European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out

TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	CESEPS
Title	Co-Evolution of Smart Energy Products and Services
ERIGrid Reference	04.008-2018
TA Call No.	4

HOST RESEARCH INFRASTRUCTURE			
Name	Austrian Institute of Technology (AIT)		
Country	Austria		
Start date	21.09.2018	**Nº of Access days**	10
End date	09.10.2018	**Nº of Stay days**	19

USER GROUP	
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Organization (Leader)	University of Twente
Country (Leader)	Netherlands

1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

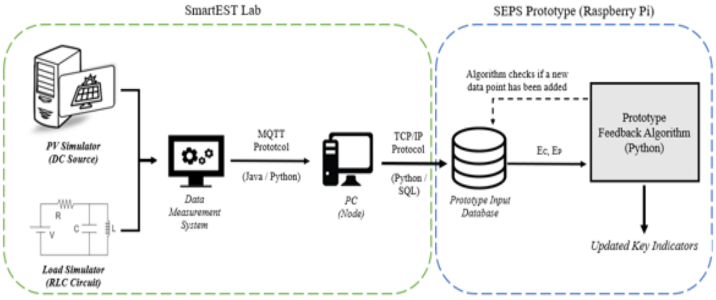

Figure 1. Test set-up for the Prototype Validation phase

Smart energy product development has typically followed a top-down, technology-driven approach where there are significant differences between the products designers have in mind and the expectations and desires from the people that are intended to use them. A co-evolutionary, design-driven approach to the development of smart energy products and services (SEPS) where user insights and expectations are included in the early stages of the product development process may create a new perspective on how to ensure these technologies are successful in facilitating energy-efficient behaviour from end-users.

The main goal of this project is to find which sociotechnical factors can determine whether a SEPS design will be successfully accepted and implemented by end-users, and how these factors can be translated into clear guidelines for creating future SEPS designs. To this end, several SEPS concepts were first tested by end users in a real-life environment; the data gathered from these tests included energy measurements as well as qualitative data capturing user insights and experiences.

This technical report covers the subsequent testing of these prototypes that took place at the Austrian Institute of Technology (AIT), which sought to validate prototype operation using the available equipment from the Smart Electricity Systems and Technology Services (SmartEST) Laboratory, as well as extending the range of conditions where the prototypes' performance was evaluated by modelling situations which were not possible during real-life user testing. The testing of each SEPS prototype consisted of two main phases:

1. <u>Use Scenario Simulation</u>: The algorithm used by each prototype to determine its LED output properties was tested by using production and consumption profiles to model four different use scenarios. Since the prototypes were designed to periodically read the required data from smart meters, a simple script was created which replicates this process by adding a new data point to the prototype's main database file at regular intervals. This data point, consisting of a pair of energy consumption and energy production values, served as the main input for the prototype's feedback algorithm which calculated the key indicator variable(s) used to set new LED properties.

2. <u>Prototype Laboratory Validation</u>: Figure 1 shows the testing set-up for this phase, where energy **generation** was modelled using a DC voltage/current source simulating a PV system. Energy **consumption**, on the other hand, was modelled using an RLC controllable load which consumed the generated power or drew power from the local grid whenever consumption exceeded generation. The main measurement system then estimated power flows in the system by constantly measuring voltage and current values in the aforementioned circuit. These measurements were periodically passed on to the SEPS prototype, which then performed the necessary calculations to determine LED properties.

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

The operation of all three SEPS prototypes was successfully validated using equipment from the SmartEST Lab, confirming that the scripts developed for each prototype can correctly interpret energy consumption and production inputs in order to give users simple, clear feedback into their household energy use. In addition to the prototype validation, four different use scenarios were modelled to visualise prototype performance in a wider range of testing conditions than those previously encountered during end-user testing. This section will present several conclusions based on the results obtained for each testing phase.

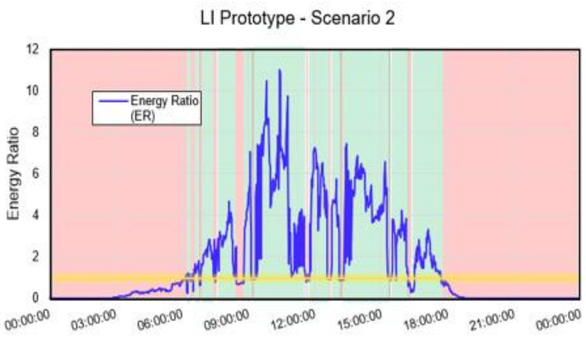

Figure 2. LightInsight (LI) prototype performance for Scenario 2.

Regarding the *simulation of use scenarios*, some prototypes' behaviour matched the patterns observed during end-user testing (e.g. LightInsight), while others showed significant variations (e.g. Bodhi). In either case, the operation period analysed was of one day only which is a relatively short period of time so it is not possible to conclude whether they significantly represent the simulated conditions. Furthermore, the modelled scenarios lack the impact of user response to prototype performance which is one of the central design components of these SEPS concepts. Despite these limitations, the modelled scenarios provide valuable insights into some of the issues these SEPS could encounter in these situations. For instance, both the CrystalLight and LightInsight prototypes would show no changes in feedback during winter days with poor PV production so an alternative algorithm should be designed to ensure some other useful information is shown during these times.

A sensitivity analysis provided additional information into the impact some key parameters have on prototype feedback. The three parameters analysed need to adapt to some extent to user behaviour or system performance; for instance, Bodhi's energy budget should motivate users to decrease their cumulative consumption by a certain amount while CrystalLight's battery capacity performs best when matching the maximum stored charge during a given day. Estimating these parameters using historical data or forecasting could significantly improve the quality of feedback presented to users.

Regarding the *lab validation tests*, the test sequences for all three prototypes were successfully translated into a clear lighting sequence which confirms that their feedback algorithms are operating correctly and further supports the results previously obtained in end-user tests. It is worth noting that the tests validated the operation of the *prototypes*, not the smart meters they will rely on for obtaining data from users' households.

Figure 3. Time-lapse showing Bodhi's lighting transitions through all three system states

The test set-up used a highly accurate measurement system to provide the required inputs instead of a smart meter; this means that in practice feedback accuracy will mostly depend on the accuracy of the smart meters themselves.

Finally, it is important to point out that one of the main challenges encountered during the lab testing was transmitting data from the measurement system to the prototypes. This issue was also encountered during end-user testing, where data from household smart meters had to be periodically passed on to each prototype, and underscores the importance of reliable communication protocols as well as adequate database management and storage.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

As a part of CESEPS, the obtained results will be disseminated through the project's communication channels. Additionally, the results will be an essential part for the CESEPS deliverables D5.1 Co-Simulation Analysis of SEPS and T5.5 Design Guidelines of SEPS. Based on the results and findings, papers are aspired to be published on suitable conferences like Cired 2019, Solar/Wind/EV Integration Workshop, SmartGreens 2019 or CCTA 2019.

Furthermore, this work is part of a Master thesis project titled "Guidelines for the Successful User-Centred Design and Implementation of Smart Energy Products" and the final results will be made public as an extensive report by the University of Twente.

4. PLANNED DISSEMINATION OF RESULTS THROUGH ERIGRID CHANNELS

Contact erigrid-ta@list.ait.ac.at to organise promotion of your results