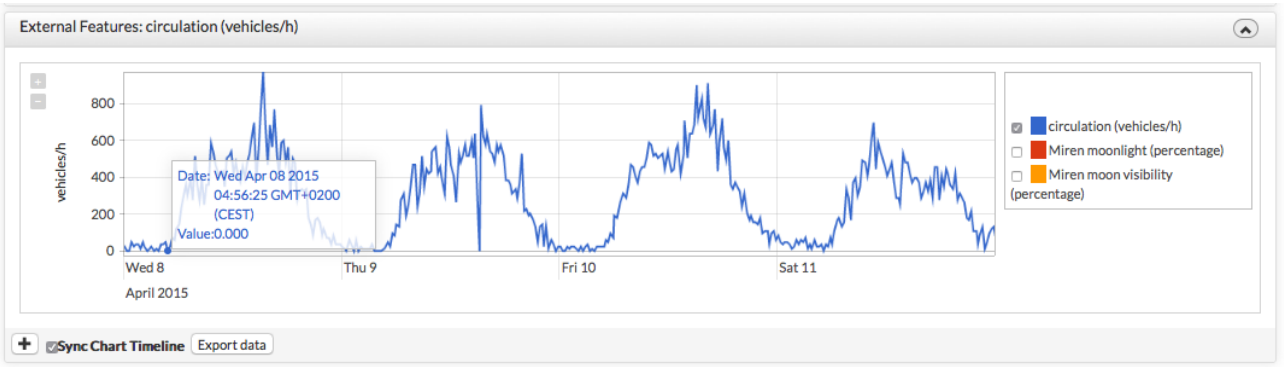

Figure 19. NRG4CAST web front-end – Miren case, showing the real time data for vehicles circulation on the selected street

We found out that with the implementation of the dynamic road classification we could achieve additional saving up to 10% and we can guarantee to the customer that the luminance of the street satisfies the street classification regulations.

11.2 FIR Pilot

As stated in chapter 11.2 in Deliverable 6.4 [2], the FIR pilot focuses on the prediction of energy demand of electric vehicles. By doing so, there are two main use cases. On the one side, the energy demand prediction can be used by grid providers to identify peak loads and therefore prevent grid failure and damage. This prognosis helps to reduce the maintenance costs. On the other side, the information can be used by charging station providers to choose profitable location to set up a charging station. Due to the low amount of electric vehicles on the street, this information gets more important since the return of an investment in a charging station can easily exceed the charging station costs if it is located in a pool location.

Further details are explained in Deliverable 6.4 [2], chapter 11.2.

11.3 NTUA pilot

NTUA installed the following meters for electrical energy consumption measurements as well as for the thermal comfort conditions:

- 33 electricity meters SIEMENS SENTRON PAC3200, PAC3100
- 16 electricity meters Schneider Electric PM3250
- 4 temperature sensors & relative humidity sensors: Siemens Q-Series Outdoor Air Relative Humidity and Relative Humidity & Temperature Sensors QFA3171D
- 4 lux meters ALRE brightness sensor AHS/O-10

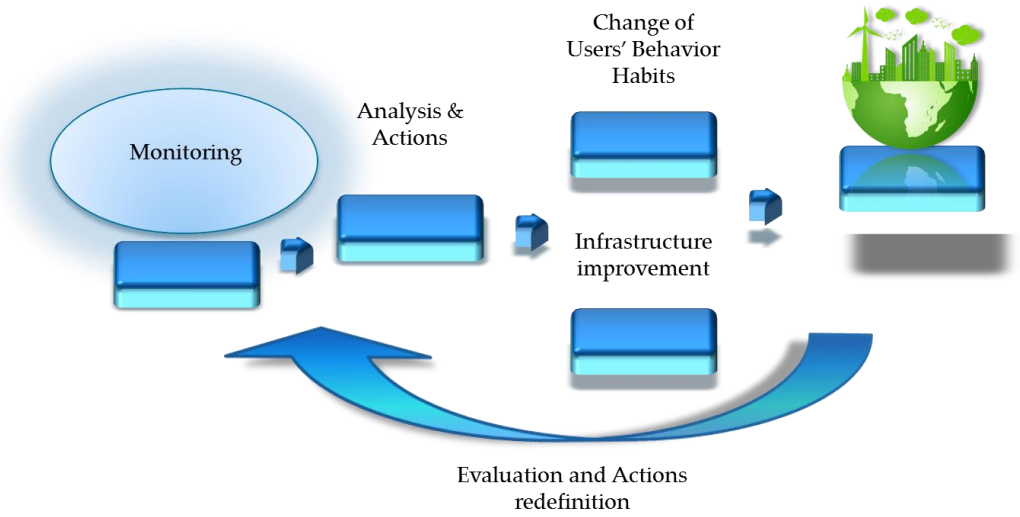

Figure 20. NTUA Pilot's scope

The overall scope of this pilot was not only the campus monitoring but also the change of user behavior habits, the energy savings actions redefinition and evaluation as well as the development of Energy Performance Certificates, the conduction of Energy Service Contracts and finally the change of load profile by using different tariffs affecting the demand response of NTUA campus.

Energy Saving Senate Committee of NTUA was responsible for the submission of several national proposals for energy saving measures applied to NTUA campus buildings. The Energy Efficiency Certificates of Campus buildings were necessary to be conducted for the submission of these proposals. NRG4CAST Toolkit reduces the time and costs of Energy Performance Certificates.

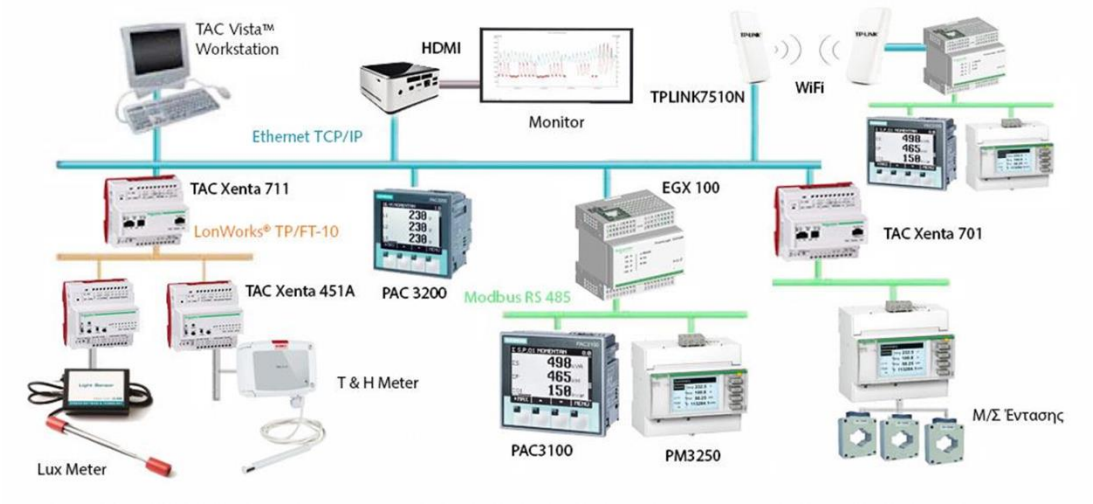

Figure 21. NTUA Pilot's systems' topology

Several energy efficiency improvements as well as actions have been decided by the facilities management after the overall installation and the analysis of the individual energy consumptions for lighting and HVAC systems through the NRG4CAST Toolkit.

The aforementioned actions being decided and taken place are the following:

Scenario 1: Lighting Schedule according to daylighting

This action took place for a week in two Lecture Room Buildings of approximately 2000 m^2 each. It included the management of lighting schedule so as lecture rooms lighting to be turned off when daylighting and use allow. Students and faculty staff were encouraged to turn off lights when exiting unoccupied rooms.

This action was decided due to High Daily Lighting Consumption according to the relative meter installed for the metering of lighting consumption as well as the lighting load prediction through the NRG4CAST Toolkit.

The yearly energy savings estimation for the whole Campus is 1052 MWh, thus approximately 85000 Euros/year.

Scenario 2: Energy Savings Campaign – Turn off Computers and printers

This action took place for two weeks in the Campus Administration Building of approximately 2500 m^2. It included the shutting down of all computers and printers after the work hours.

This action was decided due to High Level Base Load according to the relative meters.

The yearly energy savings estimation for the whole Campus is from 350 to 800 MWh/year, thus approximately from 20000 to 48000 Euros/year.

Scenario 3: Changing schedule of Lecture Rooms

This action took place for a week in the Lecture Rooms of two buildings of approximately 4000 m^2. It included the changing schedule of lecture rooms.

This action was decided due to High Daily Energy Consumption according to the relative meters.

The yearly energy savings estimation for the whole Campus is approximately from 570 to 1800 MWh/year, from 34300 to 105000 Euros/year.

Scenario 4: Night Cooling

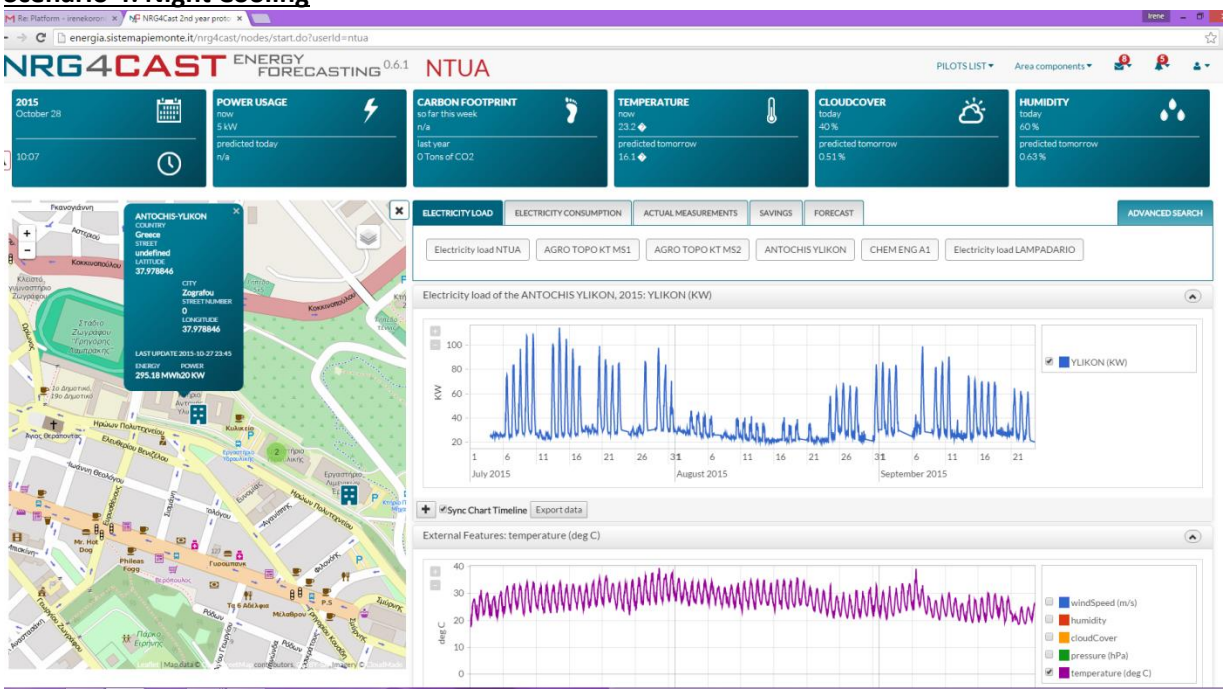

Figure 22. NRG4CAST web fron-end - NTUA Pilot, showing the demand from Antochis Ylikon Building during summer

This action took place for a week in the Laboratory Building N of Mechanical Engineers of approximately 5000 m^3. It included the night ventilation during the last week of July.

The yearly energy savings estimation for the whole Campus is approximately from 600-1000 MWh/year, 37000-60000 Euros/year.

Table 1. The list of predefined reports for the Final Prototype

- WHEN TO REPORT: daily, weekly, monthly and yearly basis
- WHAT TO REPORT:
    - electricity load (kW) of Schools (i.e. School of Mechanical Engineering)
    - electricity consumption (kWh, kWh/m2) of the whole Campus
    - electricity consumption (kWh, kWh/m2) of Schools (i.e. School of Mechanical Engineering)
    - electricity consumption (kWh, kWh/m2) of each Building separately.
    - lighting consumption (kWh, kWh/m2) of a building.
    - HVAC energy load (kW, kW/m2) of a building.
    - thermal comfort level of the office: The Dry bulb temperature C, Relative Humidity% and Illuminance lux.

- HOW TO REPORT:
    - BUILT-IN REPORTS: on a monthly basis. It includes the electricity consumption and demand of the whole Campus (kWh/month, kW/month) and each School (kWh/month, kW/month) separately. It shows top-5 Schools energy consumers (kWh/m2) of the month.
        - Correlation weather and consumption (data on weather: Athens: OWM and WWO stations (Athens)). GRAPHS SHOWING: Weather - Current thermal comfort in a psychrometric diagram
        - Correlation occupancy and consumption (data on occupancy: not specified yet.
        - Last measure visualization. GRAPHS SHOWING: Current thermal comfort in a psychrometric diagram
        - Available predictions, time window for predictions: weather forecast, data sources. WHEN TO PREDICT: daily basis. WHAT TO PREDICT: Electricity consumption (kWh, kWh/m2) of Schools (i.e. School of Mechanical Engineering), lighting consumption (kWh, kWh/m2) of a building, HVAC energy load (kW, kW/m2) of a building. HOW TO PREDICT: The platform produces energy forecasting reports for each School and lighting and HVAC energy forecasting reports of a building.

11.4 Turin Pilot

The main goal of Turin Pilot is a reduction of energy consumption in the CSI Headquarters and energy consumption monitoring and savings planning within the 32 public owned buildings in Turin, Italy.

During the 3rd year of the project all the predefined reports for the Turin pilot were implemented. There is a possibility to compare energy consumption and energy costs, to monitor and predict energy savings (Figure 23). The function to calculate Carbon footprint for the CSI building and the whole Turin pilot has been implemented within the Report Management & Visualization and Real-time Visualization GUI configuration system.

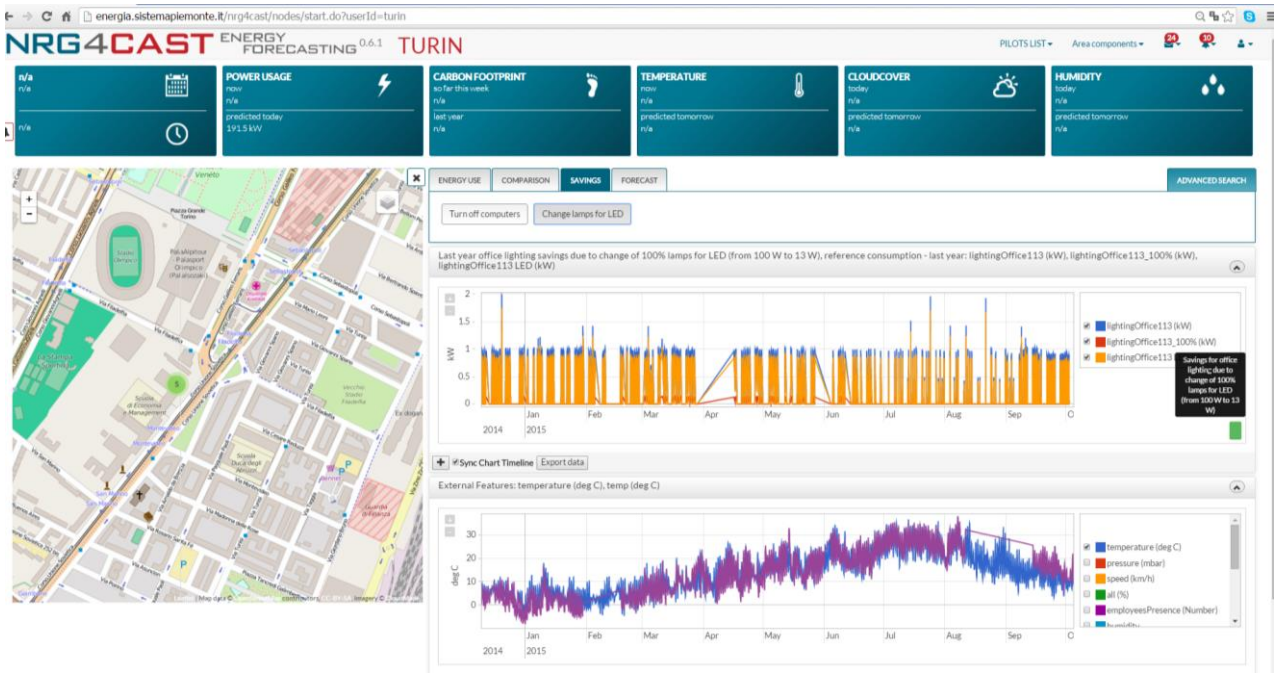

Figure 23. A set of savings reports, Turin pilot, NRG4CAST Toolkit

The data on electrical and thermal energy consumption for the 32 public owned buildings has been classified and integrated within the NRG4CAST Toolkit.

The data on electrical and thermal energy consumption for the 32 public owned buildings has been classified and integrated within the NRG4CAST Toolkit.

Table 2. Relation db connections, integration of district heating data, data on electrical consumption and 3D Energy Cadastre, Turin pilot, the 32 public owned buildings

POD	Supply	Contract	host ID	street		KEY	Building ID	descr	HOST
IT020E00155122	1050062736	21063629	11195,00	PALMIERI	58	VIA PALMIERI 58	78274	Elementary school Alfieri	BCT_440_SST_026_IP_22.6_VOL_34750_IND_PALMIERI_58
IT020E00006359	1050062243	21063161	10663,00	COLOMBO	36	COLOMBO 36	65709	Elementary school Coppino	BCT_406_SST_148_IP_129.16_VOL_25280_IND_COLOMBO_36
IT020E00357994	1050060632	21061613	10591,00	DUCA DEGLI ABRUZZI	50	CORSO DUCA DEGLI ABRUZZI 50	65366	Maternity school	BCT_414_SST_027_IP_129.167_VOL_5900_IND_DUCA_DEGLI_ABRUZZI_50
IT020E00447711	1050053949	21054639	11894,00	FERRUCCI	122	CORSO FERRUCCI 122	79120	Offices	BCT_420_SST_006_IP_17.94_VOL_12575_IND_FERRUCCI_122
IT020E00146782	1050061455	21062414	10524,00	FRANCIA	285	CORSO FRANCIA 285	80395	Professional school	BCT_447_SST_010_IP_31.196_VOL_4400_IND_FRANCIA_285
IT020E00657082	1050061280	21062240	12370,00	GALILEO FERRARIS	288	CORSO GALILEO FERRARIS 288	2744	Swimming pool	BCT_063_SST_502_IP_29.50_VOL_3500_IND_GALILEO_FERRARIS_288
IT020E00110199	1050061457	21062417	14338,00	ORBASSANO	224	CORSO ORBASSANO 224	52998	Maternity school	BCT_055_SST_028_IP_28.99_VOL_5230_IND_ORBASSANO_224_26
IT020E00140975	1050062080	21063009	10977,00	PESCHIERA	193	CORSO PESCHIERA 193	73407	Offices	BCT_426_SST_014_IP_30.34_VOL_30000_IND_PESCHIERA_193
IT020E00246315	1050060696	21061682	10859,00	PESCHIERA	380	CORSO PESCHIERA 380	80393	Elementary school	BCT_447_SST_124_IP_30.221_VOL_20430_IND_PESCHIERA_380
IT020E00137151	1050062117	21063044	10741,00	DE ALBERTIS	22	CORSO D'ALBERTIS LUIGI 22	79732	Elementary school	BCT_430_SST_005_IP_16.150_VOL_11632_IND_DE_ALBERTIS_22
IT020E00234002	1050060666	21061651	10825,00	BARDONECCHIA	34	VIA BARDONECCHIA 34	75530	Maternity school	BCT_443_SST_033_IP_30.194_VOL_33580_IND_BARDONECCHIA_34
IT020E00134122	1050061382	21062344	10688,00	BERTA	15	VIA BERTA 15	78271	Maternity school	BCT_420_SST_005_IP_129.179_VOL_14470_IND_BERTA_15
IT020E00698248	1050341455	21363508	10450,00	BOSTON	22	VIA BOSTON 22	53861	not found	BCT_033_SST_191_IP_21.143_VOL_3557_IND_BOSTON_22_int._7
IT020E00670991	1050063220	21064089	10198,00	BRACCINI	4	VIA BRACCINI 4	466	Municipality Gym	BCT_420_SST_014_IP_31.91_VOL_8000_IND_BRACCINI_4
IT020E00133789	1050061601	21062566	10140,00	BRACCINI	63	VIA BRACCINI 63	78466	Maternity school	BCT_421_SST_316_IP_28.80_VOL_4480_IND_BRACCINI_63
IT020E00132607	1050062219	21063137	10342,00	BRACCINI	70	VIA BRACCINI 70	79517	Elementary school	BCT_421_SST_018_IP_31.150_VOL_34210_IND_BRACCINI_70
IT020E00133788	1050062155	21063076	10414,00	BRACCINI	75	VIA BRACCINI 75	78467	Maternity school	BCT_421_SST_016_IP_31.165_VOL_12200_IND_BRACCINI_75
IT020E00006545	1050061216	21062173	10111,00	DEGO	6	VIA DEGO 6	23273	Offices	BCT_414_SST_026_IP_31.138_VOL_2957_IND_DEGO_6
IT020E00139535	1050061052	21062009	10804,00	DELLEANI	25	VIA DELLEANI 25	72067	Maternity school	BCT_429_SST_005_IP_21.12_VOL_15000_IND_DELLEANI_25
IT020E00147245	1050062998	21063878	10882,00	FATTORI	113	VIA FATTORI 113	76178	Maternity school	BCT_432_SST_024_IP_30.176_VOL_3350_IND_FATTORI_113
IT020E00231350	1050060787	21061758	10835,00	FREJUS	21	VIA FREJUS 21	76437	not found	BCT_442_SST_014_IP_30.160_VOL_17953_IND_FREJUS_21
IT020E00275708	1050053086	21053736	10973,00	HUGUES	10	VIA HUGUES 10	not found	Gym	BCT_431_SST_002_IP_30.90_VOL_7316_IND_HUGUES_10
IT020E00137895	1050062349	21063255	10179,00	LANCIA	140	VIA LANCIA 140	79622	School	BCT_433_SST_004_IP_129.49_VOL_15115_IND_LANCIA_140__SCUOLA_MEDIA_
IT020E00130758	1050060655	21061640	10885,00	LUSERNA DI RORA	14	VIA LUSERNA DI RORA 14	76318	Elementary school	BCT_442_SST_016_IP_30.146_VOL_19260_IND_LUSERNA_DI_RORA__14
IT020E00146450	1050062350	21063256	10846,00	MARSIGLI	25	VIA MARSIGLI 25	80544	School	BCT_432_SST_026_IP_30.218_VOL_17200_IND_MARSIGLI_25
IT020E00444160	1050060539	21061529	12380,00	MILLIO	20	VIA MILLIO 20	6026	Offices	BCT_421_SST_317_IP_25.182_VOL_5600_IND_MILLIO_20
IT020E00452545	1050061632	21062595	10897,00	MONTE ORTIGARA	95	VIA MONTE ORTIGARA 95	79749	Offices	BCT_432_SST_027_IP_30.31_VOL_10200_IND_MONTE_ORTIGARA_95
IT020E00146842	1050060663	21061648	10839,00	POZZO STRADA	12	VIA POZZO STRADA 12	72644	Maternity school	BCT_447_SST_125_IP_30.244_VOL_8200_IND_POZZO_STRADA_12_INT_001
IT020E00679241	1050075922	21076641	10910,00	ROSSELLI	105	VIA ROSSELLI 105	73060	not found	BCT_422_SST_028_IP_30.139_VOL_5608_IND_ROSSELLI_105_INT_007
IT020E00263797	1050062211	21063130	10883,00	STELVIO	45	VIA STELVIO 45	1537	Maternity school	BCT_432_SST_030_IP_30.185_VOL_3050_IND_STELVIO_45
IT020E00139532	1050062373	21063279	10440,00	TOFANE	22	VIA TOFANE 22	79606	School	BCT_429_SST_007_IP_21.56_VOL_34400_IND_TOFANE_22
IT020E00139534	1050061995	21062924	10814,00	TOFANE	28	VIA TOFANE 28	79683	Elementary school	BCT_429_SST_056_IP_21.37_VOL_17600_IND_TOFANE_28
IT020E00134649	1050062359	21063265	10494,00	TOLMINO	30	VIA TOLMINO 30	77546	Maternity school	BCT_424_SST_008_IP_129.148_VOL_3827_IND_TOLMINO_30
IT020E00134650	1050062324	21063232	10759,00	TOLMINO	40	VIA TOLMINO 40	77538	School	BCT_424_SST_009_IP_20.114_VOL_17200_IND_TOLMINO_40

The metadata, field descriptions and an example of data on energy consumption available for the 32 public building in Turin is shown below:

Table 3. Fields description and the metadata, electrical consumptions IREN db

POD	The **POD** is an alphanumeric code that uniquely identifies the point of withdrawal of electricity from the national grid.
INIZIO	Starting date of the period of interest (please consider only periods starting from the 1st day of the month, eg 1st August 2011)
FINE	End date of the period of interest (please consider only periods ending on the last day of the month, eg 31st August 2011)
Q.TA'	Active Energy consumption in the period (in kWh)
GRANDEZZA	Use the field ENERGIA ATTIVA only
TIPO CONSUMO	CERTO – Actual Consuption STIMATO – Estimated Consumption
DATA GRANULARITY	15 minutes
How often data is updated	Energy consumptions concerning the Turin Pilot will be collected in a .csv file and uploaded once a month on a url address (not FTP) to be communicated to the consortium as soon as possible.

Furthermore, we provide an example of the relation between database on electrical energy consumption provided by partner IREN, database on district heating zabbix_db provided by IREN partner and 3D Energy Cadastre provided by CSI partner respectively for a Coppino school, Colombo str. 36.

Table 4. Relationship between the district heating database, electricity consumption database and 3d energy cadastre, Coppino school, Colombo str 36.

Field name	Value
POD	T020E00006359 (The **POD** is an alphanumeric code that uniquely identifies the point of withdrawal of electricity from the national grid)
Address	Via Colombo 36
ID Edifici	65709
Descrizione	scuola elementare Coppino + alloggio custode
HOST	BCT_406_SST_148_IP_129.16_VOL_25280_IND_COLOMBO_36
IP	46233129167
HOST ID	10663
Q.TA’	Active Energy consumption in the period (in kWh)
INIZIO	Start date of the period of interest (please consider only periods starting from the 1st day of the month, eg 1st August 2011)
FINE	End date of the period of interest (please consider only periods ending on the last day of the month, eg 31st August 2011)
GRANDEZZA	Use the field ENERGIA ATTIVA only
Consumption type	CERTO – Actual Consumption STIMATO – Estimated Consumption

The detailed monitoring and prediction provided by NRG4CAST Toolkit acts as the base for decision making on energy efficiency actions in the case of Turin pilot such as replacement of obsolete working stations with portable new generation computers in 2013 and Awareness Campaign in 2014.

The specific actions taken are the following:

- Involvement of employees
- additional focus on personal benefits
- informing employees on scientific / technical issues of energy saving and energy efficiency
- encouragement towards concrete action,

- maintaining Best practices and habits in time,
- accurate monitoring and alerting possibilities,
- monitoring of energy consumption in real time for a number of appliances
- prediction of energy demand lead to significant reduction of energy consumption

These actions led to the improvement of the CSI Headquarters energy performance by 27 percent.

11.5 Iren Pilot

NRG4CAST tool, tested through pilot NUBI and pilot Reggio Emilia (see Deliverable D6.4 for use-cases description, etc. [2]), was implemented basing on data resulting from information computed by an algorithm, that includes both data directly collected by sensors and other devices and inferred data, as described in the following.

It's important to notice that, not requiring further hardware components to be installed, the computational model developed for consumption prediction will allow a reduction in equipment costs, representing, thus, a strength from a market perspective.

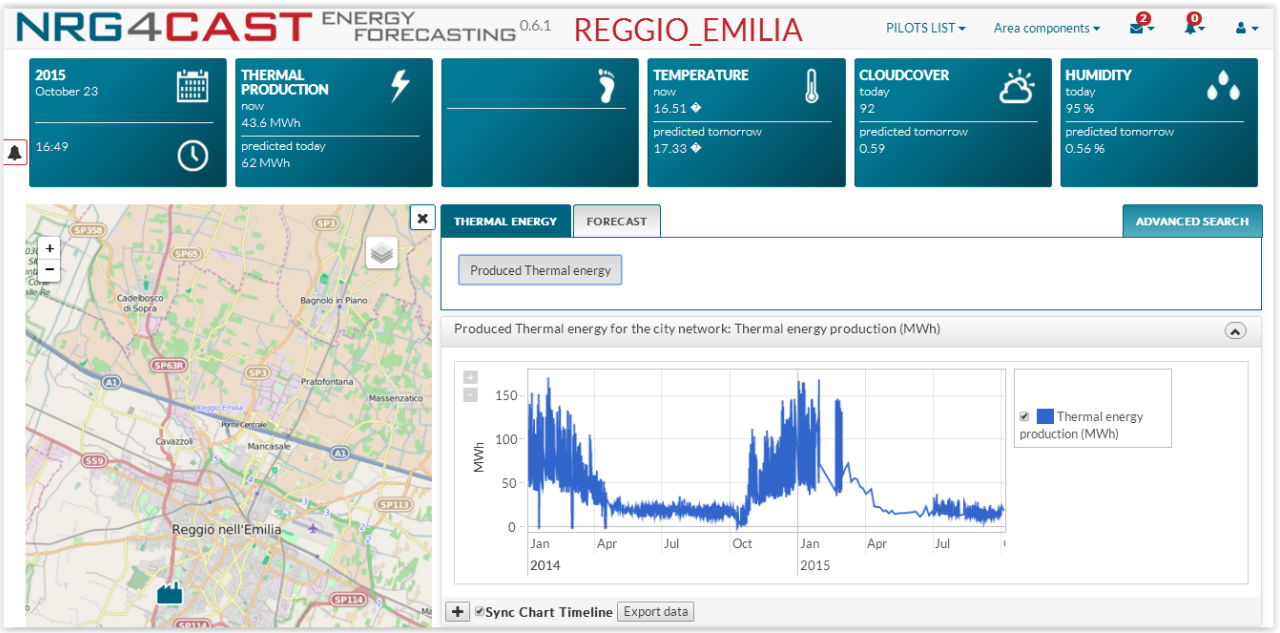

Figure 24. NRG4CAST web tool - Reggio Emilia Pilot, showing the Thermal Energy Production calculated using the prediction model

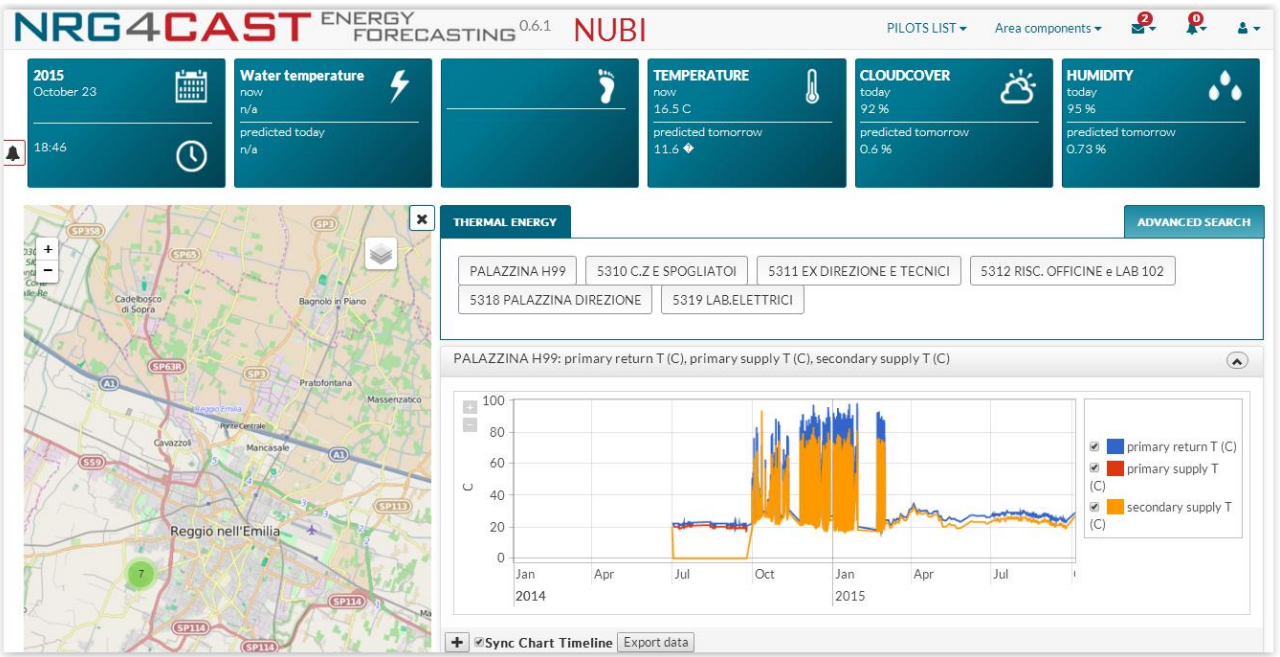

Figure 25. NRG4CAST web tool – Campus NUBI Pilot, showing the Water Temperature calculated using the prediction model

The energy consumption prediction model in the case of Campus Nubi pilot is described by Formula (1).

$$P = V * (T2-T1) * c \quad (1)$$

where

P= Heating energy consumption (W);

V= Building volume (m^3)

(T2-T1)= indoor - outdoor temperature difference (C°)

c= Energy rate coefficient (set to 38 – but further researchers on the coefficient are required. See Deliverable D5.2 [4])

The heating energy consumption which is predicted through the previous formula is used as an input for the prediction of the **Thermal Comfort Standard.** This standard is defined as the water temperature that needs to be supplied to the Campus Nubi building in order to keep a constant indoor temperature, as illustrated in Figure 26.

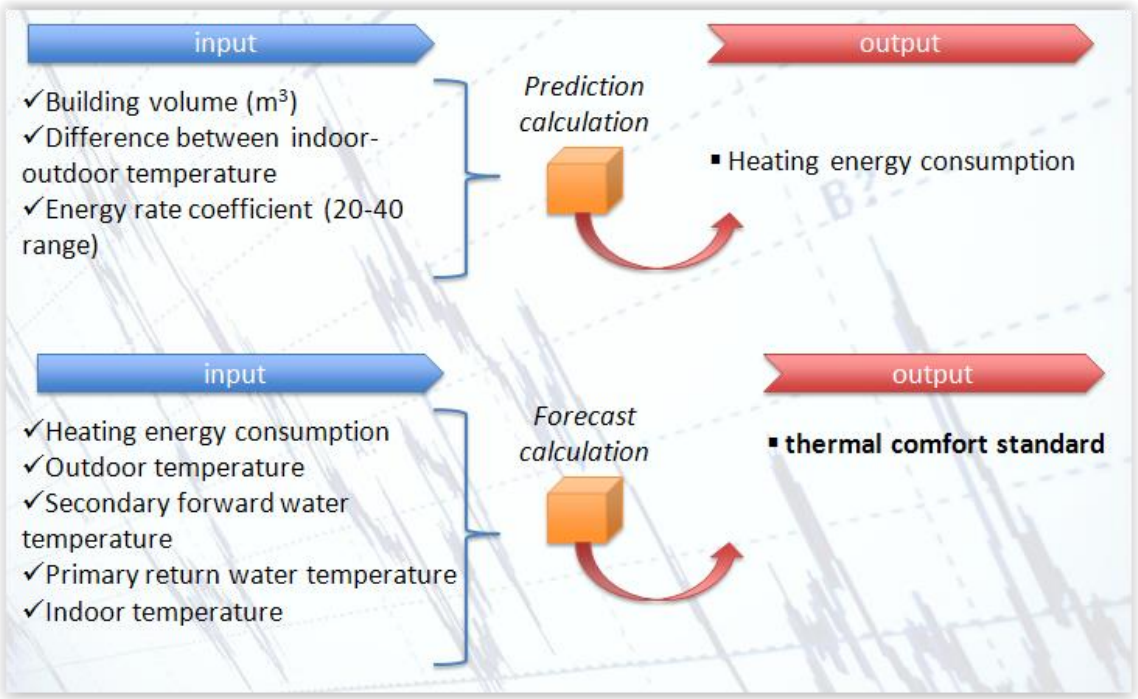

Figure 26. Prediction and forecast conceptual model

Summing up, the data implemented in the forecasting model for both Iren pilots are shown in the tables below.

Table 5. A-B Available data for the forecasting model

Reggio Emilia pilot
Data of DH production (historical)
Current data of DH production (current)
Outdoor temperature (historical)
Outdoor temperature (current)
Cloudcover
Humidity

Campus Nubi pilot
Outdoor temperature (historical)
Outdoor temperature (current)
Indoor temperature (historical)
Indoor temperature (current)
Primary return water temperature
Primary supply water temperature
Secondary supply water temperature
Alerts from each substation (e.g. on a broken sensor or a wrong water temperature), including timestamp + type of alarm (ID)
Building volume
Cloudcover
Humidity
Current energy consumption (inferred)

11.6 Virtual Integrated Pilot

The NRG4CAST Toolkit has been enhanced with the ability to define a virtual pilot in order to support the integrated city scenario. Specifically, the Sensor Registry & Consumption Centre configuration component provides a UI for the combination of objects, nodes and sensors into virtual consumption centres (Figure 27).

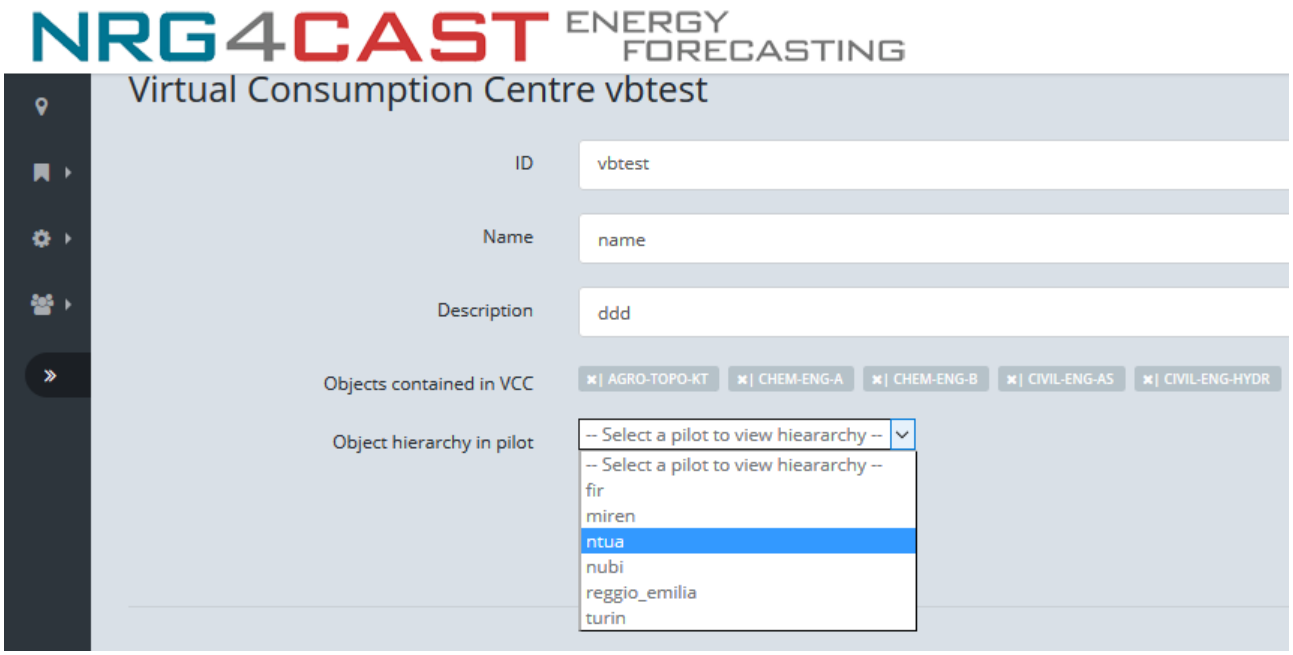

Figure 27. Virtual consumption centre configuration

Due to constraints of the NRG4CAST project, a predefined set of NRG4CAST objects containing a set of sensors has been selected. Then a virtual data stream is simulated through the creation of a virtual sensor which contains calculated average consumption in the set of the sensors. It's possible to calculate average consumption since aggregated sensor data in the Monitoring database are time aligned with known units of measurements.

The virtual consumption centre contains only the virtual sensors which is then streamed as a normal data source to the Analytical Platform in order to calculate predictions. Then the Real-time monitoring / Report Management components present forecasts with regard to the total consumption in the integrated city scenario.

12 Conclusions

The previous sections have presented in detail the work that has been performed with regard to the integration of all the software components into the Final Integrated NRG4CAST Toolkit and its final rollout.

The main results of this deliverable are the following:

1. The enhancement of the functionality of previously developed software components in accordance with the requirements of the different pilot scenarios.
2. The integration of new components: User & Role Management / Situational Awareness / Knowledge Formalization / Knowledge-driven planning & Optimization into the Final Integrated NRG4CAST Toolkit.
3. The design and implementation of a Single Sign On / Role-based Access Control mechanism and its integration into the NRG4CAST software components in order to achieve seamless authentication and authorization of the users.
4. The update and refinement of pilot scenarios specification.
5. The implementation of the virtual consumption centre configuration functionality in order to support the integrated city scenario which combines energy consumption data from sensors belonging to different isolated pilots.

The results of the validation and testing of the Final Integrated NRG4CAST Toolkit are going to be reported in Deliverable D7.5: Validation of final rollout which is going to be delivered on Month 36 of the project.

References

[1]. K. Kenda et. al., *NRG4CAST Deliverable D5.1, Decision Support System and Reasoning Framework*, November 2014.
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