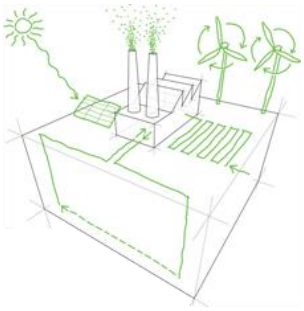
# SmartC2Net Project Newsletter



SMART C²NET

**Smart Control of Energy Distribution Grids over Heterogeneous Communication Networks**

**Newsletter #4**

**June 2015**

*IN THIS ISSUE*



Welcome to the fourth edition of **SmartC2Net** biannual Newsletter.

With this edition, we aim to inform you about the project progress and achievements.

## PUBLICATIONS

The **SmartC2Net** consortium is active promoting work carried-out by publishing at conferences and events. Within the first half of 2015, project partners have published papers at European events, very prestigious and relevant to the industry.

**VTC2015-Spring Conference**; May 2015 (http://www.ieeevtc.org/vtc2015spring/)

"Analysis of Information Quality in event triggered Smart Grid Control", by T. Kristensen, R. Olsen, J. Rasmussen

**SMARTGREENS Conference 2015**; May 2015 (http://www.smartgreens.org/?y=2015)

"Using Flexibility Information for Energy Demand Optimization in the Low Voltage Grid", by S. Bessler, D. Drenjanac, E. Hasenleithner, S. Ahmed-Khan; N. Silva

**CIRED 2015**; June 2015 ( http://www.cired2015.org/)

"Energy consumption and demand estimation from cellular network data. A real world case study.", by D. Tosi, M. La Rosa, S. Marzorati, G. Dondossola, R. Terrugia; E. Faciolo, S. Fratti

**ADHOC-NOW 2015**; June 2015 (http://www.netmode.ntua.gr/adhocnow2015/)

"Information-Quality based LV-Grid-Monitoring Framework and its Application to Power-Quality Control", by M. Findrik, Th. Kristensen, Th. Hinterhofer, R. L. Olsen, H. Schwefel

**2015 PowerTech Conference**, June 2015 (http://powertech2015-eindhoven.tue.nl)

“Smart Grid Control and Communication: the SmartC2net Real-Time HIL Approach”, by C. Ciontea, R. Pedersen, T. Kristensen, C. Sloth, R. Olsen, F. Iov

**2015 European Control Conference (ECC)**; July 2015 (http://www.ecc15.at)

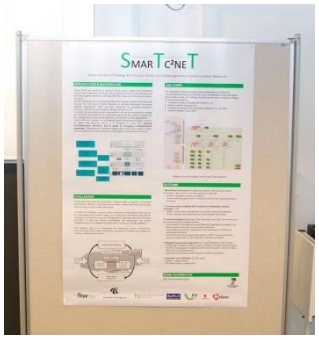
"DiSC: A Simulation Framework for Distribution System Voltage Control", by R. Pedersen, C. Sloth, R. Wisniewski, G. Andresen

In addition to the paper publication, **SmartC2Net** will publish the article entitled "On Enhancing Efficiency and Accuracy of Particle Swarm Optimization Algorithms" by S. Chiaradonna, F. Di Giandomenico, N. Murru; in International Journal of Innovative Computing, Information and Control (IJICIC). A book chapter has been published in Cyber Physical Systems Approach to Smart Electric Power Grid Power Systems (PublisherSpringer Berlin Heidelberg), with a title "Cyber Security of Smart Grid Communications: Risk Analysis and Experimental Testing" by G. Dondossola, R. Terruggia.

Furthermore, the **SmartC2Net** paper from 2014 CIGRÉ Session has been selected and published in the June edition of the "CIGRE Science & Engineering" journal, p. 30-39.

Regarding future publications, activities are currently ongoing to prepare materials to be published at Smart Grid Communication Conference 2015 in Miami, FL - US (November 2-5) and at CIGRÉ Session 2016 in Paris - France (August 21-26). For more information, please visit the publications section at the project website (http://smartc2net.eu/publications).

## PARTICIPATION IN EVENTS




### JOINT SUNSEED & SMARTC2NET EVENT

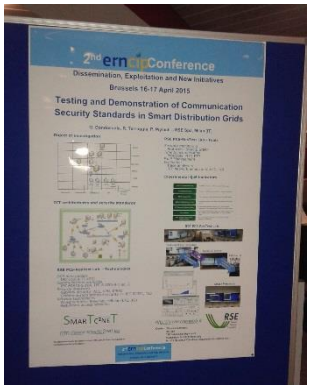
In March, **SmartC2Net** partners participated in a joint workshop with SUNSEED project on "Advanced Control, Communications and Algorithms for the Smart Grid". This event was hosted in Denmark at Aalborg University, were a project was disseminated with power point presentation and poster. For more information, please visit the event webpage available here.


### 2nd ERNCIP CONFERENCE

In April, a poster on "Testing and Demonstration of Communication Security Standards in Active Distribution Grids" was presented at the 2nd ERNCIP Conference held in Brussels.

### SMART GRIDS WEEK 2015

In May, **SmartC2Net** was disseminated at the Smart Grids Week held in Vienna. A poster on "Robustness of Smart Low-Voltage Grids utilizing ICT Awareness and Predictive Planning" was presented. For more information, please visit the event webpage here.




### EDSO for SMART GRIDS MEETING

A dissemination action of **SmartC2Net** outcome towards the European DSO community has been activated. A list of project outcomes has been shared with the EDSO members and a presentation tailored on the most interesting topics as selected by EDSO has been given at the EDSO Technical Committee meeting hosted by CEZ in Prague on May 22, 2015.

### RT15 OPAL-RT EUROPEAN USER FORUM

Also in May, **SmartC2Net** was presented at the RT15 Opal-RT European User Forum held in Barcelona - Spain, with a presentation "Power HIL Model Based Design approach for Intelligent Energy Systems Applications". For more information, please visit the event webpage here.

## EXPERT ADVISORY BOARD 3RD MEETING

The third general EEAB meeting will take place on July 17, in Germany at TU Dortmund University. The main purpose for this meeting is to present and discuss with EEAB members the preliminary assessment results of **SmartC2Net** use-cases and functionalities, to present the dissemination and exploitation activities, to follow-up on project future. The feedback from EEAB is very important for **SmartC2Net** project, allowing to evaluate the directions that the project outcomes should be oriented.

## OTHER DISSEMINATION ACTIVITIES

**SmartC2Net** is in a feed news of Danish magazines and Aalborg University website:

Elektronik & Data
http://elek-data.dk/artikel/power-stroem/nyt-dansk-testlaboratorium-skal-sikre-fremtidens-elforsyning

Energy Supply
http://www.energy-supply.dk/article/view/188506/livagtigt_laboratorium_skal_sikre_fremtidens_elforsyning#.VREce3vRbfc

Alt Om Teknik
http://www.altomteknik.dk/nyheder/2015/03/23/livagtigt-laboratorium-skal-sikre-fremtidens-elforsyning.aspx

AAU local press
http://www.aau.dk/nyheder/alle-nyheder/vis/livagtigt-laboratorium-skal-sikre-fremtidens-elforsyning.cid167125

## TECHNICAL SECTION

### RESULTS FROM VOLTAGE CONTROL

- #### MEDIUM VOLTAGE CONTROL COMMUNICATION SECURITY AND MONITORING TESTBED

The testbed on MEDIUM VOLTAGE CONTROL COMMUNICATION SECURITY AND MONITORING hosted at RSE allows exercising attack processes to voltage control communications in medium voltage grids connecting Distributed Energy Resources (DER) at the aim of measuring their effects on the communication performance and evaluating the mitigation capabilities supported by the Fault Management functionality developed in **SmartC2Net**.

The demonstration specifically allows:

- To show the standard communication flows for baseline voltage control scenarios, with focus on substation-DER communications based on the IEC 61850 protocol, enhanced with the IEC 62351-3 end-to-end security protections, deploying wireless M2M network technologies.
- To show the role of the ICT Monitoring and Fault Management functionalities in mitigating the effects of injected attacks to communications during critical voltage control scenarios, via adaptivity features of the ICT Monitoring and the Control implemented in the SAN model.

During the full demo, the power grid values are displayed by the HMI components and the ICT communications are monitored through dedicated tools based on standard monitoring protocols. Using some specific attack tools it is possible to inject malicious faults and analyse the effects on the control communications. The integration of the Fault Management, achieved by sharing the ICT monitoring data, shows the ability to recognise the performed attacks and the output alerts help to select the most appropriate recovery measures. The ICT monitoring data represent an input also to the SAN models making the next voltage control round adaptive to the values of the QoS indicators.


- **DSO CONTROL FOR ACTIVE DISTRIBUTION GRID TESTBED**

The testbed DSO CONTROL FOR ACTIVE DISTRIBUTION GRID hosted at Aalborg University, focuses on low and medium voltage control. The main specialty of this testbed is that of hardware in the control loop over realistic network, which enables the evaluation of realistic voltage control scenarios under different conditions (communication networks as well as electrical grid).

A preliminary demonstration was provided at the latest review meeting which illustrated energy management control in low and medium voltage grids with several controllable assets. In this demonstration the impact of network performance was illustrated as an issue to obtain high performance control, and thereby the need for additional mechanisms that is under development in the **SmartC2Net**.

Further integration of hardware from the industry is being done, enabling to show later the feasibility of the system under realistic conditions.

For more information, see the website: http://www.et.aau.dk/department/laboratory-facilities/smart-energy-systems-lab/

## BIG DATA FROM CELLULAR NETWORKS: HOW TO ESTIMATE ENERGY DEMAND AT REAL-TIME

### APPROACH

The energy demand forecast is based on the idea that it is possible to estimate how much energy will be consumed in a certain area by means of how many people is dynamically located there in a certain moment. This spatial and temporal information are obtained by aggregating data from cellular network events such as mobile data, voice calls and SMS.

VO divides the whole metropolitan area of Milan in about 2000 areas, called cells, where thousands of events per minute are intercepted by a group of probes, in order to collect them opportunely. Each stored event is identified by its timestamp, the IMSI (*International Mobile Subscriber Identity*) of whom "caused" it (obfuscated to keep safe the privacy of the customer) and the geographical cell where it is occurred.

While this approach to define a compelling model to estimate energy demand is based upon the assumption the events from cellular network describing the dynamic distribution of SIM cards are correlated with real Grid demand, it has been used consumption data from A2A, the main DSO for the city of Milan, covering a limited sector inside the central metropolitan area, split between twelve sections supplying a group of addresses.

Every section is related to a certain substation, which provides energy for the buildings belonging to that section (fig. 1); so, we will refer to these buildings simply as station, distinguishing each one by a primal number. Since energy requests are influenced by the climatic situation around, we decided to introduce additional parameters in this study, such as indexes related to heat (for Celsius degrees above 22 it has been considered the fitter Summer Simmer Index), cloudiness, UV.

*Figure 1. Map of analysed area with energy stations in foreground*

Knowing every station is related to a group of addresses, it needs to understand how much of each cell they occupy to take account of the only relevant percentage of event for this analysis (the events in every cell appear as equally distributed, so in this phase we assume that the same percentage of events can occur in any part of a particular cell).

Cellular events are stored in an Origin-Destination table, a matrix of time and space which describes SIM patterns from a cell to another for a certain observation period ΔT. About the climatic parameters, because of the reduced area in which addresses are close to each other, the whole group of available stations is considered as affected by the same heat/UV index and it is covered by the same cloudy (or not) sky.

Regression functions have been adopted to find statistically significant models able to describe potential correlations between cellular network events and energy consumption. In this context, cellular events grouped in the O/D matrixes introduces above and power consumption data are respectively dependent and independent variable in a univariate analysis. Once verified a notable correlation exists between these two arguments – and it does, since the $R^2$ (a decimal value from 0 to 1 stating how well data fit a statistical model) is greater than 0.5 – we can further proceed adding independent variables referred to climatic indexes to understand whether multivariate models can complement this analysis to provide better results.

The quality of the models identified has been assessed by means of the cross-validation technique to compute the absolute and relative error when estimating the energy consumption.

## RESULTS

Figure 2 shows the dispersion of the energy consumption and the cellular networks events computed in 1h time-window in the area covered by the energy stations for data collected in June 2014 in a period of two weeks specifically chosen for its meteorological variability. The graph suggests the identification of two groups of curves with a similar "electrical" behaviour (substations 1,2,3,8,9 and substations 4,7,11,12): each group has a representative curve that clearly suggests a strong correlation of the data (stations 2 and 11).

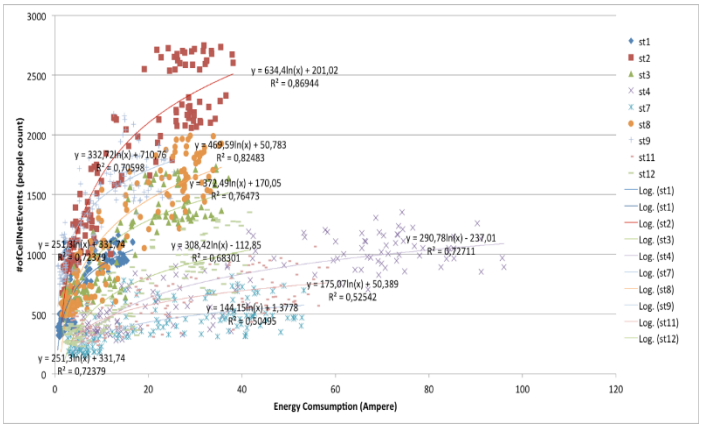



*Figure 2. Dispersion of energy consumption and people stationing around the stations*

With a multivariate regression on each station, including only climatic parameter satisfying a good $R^2$ (in this context we keep heat/SSI and UV indexes in spite of cloudiness one) two of the most representative regression functions belonging to Group 1 and Group2 have an $R^2$ of 0.93 and 0.88 (for station 2 and 11, respectively). It is a very optimistic result.

The cross-validation of the two multivariate models that refer to the aforementioned $R^2$, confirmed the quality of the models, able to estimate the energy consumption with an average relative standard error of 16.42%. Since the relative standard error is less than 25%, the two models can be considered reliable enough for general adoption.

## CONCLUSIONS

The prediction functionality is crucial for DSO long term activity and knowing how reduce its own effort, both hardware and software, lead to greater earnings. One of the further steps will focus in enclosing forecasting into different timeslots, in order to calibrate the time-window of estimation and adapt the analysis to meet correspondent requirements.

The detected models show promising results also to identify different usage categories, such as business, commercial or residential. We studied an urban area where, theoretically, cell events and power consumptions are balanced. Our hypothesis is, in fact, that network event density in this zone is proportionally related to how much energy is used, because we talked about cell with high thickness of domestic buildings, which consumptions are adjusted for little amounts of people but deeply concentrated together.

To enrich our analysis to a more thorough level, we should be able to forecast grid demand also in cases of non-urban areas, for example rural zones, where are located large industrial plants with very massive consumptions despite low people density, therefore less network events.