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Lisbon Pilot Implementation

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Authors: Nuno martins, ISA
Joana Fernandes, Lisboa E-Nova
Contributors:
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1. Introduction

The Save Energy Lisbon Pilot is one of five pilots of the EU project "Save Energy", CIP-ICT-PSP-2008-2, aimed at promoting user behaviour transformation in the use of energy, actively fostering energy consumption reduction in service buildings through the use of information and communication technologies (ICT).

The Lisbon pilot takes place at Lisbon's Municipality main office building, where 1.800 people work daily and more than 200 citizens are received by the Municipality services. The pilot is set in one of the building's blocks, where real time information on energy consumption, as well as other interactive and awareness raising actions will be organized targeting the building's energy end users, Lisbon Municipality technicians. Being an administrative services building, the main area for user energy savings is electricity, mainly through lights and office equipments.

The project started on March 1, 2009 and will run over a 30 months period. The test period started in March 2010, when the block's energy consumption started to be monitored and the contact with the users started in May 2010, being this phase expected to last a minimum period of 18 months.

2. Lisbon Municipality building

The Lisbon Municipality Central Office Building is located in Entrecampos and was built in the 1990's. It's a concrete frame, multi-storey building, with a high proportion of glazing, featured by 6 volumes, all interconnected, with a total area above the ground of 28.000 sqm; total area under the ground 17.000 sqm and useful area for working places 18.000 sqm.

With approximately 1800 employees and 200 daily visitors, the building provides municipal administrative services (urban management, project development, financial services, and public relations).

During 2008 and 2009 the building's energy performance and indoor air quality analysis was assessed. Electricity is main energy source of the building, with an annual average consumption of 3.300 MWh, monthly distributed according to the consumption profile in Graph 1.

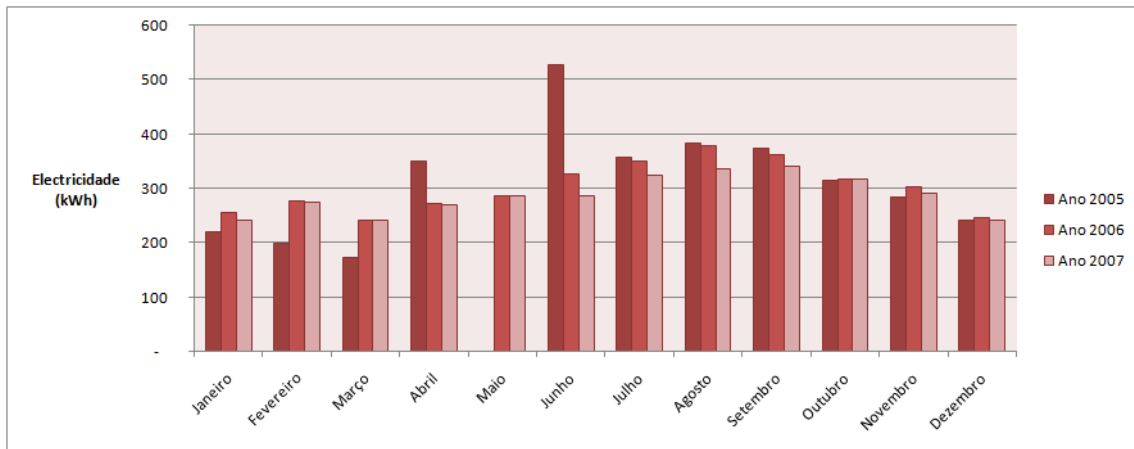


Figure 1 – Lisbon’s Main Office Building electric consumption per month, years 2005, 2006, 2007

The distribution of this consumption per type of appliance is presented in Graph 2: 36% UPS, 3% ventilation system, 7% air treatment units (UTANS), 3% circulation pumps, 9% chillers, 4% elevators, 21% lighting, 16% equipments and 1% water and swage pumps.

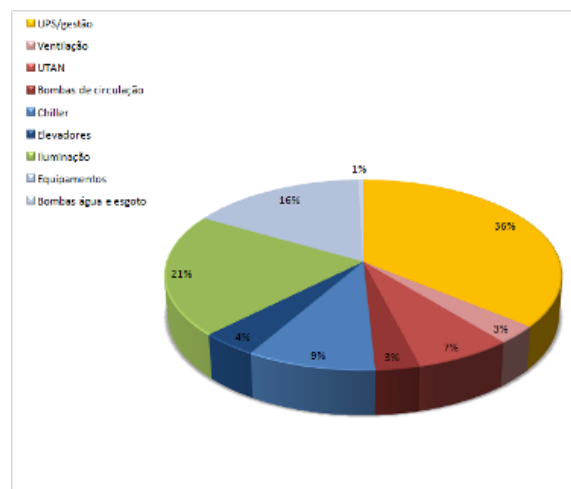


Figure 2 – Distribution of the electricity consumption per type of use (base 2007)

Results revealed a B- energy class building, with an average consumption of 120kWh/sqm.year. This simulation was obviously validated taking into account the building effective consumption, cross-referencing it with consumption data for the three previous years (2005, 2006 and 2007). According to the Portuguese legislation, this building complies with the actual framework for new or totally refurbished buildings, Decree-law 79/2006, Regulations on HVAC Systems in Buildings (RSECE), which establishes B- as the minimal energy class. This clearly indicates a very well managed building, which already integrates several energy efficiency measures, such as reflecting glass and external thermal insulation. Measures such as daylight control systems and substitution of the existing underground car parking lightning with more efficient lighting are additionally under consideration.



The formal energy certification is currently in progress.

2.1 Lisbon Save Energy Pilot

The Lisbon Save Energy pilot is based on a monitoring and active interaction approach.

It's based in two blocks, block 1B and 2B. Both blocks are used for administrative services and have a medium area of 500 sqm, with approximately 50 technicians in each block that work from 9 a.m. to 6 p.m.

The average occupation per person in an open space office area is 0.10 sqm/person. Apart from the lights, T5 fluorescent lamps with electronic bulbs and an average installed capacity of 8W/sqm, the equipments installed are mainly desk computers, an average power of 140kW, three printers, with an average power of 250kW, scanners and plotters, as well as a TV. As in any other office areas we can also find radios, two coffee machines, and a micro-wave. As a reference value it is important to refer that the power capacity defined by RSECE (DL 79/2006) for equipments in office buildings is 15W/sqm.

The baseline consumption in the pilot area of the building was assessed during the month of May, once all the monitoring equipments had been successful installed.

The pilot's overall electricity consumption is being monitored, as well as three circuits: lights, plugs and HVAC system. The results present an average electricity consumption of 95kWh/day. This distributes almost 60% of the electricity consumption in the lights circuit, 30% for the plugs circuits, meaning all the equipments, 7.5% for the HVAC system and 2.5% for the vending machines and general services equipments. As for comfort conditions the medium indoor temperature is 24°C, relative humidity is at 40% and the CO₂ levels indicate a medium of 400 ppm. The annual energy consumption per sqm being monitored is 60kWh/sqm.year. This means that the monitoring equipments are capturing nearly 50% of the total energy consumption of the area, being this the exclusively electric consumption.

The 1B block is the active interaction block and the 2B block is the exclusive monitoring block.

3. User behaviour change

The 1B block is where the user behaviour change testing will take place, while the 2B block intends only to provide information on the usual consumption pattern of the users, being a real



time comparing pattern to access the effective energy consumption reductions derivate from the interaction with the 1B block users.

The objectives of the active interaction with users are promoting users engagement and sustainable motivation towards energy consumption and foster users' behaviour transformation in energy use through the adoption of more energy efficient behaviours.

The key words of this work are: **trust, understandable language, link to users' reality and dynamics**. Keep this key words in mind is essential because service building users first approach to energy efficiency in their work space is trust on data confidentiality "What will you do with this data?", "Will everyone know that's my consumption?". "Will my boss think I'm working less if I consume less?". Secondly, the need for an understandable language, kWh are most of the time meaningless measures, so it's essential to cross reference it with Euros, CO₂ emissions (because like it or not are the popular face of energy efficiency concerns) and to conventional, daily, home applications that directly means something, because the reaction on consuming less in service buildings is also "Why care, we do not even pay this bill!!".

The communication strategy in the 1B block is based in progressive and constant actions:

- hall display with the overall consumption,
- website with real time and historical data,
- applets with regular pop ups,
- interface with domestic appliances,
- web 2.0 tools,
- serious game,
- internal workshops,
- user feedback loop to the project functionalities.

3.1 Hall display

In the pilot area, users have access to the block's energy consumption, global consumption of the electric circuits and desegregated consumption per circuits: lights, plugs and HVAC.

This is daily available thought the hall display.



Figure 3 – Lisbon pilot 1B block hall display

The hall display is available since May 2010 and will be active until the end of the pilot testing period. It presents, graphically, the evolution on the daily consumption and separately the total consumption since the beginning of the monitoring in terms of kWh, Euros and CO₂ emissions (result of Portugal's electricity mix). It also presents the instantaneous consumption in the three circuits being monitored separately and the comfort conditions in the open space.

From May to October 2010 the evolution of the consumption was exclusively represented by red bars with hourly consumption. During the first months of the project, the baseline consumption of the block was assessed and in the beginning of October an average consumption evolution line will also be on the display, indicating the medium consumption and the periods when that consumption is exceeded. The bar will be green and whenever that consumption is exceeded it will turn red!

3.2 Website with real time and historical data

Additionally to the display of consumptions in public monitor installed in the block's main hall, users have also access to the historical data being collected both the 1B and the 2B blocks.

This will allow users to consult the historical data being collected in all the circuits, plus the consumption being collected through the i-plug sockets, placed all over the block, monitoring desk consumptions, printers, coffee-machines, etc.

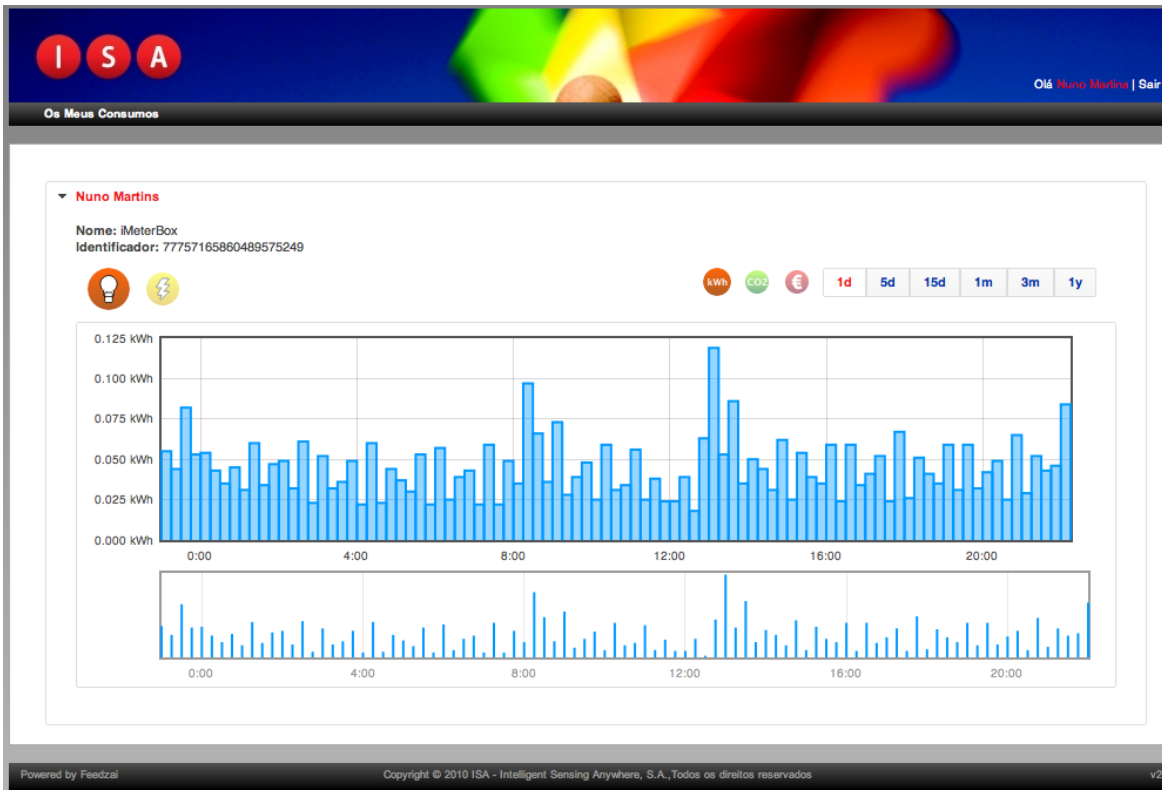


Figure 4 – Web site with real time and historical data

This functionality is expected to be available in the beginning of October.

The website will also gather tips and a list of relevant issues to those who want to know more about energy, energy efficiency, renewable energies and other related subjects.

3.3 Applets with regular pop ups

The SAVE ENERGY project will be in force, in pilot, for more than a year. Users’ motivation towards the project can’t be bias and for that it’s essential to keep a dynamic. This will be achieved not only through the progressive enrol of users to all this communication actions but also through applets displays, to be installed in every individual computer. These applets will provide messages on energy efficiency behaviours, constantly remind users of the project and engaging them to behaviour change in energy use. A thorough list of recommendations and messages to present is being gathered and a first list will be available in September. The list of measures includes both the services and the residential sector, so users can also benefit from behaviour changes at their home, looping the SAVE ENERGY results into the residential sector. Of course this list is to continually improved, also with the contributions received from users on what are their interests and lacks of information.



Figure 5 – Example of the applets to be installed in every individual PC.

3.4 Interface with domestic appliances

One of the key words identified as essential to the communication strategy is the link to **users' reality**. Not only is this essential for users to actually perceive and quantify energy savings in the office, as it is also important to connect that with their home appliances and give them the opportunity to directly benefit from the SAVE ENERGY project, better even if that benefit can relate to economic savings. Having this in mind, one of the actions to take place in the Lisbon pilot is the distribution to the pilot users of smart plugs, devices that allow us to, in a simplified manner, assess the consumption of electric appliances. The objective is also to foster people's curiosity on equipments consumption and induce them to develop some domestic experiences that allow them to gain equipments consumption sensibility and exchange that information between users. This will foster the creating of a critical mass of users on energy efficiency.



Figure 6 – Example of the smart plugs that will be available for users.

3.5 Web 2.0 tools

The SAVE ENERGY project has available a wide variety of Web 2.0 tools.

The Lisbon pilot is embraced by these tools through its blogspot, where the pilot users and all the interested people in the project will be able to consult the public project results, in a clear interface with users and other realities.

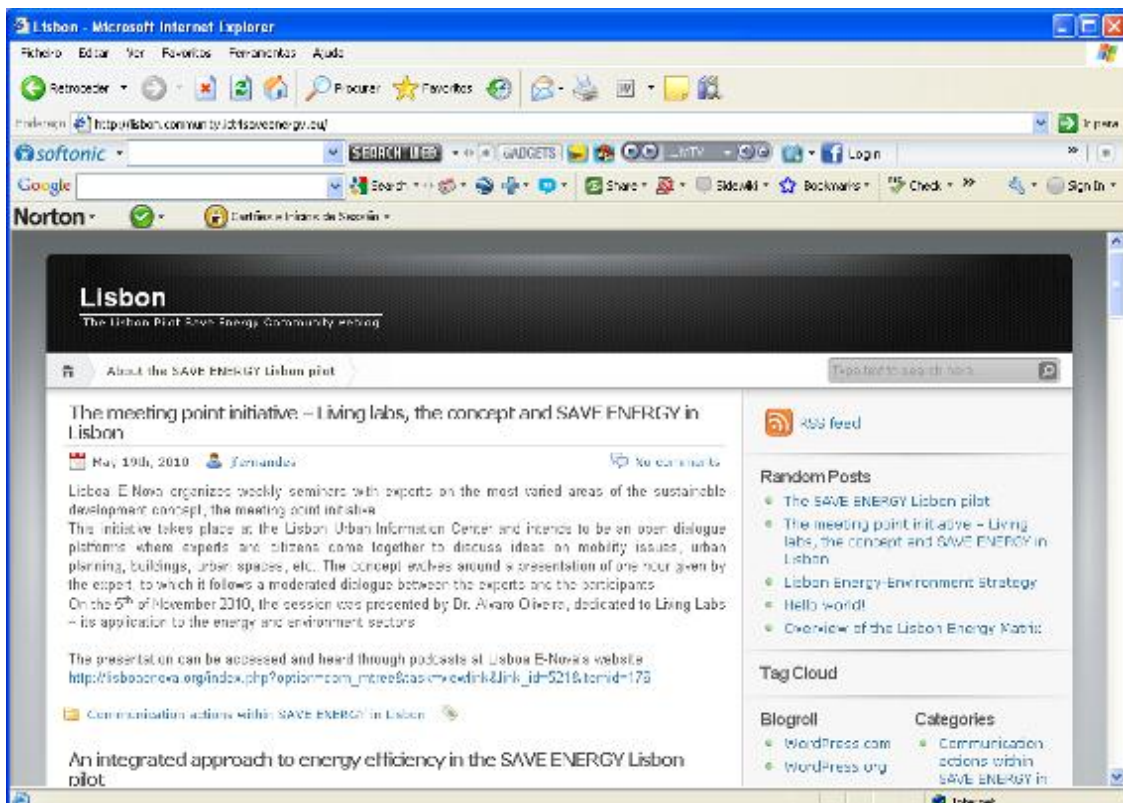


Figure 7 – <http://lisbon.community.ict4saveenergy.eu/>

The first posts on the blog presented the project concept, the integrated approach to the Lisbon Municipality Main Office Buildings and provided also some insight on Lisbon's energy matrix.

The existence of the Lisbon Pilot Community blog will be communicated to the Lisbon pilot users in the beginning of November.

3.6 Serious Game

All the SAVE ENERGY pilots users will be invited to play the serious games.

As soon as this tool is available it will be presented to the Lisbon pilot users, expectably in October or November.

3.7 Internal workshops

All the actions developed in the Lisbon pilot are organized within a small communication workshop to the users. It is intent to be an informal contact platform with the users where they can place their questions face to face, interact with the project promoters and physically manage the tools being introduced along the project.

The first workshop was held on the 20th of May, when the hall display was connected. A brief presentation on the SAVE ENERGY project was given and the project brochure was distributed along with a summarizing leaflet in Portuguese that presented the SAVE ENERGY overall concept as well as the display indicating the parameters being monitored.



Figure 8 – Connection of the hall display and explanation leaflet distributed



4. Technical Implementation

Lisbon pilot consists in one of the five pilot experiments. In terms of building challenges, there were not many points to address, due to the recent construction of the building. Let us remember that the building is relatively recent, well insulated and as HVAC system. Nevertheless, the electricity bill has revealed it-self, way of the planned edge. The installed monitoring solution intends to demonstrate the excessive consumption at two twin offices, in different floors.

For the purpose, a monitoring system was installed in both floors, as described below.

Three levels of measurement compose the installed system:

- Floor level:
 - General Consumption;
 - Lighting;
 - Plugs;
 - Service Areas;
- Work Station Level (Sub-metering experiments)
 - Desk;
 - Printer;
 - Coffee Machine;
- Comfort Parameters:
 - Temperature;
 - Humidity;
 - CO₂ Levels.

The envisaged system allows us then, to have clear figures about the consumption at each monitored floor.

In terms of technical implementation, the system architecture can be described as it follows:

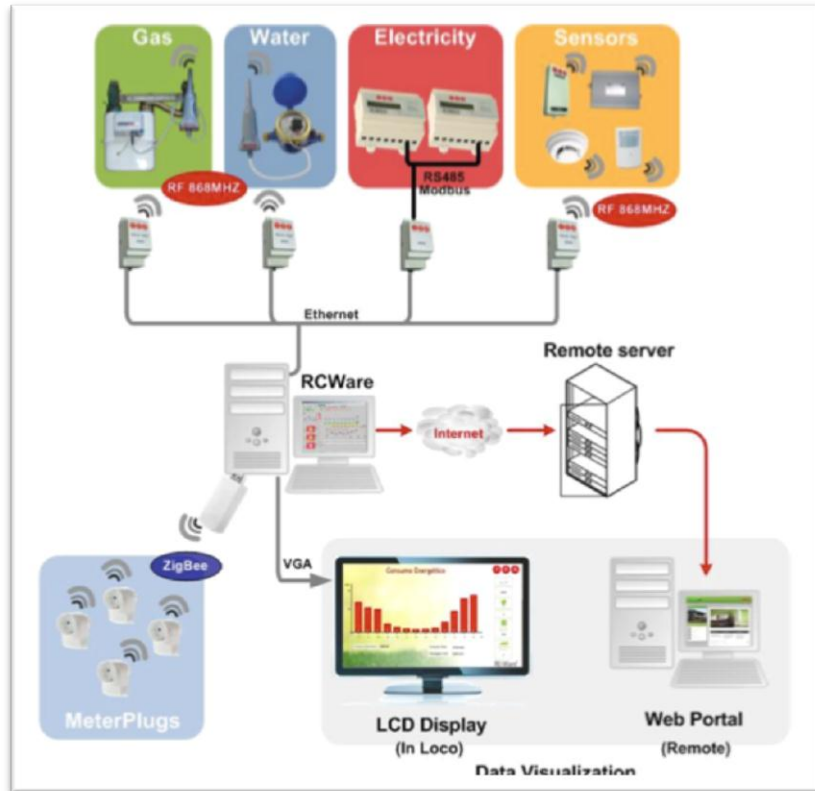







Figure 9 - Typical ISA system architecture

The scheme presented at Figure 9, represents one of the main architectures used by ISA at building level. In terms of objectives it encompasses all the challenges Figure 9 addressed by SAVE ENERGY, although the focus in the Lisbon Pilot are electricity and comfort parameters measurement.

By now it is time to better describe the installed system at Lisbon Municipality, and explain to the reader, from a technological perspective, what are the components that comprise the installed solution:

Table 1 - Equipment installed at Lisbon Municipality

	<p>iMeterRain DIN:</p> <p>The iMeterRail DIN measures the energy consumption and other electric parameter such as voltage, current, power factor, frequency, among others.</p>	<p>Electricity Measurement</p>
	<p>iPlugMeter:</p> <p>The iPlugMeter measures the energy consumption at plug (socket) level and communicate via Bluetooth or ZigBee.</p>	
	<p>iPoint:</p> <p>The iPoint measures the air humidity and temperature and send the measures via radio frequency (RF) to other equipment with RF receiver, such as the ISA aggregator. The iPoint casing will also comprise CO2 levels measurements, but with different sensor, the communication module is the same.</p>	<p>Comfort Parameters Measurement</p>
	<p>iMeter Bridge:</p> <p>This bridge can be RS485 to TCP/IP bridge, Bluetooth to TCP/IP bridge, ZigBee to TCP/IP bridge, RF to TCP/IP bridge or Zwave to TCP/IP bridge</p>	<p>Communications</p>
	<p>RC Ware:</p> <p>This solution will act as the hub for the communication and sensors spread throughout the blocks. It will also be used to display the data collected.</p>	

The previous equipments are physically installed at two different level blocks. The communication is done to a common aggregator, the RC Ware system. At the aggregator level, information is dispatched to the iCenter OS service, and also the local display, which provides to the users with local real time information.

Regarding the installed system, it has become clear that a three level of measuring is available. In order to never forgetting the pilot objectives, induce behaviour transformation through the use of ICT, thus saving energy, information must be provided to the users.

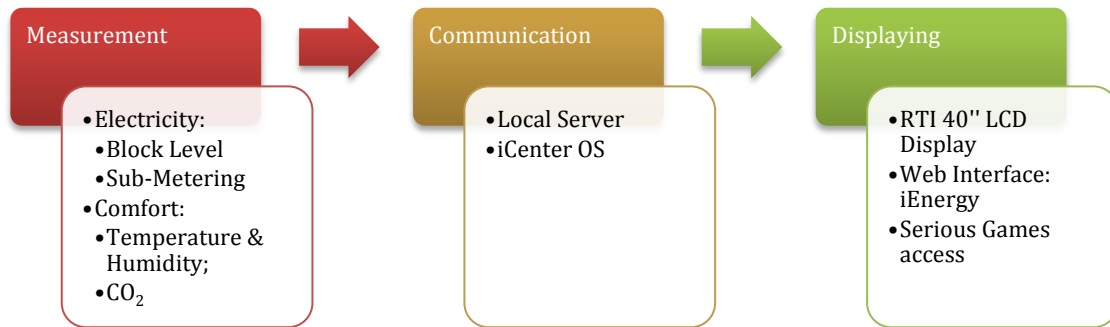


Figure 10 - Architectural Process - From data collection to data display

This process can also be illustrated, and completed with the Lisbon Pilot architecture, that was envisaged at **Deliverable 2.4 – Pilot Implementations Plan**.

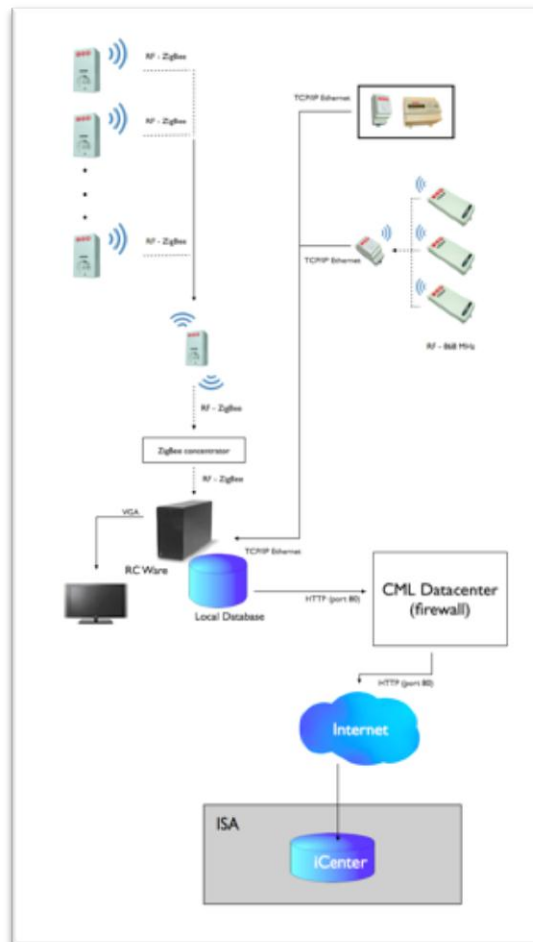


Figure 11 - Lisbon Technical Solution

The previous solution is design to maintain a continuous monitoring *in-situ*, although for pilot purposes it's set up for 15 time intervals measurements, that are communicated to the iCenter OS service each hour, thus providing us with the needed granularity for our analysis.

In terms of installation, the jobs were undertaken smoothly with no constrains to be denoted.

To illustrate the physical implementation we attach several pictures of the two days installation that occurred last April:

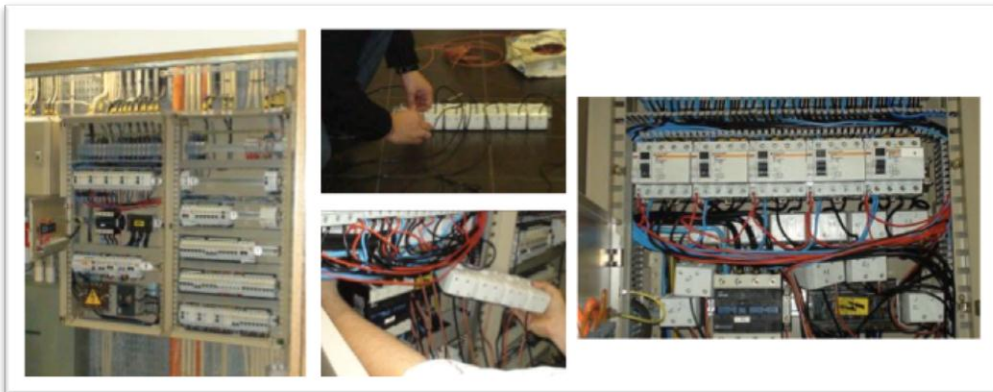


Figure 12 - Installation of IMeterRail DIN at both levels

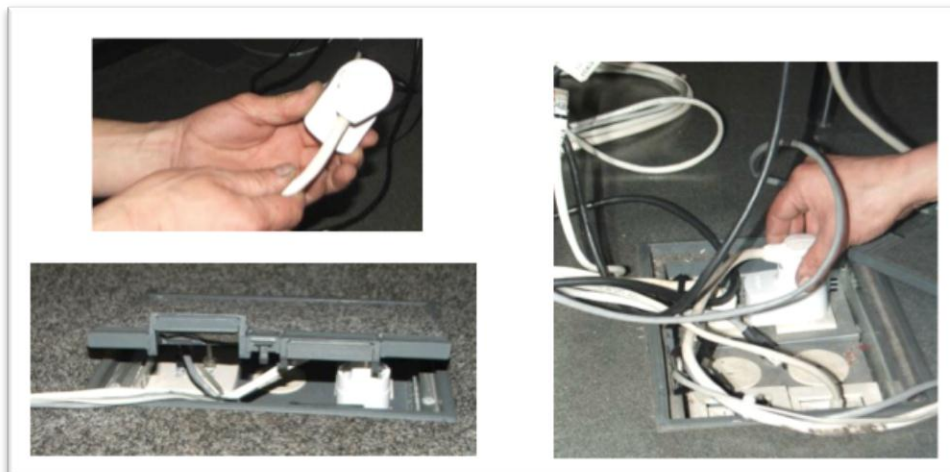


Figure 13 - Installation of sub-metering system

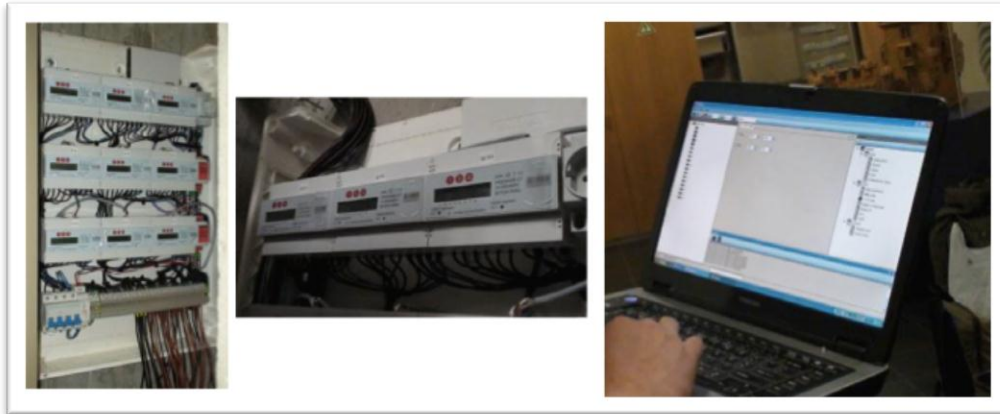


Figure 14 - Electricity Metering Systems installed and RC Ware aggregator running

In terms of communicated data we should highlight the easy and swift integration with iCenter OS service, where are currently around 500 tags capable of providing us information about consumptions and signal quality. But for pilot (Serious Games integration) purposes, we only present tags relative to consumption.

Table 2 - Tag Map used for the Serious Games at Lisbon Pilot

Local	Description	Variable	Tag
Bridge 1	1b Floor Total	Total Active Energy	51
Bridge 1	OpenSpace Plugs	Total Active Energy	97
Bridge 1	Hair Dryer and Copy Machine	Total Active Energy	120
Bridge 1	fan coils	Total Active Energy	143
Bridge 1	Open Space + WC Lightning	Total Active Energy	166
Bridge 1	OpenSpace+Z.Tec. Lightning	Total Active Energy	189
Bridge 1	(A)Coffee M+(B)General Services	Total Active Energy	212
Bridge 1	OpenSpace Plugs	Total Active Energy	235
Bridge 2	2B Floor Total	Total Active Energy	465
Bridge 2	General Services Plugs	Total Active Energy	488
Bridge 2	OpenSpace Plugs	Total Active Energy	511
Bridge 2	Copy Machine+HandDryers	Total Active Energy	534
Bridge 2	Fan Coils	Total Active Energy	557
Bridge 2	OpenSpace + WC Lightning	Total Active Energy	580
Bridge 2	OpenSpace + Z.Tec. Lightning	Total Active Energy	603
Bridge 2	Dress Room Lift Lightning	Total Active Energy	626
Bridge 2	OpenSpace PPlugs	Total Active Energy	649

In terms of user services Local RTI are available as illustrated in the following picture:

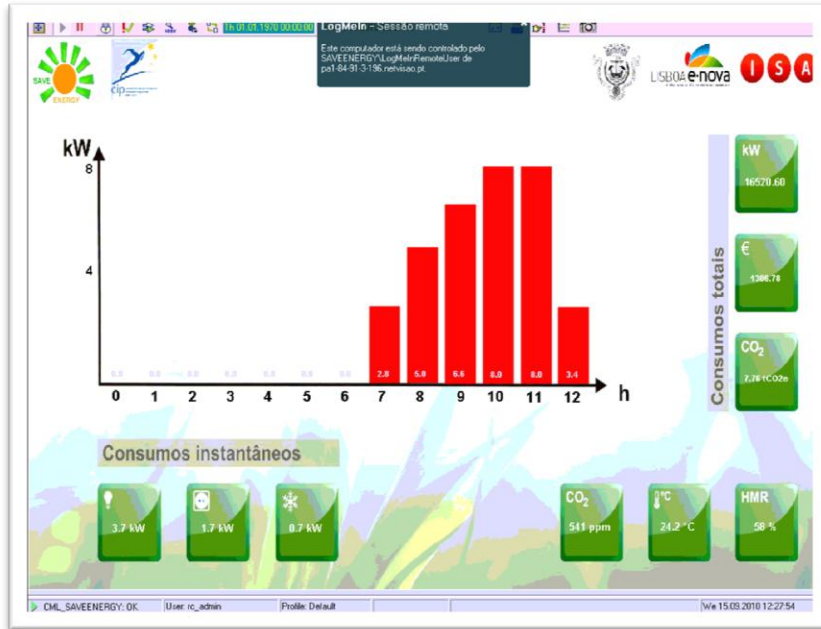


Figure 15 - Remote session of Lisbon Real Time Information (RTI) Display

Information will also be accessible through a web site that will be provided to the Lisbon Municipality Users. This website will provide users information with drill down and panning features and the data will be available in kWh, € and also kg of CO₂.

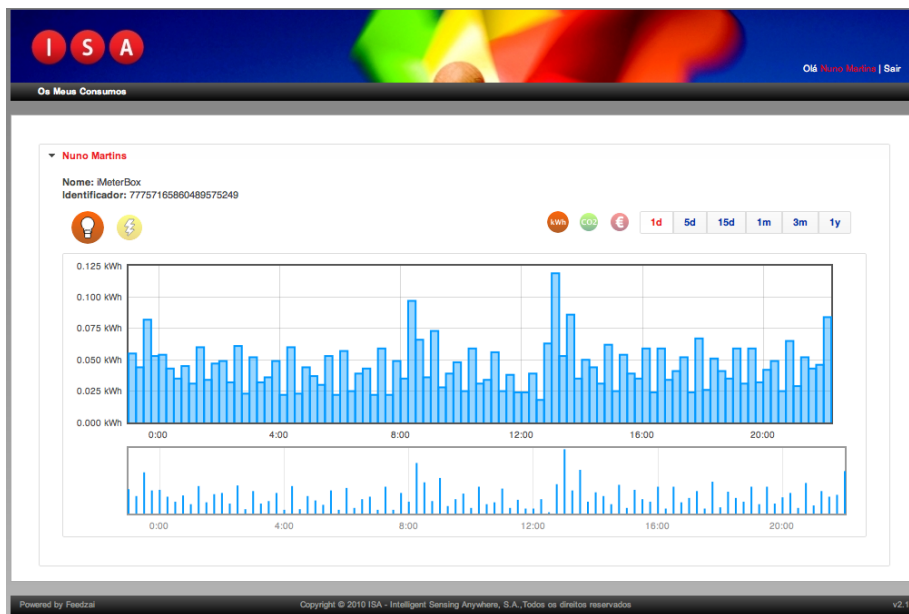


Figure 16 - Website providing consumption information.



Figure 17 - Website providing power information

5. Conclusions

From the technical point of view, the project is implemented with success, as reported before. The monitoring system has already proven to be worthy of use. A malfunction on the time setting machine – for the absence periods of the building – has pointed out a source of waste in the energy consumption. The weekend periods at Block B1 are with an extremely high baseline, which represents around 13% of the net energy consumption. Therefore, the detection of such issue can be used as a trigger to stimulate more efficient behaviours and, of course, involve the users in the optimization process, by doing simple chores as turn the lights and HVACs on Fridays, always turn off desktop computers and monitors, among other.

We believe that in the next months the SAVE ENERGY project will allow us to work with the buildings managers and pilot users on the continuous improvement of the building energy efficiency performance.