Design and implementation of a Web-GIS monitoring platform for zero energy settlements and districts

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Web-GIS Platform for Monitoring of ZERO PLUS

Design and Construction of 4 Zero Energy Settlements

OBJECTIVES

- Regulated energy consumption up to 20kWh/m²/year
- Renewable energy production at settlement level of at least 50kWh/m²/year
- Investment cost reduced by at least 16% compared to current costs for single NZEBs
Web-GIS Platform for Monitoring of ZERO PLUS

Design and Construction of 4 Zero Energy Settlements

York, UK
3 houses
- PV panels
- HIVE smart thermostat
- TESLA battery

Voreppe, France
Apartment building
- DUALSUN solar panels, thermal and photovoltaic
- ANERDGY MRE C05
- Heat exchanger of the biomass urban heating network

Granarolo dell’ Emilia
2 villas
- Fibran insulation
- PV panels
- ABB React+

Nicosia, Cyprus
Prefabricated demo house
- Fibran insulation
- HVAC FREESCOO
- FAE HCPV
A Web-GIS platform has been created in order to:

- To **support effective monitoring** of the case studies and **collect all energy and environmental data** regarding the performance of the four settlements.

- To **assess the performance** of the involved systems and technologies and also the global energy and environmental performance of the settlements.

- To **implement an optimised maintenance methodology** for all systems and techniques in order to achieve the best possible performance and cost effective operation.

- To **analyse** in depth the results of the monitoring and generate proper technical information for future feasibility analyses and design.
Web-GIS Platform for Monitoring of ZERO PLUS

OVERALL PLATFORM LAYOUT
The Web-GIS platform is organized in 4 levels:

- **Level 4:** The Web-GIS Dashboard
- **Level 3:** Energy Production Technologies
- **Level 2:** Energy demand profiles for buildings and districts
- **Level 1:** Indoor Environmental Quality of Users
Intelligent models have been created that support fault diagnosis and maintenance:

**MODELS FOR LEVEL 1 INDOOR AIR QUALITY**

- Real-time synchronisation of all indoor environmental quality indices
- Extraction of PMV and PPD
- Setting the indoor comfort set-points and requirements
- Fault detection of the various sensors: Definition of acceptable range of measurements

**MODELS FOR LEVELS 2 AND 3 DEMAND AND PRODUCTION OF SETTLEMENTS**

- Statistical and probabilistic analysis of energy demand and energy production profiles
- Prediction of energy demand and production 24 hours ahead: ANN
- Linking of the energy demand and production profiles with specific subsystems to support maintenance: Error calculation for predicted and actual energy from the various RES.
- Fault detection of the subsystems: Definition of acceptable range of measurements

**MODELS FOR LEVEL 4 THE Web-GIS PLATFORM AND DASHBOARD**

- Supervisor models to manage the most complex functionalities, such as user interface, database components’ interactions
Web-GIS Platform for Monitoring of ZERO PLUS

WebGIS library: To display GIS information like maps (OpenStreet, Google Maps etc.), streets etc. and 3D objects like buildings, cars etc.

Graphs library: To generate the various graphs used in the dashboard.

Auxiliary library: Used to construct the dashboard and asynchronous communicate with the database.

Client – modern web browser

jQuery - user interface

HIGHCHARTS

GeoServer

PostGIS

Apache Tomcat

PostgreSQL

Data base

Job Scheduler

Case Studies

Data Collector

IP Connect

HTTPS
In the ZERO-PLUS buildings, a KNX IP router gathers the measurements from the various measuring equipment installed in the buildings using the KNX protocol. The KNX IP router transfers the measurements to the Web-GIS platform via a secured REST API.

Schematic representation of the monitoring devices and data acquisition units at building and settlement level along with their interconnection to the Web-GIS platform:
Measurements gathering
Web-GIS platform walkthrough

ZeroPlus WebGis Platform

User Name:

Password:

Login

Test account:
researcher.researcher
Web-GIS platform walkthrough
Italian settlement, Novafeltria

General information

<table>
<thead>
<tr>
<th>Country</th>
<th>Italy</th>
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<tbody>
<tr>
<td>Region</td>
<td>Novafeltria</td>
</tr>
<tr>
<td>Net floor area</td>
<td>4000m²</td>
</tr>
<tr>
<td>Number of buildings</td>
<td>4</td>
</tr>
<tr>
<td>RES</td>
<td>Wind Rail, SBSkin</td>
</tr>
</tbody>
</table>

The demonstration case study belonging to the Italian NZE settlement of Novafeltria (RN) is represented by four residential single-family villas, i.e. ground floor buildings. Each villa can host an average of 3 people, with a maximum of 5 people. The main geometrical and dimensional characteristics of the settlement and the standard villa are listed below. Total lot area of the settlement: about 30,150 m² (including public spaces) Total lot area dedicated to the demonstration case study: about 2500 m², with 1600 m² occupied by the total lot area of the all villas and the remaining area by the private street Lot area of each villa: about 400 m², with 130 m² occupied by the building and the remaining area by the private garden Total net floor area: about 100 m², with 80 m² of residential net floor area (i.e. excluding the private garage)
Web-GIS platform walkthrough

Case Study: Novafetria, Italy

General Information  Detailed Information  Key Performance Indicators  Historical data

Energy Production  Energy Consumption  Indoor Environmental Quality

Settlement Energy Production

Settlement total energy production

0 Wh  250 Wh  500 Wh  750 Wh  1000 Wh

30/12/2016 13:00  30/12/2016 14:00  30/12/2016 15:00  30/12/2016 16:00  30/12/2016 17:00  30/12/2016 18:00  30/12/2016 19:00  30/12/2016 20:00  30/12/2016 21:00  30/12/2016 22:00

localhost:/CesiumHighChart/public_html-map.php#tabsGl:2
Web-GIS platform walkthrough

Case Study: Novafetria, Italy

General information  Detailed information  Key Performance Indicators  Historical data

Measurement: Settlement buildings electric power

[Graph showing outdoor air temperature and settlement buildings electric power over a period from 29/09/2016 to 29/12/2016.]

Download PNG image  Download JPEG image  Download PDF document  Download SVG vector image  Download CSV  Download XLS  View data table

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AETHERIA HEIGHTS
Web-GIS platform walkthrough
Web-GIS platform walkthrough

Building level

General  Energy  Indoor Environmental Quality  Historical data

General  Consumption  Production

Electric Equipment

Light

HVAC

Electric Equipment

Space equipment electric power  Space light electric power  Space HVAC electric power

0 W  100 W  200 W  300 W  400 W

0 10 20 30 40 50 60 70 80 90 100

30/12/2016 11:00  30/12/2016 12:00  30/12/2016 13:00  30/12/2016 14:00  30/12/2016 15:00  30/12/2016 16:00  30/12/2016 17:00  30/12/2016 18:00  30/12/2016 19:00  30/12/2016 20:00  30/12/2016 21:00  30/12/2016 22:00

236.874 W  13.5795 W  13.976 W

1 000 kWh  1 402.21 kWh  3 348 kWh
Web-GIS platform walkthrough
Data sources for the four case studies

- **Italy**
  - IEQ (T, RH CO₂), energy consumption (KNX IP router)
  - Heating/cooling set Point (HVAC controller, Rotex G1)
  - PV energy production and battery storage (ABB Aurora Vision)
  - Outside meteorological conditions (Vantage Pro2™ Plus with 24-Hr Fan Aspirated Radiation Shield)

- **France**
  - IEQ (T, RH CO₂), energy consumption, energy production (PV, hot water) (KNX IP router)
  - Outside meteorological conditions (Vantage Pro2™ Plus with 24-Hr Fan Aspirated Radiation Shield)

- **UK**
  - IEQ (T, RH, CO₂), energy consumption (Orsisenergize)
  - T, heating set point (Hive)
  - Energy production and battery storage (Tesla Power Wall)
  - Outside meteorological conditions (Vantage Pro2™ Plus with 24-Hr Fan Aspirated Radiation Shield)

- **Cyprus**
  - IEQ (T, RH CO₂), energy consumption (KNX IP router)
  - Energy production (electrical, hot water), Heating/cooling set point, HVAC consumption (Frescoo and FAE industrial controller)
  - Outside meteorological conditions (Vantage Pro2™ Plus with 24-Hr Fan Aspirated Radiation Shield)
High Quality Datasets

Design and Implementation of procedures to ensure collection of high quality datasets

Correction of equipment/sensor failure

- Every new measurement is checked with fault detection function. If fault found then:
  - Email to the **Rescue Person** to resolve issue
  - Automatically create a entry on Google Sheets for the specific case study for having Error Log.

Correction of electrical power disruption

- Every 15 min is checked if all measurements for each one of the case study are inserted on the webGIS. If not:
  - Email to the **Rescue Person** to resolve issue
  - Automatically create a entry on Google Sheets for the specific case study for having Error Log.
High Quality Datasets

Design and Implementation of procedures to ensure collection of high quality datasets

Correction of errors at data transfer

- On every data logger the local history for measurements is enabled if exist. When internet connection is restored the measurements will be transmitted to the webGIS platform
  - Email to the Rescue Person to resolve issue
  - Automatically create a entry on Google Sheets for the specific case study for having Error Log.

Correction of Problems on WebGIS platform

- External service (uptimerobot) checks every 5 min of WebGIS platform is up and running. If no:
  - Email and SMS to TUC to investigate and solve the issue
- Every 15 min is checked if all measurements for each one of the case study have correct time
  - Email and SMS to TUC to investigate and solve the issue
Web-GIS Platform for Monitoring of ZERO PLUS

Web-GIS platform accessibility

The communication protocol between the Front End and the end user is performed via Internet using secure transfer protocols. The various end user categories have specific privileges for security purposes:

**Administrator:** *access to all available data* from all settlements and *capability to modify the database*.

**Researchers:** will have *only read access to all available data* from all settlements.

**Building owners:** The building users have access to *their own building data*.

Web-GIS platform security

- All the data transfer between the platform and the outside word is encrypted (SSL/TLS for the website and REST API).
- All password are stored in an encrypted form.
- Each component of the platform have access only to the minimum amount of data ie. Gathering data component for Italy case study can only write data to specific table on database and unique username/password.
Weather data from Italian Case Study
IEQ from Italian Case Study
Weather data from France Case Study
IEQ data from France Case Study

Indoor temperature (°C)

- 1: Temperature
- 2: Temperature
- 3: Temperature
- 4: Temperature
IEQ data from France Case Study

Graph showing RH data from 10/11/2019 to 16/11/2019.
IEQ data from France Case Study
WEB-GIS PLATFORM SUPPORTS THE POST OCCUPANCY EVALUATION

THANK YOU FOR YOUR ATTENTION