Supplementary Material ☆

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1. Introduction

This document provides supplementary information for the Chapter 3 (Non-Intrusive Energy Monitoring and Eco-Feedback Deployments in the Real-World). More concretely, additional figures are presented to illustrate the complexity of the real-world deployment process. Additionally, this document provides English translations for the User Interfaces that were used in the different deployment.

2. Deployments Timeline

In Figure 1 we present the timeline of the three deployments, where the start and end dates of each deployment are relative to the date of the first and last obtained measurements, respectively.

☆for Understanding the Practical Issues of Deploying Energy Monitoring and Eco-Feedback Technology in the Wild: lesson learned from three long-term deployments

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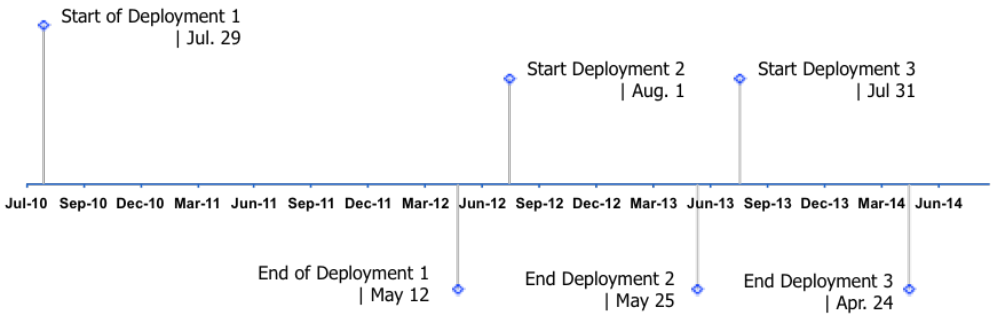

Figure 1: Research platforms deployment timeline

2.1. First Deployment

In Figure 2 we present the major milestones of the entire deployment including an overview of how the number of participating households evolved over time.

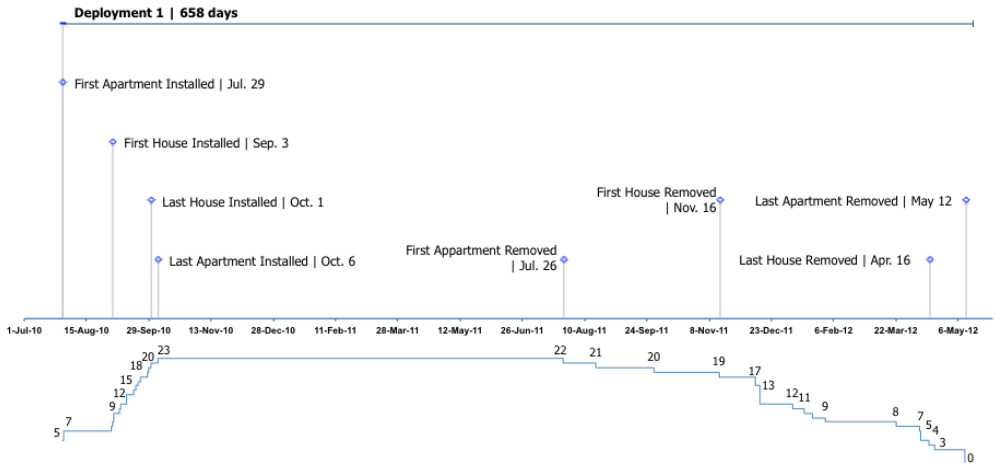

Figure 2: Major milestones of deployment one (top); active installations over time (bottom)

During the installations, the teams made sure that all the sensor and

netbook cables were hidden from sight, with only the output ends passing to the front. Also, since both sensors had very short cables we decided to attach our meter to the fuse box door with velcro as shown in Figure 6.

2.2. Second and Third Deployments

In Figure 3 we present the major milestones of the two deployments including an overview of how the number of monitored apartments evolved over time.

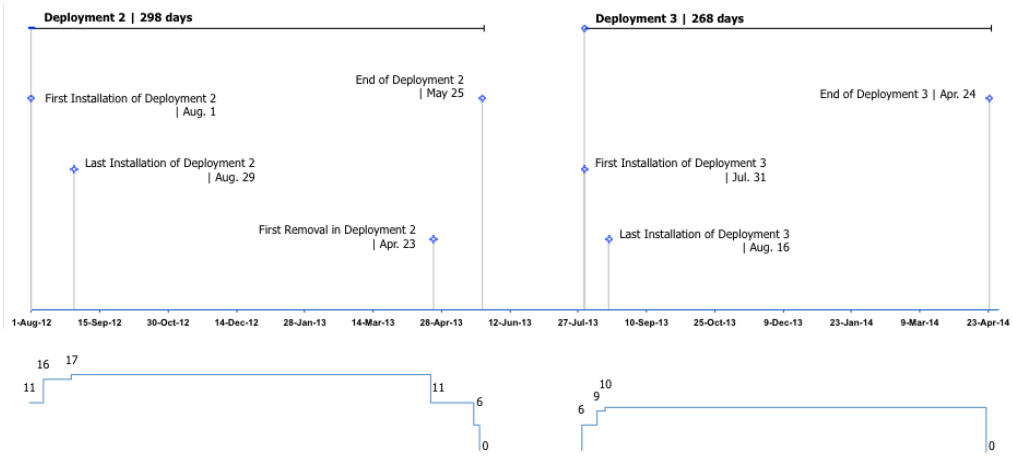

Figure 3: Major milestones of deployments two and three (top); active installations over time (bottom)

3. Single-House Energy Monitoring and Eco-feedback Platform

3.1. Data acquisition and load monitoring

In this platform, the current waveforms are sensed using standard non-invasive split-core (clamp-on) AC current sensors, similar to the one shown on the left side of figure 4. The voltage is measured with a custom-made

voltage transformer that steps down the 230 V input voltage to 0.5 V (figure 4 -– center), such that it can be correctly sampled by the sound-card. The two sensors are connected to the sound-card using 3.5 mm TRS splitters (figure 4 -– right).

Figure 4: Sensing hardware: split-core current sensor (left), voltage transformer (center) and TRS splitter connectors (right)

The netbook and the sensors are installed in the main power feed (see figure 5), thus covering the entire house consumption and eliminating the need for additional sensing locations.

Figure 5: Current and voltage sensors installed in the main power feed

3.2. Energy eco-feedback

The energy eco-feedback is provided on-site using the built-in display of the netbook (see figure 6).

Figure 6: Energy eco-feedback is provided on-site using the netbooks' built-in LCD screen

The first interface consisted mostly of traditional column charts to display the consumption information. The system displays a column chart with the total energy consumption over the current day and the consumption of all the previous days. It is also possible to compare the consumption of the current week against the previous week based on a daily average. In Figure 7 we present an example of the daily consumption in a column chart, where each column represents the different hours of the day.

The second version was designed based on feedback we received from the deployment of the first version. In this interface, we used a gauge analogy to display consumption information to the user. The interface displays information for the hourly, weekly, monthly and yearly consumption and is organized in a tabbed menu. The consumption levels are mapped using a color scale going from green to dark red, and if the mouse cursor hovers over the gauge it displays information about CO_2 emissions and the cost associated with that time slot. In Figure 8 we show a screenshot of the hourly consumption screen, where the dots represent power events (i.e., the instants when appliances change their operation status).

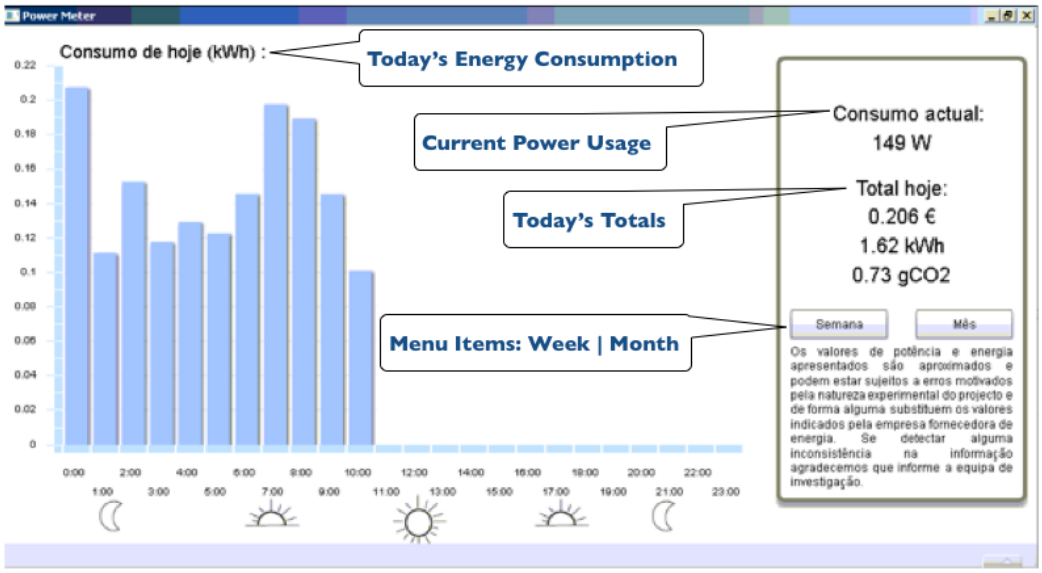

Figure 7: Eco-feedback interfaces used in deployment one: version 1

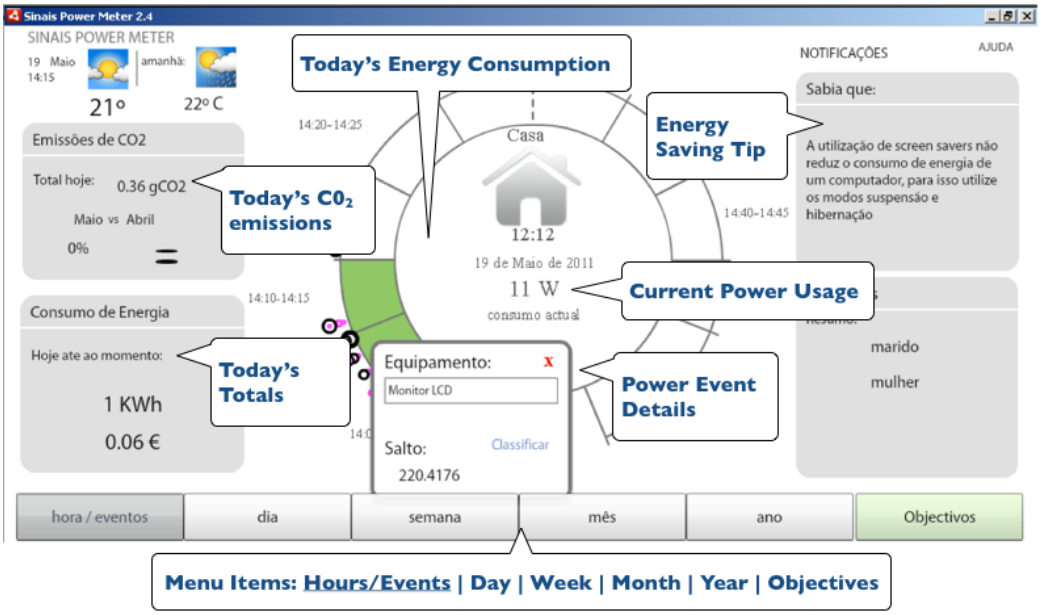

Figure 8: Eco-feedback interfaces used in deployment one: version 2

4. Multi-House Energy Monitoring and Eco-feedback Platform

4.1. Data acquisition and load monitoring

The current and voltage signals for all the monitored houses are acquired from the building main electric panel (figure 9 -– left) and processed by a single computer using a dedicated DAQ board (figure 9 -– right).

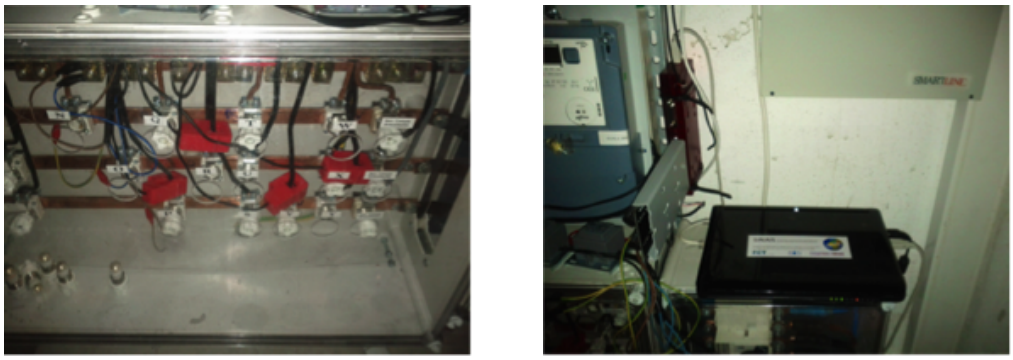

Figure 9: Multi-house platform installation: current sensors (left), voltage sensors and DAQ (right)

4.2. Energy eco-feedback

The multi-house energy monitoring and eco-feedback platform enable householders to access the eco-feedback in different places of the house, or even outside the household premises if there is an Internet connection available. As such, in the case of the two deployments of this platform, the eco-feedback was provided using custom-made mobile applications running on 7" Android tablets.

The eco-feedback application used in the second deployment involves two main modes of operation. When it is not used for two minutes it goes to the *Energy Awareness* mode, showing the consumption mapped as a digital

illustration of the local endemic forest. Once the user interacts with the tablet, by pressing the back softkey, the system goes to the *Detailed Consumption* mode, showing daily, weekly and monthly information about the home energy consumption(see figure 10).

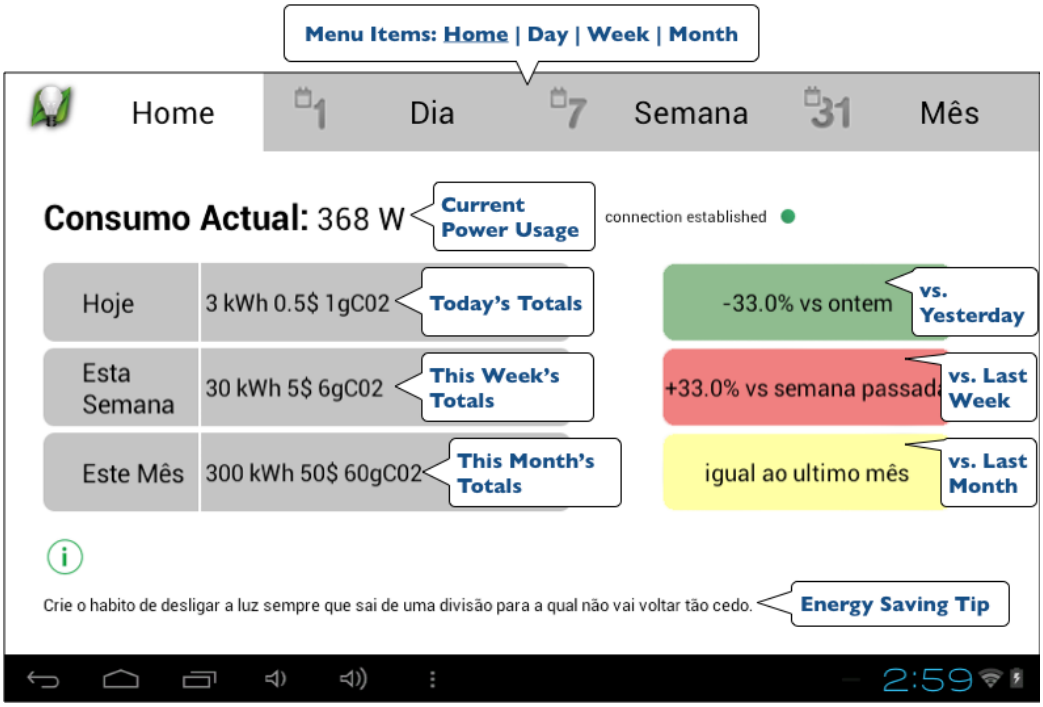

Figure 10: Energy eco-feedback applications used in deployment two: detailed consumption mode

With respect to the eco-feedback system used in the third deployment, the *Energy Awareness* mode was replaced with information about the electric energy generation in Madeira island. The developed application is composed of a set of tabs presenting the electric generation information, and summaries of the consumption on a daily, weekly and monthly basis.

The energy generation view was the default mode of the app, and the

system reverted to this visualization when no interaction happened during a pre-defined period. The electric energy generation was represented using a cumulative area chart of all the sources of energy used during the day, their quotas relative to each other. A forecast of the sources that would be available for the rest of the day was also available (Figure 11).

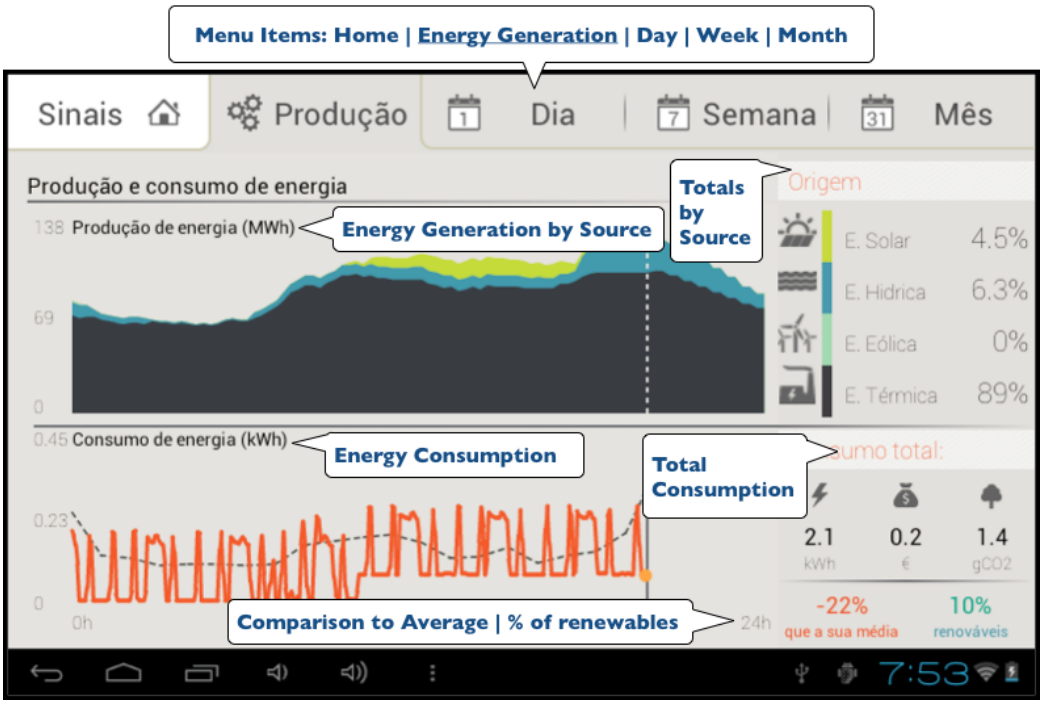

Figure 11: Energy eco-feedback applications used in deployment three: energy generation information

The home view (Figure 12) shown two charts representing the consumption of the current day, week, and month, as well as a comparison between homologous periods.

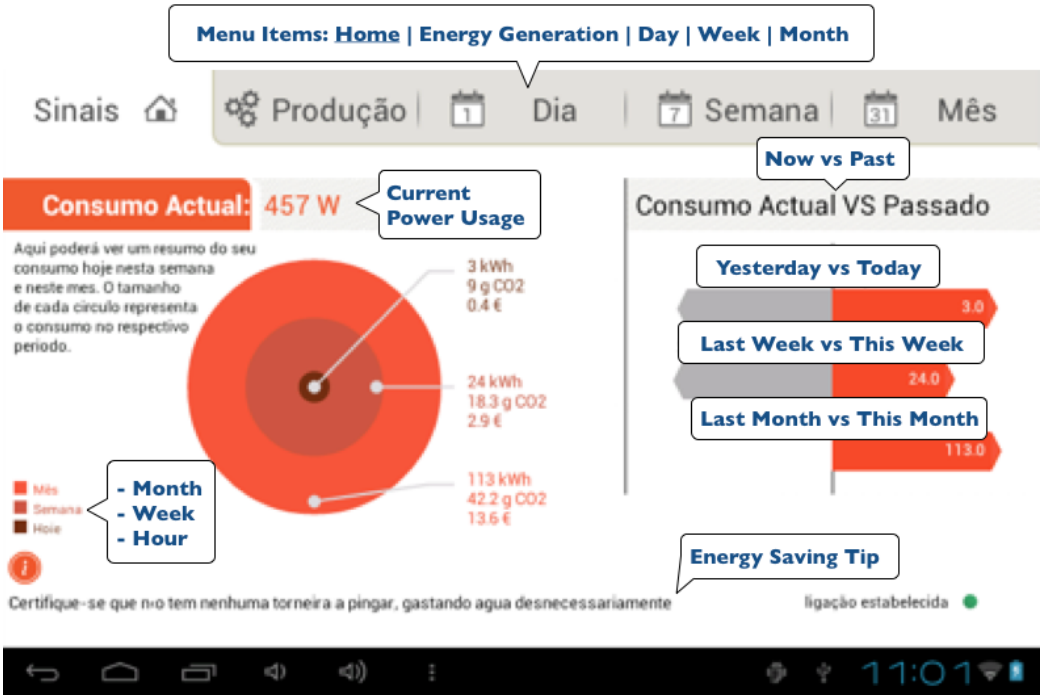

Figure 12: Energy eco-feedback applications used in deployment three: consumption summary