THEME [ENERGY.2012.7.1.1] Integration of Variable Distributed Resources in Distribution Networks

FINAL REPORT

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1. Publishable Summary

1.2 Executive summary

A large share of the recent renewable energy sources (RES) installed capacity has already taken place in insular electricity grids, since these regions are preferable due to their high RES potential. However, the increasing share of RES in the generation mix of insular power systems presents a big challenge in the efficient management of the insular distribution networks, mainly due to the limited predictability and the high variability of renewable generation, features that make RES plants non-dispatchable, in conjunction with the relevant small size of these networks. In parallel, the Smart Grid initiative, integrating advanced sensing technologies, intelligent control methods and bi-directional communications into the contemporary electricity grid, provides excellent opportunities for energy efficiency improvements and better integration of distributed generation, including RES such as wind and photovoltaic systems, coexisting with centralized generation units within an active network. SINGULAR investigates the effects of large-scale integration of renewables and demand-side management on the planning and operation of insular (non-interconnected) electricity grids, proposing efficient measures, solutions and tools towards the development of a sustainable and smart grid. Different network operation procedures and tools, based on innovative approaches of predictive electricity network operation, developed. A set of electricity network planning procedures and tools has been developed to implement robust insular electricity network planning. The goal is the generation of effective solutions and information so that the integration of insular and highly variable energy resources is maximized. The operation and planning tools and procedures have been applied in different insular electricity grids in five countries across Europe for extensive demonstration, allowing the development of generalized guides of procedures and grid codes specific for future generation of smart insular electricity grids.

SINGULAR involves the following partners:

Part. no.	Participant organisation name	Part. short name	Country
1.	Universidade da Beira Interior	UBI	Portugal
2.	Smartwatt – Energy Services, SA	SMARTWATT	Portugal
3.	Electricidade dos Açores, SA	EDA	Portugal
4.	Aristotelio Panepistimio Thessalonikis	AUTH	Greece
5.	Hellenic Electricity Distribution Network Operator S.A.	HEDNO	Greece
6.	Universidad de Castilla - La Mancha	UCLM	Spain
7.	Instituto Tecnológico de Canarias, S.A.	ITC	Spain
8.	Concepto Sociologico SME	CS	Spain
9.	Politecnico di Torino	POLITO	Italy
10.	Wave for Energy S.r.L.	W4E	Italy
11.	Comune di Pantelleria	PANTELLERIA	Italy
12.	Agenzia Nazionale per le Nuove Tecnologie, L'energia e lo Sviluppo Economico Sostenibile	ENEA	Italy
13.	Alstom Power	ALSTOM	Switzerland
14.	Universitatea Politehnica din Bucuresti	UPB	Romania

15.	Societatea Comerciala de Distributie si Furnizare a Energiei Electrice - Electrica SA	ELECTRICA	Romania
16.	Intelen Services Limited	INTELEN	Cyprus

The activities of SINGULAR are shared between the partners and divided into twelve (12) different workpackages (WPs). SINGULAR is organized in two main phases with distinct Work Packages (WPs). Two additional WPs (WP1 and WP12) are dedicated to the project management and the project dissemination and span the entire duration of SINGULAR. The organization of the phases and the respective WPs is presented in the following:

1st Phase: RES forecasting, Power Analysis, Scheduling & Planning Tools (Work Packages: 2-7)

The first phase of SINGULAR was comprised: a) the development of RES forecasting tools, b) the investigation of EES management methods, c) the development of power analysis tools, d) the development of scheduling tools, e) the development of innovative market design schemes oriented to the introduction of competitiveness in the operation of insular electricity grids, and f) the development of planning procedures and tools for distribution grid development. Hence, this first phase was strongly connected with the technology creation stage, based on advanced and wide-ranging R&D activities developed in Universities, Polytechnic Institutes, and SMEs. Specifically, this phase included the following Work Packages (WPs):

- WP 2: Development of RES Forecasting Tools (M1-M36)
- WP 3: Investigation of EES Management Methods for Insular Networks (M1-M12)
- WP 4: Development of Power Analysis Tools (M1-M12)
- WP 5: Development of Scheduling Tools (M4-M21)
- WP 6: Competitive Operation of Insular Electric Networks (M10-M18)
- WP 7: Planning Procedures and Tools for Distribution Grid Integration (M10-M24)

2nd Phase: DSM, Testing & Validation, Grid Codes, Evaluation & Conclusions (Work Packages: 8-11)

The second phase of SINGULAR comprised: a) the implementation of DSM, b) the testing and validation of the developed models and tools in selected pilot sites, c) the development of grid codes for the connection of RES in insular electricity grids, and e) the evaluation, recommendations and roadmapping of SINGULAR. Hence, this second phase was strongly connected with the demonstration stage, including large-scale production-line demonstrators for validation and market applications in DSOs, Enterprises and SMEs. Specifically, this phase included the following Work Packages (WPs):

- WP 8: Implementation of DSM (M13-M30)
- WP 9: Testing and Validation (M22-M36)
- WP 10: Development of Grid Codes (M28-M33)
- WP 11: Evaluation, Recommendations and Roadmapping (M29-M36)

1.2 Summary description of SiNGULAR context and objectives

SINGULAR provided recommendations as well as scalable and replicable solutions for all regulatory, technical and economic challenges of integrating a very large share of RES in insular electricity grids, while maintaining secure, reliable and high-quality power. Specifically, it focused on the development of:

a) smart insular electricity network operation tools,

b) insular electricity network planning procedures and tools for grid integration, and

c) insular electricity network grid codes for grid connection of DG plants, further explained in the sequel.

Smart insular electricity network operation tools, including the short-term and very short-term forecasting for medium-/small-scale RES, risk management techniques for network failures, the integration of forecast uncertainty in optimal power flows, the state estimation in distribution networks with substantial RES penetration, the optimization of network reconfiguration and scheduling of DG resources, etc., have been thoroughly developed, providing valuable assistance towards the improvement of the distribution network operation.

In all these methodologies and tools, the modeling of risk and uncertainty was the key to successful sustainable grid integration of DG, for both secure operation and economic incentives. In addition, the limited predictability and high variability of RES injection also required higher operational reserves to ensure that the network can operate in a safe, reliable and efficient manner. Thus, special attention has been given to the qualitative and quantitative determination of the required reserves, using innovative stochastic optimization models, so that specific reliability targets are met.

In parallel, the gradual increase of DG in insular electricity grids facilitates the introduction of a competitive market operation. Up to recent years, economies of scale in insular systems, i.e. the large size of the production facilities relative to the size of the market, prevented the introduction of competitive electricity markets in small insular power systems. Nowadays, with the boost of DG and the involvement of new electricity producers, conditions of perfect competition (large number of small-sized producers and consumers) are being formed, which, in turn, may allow the operation of a competitive electricity market in small insular systems. However, since a large portion of the DG has been intermittent and volatile renewables, innovative market designs has been required to cope with the increased uncertainties and associated market risks introduced by the RES. In this context, innovative market design schemes have been examined, especially for the short-term (i.e. day-ahead, intra-day and real-time) market operations in order to cope with the limited predictability and high variability introduced by RES, using frequently revised forecasts, sub-hourly dispatch periods, look-ahead features, and advanced stochastic optimization models and tools.

State-of-the-art and new methods proposed as tools for the efficient, reliable and secure operation of the power system has been implemented in insular electricity grids with increased RES penetration. These methods include:

a) the increasing Electrical Energy Storage (EES), e.g. in the form of hybrid plants (RES plants coexisting with pumped-storage plants),

b) the participation of plug-in electric vehicles, and

c) the aggregation of intermittent and volatile renewable generation with different types of reserves (including also flexible loads, EES and electric vehicles) into a portfolio that collectively behaves reliably as dispatchable thermal generation.

Additionally, control and communication technologies provided the end-users of energy with the ability to manage their electric loads in real-time in response to volatile energy prices. The Distribution System Operator (DSO) needs to manage these demand response opportunities, which are similar to the wholesale sell and buy bids but much more numerous and geographically dispersed. The successful implementation of DSM programs is crucial for the establishment of smart grids in insular electricity networks. In this context, SINGULAR focused on the installation of a specific number of smart metering devices along with their associated IT equipment in order to demonstrate the potential of demand response and resource aggregation.

Regarding the long-term planning horizon, SINGULAR team focused on effective distribution network planning procedures in terms of the geographical assessment for potential DG integration, the optimization of the network expansion and reinforcement, the distribution network flow and contingency analysis, and the economic impact of grid investments. Long-term combined generation and transmission and distribution expansion models have been developed and applied in the project-related insular power systems, in order to derive the overall expansion cost minimization under large-scale RES penetration, increased reserve requirements, demand response programs and with the presence of EES technologies (e.g. hybrid plants, plug-in electric vehicles, etc.). The insular specificities have been evaluated in terms of their economic impact on the overall social welfare in the long- and mid-term.

The RES support mechanisms have been evaluated in terms of (a) their fitting with the existing electricity market design, and (b) their economic impact on native islanders, considering social-driven criteria motivating the permanent residence in these islands.

The presence of DG in distribution networks changes the occurrence of fault currents and harmonic distortion, having an impact on power factors and their direction from the viewpoint of the network's protection system. The protection of DG has been coordinated with the protection of the distribution network and all possible operating conditions considered.

Another issue comes from the operational engineering requirements of the networks where DG is connected, such as the need for managing islanding operation and the characteristics of the protection systems operating at the network interconnection.

The use of DG has a significant impact on the distribution network performance and this emphasises the need for new optimized connection and protection schemes, real-time supervision and operation measures, and remedies for harmonics and other disturbances that could be generated by power electronic interfaces. The respective solutions require active real-time management of DG and loads, considering appropriate coordination with the distribution network operation.

All aforementioned operation and planning tools and procedures have been applied in different insular electricity grids, in combination with DSO’s experience and the distribution network regional context, thus replicable distribution network grid codes specific for the future generation of insular electricity

grids have been provided. These distribution network grid codes addressed critical issues such as the energy quality, DG technology requirements, suitable procedures for the DG units, the network operation and protection, etc.

Since the insular electricity grids are expected to be more dependent on renewables as compared to other electricity networks, the implementation of all these new methodologies, tools, services, guides and grid codes for the efficient operation and planning of insular networks is more challenging than for the interconnected distribution networks, taking into account the variability of renewable generation. However, the outcome of the proposed research in pilot insular networks could be partially extended and generalized for the interconnected networks, as well.

The novel and singular aspect of SINGULAR arises precisely from targeting these insular electricity grids, as occurs in several countries in Europe, such as Portugal (Azores islands), Greece (Crete island), Spain (Canary islands), Italy (Pantelleria island), Malta and Cyprus (themselves island nations). In addition, for an eastern European country, such as Romania, an island is considered in a small region close to the Danube delta (the Great Island of Brăila). Still, this region has different characteristics from the ones of other islands bringing a complementary perspective.

1.3 Description of the main S&T results/foregrounds

1.3.1 WP2 – Development of forecasting tools

Work package objectives:

- Generate meteorological forecast information and gather the needed technical information for construction training and parameterization of the forecasting services.
- Development forecast models for different generation (wind, hydro, PV, wave, geothermal, cogeneration, biomass) and for consumption.
- Deployment of the forecasting systems for the target locations in the multiple islands (São Miguel, Crete, Brăila, La Graciosa, Pantelleria and El Hierro).
- Generating continuous forecasts, for all target locations, for the remaining report period, to stay operational after the end of the project.

Progress towards objectives:

Summary:

- Activities that summarize the progress towards the objectives:
    - Data gathering from DSO information;
    - NWP meteorological forecast service;
    - Research in innovative mathematical models, for different forecast applications;
    - Development of a web platform to share and show online forecasts;
    - Continuous forecast service;
    - Performance evaluation of the forecast models;

  All the objectives have been accomplished:
    - Some pilots have more complete and accurate forecast systems, depending on the data that was available to develop the correspondent forecast system. The most complete and robust forecast systems were implemented for the most significant pilots, São Miguel (Azores) and Crete.
    - Additionally to the initial objectives, an extra pilot have been implemented, the island of El Hierro (Canary Islands, Spain).
    - The service is free and available for all the pilots, providing to the insular DSO a practical continuous contact with new approaches of forecast, with possibility of integration in their power system management process.
    - The probabilistic forecast developments were much more interesting (modeling, results and applications) than what was initially planned in the objectives.
    - The performance of the forecast models is at the best level of the most current state of the art, becoming better than the expected in what was initially planned in the objectives.
    - All milestones and deliverables have been accomplished:

- Report with the state-of-art and model description, with a very high number of downloads (Deliverable 2.1);
- Web platform with all forecast services for all pilots (Deliverable 2.2);
- Performance Analysis of the forecast models, evaluating real measurements and continuous forecast service (Deliverable 2.3).

Progress towards objectives detailed for each task:

Task 2.1: Data gathering for target locations and power variables to be forecasted (M1 – M3)

This task collected a set of information related with the renewable power plants, wind farms, PV plants, small-hydro, wave, geothermal, cogeneration, other. Real time series about the generation and environmental measured variables were collected for one year of historical data, a reference period selected for construction and training the forecast models. For modeling demand side, real time series of consumptions in the substations were collected for the distribution substations or feeders, for the distribution systems selected in the several islands.

Task 2.2: NWP reanalysis for target locations, for an historical period of 1 year (M4 – M6)

Once the target locations and type of forecast needed were defined in Task 2.1, the setup and parameterization of the meteorological forecast (NWP) followed up. The same setup and parameterization ran permanently along all the time of the project. Were also executed every day 4 runs of the forecasts for the next seven (7) days, for all the target locations, for the meteorological variables needed, and with a time resolution of one (1) hour.

Task 2.3: Development of forecast models (M4-M12)

Multiple forecast models were developed in this task, namely:

- Wind farm power forecast, based on Kernel Density Estimator models, designed to forecast the power output of a whole wind farm. Meteorological forecast information (wind speed, wind direction, pressure, temperature, wind gust) was utilized. Different forecast techniques were tested and compared. Models were created to produce forecast uncertainty evaluation (probabilistic and quantile models).
- PV plant power forecasts, based on a mix of analytical solar irradiation model assimilating meteorological forecast. The meteorological forecast (irradiance, temperature, cloud cover, fog was assimilated in the model in order to integrate the meteorological effect in the PV plant generation. The modeling of uncertainties based on quantile regression approach was also implemented.
- Small-hydro power generation, based on a mix of analytical hydrometric models for day forecast. The analytical model uses the meteorological forecast of precipitation to evaluate the daily increase or decay of small-hydro generation. The daily forecast resulting from this model is used as input to predict the hourly power output of the hydro plant.
- Power generation from waves: The analytical models considered here are of two types: wave prediction models and wave energy converter power prediction model. The former aim to predict the incoming wave in a wave farm and it is based on the modeling of the sea dynamics (wind, tide, streams, temperature, etc) on a wide area around the wave farm. The latter uses the output of the former to simulate the control of the plant and predict the power output.

- Independent small thermoelectric generation (cogeneration, biomass and geothermal) forecasts. These forecasts are based in operation strategy; the forecast methodology consisted in capturing of the seasonal and periodic baseline pattern of the plant operation. Time series were used for the implementation of these models.
- Load forecast on distribution substations (active and reactive power). Also KDE and time-series analysis were used to capture the seasonal and cyclic pattern and exceptions. Some meteorological variables (temperature, humidity, cloud cover) were used to adjust the forecast to the meteorological influence factors. These models were designed to be adapted to different types of loads characteristics and sizes.

Task 2.4: Training and parameterization of forecast models (M7-M18)

For each target location, the models were parameterized and trained. In this process, information from Task 2.1 and Task 2.2. was used in the models developed in Task 2.3. This task was done in approximately 6 month, However, it was also done in parallel with Task 2.3, where the earlier developed models would be first trained and parameterized.

Task 2.5: Deployment of forecasting services (M13-M36)

The deployment of the forecasting service included the development of the web service platform and the link with local utility information systems. The system is operational, producing for each target location one (1) hour interval forecasts for a seven (7) days horizon, refreshed four (4) times per day. After the setup of the operation, the forecast system provided forecasts permanently for the rest of the project time and continues providing the service after the end of the project. This continuous stream of forecasts is monitored in order to validate the models, and the forecasts were used in the other WP. This task was coordinated by Smartwatt but the role of the local utilities partners or partners that worked close with the utilities was very important for the usage and test of the service products. The forecasting services were used to evaluate the performance of the models, producing analyses of the forecasts and evaluations of the contribution of the forecast application to the objectives of SiNGULAR.

Significant results:

- State of the art characterization about different RES and load forecast, published in Deliverable 2.1, published in the SiNGULAR Book.
- Data, models and forecast benchmark for different insular locations, available in the web platform.
- Probabilistic forecast and pdf representation for most of the forecast applications.
- Continuous Forecast in the web platform, available at (http://smartwatt.net/SingularWeb/).

Journal Papers

[WP2.1] J.M. Lujano-Rojas, G.J. Osório, J.C.O. Matias, J.P.S. Catalão, "A heuristic methodology to economic dispatch problem incorporating renewable power forecasting error and system reliability", Renewable Energy (ELSEVIER), Vol. 87, pp. 731-743, March 2016. http://dx.doi.org/10.1016/j.renene.2015.11.011

[WP2.2] O. Abedinia, N. Amjady, M. Shafie-khah, J.P.S. Catalão, "Electricity price forecast using combinatorial neural network trained by a new stochastic search method", Energy Conversion and Management (ELSEVIER), Vol. 105, pp. 642-654, November 2015. http://dx.doi.org/10.1016/j.enconman.2015.08.025

[WP2.3] G.J. Osório, J.C.O. Matias, J.P.S. Catalão, "Short-term wind power forecasting using adaptive neuro-fuzzy inference system combined with evolutionary particle swarm optimization, wavelet transform and mutual information", Renewable Energy (ELSEVIER), Vol. 75, pp. 301-307, March 2015. http://dx.doi.org/10.1016/j.renene.2014.09.058

[WP2.4] G.J. Osório, J.C.O. Matias, J.P.S. Catalão, "Electricity prices forecasting by a hybrid evolutionary-adaptive methodology", Energy Conversion and Management (ELSEVIER), Vol. 80, pp. 363-373, April 2014. http://dx.doi.org/10.1016/j.enconman.2014.01.063

Conference Papers

[WP2.5] A. Tascikaraoglu, N.G. Paterakis, J.P.S. Catalão, O. Erdinc, A.G. Bakirtzis, "An EMD-ANN based prediction methodology for DR driven smart household load demand", in: Proceedings of the 18th Intelligent Systems Applications to Power Systems Conference and Debate — ISAP 2015 (technically co-sponsored by IEEE), Porto, Portugal, USB flash drive, September 11-17, 2015. http://dx.doi.org/10.1109/ISAP.2015.7325544

[WP2.6] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "Including forecasting error of renewable generation on the optimal load dispatch", in: Proceedings of the IEEE Power Tech 2015 Conference, Eindhoven, Netherlands, USB flash drive, 29 June - 2 July, 2015. http://dx.doi.org/10.1109/PTC.2015.7232495

[WP2.7] G.J. Osório, J.C.O. Matias, J.P.S. Catalão, "Hybrid evolutionary-adaptive approach to predict electricity prices and wind power in the short-term", in: Proceedings of the 18th Power Systems Computation Conference — PSCC 2014 (technically co-sponsored by IEEE), Wroclaw, Poland, USB flash drive, August 18-22, 2014. http://pscc.ee.ethz.ch/uploads/tx_ethpublications/pscc2014_072_01.pdf

Deviations / Difficulties:

- Several miss performances have been detected, and adjustments with new data and model tunings have been done continuously through the development, but mostly in the last months, due to the validation period. Performance models will improve permanently with new data and updates to the continuous forecast service for the majority of the pilots.
- Renewable systems and real data were not available yet in some pilots (and RES in Pantelleria, and Wind and PV Power in La Graciosa); in these cases were created virtual forecasting models correspondent to virtual Wind farms or virtual PV plant, both with 1 MW of installed capacity.

- Real data was not available to acquire in some pilots, as in PAntelleria and La Graciosa, for some applications; in these cases it was not possible to train and test directly the implemented models. For these situations it was not verified/analyzed the performance of these virtual forecast models.
- For security reasons it was not possible to integrate a direct and online access to the SCADA data: only for Crete it was given fully access to SCADA data, regarding the forecasted RES and load. In these cases that were not fully integrated, when possible, it was used offline data for performance evaluation.

1.3.2 WP3 – Investigation of EES Management methods for Insular networks

Workpackage objectives:

The aim of WP3 is to define and evaluate advanced methods for managing EES with the objective of stabilizing and optimizing insular electricity grids. The proposed EES management methods, for different types of RES integration mix, together with the real-world characteristics of various insular networks, will permit to properly assess the value and benefits of EES for this particular type of system in what regards operational security, reliability, emissions, sustainability and cost effectiveness.

Progress towards objectives:

Summary: The objectives described above were met through working on the Tasks associated to WP3 that are explained below. No issues were identified through completing the following tasks. Regarding Task 3.3 the management methods were test through modelling simulations and were also tested in WP9.

Progress towards objectives detailed for each task:

Task 3.1: Assess and quantify the requirement for the application of EES in insular networks

In task 3.1 the present insular grid code requirements were reviewed. Furthermore, the main constraints imposed by present insular grid codes towards the large-scale integration of RES (e.g. onshore wind and photovoltaic power) were assessed and quantified. In order to make conclusions and recommendations regarding grid codes for storage systems the existing codes from the project pilots were compared to gird codes from countries with high renewable energy penetration like Germany and Demark.

The types of EES were reviewed according to their applications in insular networks and their economic benefits. An assessment of the benefits and drawbacks of each category of EES based (among others) on their storage cycle was also conducted. Also, the requirements of EES in insular networks were determined.

Task 3.2: Define EES management methods for insular networks

For the purposes of Task 3.2 the following work was carried out:

- *Detailed analysis of EES management methods:* Management methods for storage systems were reviewed. The literature review covered a variety of systems and roles of storage within insular networks.

- *Comparison between storage and Demand Side Management (DSM):* The analysis includes a summary of research based participatory schemes on demand side management to improve flexibility features on energy consumption, in comparison with other mechanisms like storage, generation management and grid reinforcement. Based on the information collected DSM was compared to storage in a variety of concepts.
- *Comparison between energy storage and connection with mainland networks:* The connection of island networks to the mainland network is another strategy that could be competing with storage. In order to investigate this case a mathematical model was developed and Crete was used as an example. The interconnection of the Crete Island to the mainland network was assessed as an alternative to the installation of storage, in order to assess the impact on the RES penetration and if even in this case storage systems would still be required.
- *Economic benefits from storage systems in insular networks:* The economic aspects of storage were analysed. For that the cases of La Graciosa and Crete are used as an example. The effect that the installation of storage will have on the systems is shown through calculating the cost of electricity and the investment costs.
- *The role of storage in a cost effective decarburization of the energy sector:* A model was developed with the aim to highlight the fact that the objective of a cost effective CO2 reduction must consider all energy forms, namely electricity, heating & cooling and transportation fuels. These statements are backed up by scenario modelling for simple energy systems with real consumption and weather data (complete year, hour by hour). The role of storage in these scenarios was also highlighted.
- *Development of management methods for insular networks:* Based on the literature review on management methods for insular networks the following management methods were developed for different applications.
  - The first one refers to frequency regulation through batteries and a hybrid system comprised of a battery and a power energy storage (supercapacitor and flywheel). A real-time control strategy was developed, consisting in a first-order low pass filter to smooth the primary frequency control signal to set the Energy Storage (ES) output while the Power Storage (PS) deals with the high frequency signal. The single EES responds to the "raw" frequency signal. Real frequency data from the Island with 1 second resolution (1Hz) was used as input for the implemented primary frequency control strategy.
  - The second management method refers to a hydrogen generation and storage system that uses curtailed wind power. Two scenarios were studied; one where the stored hydrogen is converted back to electricity and in the other it is used for heating purposes.
  - For the island of La Graciosa a management method applies to a Low Voltage system with several micro-generation sources. The objective of the control strategy is to optimize the cost but at the same follow the requirements of the DSO.
  - Based on insular system requirements another management method was developed for coupling a desalination plant with a wind farm and storage. For this case the objective of the

management method is to minimize the cost of the desalinated water by reducing the energy consumed in the desalination processes.

- Finally a management method for bulk energy storage was developed. For this case the objective is to increase the lifetime of the storage system and at the same time increase the penetration of renewable energy to the network. This study also had the objective to calculate the total storage capacity that will have to be installed for the cases of Crete and São Miguel. Two categories of storage, batteries and Pumped Hydro Energy Storage (PHES), were evaluated by the mathematical model developed.

Task 3.3: Test the advanced EES management methods tailored for insular networks

For Task 3.3 the management methods developed for insular networks were tested in the test cases specified. The testing was done through mathematical modelling for which real data for power generation and demand from the project pilots were used.

The optimal sizing and storage cycle type of EES based on the grid code requirements were assessed. Finally, the value and benefits of EES systems for insular networks were assessed and quantified.

Task 3.4: Consolidation of obtained results and provision of recommendations

In Task 3.4 recommendations for updating the existing insular grid codes regarding EES and for incentives towards the development of EES incentives were made.

Significant results:

The above mentioned tasks were successfully completed and incorporated in the deliverables of WP3.

Grid code review and recommendations

Among the main results of this WP are the recommendations that were made for updating the existing grid code requirements in insular networks. After a careful examination of the grid codes that are applied to the project pilots and the grid code requirements in other countries several conclusions were made. The proposed additions to the existing grid codes will assist the implementation of RES in insular networks.

Through an extensive search on grid code requirements it was concluded that even though regulations regarding the quality of the supplied energy exist, specific regulations for EES systems in most countries have not been proposed.

It will be essential for insular networks where the need for storage systems is high, the characteristics of the supplied energy and the function of the aforementioned systems to be well regulated in order to achieve much higher penetration of renewable energy to the network, better regulated power flow and system reliability.

As an outcome of above actions it was recommended that the following should be added to the grid codes of insular networks:

- A detailed definition of EES systems of all scales (include smaller scale systems that can be used in smaller networks)
- Provisions for the quality of the power provided by EES systems
- Information regarding the ramp rate, minimum operation hours and minimum production of EES

- A scheduling plan that will also include both Hybrid Power Plants (HPP) and EES
- Regulation regarding harmonics
- Regulation regarding droop characteristics for the regulation of frequency and voltage
- Provisions regarding safety regulations, system protection, monitoring and information exchange

Another significant result of WP3 is the review of the current EES management methods. These were assessed based on their suitability for insular networks and recommendations regarding the specific requirements of the project pilots were made.

Value of storage systems

The work done in WP3 showed the value of storage and the benefits that storage can have when deployed in insular systems. Based on the more generic approach that was followed at the model developed for the decarburization of the energy sector, it was shown that the cost and emission optimal solution space, the Pareto frontier, is pushed towards lower costs and emissions when a complete energy system is considered. Furthermore, it was shown that when electric and thermal energy storage is included in the system a more cost effective reduction can be achieved (Figure 1).

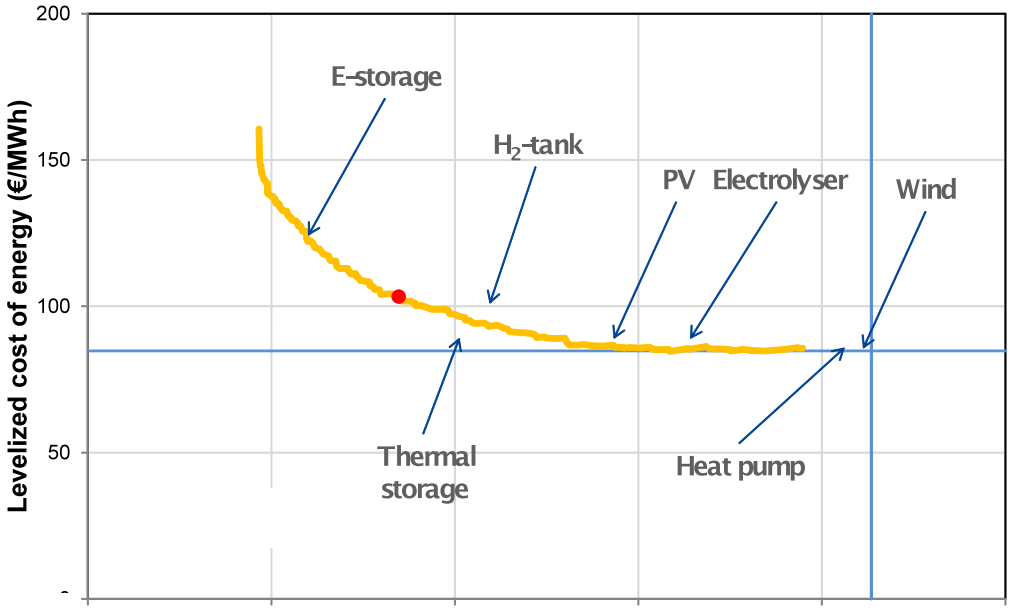

Figure 1: Pareto frontiers for electricity, heating and transportation fuel (hydrogen)

The value of storage and the impact of introducing bulk energy storage to an insular network were also shown. By using data from the island of Crete, and by assuming a five (5) hour storage system, it was shown that when storage is introduced in the system and for a certain percentage of renewable energy penetration to the network the levelized cost of electricity can be reduced.

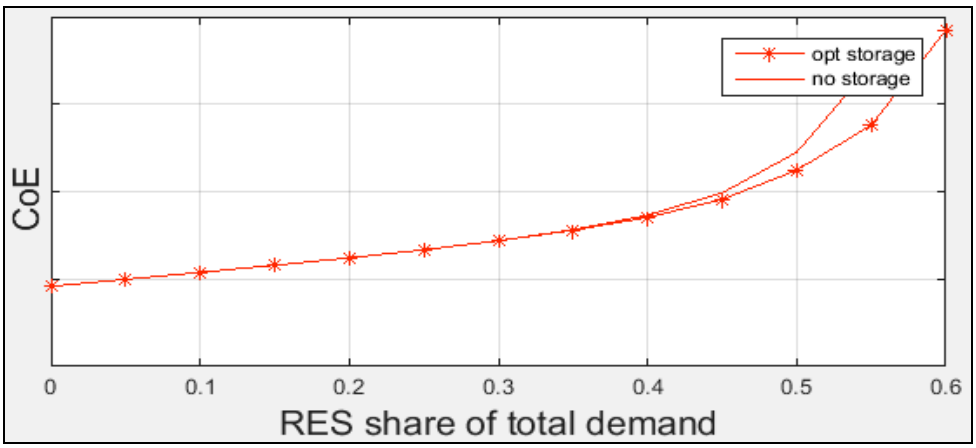

Figure 2: Comparison for CAPEX for the system with and without storage for 5 hrs storage discharge

For the case of La Graciosa a similar result was obtained. In this case PV power is used instead of wind and again when the RES is over a threshold storage becomes economical. The following chart (figure 3) shows the LCoE for different RES penetration to cover the energy needs of the island and the optimal topology for each case.

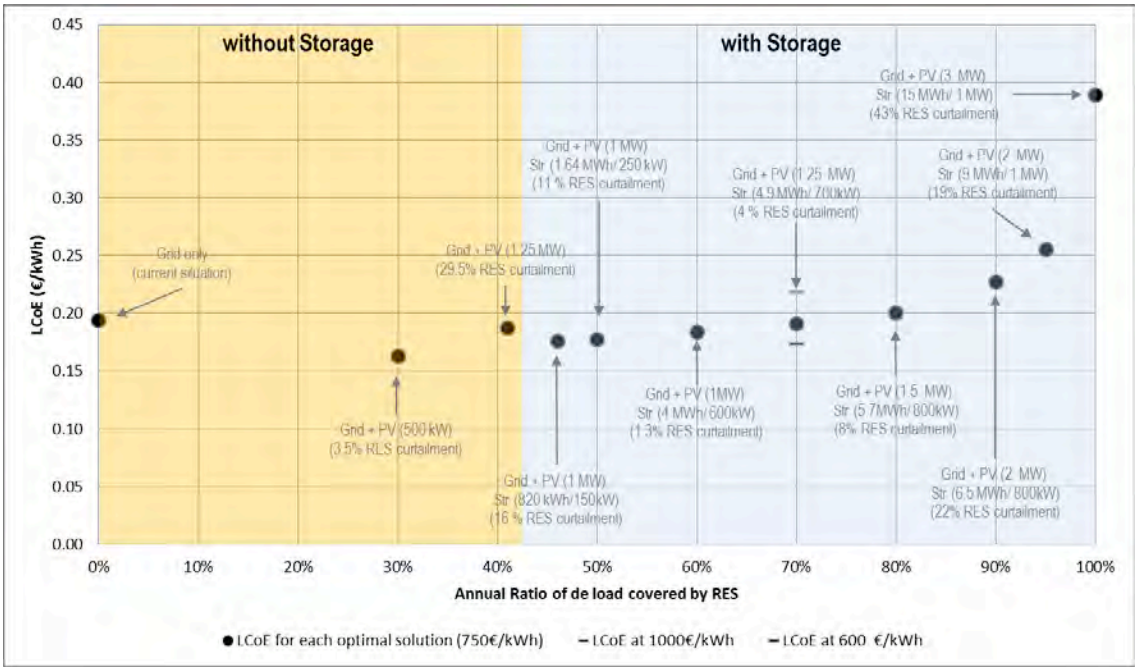

Figure 3: LCoE for different RES penetration with and without storage, comparing the optimal solution for each case

Examining Figure 3, we can compare in terms of LCoE the implementation of RES based in solar energy with or without storage. The current situation is showed at first point at left (0% of RES: 0.194 €/kWh). As solar energy is installed in La Graciosa the LCoE starts to decrease until the excess of RES is excessive. At this moment (46% or RES penetration) Storage is a feasible option until 70% of RES penetration. At 70%, a sensitivity analysis is showed in function of storage investments costs (from 600 €/kWh to 1000 €/kWh).

Management methods for storage systems in insular networks

Regarding the developed management methods for the energy storage systems the key findings were:

For the community storage system where storage is located at a low voltage network the objective of the management method was to:

- Reduce the global cost of the energy consumed by the community
- Send to Grid operator the forecast of the energy flow through PCC and the Energy and Power available in the battery during the next hours.
- Receive orders from the Grid Operator in case of emergency
- Ensure that the energy flow through the PCC is within the range of the forecasted value.

The cost benefits from this method were seen in Figure 3.

Regarding the case of an EES supporting insular networks the pilots of Crete and S. Miguel are used. For these two examples a BESS (Battery Energy Storage System) and a PHES system were modelled and implemented and the energy stored during the operation of the systems was shown. It is obvious that the systems would benefit from the implementation of storage by integrating more energy produced by renewable sources. One of the main conclusions of this task was the charging sensitivity analysis that was performed for the BESS. Initially the model was set to charge the battery at all points satisfying the condition 'generated energy > demand'. It is well known though that charging cycles reduce the life of the battery it is important to consider whether, under certain circumstances, the battery does not require charging. If the amount of excess power generated over the demand is minimal it may be more beneficial to the battery system to ignore the additional power and reduce the number of charging cycles performed. Analysis was performed to assess this assumption and consider whether increasing the criteria to only charge the battery when generating a set percentage over the demand would assist in reducing the cycle count and improving the battery life.

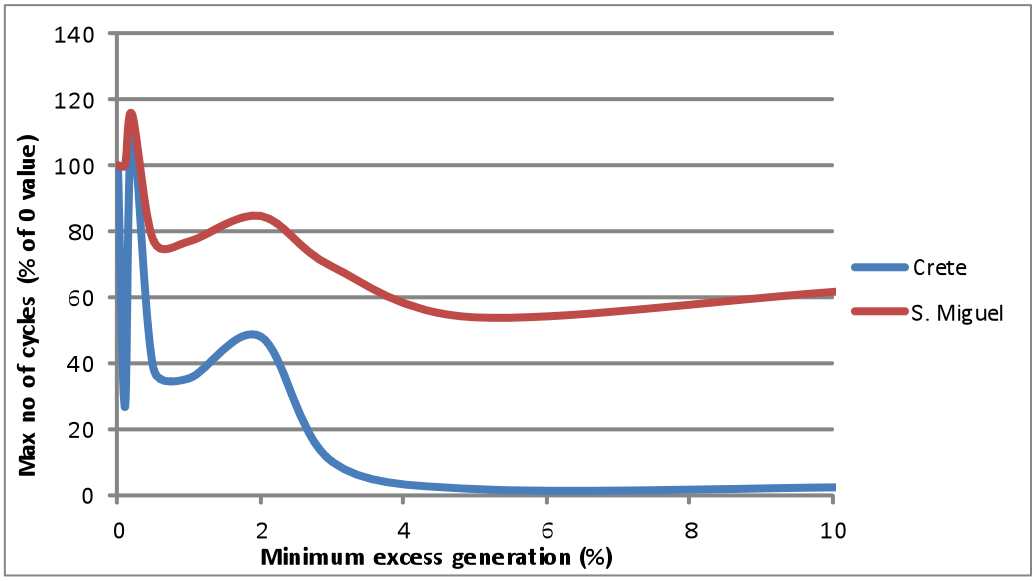

Figure 4: Maximum number of cycles per cell. Charging only when generation is a set percentage above demand

In Figure 4 it is shown that the implementation of a very small excess on the charging criteria greatly reduces the number of cycles performed and thus greatly improves the battery life. Overall, a

compromise is made, suggesting the most efficient excess criteria to be around 4% for the two cases that were studied.

Regarding the use of energy storage for frequency regulation and based on the mathematical model developed, it was found that a hybrid system, battery combined with a supercapacitor or flywheel, will be preferred to a stand-alone energy storage device. The developed management method for the hybrid system resulted in higher system availability, longer lifetime for the battery and the total energy provided by the system was increased when compared to a standalone battery. In Figure 5 the applied management method is presented; the battery of the hybrid system has a much smoother output and the system is responding to all frequency fluctuations.

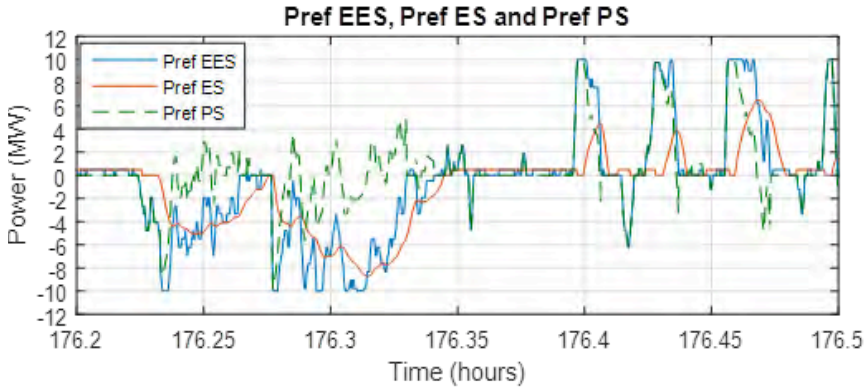

Figure 5: Output of a standalone storage system (EES) and of a hybrid system comprised of a battery (ES) and a flywheel (PS)

The second management method developed was for a hydrogen generation and utilisation system. The outcome of this study was that the use of curtailed renewable energy for the production of hydrogen can be feasible especially in the case when the produced hydrogen is used as a fuel for transportation or heating. This method can be seen as an alternative approach and as an indirect storage of curtailed renewable energy. The results are shown in Figure 6.

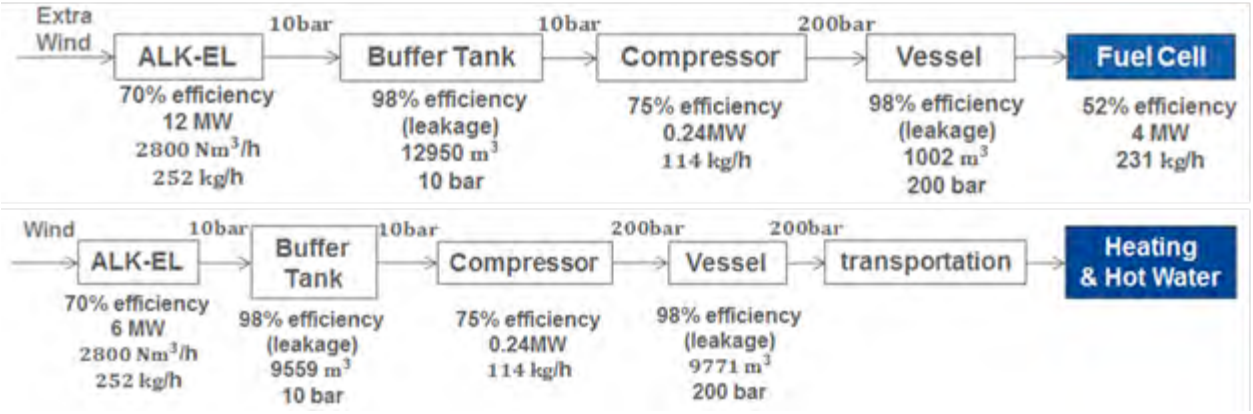

Figure 6: Process schematic of H2 scenarios under consideration

The developed cost model demonstrated some first cost results for the scenarios described above (Figure 6). The initial capital investment for a system described under scenario 1 is around 57 m€ and the levelized cost of H2 is 12.41€/kg whereas the electricity price is 0.75 €/kWh. The second scenario

has a higher capital investment of around 76 m€ excluding the hydrogen burner and the transportation cost and a similar cost of H2 of 12.14 €/kg and the heat price is 0.36 €/kWh.

Storage compared to other options

Finally two competing solutions to storage were analysed. Regarding the assessment of DMS, it was concluded that storage and DSM can serve the same purpose but they can also be combined.

Regarding the connection of island networks to the mainland, it was concluded that storage can allow higher renewable energy integration. The interconnection of the island to the mainland grid, via HVDC transmission lines, has been an active area of research aiming to better explore the renewable energy resource of Crete. In this work, minimal operational constraints for the Crete network are established and maximum renewable energy penetration limits are estimated for different load conditions with and without HVDC interconnection. The operational constraints of the Crete power system are based on the minimum primary reserve requirements to support maximum infeed losses and to limit the Frequency Rate of Change (FRoC) in all load conditions. Based on the defined constraints, the minimum capacity in MW of power plants operating in Crete should not be less than 60% of the peak load. The total amount of RES energy (GWh) that can be integrated into the electrical network will strongly depend on how flexible the conventional power plants can operate, increased operational range and inertia constants are two critical parameters to allow higher RES shares.

Different solutions aiming to allow higher RES shares in the island were analysed, namely: the solution of connecting the island with one or two 350MW HVDC cables to the mainland, increase the flexibility of the operating conventional power plants and include energy storage systems to supply a percentage of the required primary control reserve.

During low demand periods, between midnight and 6 am, the network is operating almost in its minimal operating limit (minimum load of conventional power plants) without flexibility to allow higher shares of RES. Substantial new renewable energy can be integrated on Crete with small to moderate increase in the flexibility of the running conventional power plants or adding storage systems, without the need for HVDC interconnection.

Based on this analysis we estimated that storage systems providing 30% of the required primary reserve of the network, storage capacity between 6 to 10MW, and a 10% reduction in the minimum operational set point (min. load) of the conventional power plants would allow higher RES shares than a one cable 350MW HVDC transmission solution. 20% reduction in the minimum load of the operating conventional power plants, and the aforementioned storage system, would permit the same RES penetration than the two cables HVDC transmission system.

Applications and role of storage

Finally, the future applications of storage systems were assessed during WP3. The main conclusion from this literature search was that storage systems have various benefits and applications at different voltage levels and different locations within a power network. There are plenty of opportunities for storage systems in all voltage levels of the distribution network to support higher shares of RES integration, to optimize the assets of customers and the utilization of the electrical network infrastructure. In the near future local policy, regulations and market conditions are still going to be key factors for the deployment of energy storage systems.

In the low voltage level, energy storage systems are expected to play an important role. They can allow higher integration of distributed generation at the existing infrastructure, support the system voltage stability, mitigate concerns related to multidirectional power flow and increase the supply reliability by providing UPS services to customers and/or provide ways for the DSO to reduce the duration of shortages.

At the medium voltage, multi-directional power flow is expected, and, again, the protection system coordination and voltage stability are key issues to be addressed. Energy store systems can support the stability of the network providing ancillary services, as voltage regulation, and smooth RES variability, that should reduce voltage instabilities. Medium voltage costumers can take the advantage of storage systems capabilities to support the network to make their business more profitable – providing demand side response and other ancillary services. While, at the same time, reducing their energy costs and increasing the supply reliability.

Significant costs and loss of production can be avoided by guaranteeing the security and quality of the electricity supply for industrial customers, at the high voltage level. Energy storage systems have already been applied in several sectors to mitigate these issues. There are a strong trend to increase the integration of energy storage systems, CHP and distributed generation to optimize the industrial resources, reduce the electricity costs while increasing the supply security and quality.

Deliverables D1, D2 and D3 were submitted on time with a short delay on the submission of D2.

Journal papers:

[WP3.1] E. Heydarian-Forushani, M.E.H. Golshan, M. Shafie-khah, J.P.S. Catalão, "Robust scheduling of variable wind generation by coordination of bulk energy storages and demand response", Energy Conversion and Management (ELSEVIER), Vol. 106, pp. 941-950, December 2015. http://dx.doi.org/10.1016/j.enconman.2015.09.074

[WP3.2] E.M.G. Rodrigues, G.J. Osório, R. Godina, A.W. Bizuayehu, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "Modelling and sizing of NaS (sodium sulfur) battery energy storage system for extending wind power performance in Crete island", Energy (ELSEVIER), Vol. 90, pp. 1606-1617, October 2015. http://dx.doi.org/10.1016/j.energy.2015.06.116

[WP3.3] G.J. Osório, E.M.G. Rodrigues, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "New control strategy for the weekly scheduling of insular power systems with a battery energy storage system", Applied Energy (ELSEVIER), Vol. 154, pp. 459-470, September 2015. http://dx.doi.org/10.1016/j.apenergy.2015.05.048

[WP3.4] E.M.G. Rodrigues, R. Godina, S.F. Santos, A.W. Bizuayehu, J. Contreras, J.P.S. Catalão, "Energy storage systems supporting increased penetration of renewables in islanded systems", Energy (ELSEVIER), Vol. 75, pp. 265-280, October 2014. http://dx.doi.org/10.1016/j.energy.2014.07.072

Conference papers:

[WP3.5] A.A.S. de la Nieta, T.A.M. Tavares, J.P.S. Catalão, J. Contreras, "Optimal coordinated wind and generic storage system bidding in electricity markets", in: Proceedings of the 25th Australasian Universities Power Engineering Conference — AUPEC 2015

(technically co-sponsored by IEEE), Wollongong, Australia, USB flash drive, 27-30 September, 2015. http://dx.doi.org/10.1109/AUPEC.2015.7324854

[WP3.6] E.M.G. Rodrigues, R. Godina, G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "Comparison of battery models for energy storage applications on insular grids", in: Proceedings of the 25th Australasian Universities Power Engineering Conference — AUPEC 2015 (technically co-sponsored by IEEE), Wollongong, Australia, USB flash drive, 27-30 September, 2015. http://dx.doi.org/10.1109/AUPEC.2015.7324861

[WP3.7] E.M.G. Rodrigues, R. Godina, G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "Assessing lead-acid battery design parameters for energy storage applications on insular grids: a case study of Crete and São Miguel islands", in: Proceedings of the IEEE Region 8 International Conference on Computer as a Tool — EUROCON 2015, Salamanca, Spain, USB flash drive, 8-11 September, 2015. http://dx.doi.org/10.1109/EUROCON.2015.7313797

[WP3.8] E. Heydarian-Forushani, M.E.H. Golshan, M. Shafie-khah, J.P.S. Catalão, "Optimal coordination of battery energy storages and demand response programs with application to wind integration", in: Proceedings of the IEEE International Conference on Smart Energy Grid Engineering — SEGE'15, Oshawa, Canada, USB flash drive, August 17-19, 2015. http://dx.doi.org/10.1109/SEGE.2015.7324594

[WP3.9] E.M.G. Rodrigues, G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "New schedule management approach of energy storage system in insular power system", in: Proceedings of the IEEE International Conference on Smart Energy Grid Engineering — SEGE'15, Oshawa, Canada, USB flash drive, August 17-19, 2015. http://dx.doi.org/10.1109/SEGE.2015.7324577

[WP3.10] A.A.S. de la Nieta, T.A.M. Tavares, R.F.M. Martins, J.C.O. Matias, J.P.S. Catalão, J. Contreras, "Optimal generic energy storage system offering in day-ahead electricity markets", in: Proceedings of the IEEE Power Tech 2015 Conference, Eindhoven, Netherlands, USB flash drive, 29 June - 2 July, 2015. http://dx.doi.org/10.1109/PTC.2015.7232441

[WP3.11] E.M.G. Rodrigues, G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "An innovative technique for energy storage system management based on vanadium redox batteries", in: Proceedings of the 5th International Conference on Power Engineering, Energy and Electrical Drives — PowerEng 2015 (technically co-sponsored by IEEE), Riga, Latvia, USB flash drive, May 11-13, 2015. http://dx.doi.org/10.1109/PowerEng.2015.7266373

[WP3.12] E.M.G. Rodrigues, C.A.S. Fernandes, R. Godina, A.W. Bizuayehu, J.P.S. Catalão, "NaS battery storage system modeling and sizing for extending wind farms performance in Crete", in: Proceedings of the 24th Australasian Universities Power Engineering Conference — AUPEC 2014 (technically co-sponsored by IEEE), Perth, Australia, USB flash drive, 28 September - 1 October, 2014. http://dx.doi.org/10.1109/AUPEC.2014.6966547

[WP3.13] A.A.S. de la Nieta López, J. Contreras, J.P.S. Catalão, "Short-term effects of optimal wind-pumped hydro storage energy offers in day-ahead electricity markets", in: Proceedings of the 20th Conference of the International Federation of Operational Research Societies — IFORS 2014, Barcelona, Spain, USB flash drive, 13-18 July, 2014. http://www.euro-online.org/conf/ifors2014/treat_abstract?paperid=13980

[WP3/14] P. Medina, A.W. Bizuayehu, J.P.S. Catalão, E.M.G. Rodrigues, J. Contreras, "Electrical energy storage systems: technologies' state-of-the-art, techno-economic benefits and applications analysis", in: Proceedings of the 47th Hawaii International Conference on System Sciences — HICSS 2014 (technically co-sponsored by IEEE), Big Island, Hawaii, USA, USB flash drive, January 6-9, 2014. http://dx.doi.org/10.1109/HICSS.2014.290

1.3.3 WP4 – Development of power analysis tools

Workpackage objectives:

The objectives of WP4 are the following:

- Definition of the data structures and models of the power and distribution system components.
- Development, testing and validation of the computational tools for power flow and fault calculations, market-based security assessment, reliability and power quality assessment.
- Preparation of the documentation to assist the application of the computational tools in the development of analysis and optimization tools in other WPs.

Progress towards objectives:

Summary: The objectives have been reached in the first period of evaluation. All the WP4 Deliverables have been reviewed and approved in the first review meeting. During the second period of evaluation, the activity has been carried out concerning the publications referring to the WP4 topics. The review process of some papers has been relatively long for some contributions, also requiring in some cases to revise the writing in order to respond to the Reviewers' comments and remarks.

Progress towards objectives detailed for each task:

Task 1: Data structures and models of the power and distribution system components

Achievements made with reference to planned objectives: The data structures for power flow calculations have been prepared with reference to the implementation of power flow calculations with time interval data. The modelling framework has been established on the basis of a literature review of the state-of-the-art and of the partners' experience for most of the components, in such a way to provide the input data for the power flow calculations. The activity has resulted in preparing the data for the implementation of the new tool called DERMAT (Distributed Energy Resource calculations with MATlab®), developed in WP4 to cover different aspects of the power system analysis, in particular for steady-state analysis. The DERMAT tool has been developed with the intention to be used in the project, with flexible routines coded in such a way to be usable in other procedures. The

inputs and outputs are managed through data files of text type with predefined formats. The details of data structures have been included since the beginning in the specific DERMAT Users' Guide.

A unified framework has been constructed to introduce the active power patterns (and for the models with non-controllable voltage/reactive power also the reactive power at the node) at the relevant node of the network. The information on the power patterns are determined from a pre-processing phase with respect to the power flow calculations with time interval data. The environmental data on wind and solar irradiance have been gathered from the available sources, using consistent modelling with respect to what indicated in WP2 (with Beta probability distributions), as well as an extended model taking into account the correlations among the probability distributions. A novel function has been developed to handle data inputs at different time steps and representation (e.g., regular or irregular in time) and obtain a regular pattern to be processed from the power flow solver within the user-defined time period; the results are published in [WP4.17]. Dedicated models have been formulated and applied for different types of system components.

The aggregate residential load has been characterized by resorting to a probabilistic approach based on load variations [WP4.10]. The approach has been extended to the direct generation of aggregate residential load patterns, with a novel procedure that takes into account their coupling in time [WP4.8]; this procedure is suitable to construct a set of aggregate residential load patterns to be used in scenario studies. The generation of load patterns for scenario studies has been also addressed in [WP4.11] by resorting to artificial neural networks. A further contribution [WP4.9] has addressed the determination of the time intervals in which the aggregate residential demand is more flexible as a whole.

Advanced modelling of renewable energy sources has been addressed, by formulating an energy conversion model for photovoltaic (PV) systems [WP4.1], based on the environmental predictions already compared with experimental results [WP4.2]. In the representation of solar irradiance measurements data, used in evaluations referring to the operation of PV systems, the presence of irradiance spikes depending on the "broken clouds" phenomenon has been found to be relevant on 1-min scale, becoming smoothed on 15-min scale. The results from [WP4.2] also show that the application of the PV system model developed in the paper (comparing the experimental measurements with the power output coming from the model) may provide useful information for the fault diagnosis of a portion of a PV array. In [WP4.3], solar irradiance profiles have been normalized in time and amplitude, in order to avoid the differences caused by the evolution of the Sun in the different days of the year. The bi-normalization procedure produces comparable normalized patterns for the various type of days of the year. The normalized patterns have been subject to clustering in order to obtain a meaningful grouping of similar days.

A comprehensive approach has been used to address the sea wave energy production, passing from the characteristics of the sea waves to the electrical power production, also taking into account different forms of storage inside the specific Inertial Sea Wave Energy Converter (ISWEC) installed in the island of Pantelleria (Italy) before the end of the project. After initial testing as hardware-in-the-loop [WP4.4], a model using wave forecasts [WP4.7] has been developed and used for dynamic simulations [WP4.6] as well as for analysing the effects of faults in the case of grid connection through inverters

[WP4.5]. Specific modelling has been developed for multi-energy systems [WP4.12], demand response [WP4.15] also in a multi-energy context [WP4.13], and storage [WP4.14].

Task 2: Power flow and fault analysis tools

Achievements made with reference to planned objectives: the routines included in the tool can handle the deterministic and probabilistic load flow considering all the possible network structure (i.e., radial, weakly meshed and meshed), fault currents and voltage dips calculation. The DERMAT tool has been structured with the possibility of creating links with external Matlab modules calculating the active and reactive power patterns of generators and loads by using specific information (on the technologies and on ambient variables) and models. Furthermore, lately a harmonic probabilistic power flow has also been included. In all the calculations, the correlations among loads and generation can be taken into account.

The DERMAT tool has been implemented in the base Matlab® language (the Statistics toolbox is needed only for the probabilistic power flow calculations) and without preparing dedicated graphical interfaces, in order to be more easily portable to be integrated in other tools. The power flow calculation methods supported include: (i) Backward/Forward Sweep (BFS) for radial networks, (ii) BFS for weakly meshed networks, and (iii) full Newton-Raphson AC power flow for meshed networks.

The probabilistic power flow takes into account correlations among the random variables [WP4.16]. From the power flow results, the short circuit currents at the nodes (for three-phase, phase-to-phase and phase-to-earth faults) are computed. All the power flow calculations are carried out sequentially at different time periods. Specific features are introduced in the computational modules to represent the interface with the grid through different types of connections (with transformers or converters) including the steady-state voltage control capabilities. The results of the fault analysis are also used to provide the basic information for the power quality modules used in Deliverable D4.3 (voltage dip analysis, integrated in DERMAT).

Task 3: Security assessment tools

Achievements made with reference to planned objectives: some changes to the original schedule have been introduced in this Task (see section 1.4 for details). The initial “market-based” view of the security assessment tools has been reformulated without considering the effect of competitive markets in the islands [WP4.20]. Within this framework, a specific module has been set up to perform N-1 contingency analysis in an optimal power flow (OPF) of a distribution network minimizing resistive losses and considering embedded generation. The formulation of the OPF takes into account the interconnection switches in the service restoration process. In the mathematical formulation, the system is modelled through linear expressions transforming the Non-Linear Problem into a Mixed-Integer Linear Problem (MILP). It includes binary variables to represent switches, which can be opened or closed depending on the context [WP4.18]. Moreover, the system maintains radiality through different switching combinations. The MILP model has been used to study islanding conditions in a network containing wind power and storage [WP4.19]. For a system containing a synchronous generator, a local generation connected to the grid through an inverter and some loads, the contribution of the inverter to the short circuit current during a fault in the network has been simulated. The Low Voltage Fault Ride Through (LVFRT) capability has been assessed for this model

by considering the possibility of the local system supplied by a power converter to remain connected during short circuit faults.

Dynamic analysis for weak networks has been reviewed in [WP4.30], and then has been addressed by resorting to a novel type of solver to address dynamic calculations, based on the Torelli's control box (TCB) [WP4.29]. The general concept of TCB is that a mathematical programming problem can be formulated by using a set of differential equations, with the solution of the problem reached at the equilibrium point. If the solution satisfies suitable properties (from Lyapunov conditions) and belongs to the region of attraction of the initial conditions, it can be guaranteed that the solution point is reached, determining the solution point through the convergence of an artificial dynamic model. The use of the TCB approach enables the user avoiding the drawbacks of some numerical algorithms that could fail to converge because of high non-linearity of the first-order conditions. The TCB approach has been also used to construct a new type of solver for distribution network optimal reconfiguration [WP4.31].

On the control point of view, a key result has been obtained by the development of an advanced control technique for inverter-interfaced generation behaving as a Virtual Synchronous Generator (VSG), whose simulated behaviour has led to promising results [WP4.24]. In [WP4.25] a Direct Lyapunov control technique is applied to enable continuous injection of the maximum active power at the fundamental frequency from the local generation source to the power grid, compensating the reactive power and harmonic current components of the grid-connected loads. The method has been applied in [WP4.27] by addressing the DC-voltage variations at the DC-side of the interfacing system. In [WP4.26] the passivity-based control technique is considered to analyse the dynamic and steady-state behaviours of local generation units during grid integration and power sharing with loads. The compensation of instantaneous variations in the reference current components of the local generation units at the AC-side, and DC-link voltage variations at the DC-side of the grid-interface converters, are considered in the control loop of DG units, which is the main contribution and novelty of this control technique over other control strategies.

Task 4: Reliability and power quality assessment tools

Achievements made with reference to planned objectives:

A number of tools have been implemented in order to address reliability, power quality and security assessment aspects. The specific features of the tools implemented for reliability analysis are the possibility of determining the distribution system reliability indices in deterministic and probabilistic frameworks [WP4.23], and the possibility of incorporating the calculation of the reliability costs in the reliability study. Reliability objectives have been considered in a multi-objective optimization framework applied to distribution systems, solved with the powerful ε-constrained numerical technique [WP4.22]. A refined version of this technique has been presented in [WP4.21].

For power quality analysis, the harmonic power flow has been integrated in the DERMAT tool, also developing a probabilistic harmonic power flow version [WP4.33]. Power quality has been addressed by calculating the related indices for different distribution systems structures with distributed generation. Likewise, voltage dip analysis has been integrated in DERMAT through the calculation of the voltage dip matrices starting from the results of the short circuit calculations.

Moreover, the possibility of addressing multiple measurements of voltage and current waveforms from three-phase systems to calculate the relevant indicators for harmonics and interharmonics, as well as combined indicators of harmonic/interharmonic distortion and unbalance, have been implemented in the new tool WUDIS (Waveform Unbalance and DIStortion), calculating the waveform distortion and unbalance indicators in unbalanced systems operating under waveform distortion. The WUDIS tool allows for the elaboration of the field measurements starting from an input text (.TXT) file with two alternative data formats (1: time, voltage at phase 1, currents at the three phases; 2: time, voltage at the 3 phases, currents at the 3 phases). Furthermore, there is the possibility of elaborating multiple data gathered at successive time intervals during a measurement campaign on the field (e.g., sequences of 10-periods data gathered each 15 min). The indicators calculated take into account the simultaneous presence of harmonic/interharmonic distortion and network unbalance, and include harmonic distortion indicators (for harmonic groups and subgroups), interharmonics indicators (for interharmonic groups), network unbalance indicators (evaluated for the phase currents and for the neutral current). The WUDIS tool has been applied to data coming from a PV system operating in variable sky conditions, including partial shading [WP4.32]. On the same PV system, the presence of supraharmonics due to the operation of the grid connecting inverters has been studied by using experimental results [WP4.34]. Finally, active filtering for eliminating harmonics in the distribution networks has been addressed by indicating a specific control strategy for the interconnecting converters [WP4.35].

Significant results:

The main results can be summarized into:

- Implementation of the tool DERMAT (power flow/short circuit/harmonic analysis with uncertainties)
- Implementation of Optimal Power Flow (OPF) for distribution systems
- Analysis of Inertial Sea Wave Energy Converter (ISWEC)
- Detailed characterization of photovoltaic (PV) systems
- Implementation of the tool WUDIS (harmonic analysis)
- New control technique applied to a Virtual Synchronous Generator (VSG)
- Network reconfiguration and dynamic analysis with the Torelli's Control Box (TCB)
- Scientific publications in international journals and conference proceedings

DERMAT

Formulation and implementation of the software tool DERMAT, operating in a multi-slack framework with multiple executions in a given time frame at user-defined time steps. The implementation has been designed to be open for the integration of further modules (with possible update of the internal code), with specific innovations on:

- Treatment of the data input from information gathered at different time steps.
- Handling data uncertainty from correlated probability distributions.
- Automatic selection of the solver on the basis of the network data.

- Calculation of the probabilistic harmonic power flow in a time interval.

OPF

Implementation of distribution system Optimal Power Flow (OPF), with specific innovations on:

- Study of the conditions for N-1 contingency analysis in an optimal power flow (OPF) of a distribution network minimizing resistive losses and considering embedded generation.
- The formulation of the OPF takes into account the interconnection switches in the service restoration process.
- In the mathematical formulation, the system is modelled through linear expressions transforming the Non-Linear Problem into a Mixed-Integer Linear Problem (MILP). It includes binary variables to represent switches, which can be opened or closed depending on the context.
- The system maintains radial configurations through different switching combinations.

ISWEC

Analysis of the Inertial Sea Wave Energy Converter (ISWEC) on the basis of the design data of a real prototype, with specific innovations on:

- Estimation of the ISWEC performance starting from the sea waves characterization, to produce wave height patterns and determine the power output and the productivity in a given time period.
- Analysis of the power transfer scheme inside ISWEC, also taking into account internal storage (flywheel, batteries and ultracapacitors).
- Study of the power output with the impact of the internal storage on decoupling the generated power from the power delivered to the grid, smoothing the power output and provide constant power to the grid in some time intervals, to delay and condition the variation of the delivered power level in order to make it more predictable.
- Analysis of the ISWEC connection to the grid, including short-circuit assessment for internal and external faults.

PV

Detailed characterization of PV system modelling, with specific innovations on:

- Detailed model of PV conversion from solar irradiance to AC power output and comparison among measurements and short/term predictions.
- Representation of solar irradiance data in a bi-normalized way to identify similarities among the days of the year through clustering procedures.
- The PV model is useful also for diagnosis purposes, enabling the operators discovering failures in the PV system when discrepancies between PV power measurements and simulations are found.

WUDIS

Implementation of the harmonic analysis tool WUDIS (Waveform Unbalance and DIStortion), with specific innovations on:

- Implementation of the tool for calculation of the harmonic distortion and unbalance indicators (based on the symmetrical component transformation) from on-site measurements processed through a data acquisition system.

- Extension of the harmonic distortion indicators to unbalanced networks and of unbalance indicators to the systems with distorted waveforms, with application to photovoltaic systems characterized by their structural unbalance and unbalance from partial shading.

VSG

Development and simulation of an advanced control technique for inverter-interfaced generation behaving as a Virtual Synchronous Generator (VSG), with specific innovations on:

- Detailed voltage control loop with modelling of inverter capability and non-idealness of the inverter (losses).
- Set up of the reference voltage in order to guarantee good transient response in normal conditions.
- Dedicated inverter protection scheme to allow appropriate fault ride-through capability.

TCB

Proofs of concept and solutions of dedicated problems of network reconfiguration and dynamic analysis with the TCB, with specific innovations on:

- Solution of distribution system reconfiguration with minimization of the network losses.
- Solution of the dynamic equations for distribution networks.
- Dynamic calculations on weak distribution networks.

Publications

The publications totally or mainly containing WP4 results include 1 book chapter, 13 articles in International journals (of which 3 published in open access mode), and 21 articles appearing in International Conference Proceedings. The list of papers is reported below, partitioned into similar topics. Journal papers and the book chapter are highlighted in bold. Some papers refer to more than one WP and are reported here to indicate the contribution specifically related to WP4.

Models of renewable energy systems (in particular, referring to photovoltaic systems and wave energy systems:

[WP4.1] G. Chicco, V. Cocina, P. Di Leo, F. Spertino, A. Massi Pavan, Error Assessment of Solar Irradiance Forecasts and AC Power from Energy Conversion Model in Grid-connected Photovoltaic Systems, Energies, Vol. 9 (8), 2016, pp. 1-27, doi:10.3390/en9010008 (published in open access mode).

[WP4.2] G. Chicco, V. Cocina, P. Di Leo, F. Spertino, Weather forecast-based power predictions and experimental results from photovoltaic systems, 22nd International Symposium on Power Electronics, Electrical Drives, Automation and Motion (Speedam 2014), Ischia, Italy, 18-20 June 2014.

[WP4.3] G. Chicco, V. Cocina, F. Spertino, Characterization of solar irradiance profiles for photovoltaic system studies through data rescaling in time and amplitude, 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania, 2 - 5 September 2014, paper 52.

[WP4.4] G. Bracco, E. Giorcelli, G. Mattiazzo, V. Orlando, M. Raffero, Hardware-In-the-Loop test rig for the ISWEC wave energy system, Mechatronics, Vol. 25, February 2015, pp. 11–17, doi:10.1016/j.mechatronics.2014.10.007.

[WP4.5] F. de Bosio, M. Pastorelli, A. Mazza, G. Chicco, G. Bracco, E. Giorcelli, G. Mattiazzo, M. Raffero, Sea-wave power converter modeling for fault conditions analysis, IEEE PowerTech 2015, Eindhoven, The Netherlands, 29 June - 2 July 2015.

[WP4.6] M. Bergmann, G. Bracco, E. Giorcelli, G. Mattiazzo, M. Ponzetta, F. Gallizio, A. Iollo, A two-way coupling CFD method to simulate the dynamics of a wave energy converter, Proc. MTS/IEEE OCEANS'15, Genova, Italy, 18-21 May 2015, doi:10.1109/OCEANS-Genova.2015.7271481

[WP4.7] G. Bracco, A. Carillo, E. Giorcelli, L. Liberti, G. Mattiazzo, G. Sannino, G. Vissio, Use of wave forecast for the regulation of ISWEC, 11th European Wave and Tidal Energy Conference (EWTEC 2015), Nantes, France, 6-11 September 2015

Models of electrical demand, multi-energy demand, demand response and storage:

[WP4.8] I.A. Sajjad, G. Chicco, R. Napoli, Probabilistic generation of time-coupled aggregate residential demand patterns, IET Generation Transmission and Distribution, Vol. 9, No. 9, 2015, pp. 789–797, doi: 10.1049/iet-gtd.2014.0750 (published in open access mode).

[WP4.9] I.A. Sajjad, G. Chicco, R. Napoli, Demand Flexibility Time Intervals for Aggregate Residential Load Patterns, IEEE PowerTech 2015, Eindhoven, The Netherlands, 29 June - 2 July 2015.

[WP4.10] I.A. Sajjad, G. Chicco, R.Napoli, A Probabilistic Approach to Study the Load Variations in Aggregated Residential Load Patterns, 18th Power Systems Computation Conference (PSCC), 18-22 August 2014, Wroclaw, Poland, paper 546, DOI: 10.1109/PSCC.2014.7038105.

[WP4.11] S.I. Vagropoulos, E.G. Kardakos, C.K. Simoglou, A.G. Bakirtzis, J.P.S. Catalão, Artificial Neural Network-based Methodology for Short-Term Electric Load Scenario Generation, ISAP 2015, Porto, Portugal, September 2015

[WP4.12] N. Neyestani, M. Yazdani-Damavandi, M. Shafie-khah, G. Chicco, J.P.S. Catalão, Stochastic Modelling of Multienergy Carriers Dependencies in Smart Local Networks with Distributed Energy Resources, IEEE Transactions on Smart Grid (ISSN 1949-3053), vol. 6, no. 4, July 2015, pp. 1748 - 1762, doi: 10.1109/TSG.2015.2423552.

[WP4.13] N. Neyestani, M.Y. Damavandi, M. Shafie-khah, J.P.S. Catalão, G. Chicco, Uncertainty characterization of carrier-based demand response in smart multi-energy systems, Proceedings of the 5th International Conference on Power Engineering, Energy and Electrical Drives (PowerEng 2015), Riga, Latvia, May 11-13, 2015 (Best Presentation Award).

[WP4.14] A.W. Bizuayehu, P. Medina, J.P.S. Catalão, E.M.G. Rodrigues, J. Contreras, Analysis of Electrical Energy Storage Technologies' State-of-the-Art and Applications on Islanded Grid Systems, IEEE PES Transmission & Distribution Conference & Exposition, Chicago, IL, April 2014.

[WP4.15] M. Asensio, J. Contreras, Impact of Demand Response in an Isolated System with High PV Penetration, 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania, 2 - 5 September 2014.

Power flow data representation and power flow calculations under uncertainty

[WP4.16] A. Mazza, G. Chicco, E. Bakirtzis, A. Bakirtzis, A. De Bonis, J.P.S. Catalão, Power Flow Calculations for Small Distribution Networks under Time-Dependent and Uncertain Input Data, 2014 IEEE PES Transmission & Distribution Conference & Exposition, Chicago, IL, 14-17 April 2014.

[WP4.17] G. Chicco, V. Cocina, A. Mazza, F. Spertino, Data Pre-Processing and Representation for Energy Calculations in Net Metering Conditions, IEEE EnergyCon 2014, Dubrovnik, Croatia, 13-16 May 2014, paper 262.

Contingency assessment and network islanding

[WP4.18] P. Meneses de Quevedo, J. Contreras, M.J. Rider, J. Allahdadian, Contingency Assessment and Network Reconfiguration in Distribution Grids Including Wind Power and Energy Storage, IEEE Transactions on Sustainable Energy, vol. 6, no. 4, pp. 1524-1533, October 2015.

[WP4.19] P. Meneses de Quevedo, J. Allahdadian, J. Contreras, G. Chicco, Islanding in Distribution Systems Considering Wind Power and Storage, Sustainable Energy, Grids and Networks, accepted, in press, doi:10.1016/j.segan.2015.12.002.

[WP4.20] A. W. Bizuayehu, E. M. G. Rodrigues, S. F. Santos, J. P. S. Catalão, J. Contreras, Assessment on Baseline and Higher Order Grid Security Criteria: Prospects for Insular Grid Applications, IEEE PES General Meeting 2014, Washington DC, USA, July 2014.

Distribution network reconfiguration (multi-objective reconfiguration with losses and reliability)

[WP4.21] N.G. Paterakis, A. Mazza, S.F. Santos, O. Erdinc, G. Chicco, A.G. Bakirtzis, J.P.S. Catalão, Multi-Objective Reconfiguration of Radial Distribution Systems using Reliability Indices, IEEE Transactions on Power Systems, accepted, in press, doi:10.1109/TPWRS.2015.2425801.

[WP4.22] N.G. Paterakis, S.F. Santos, J.P.S. Catalão, A.G. Bakirtzis, G. Chicco, Multi-objective optimization of radial distribution networks using an effective implementation of the ε-constraint method, Proceedings of the 24th Australasian Universities Power Engineering Conference — AUPEC 2014, Perth, Australia, 28 September - 1 October, 2014.

[WP4.23] N.G. Paterakis, S.F. Santos, J.P.S. Catalão, A. Mazza, G. Chicco, O. Erdinc, A.G. Bakirtzis, Multi-Objective Distribution System Reconfiguration for Reliability Enhancement and Loss Reduction, 2015 IEEE Power & Energy Society General Meeting, PESGM 2015, Denver, Colorado, USA, July 26-30, 2015.

Advanced inverter control for acting as a Virtual Synchronous Generator

[WP4.24] S. Rubino, A. Mazza, G. Chicco, M. Pastorelli, Advanced Control of Inverter-interfaced Generation Behaving as a Virtual Synchronous Generator, IEEE PowerTech 2015, Eindhoven, The Netherlands, 29 June - 2 July 2015.

[WP4.25] E. Pouresmaeil, M. Mehrasa, J.P.S. Catalão, A multifunction control strategy for the stable operation of DG units in smart grids, IEEE Transactions on Smart Grid, Vol. 6, No. 2, pp. 598-607, March 2015, doi:10.1109/TSG.2014.2371991.

[WP4.26] M. Mehrasa, E. Pouresmaeil, H. Mehrjerdi, B.N. Jørgensen, J.P.S. Catalão, "Control technique for enhancing the stable operation of distributed generation units within a microgrid", Energy Conversion and Management, Vol. 97, pp. 362-373, June 2015, doi:10.1016/j.enconman.2015.03.078.

[WP4.27] M. Mehrasa, E. Pouresmaeil, B.N. Jørgensen, J.P.S. Catalão, "A control plan for the stable operation of microgrids during grid-connected and islanded modes", Electric Power Systems Research, Vol. 129, pp. 10-22, December 2015, doi:10.1016/j.epsr.2015.07.004.

[WP4.28] S.K. Hoseini, E. Pouresmaeil, S.H. Hosseinnia, J.P.S. Catalão, "A control approach for the operation of DG units under variations of interfacing impedance in grid-connected mode", International Journal of Electrical Power & Energy Systems, Vol. 74, pp. 1-8, January 2016, doi:10.1016/j.ijepes.2015.07.019.

Dynamic analysis, TCB applications and control with distributed generation

[WP4.29] F. Torelli, A. De Bonis, P. Montegiglio, A. Mazza, G. Chicco, J.P.S. Catalão, A new approach for solving DAE systems applied to distribution networks, 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania, 2 - 5 September 2014.

[WP4.30] A. De Bonis, J.P.S. Catalão, A. Mazza, G. Chicco, A review on the dynamic analysis of weak distribution networks, 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania, 2 - 5 September 2014.

[WP4.31] A. De Bonis, J.P.S. Catalão, A. Mazza, G. Chicco, F. Torelli, A Novel Optimization Algorithm Solving Network Reconfiguration, 18th Power Systems Computation Conference (PSCC), 18-22 August 2014, Wroclaw, Poland, paper 449.

Power quality assessment

[WP4.32] G. Chicco, F. Corona, R. Porumb, F. Spertino, Experimental Indicators of Current Unbalance in Building Integrated Photovoltaic Systems, IEEE Journal of Photovoltaics, vol. 4, no. 3, May 2014, pp. 924-934, doi:10.1109/JPHOTOV.2014.2307491 (published in open access mode).

[WP4.33] G. Chicco, A. Mazza, A. Russo, V. Cocina, F. Spertino, Probabilistic harmonic power flow calculations with uncertain and correlated data, chapter 3 of the book J.P.S. Catalão (ed.), “Smart and Sustainable Power Systems: Operations, Planning, and Economics of Insular Electricity Grids”, June 18, 2015, CRC Press, CAT# K25101, ISBN 9781498712125 (http://www.crcpress.com/product/isbn/9781498712125).

[WP4.34] G. Chicco, A. Russo, F. Spertino, Supraharmonics: Concepts and Experimental Results on Photovoltaic Systems, XII Conference-Seminar International School on Nonsinusoidal currents and compensation, Lagow, Poland, 15-18 June 2015.

[WP4.35] M. Mehrasa, E. Pouresmaeil, M.F. Akorede, B.N. Jørgensen, J.P.S. Catalão, Multilevel converter control approach of active power filter for harmonics elimination in electric grids, Energy, Vol. 84, May 2015, pp. 722-731, doi:10.1016/j.energy.2015.03.038.

Deviations (from the project workprogram):

During the evolution of the project, the opportunity to extend the activity to a new pilot site – the El Hierro power station in Canary Islands – has emerged. The El Hierro power station (to be inaugurated on July 27, 2014), is a high profile project which is having a great impact in the world media, as a paradigmatic action towards achieving 100% RES islands. The collaboration with the operation of the wind-pumped-hydro power station supplying clean electricity to the whole island of El Hierro, is an extraordinary opportunity to validate the reliability and practical application of the forecasting tools and interfaces for the integration of the information into other power system management tools developed in SINGULAR.

In order to catch this opportunity within SiNGULAR, a budget transfer from WP4 to WP2 has been introduced, by shifting 7.5 person months from WP4 to WP2 for the ITC partner, without changing the EU contribution to the project (as this change is totally applied to the person-months of the ITC partner only).

The reduction of the number of person months in WP4 had the consequence of reducing the amount of work done in WP4. The contents to be reduced have been selected in a detailed way:

- The security assessment tools have been developed by reducing the "market-based" contents, as from the preliminary analysis of the sites it emerged that there is no competitive electricity market in the islands considered. Hence, the optimal power flow run for security assessment purposes has taken into account reliability indices, reliability costs and customer damage functions outside a competitive market framework.
- The analysis of detailed models of energy production from wind and hydroelectric systems integrated with storage has been limited. The forecast values of power produced in WP2 for the specific sites have been used as input data for DERMAT.
- The state estimation module has been skipped. This has not affected the main results of the project, also because of the absence of relevant data coming from the pilot sites. The calculations of the network variables has been done with forecast input data for loads and generations and with the results calculated from the other tools developed in WP4.
- Flicker has not been explicitly addressed, as fully conventional reporting of the data measured through a flickermeter is considered.

On the other hand, additional work has been done on specific aspects:

- On the power quality side, unbalance and harmonic/interharmonic distortion indicators have been successfully applied to the analysis of distribution systems with RES (in particular, exploiting the structural characteristics of the photovoltaic systems). Correspondingly, the title of Deliverable D4.3 has been changed from "Report on the mathematical formulation of the developed reliability and market-based security assessment tools" to "Report on the mathematical formulation of the developed reliability, power quality and security assessment tools".

- The TCB approach has been successfully applied also to distribution system reconfiguration, solving a challenging problem with discrete variables through the application of the artificial dynamic model on which the TCB approach is based.
- During the project development, new ideas on advanced control technique for inverter-interfaced generation behaving as a Virtual Synchronous Generator (VSG) have emerged, leading the POLITO participants to dedicate part of their efforts to this topic, with promising results.

The following corrective actions have been identified and applied: the forecasting models, initially foreseen for La Graciosa, have been extended to a second site in the Canary Islands (El Hierro island).

1.3.4 WP5 – development of scheduling tools

Workpackage objectives:

The objectives of WP5 are the following:

- Development of innovative advanced stochastic optimization models and tools for the short-term and very short-term operation of insular electricity networks under large-scale RES integration.
- Incorporation of state-of-the-art and development of new methods for the efficient and reliable operation of the power system (e.g. hybrid plants, storage, plug-in electric vehicles, VPPs, etc.).
- Development of integrated software tools to operate as stand-alone applications or incorporated in the associated EMS of the insular power systems.

Progress towards objectives:

Summary: In order to meet the aforementioned objectives, since the beginning of the project the associated work was organized in four distinct tasks (Tasks 5.1-5.4). The partners involved in WP5 did not encounter substantial problems to fulfill the prescribed activities and complete the relevant deliverables on time. The work progress in all Tasks for the entire duration of the project is briefly summarized as follows:

Progress towards objectives detailed for each task:

Task 5.1: Scenario generation for the modeling of the random system and unit parameters

In this Task, the methodologies for the creation of the scenarios regarding various system and unit parameters (i.e. insular system load, RES injection, units' availability) has been first developed. Two different approaches, one based on probabilistic analysis and one based on time series analysis (ARIMA models), were developed for the generation of the system load and the RES production scenarios that capture the spatial and temporal correlations of the corresponding variables. Monte Carlo simulation was adopted for the creation of the units' availability scenarios. Appropriate scenario reduction techniques were applied in order to alleviate the computational complexity and burden on the scheduling tools, while preserving the features of the original scenario sets. In order to account for the statistical correlation of the power output from neighboring RES plants, an appropriate algorithm

has been implemented for the generation of spatial cross-correlated scenarios regarding the RES electricity injection.

Task 5.2: Development of scheduling models

In this Task, the core scheduling models for the short-term operation of the insular power systems have been developed. Regarding the mathematical formulation, two different approaches have been followed, described as follows:

The first approach was oriented to the development of short-term scheduling optimization models based on mixed-integer linear programming (MILP). Various novel deterministic and stochastic unit commitment and economic dispatch models were developed, aiming at the minimization of the total operating cost of the conventional (thermal) generating units in an insular power system for the next 24-48 hours, while respecting all system and generating units' operating constraints. The minimization of the thermal unit cost results in the maximization of the cost-free renewable energy sources (RES) injection. Special attention has been given on the realistic modeling of the conventional generating units' operating phases (i.e. synchronization, soak, dispatch and desynchronization). A detailed representation of the generating units' operating and inter-temporal constraints (e.g. start-up/shut-down procedures, minimum up/down time constraints, ramp rate limits, power output and reserves provision constraints, etc.) have also been provided. The transmission network representation was properly incorporated in the optimization models under a DC power flow approximation. Moreover, special attention has been given to the qualitative and quantitative determination of the required reserves (primary, secondary, tertiary spinning/non-spinning) through innovative stochastic optimization models, so that specific reliability targets posed by international rules and practices are met.

The second approach was based on risk analysis to address the increase of RES variability and uncertainty. An advanced probabilistic unit commitment and economic dispatch model was designed to minimize the sum of the estimated costs based on risk cost analysis. These costs are the sum of the estimated real operation costs and the estimated costs of operating outside normal conditions. The probabilistic estimation of costs is not based on scenarios, but on the expected risk estimation approach that uses directly the probability density functions. In this approach a reserve level is not predefined, but reliability and irregular operation risk minimization leads to solutions with enough dynamic reserve levels. This scheduling model consists in evaluating the adequacy of each possible combination of thermal generators online in the unit commitment problem for each hour of a probabilistic net load forecast, avoiding the need of developing a large number of scenarios, modeling explicitly the impact of the forecast uncertainty and considering the possibility of single thermal unit failure. The fuel consumption curves of thermal units, the probabilities of the thermal generators operating inside/outside of their appropriate range of power (i.e., risk of load shedding and wind shedding necessity based on probabilistic forecasts) and the probability of normal operation after the occurrence of wind spillage were also considered in the objective function of the problem.

Task 5.3: Incorporation of state-of-the-art and development of new methods for the efficient and reliable operation of the power system

The state-of-the-art methods for the efficient and reliable operation of the electricity networks that have been evaluated in this activity include: a) the flexible consumption along with dynamic pricing

(price-responsive demand) in a smart-grid environment, and b) the increasing electrical energy storage capacity. In addition, special attention has been given to the study of the effects of the expected active participation of electric vehicles into the insular networks, mainly regarding the valuable assistance they can provide (e.g. through the provision of certain types of reserves) towards the large-scale RES integration in these networks. Finally, the concept of Virtual Power Plants (VPPs) has been employed for the coordination of all aforementioned means towards the electricity network efficiency and reliability improvement.

The mathematical formulation regarding the integration of all these novel emerging methods and tools from the system operator perspective in the relevant short-term scheduling models (i.e. unit commitment and economic dispatch models) already developed in Task 5.2 have been completed successfully.

Task 5.4: Development of integrated software tools

The core scheduling models have been developed in high-level commercially available software such as GAMS or MATLAB, which allow for a compact and precise representation of large-scale and complex optimization problems. Such a computational environment also allows for the use of state-of-the-art solvers such as CPLEX, which is a high-performance solver suitable for linear and mixed-integer linear programming.

In this Task, the integration of the various scheduling models in ready-to-use software tools, which operate either as stand-alone applications in the pilot sites or through web-based platforms, was completed successfully. In this framework, two ready-to-use operational software tools were developed, namely, Short-Term Electric Power System Scheduling (STEPS) and Risk-based Power Scheduling Tool (RiSch), each oriented to different generation mix and insular power system size and requirements. Both tools are briefly described in the following paragraph.

Significant results:

In the framework of WP5, significant results have been produced during the entire duration of the project, briefly described as follows:

First, an analytical state-of-the-art review on methodologies and tools proposed by the research community as well as practical applications currently used in the power industry for the short-term scheduling of the electricity networks has been conducted. Special attention has been given on the presentation of state-of-the art and emerging methods for the efficient and reliable operation of the electricity networks, (e.g. price-responsive demand, storage, electric vehicles, Virtual Power Plants, etc.). As already mentioned, the mathematical formulation of scenario generation algorithms and various complex optimization models that have been developed for the optimal short-term scheduling of insular electricity networks have been developed and implemented in specific real-life insular power systems.

The main outcome of WP5 consists in the development and real-life implementation of two ready-to-use short-term scheduling tools, namely, Short-Term Electric Power System Scheduling (STEPS) and Risk-based Power Scheduling Tool (RiSch).

AUTH undertook the development and deployment of the STEPS tool in the pilot site of Crete, Greece. STEPS is an integrated software tool that currently operates on-line as stand-alone application that is easily accessible by the respective Operator (HEDNO), providing useful information for the daily scheduling of the generating system of the Crete island.

On the other hand, Smartwatt undertook the development and deployment of the RiSch tool in the pilot site of São Miguel-Azores, Portugal. RiSch is an integrated tool that currently operates on-line in a web-based application that is easily accessible by the respective Operator (EDA), providing useful information for the daily scheduling of the generating system of the São Miguel island.

It is noted that both tools have been developed "from scratch" in line with the particular needs of the insular power system of Crete, Greece, and Sao Miguel, Azores, respectively, which are the main SiNGULAR pilot sites. However, they can be easily adapted and parameterized in order to operate in any other insular power system. An overview of both tools as well as further details on their scope, key functionalities and integration aspects can be found in Deliverable 5.2.

Regarding WP5 deliverables, D5.1 has been successfully completed and submitted to the EC in time (M12), while D5.3 (common deliverable with family projects iGREENGrid and SuSTAINABLE) was successfully completed and submitted to the EC with a short delay (M7 instead of M4). Both, were approved during the 1st review (Sep. 2014). D5.2 has been successfully completed and submitted to the EC in time (M21, Aug. 2014) and was also revised following the clarifications and comments follewing the review, although it did not officially fall within the first reporting period. Some clarifications/additions asked that were carried out and the revised version was submitted to the EC in M26.

During the full duration of the project, the measurable results yielded by the activities of WP5 led to one (1) book chapter, seventeen (17) publications in peer-reviewed scientific journals and twenty-four (24) announcements in energy-related international conferences, listed as follows:

Book Chapter

1. E.A. Bakirtzis, E.G. Kardakos, S.I. Vagropoulos, C.K. Simoglou, and A.G. Bakirtzis, "Scheduling Models and Methods for Efficient and Reliable Operations," *Chapter 4 in Book: "Smart and Sustainable Power Systems: Operations, Planning and Economics of Insular Electricity Grids "*, CRC Press, Taylor and Francis Group, Jun. 2015.

Journal papers

[WP5.1] C.K. Simoglou, E.G. Kardakos, E.A. Bakirtzis, D.I. Chatzigiannis, S.I. Vagropoulos, A.V. Ntomaris, P.N. Biskas, A. Gigantidou, E.J. Thalassinakis, A.G. Bakirtzis, and J.P.S. Catalão, "An advanced model for the efficient and reliable short-term operation of insular electricity networks with high renewable energy sources penetration," *Renewable & Sustainable Energy Reviews*, vol. 38, pp. 415-427, Oct. 2014.

[WP5.2] E. Heydarian-Forushani, M.P. Moghaddam, M.K. Sheikh-El-Eslami, M. Shafie-khah, J.P.S. Catalão, "Risk-constrained offering strategy of wind power producers considering intraday demand response exchange", *IEEE Transactions on Sustainable Energy*, Vol. 5, No. 4, pp. 1036-1047, Oct. 2014.

[WP5.3] E. Heydarian-Forushani, M.P. Moghaddam, M.K. Sheikh-El-Eslami, M. Shafie-khah, J.P.S. Catalão, "A stochastic framework for the grid integration of wind power using flexible load approach", *Energy Conversion and Management*, Vol. 88, pp. 985-998, Dec. 2014.

[WP5.4] N.G. Paterakis, O. Erdinc, A.G. Bakirtzis, J.P.S. Catalão, "Qualification and quantification of reserves in power systems under high wind generation penetration considering demand response", *IEEE Transactions on Sustainable Energy*, Vol. 6, No. 1, pp. 88-103, Jan. 2015.

[WP5.5] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "A new scenario generation-based method to solve the unit commitment problem with high penetration of renewable energies", *International Journal of Electrical Power & Energy Systems*, Vol. 64, pp. 1063-1072, Jan. 2015.

[WP5.6] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "A probabilistic approach to solve the economic dispatch problem with intermittent renewable energy sources", *Energy*, Vol. 82, pp. 949-959, Mar.2015.

[WP5.7] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "A fast method for the unit scheduling problem with significant renewable power generation", *Energy Conversion and Management*, Vol. 94, pp. 178-189, Apr. 2015.

[WP5.8] N.G. Paterakis, O. Erdinc, A.G. Bakirtzis, J.P.S. Catalão, "Load-following reserves procurement considering flexible demand-side resources under high wind power penetration", *IEEE Transactions on Power Systems*, Vol. 30, No. 3, pp. 1337-1350, May 2015.

[WP5.9] E. Heydarian-Forushani, M.E.H. Golshan, M. Shafie-khah, J.P.S. Catalão, "Robust scheduling of variable wind generation by coordination of bulk energy storages and demand response", *Energy Conversion and Management*, Vol. 106, pp. 941-950, Dec. 2015.

[WP5.10] M. Shafie-khah, E. Heydarian-Forushani, M.E.H. Golshan, M.P. Moghaddam, M.K. Sheikh-El-Eslami, J.P.S. Catalão, "Strategic offering for a price-maker wind power producer in oligopoly markets considering demand response exchange", *IEEE Transactions on Industrial Informatics*, Vol. 11, No. 6, pp. TBD, Dec. 2015.

[WP5.11] C.K. Simoglou, E.A. Bakirtzis, P.N. Biskas, and A.G. Bakirtzis, "Optimal operation of insular electricity grids under high RES penetration," *Renewable Energy*, vol. 86, pp. 1308-1316, Feb. 2016.

[WP5.12] J.M. Lujano-Rojas, G.J. Osório, J.P.S. Catalão, "New probabilistic method for solving economic dispatch and unit commitment problems incorporating uncertainty due to renewable energy integration", *International Journal of Electrical Power & Energy Systems*, 2015 (accepted).

[WP5.13] J.M. Lujano-Rojas, G.J. Osório, J.C.O. Matias, J.P.S. Catalão, "A heuristic methodology to economic dispatch problem incorporating renewable power forecasting error and system reliability", *Renewable Energy*, 2015 (accepted).

[WP5.14] A.V. Ntomaris and A.G. Bakirtzis, "Stochastic scheduling of hybrid power stations in insular power systems with high wind penetration," *IEEE Transactions on Power Systems*, vol. XX, no. XX, pp. XX-XX, *in press*.

[WP5.15] M. Asensio and J. Contreras, "Stochastic unit commitment in isolated systems with renewable penetration under CVaR assessment," *IEEE Transactions on Smart Grid*, vol. XX, no. XX, pp. XX-XX, *in press*.

[WP5.16] M. Asensio and J. Contreras, "Risk-constrained optimal bidding strategy for pairing of wind and demand response resources," *IEEE Transactions on Smart Grid*, vol. XX, no. XX, pp. XX-XX, *in press*.

[WP5.17] S.I. Vagropoulos, E.G. Kardakos, C.K. Simoglou, and A.G. Bakirtzis, "ANN-based scenario generation methodology for stochastic variables of electric power systems," *Electric Power Systems Research*, *in press.*

Conference papers

[WP5.18] J.M. Lujano-Rojas, G.J. Osório, J.P.S. Catalão, "A probabilistic approach to solve economic dispatch problem in systems with intermittent power sources", in *Proc. of the 2014 IEEE PES Transmission & Distribution Conference & Exposition — T&D 2014*, Chicago, Illinois, USA, , 14-17 April, 2014.

[WP5.19] J.M. Lujano-Rojas, G.J. Osório, J.P.S. Catalão, "Probabilistic approach to describe greenhouse gas emissions and their impact in the operation of insular power systems", in *Proc. of the 2014 IEEE Power & Energy Society General Meeting — PESGM 2014*, Washington, DC Metro Area, USA, 27-31 July, 2014.

[WP5.20] V. Guerrero, A.S. de la Nieta, J. Contreras, and P.F Correia, "Unit commitment with wind generation and reversible-hydro system in islands," in *Proc. of 19th World Congress The International Federation of Automatic Control,* pp. 4050-4055, 24-29 August 2014, Cape Town, South Africa.

[WP5.21] S.I. Vagropoulos, C.K. Simoglou, A.G. Bakirtzis, E.J. Thalassinakis, and A. Gigantidou, "Assessment of the impact of a battery energy storage system on the scheduling and operation of the insular power system of Crete", in *Proc. of 49th UPEC 2014*, Cluj-Napoca, Romania, September 2014.

[WP5.22] M. Asensio and J. Contreras, "Impact of demand response in an isolated system with high PV penetration," in *Proc. of 49th UPEC 2014*, Cluj-Napoca, Romania, September 2014.

[WP5.23] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "Probability theory-based economic dispatch model for insular power systems", in *Proc. of the 24th Australasian Universities Power Engineering Conference — AUPEC 2014*, Perth, Australia, 28 September - 1 October, 2014.

[WP5.24] A.V. Ntomaris, S.I. Vagropoulos, and A.G. Bakirtzis, "Integration of hybrid power stations in the insular power system of Crete," in *Proc. of ISGT Europe 2014*, Istanbul, Turkey, 12-15 October 2014.

[WP5.25] A.V. Ntomaris, E.A. Bakirtzis, D.I. Chatzigiannis, C.K. Simoglou, P.N. Biskas, and A.G. Bakirtzis, "Reserve quantification in insular power systems with high wind penetration," in *Proc. of ISGT Europe 2014*, Istanbul, Turkey, 12-15 October 2014.

[WP5.26] E.G. Kardakos, C.K. Simoglou, and A.G. Bakirtzis, "Optimal bidding strategies of a mixed RES portfolio by stochastic programming," in *Proc. of ISGT Europe 2014*, Istanbul, Turkey, 12-15 October 2014.

[WP5.27] E.G.Kardakos, C.K. Simoglou, and A.G. Bakirtzis, "Hydrothermal Producer Offering Strategy in a Transmission-Constrained Electricity Market - An MPEC Approach," in *Proc. of ISGT Europe 2014*, Istanbul, Turkey, 12-15 October 2014.

[WP5.28] M. Shafie-khah, A.A.S. de la Nieta, J.P.S. Catalão, E. Heydarian-Forushani, "Optimal self-scheduling of a wind power producer in energy and ancillary services markets using a multi-stage stochastic programming", in *Proc. of the 2014 Smart Grid Conference — SGC'14 (technically co-sponsored by IEEE)*, Tehran, Iran, December 9-10, 2014.

[WP5.29] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "A new methodology for solving the unit commitment in insular grids including uncertainty of renewable energies", in: *Proc. of the 5th International Conference on Power Engineering, Energy and Electrical Drives — PowerEng 2015*, Riga, Latvia, , May 11-13, 2015. ***Best Presentation Award***

[WP5.30] C.K. Simoglou, E.G. Kardakos, and A.G. Bakirtzis, "Benefits of demand response on a wind power producer bidding strategy," in *Proc. of IEEE PowerTech 2015*, 29 June – 02 July 2015, Eindhoven, The Netherlands.

[WP5.31] S.I. Vagropoulos, I.M.D. Katsolas, A.G. Bakirtzis, "Assessment of load shifting potential on large insular power systems," in *Proc. of IEEE PowerTech 2015*, 29 June – 02 July 2015, Eindhoven, The Netherlands.

[WP5.32] A.V. Ntomaris and A.G. Bakirtzis, "Stochastic day-ahead scheduling of thermal and hybrid units in insular power systems with high wind penetration," in *Proc. of IEEE PowerTech 2015*, 29 June – 02 July 2015, Eindhoven, The Netherlands.

[WP5.33] A.A.S. de la Nieta, T.A.M. Tavares, R.F.M. Martins, J.C.O. Matias, J.P.S. Catalao, and J. Contreras, "Optimal generic energy storage system offering in day-ahead electricity markets," in *Proc. of IEEE PowerTech 2015*, 29 June – 02 July 2015, Eindhoven, The Netherlands.

[WP5.34] N.G. Paterakis, J.P.S. Catalão, A.V. Ntomaris, O. Erdinc, "Evaluation of flexible demand-side load-following reserves in power systems with high wind generation penetration", in *Proc. of the IEEE Power Tech 2015 Conference*, Eindhoven, Netherlands, , 29 June - 2 July, 2015.

[WP5.35] G.J. Osório, J.M. Lujano-Rojas, J.C.O. Matias, J.P.S. Catalão, "Including forecasting error of renewable generation on the optimal load dispatch", in *Proc. of the IEEE Power Tech 2015 Conference*, Eindhoven, Netherlands, 29 June - 2 July, 2015.

[WP5.36] N.G. Paterakis, A.A.S. de la Nieta, J.P.S. Catalao, A.G. Bakirtzis, A. Ntomaris, and J. Contreras, "Evaluation of load-following reserves for power systems with significant RES penetration considering risk management," in *Proc. of 2015 IEEE International Conference on Smart Energy Grid Engineering (SEGE)*, 17-19 August 2015, Oshawa, Canada. ***Best Paper Award***

[WP5.37] S.I. Vagropoulos, E.G. Kardakos, C.K. Simoglou, A.G. Bakirtzis, and J.P.S. Catalão, "Artificial neural network-based methodology for short-term electric load scenario generation", in *Proc. of 18th Intelligent Systems Applications to Power Systems Conference and Debate* (*ISAP 2015)*, 11-17 September 2015, Porto, Portugal.

[WP5.38] A.A.S. de la Nieta, T.A.M. Tavares, J.P.S. Catalao, and J. Contreras, "Optimal coordinated wind and generic storage system bidding in electricity markets," in *Proc. of 2015 Australasian Universities Power Engineering Conference (AUPEC),* 27-30 September 2015, Wollongong, Australia.

[WP5.39] E. Heydarian-Forushani, M.E.H. Golshan, M. Shafie-khah, J.P.S. Catalão, "Impacts of stochastic demand response resource scheduling on large scale wind power integration", in *Proc. of the 25th Australasian Universities Power Engineering Conference — AUPEC 2015* (technically co-sponsored by IEEE), Wollongong, Australia, 27-30 September, 2015.

[WP5.40] A.A.S. de la Nieta, R.F.M. Martins, J.P.S. Catalão, J. Contreras, "Optimal coordinated wind-photovoltaic bidding in electricity markets", in *Proc. of the 25th Australasian Universities Power Engineering Conference — AUPEC 2015*, Wollongong, Australia, 27-30 September, 2015.

[WP5.41] J.M. Lujano-Rojas, G.J. Osório, M. Shafie-khah, J.P.S. Catalão, "Analytical solution of dynamic economic dispatch considering wind generation", in *Proc. of the 2016 IEEE PES Transmission & Distribution Conference & Exposition — T&D 2016*, Dallas, Texas, USA, 2-5 May, 2016 (accepted).

1.3.5 WP6 - Competative operation of Insular Electric Networks

Workpackage objectives:

The objectives of WP6 are the following:

- Development of market design schemes oriented to the introduction of competition in the short-term operation of insular electricity grids.
- Examination of the applicability of standard market design schemes, already implemented in interconnected power systems, in the project-related insular power systems and subsequent adjustment to facilitate the project targets (large-scale RES penetration, demand response programs, etc.)
- Development of economic models for equitable settlement of the market participants and customers for supplying energy, reserves, demand response and other energy services.
- Formulation and testing of the scenarios under which the development and implementation methods will be validated.

Progress towards objectives:

Summary: In order to meet the aforementioned objectives, since the beginning of the project the associated work was organized in three distinct tasks (Tasks 6.1-6.3). The partners involved in WP6

did not encounter substantial problems to fulfill the prescribed activities and complete the relevant deliverables. The work progress in all Tasks until the end of May 2014 (end of 1st project review period) is briefly summarized as follows:

Progress towards objectives detailed for each task

Task 1: Economic framework of insular electric networks

In this task the setting-up of the economic framework currently deployed at electric distribution systems around Europe has been developed. The market players were identified and characterised through their attributes and interface with the market model implemented. Also, for a larger picture, the business issues were investigated at the national levels separately (performed accordingly with the individual application sites from each partner). A special attention was paid to defining the cost-benefit leverage mechanisms, which are of a great importance for the future multi-stakeholders operation of electric systems

The main goal achieved was the complete analysis of the recent market rules and the remuneration schemes in the distribution network level in order to consider new proposals that improve the insular regulatory framework. The new context where distribution generation (DG) is integrated in the distribution system is the main challenge for distribution companies to be able to meet new technical and operational requirements.

Task 2: Development of risk analysis models and tools

In this task methodologies and tools for analyzing the risk associated to the operation of a selected mix of resources in the insular network application, under different degrees of risk aversion characterizing the stakeholders were developed. Different alternatives, each of which containing set of resources exploiting various energy vectors, were analyzed in order to establish the most convenient solution in terms of economic operation of the insular system and sustainability under uncertainty. The key aspects considered were the availability of energy sources and reserves, the complementary exploitation of different energy sources, the role of storage, the economics of the connection to the insular network, and the effects of the possible connection to external systems.

The core achievement of this research activity was the analysis and reconfiguration of weakly meshed distribution networks through well-established linearized power flow model, using conventional optimization approaches in order to improve their performance. In addition, it focused on optimum power supply and operation analysis being the main objective the minimization of the power losses and operation costs in distribution networks, considering key electrical grid operating parameters as a power system constraint

Task 3: Scenario analysis for the modeling of the insular electricity grids

The main aspect of this task was the identification of existing and alternative solutions and the conduction of a feasibility study on the economic competitiveness in the short-term operation of insular electricity grids. Two sets of scenarios were constructed. A first set reproduced the characteristics of the insular networks located in the application sites selected for SINGULAR (adding further dedicated options with respect to the installed structures in order to provide a wider assessment). Another set of scenarios were more generally include a wide number of options in order

to develop scenario analysis tools operating in an integrated way. The scenarios also considered different options concerning possible incentives or penalties (related to renewable energy deployment, energy efficiency and environmental impact) that have been or could be introduced for the exploitation of the various energy sources.

The ultimate goal of the present task was primarily to create practical tools that may help analyzing distribution networks, and in second place pursue an economical operation through minimization of power losses in distribution systems; in a way that they may perform in a secured and efficient manner from the grid operator's point of view. A practical tool was achieved, which may help distribution operators to comply with an up to date technical and operational requirements in future distribution grids. Besides, it may contribute to power system stakeholders to become economically benefited from intended savings in operation costs.

Significant results:

At the end of May 2014, Tasks 6.1, 6.2, and 6.3 have been completed. Specifically, a state-of-the-art review on European energy systems technical and legal frameworks proposed by the research community as well as specific network codes currently used in the electricity networks has been achieved.

UCLM has developed algorithms for the analysis and reconfiguration of weakly meshed distribution networks through a well-established linearized power flow model, using conventional optimization approaches in order to improve their performance. In addition, it focuses on optimum power supply and operation analysis where the main objective is the minimization of the power losses and operation costs in distribution networks, considering key electrical grid operating parameters as a power system constraint.

With respect to the implementation of all methods and tools developed and presented in the framework of WP6, Smartwatt has undertaken the development and deployment of the electric price signals in insular systems.

POLITO has undertaken the development of the detalied model of the Italian electric power system, The model was constructed starting with the regulatory framework for electricity and to the electricity market.

With respect to the implementation of all methods and tools developed and presented in the framework of WP6, Smartwatt has undertaken the development and deployment of the electric price Signals in insular Systems and the development of the risk aspects in distribution systems and islands. This approach was performed by taking into account the resources availability as well as risk-aversion margins imposed by the demand side and the RES penetration.

AUTH prepared an extensive scenario-based simulation analysis of the Crete power system operation for the year 2015 on an hour-by-hour basis aiming at the evaluation of the impact of RES penetration on the daily power system operation in terms of various power system operation indices, such as the total energy production per generating unit technology, the total CO_2 emissions, the total production cost, etc.. Additionally, the effect that the installation and operation of a pumped-storage plant may have on the short-term operation of an insular power system was also investigated.

ITC developed a report regarding Lanzarote-Fuerteventura power system, based on a wide array of technologies available and local electricity market constraints.

Finally, the deliverables D6.1 and D6.2 have been successfully completed and submitted to the EC in time.

During the first 18-month period, the measurable results yielded by the activities of WP6 led to two announcements in forthcoming energy-related international conferences, listed as follows:

Publications

The publications totally or mainly containing WP6 results include 1 book chapter, 1 article in International journals (published in open access mode), and 15 articles appearing in International Conference Proceedings. The list of papers is reported below, partitioned into similar topics. Journal papers and the book chapter are highlighted in **bold**. Some papers refer to more than one WP and are reported here to indicate the contribution specifically related to WP6.

Models of renewable energy systems (in particular, referring to photovoltaic systems and wave energy systems:

[WP6.1] R. Vatu, O. Ceaki, N. Golovanov, R. Porumb, G. Seritan, Analysis of storage technologies within smart grid framework, IEEE Universities' Power Engineering Conference - UPEC 2014, 2-5 September, Cluj, Romania

[WP6.2] O. Ceaki, R. Vatu, N. Golovanov, R. Porumb, G. Seritan, Analysis of the grid-connected PV plants behavior with FACTS influence, IEEE Universities' Power Engineering Conference - UPEC 2014, 2-5 September, Cluj, Romania

[WP6.3] R. Vatu, O. Ceaki, N. Golovanov, R. Porumb, G. Seritan, Competitive electricity market schemes within smart grids framework, IEEE International Symposium on Fundamentals of Electrical Engineering – ISFEE 2014, 28 – 29 November, Bucharest, Romania

[WP6.4] O. Ceaki, R. Vatu, N. Golovanov, R. Porumb, G. Seritan, Analysis of SVC influence on the power quality for grid – connected PV plants, IEEE International Symposium on Fundamentals of Electrical Engineering – ISFEE 2014, 28 – 29 November, Bucharest, Romania

[WP6.5] R. Porumb, G. Seritan, Load profiles definition for the electrical distribution operator, IEEE International Conference on Modern Power Systems – MPS 2015, 17 – 20 May 2015, Cluj, Romania

[WP6.6] G. Seritan, I. Tristiu, Continuity of supply, a key parameter for smart grids' resilience evaluation, IEEE International Conference on Modern Power Systems – MPS 2015, 17 – 20 May 2015, Cluj, Romania

[WP6.7] G. Sava, S. Costinas, R. Porumb, N. Golovanov, Power quality measurements and analysis for a Romanian WPP, IEEE PowerTech, 29 June - 2 July 2015, Eindhoven, Holland

[WP6.8] V. Boicea, R. Porumb, Loss minimum reconfiguration through deterministic iterative improvement and simulated annealing, International Conference on Optimization of

Electrical & Electronic Equipment (OPTIM 2015), 02 - 04 September 2015, Antalya, Turkey,

[WP6.9] M. Pagano, R. Porumb, Analysis of windfarm output variation impact on environment. A Romanian case, U.P.B. Scientific Bulletin, Series C (in press)

[WP6.10] M. Mancasi, R. Vatu, Smart grids reliability indices assessment using sequential Monte Carlo method, IEEE International Conference on Environment and Electrical Engineering 2015, 10 – 13 June, Rome

[WP6.11] R. Vatu, O. Ceaki, M. Mancasi, R. Porumb, G. Seritan, Analysis of ancillary services within smart grid framework, IEEE Modern Electric Power systems Conference – MEPS 2015, 6 – 9 July, Wroclaw, Poland,

[WP6.12] O. Ceaki, R. Vatu, M. Mancasi, R. Porumb, G. Seritan, Analysis of electromagnetic disturbances for grid – connected PV plants, IEEE Modern Electric Power Systems Conference - MEPS 2015, 6 – 9 July, Wroclaw, Poland,

[WP6.13] R. Vatu, O. Ceaki, M. Mancasi, R. Porumb, G. Seritan, Power quality issues produced by embedded storage technologies in smart grid environment, IEEE Universities' Power Engineering Conference - UPEC 2015, 1 – 4 September, Stoke – on – Trent, UK,

[WP6.14] M. Mancasi, R. Vatu, O. Ceaki, R. Porumb, G. Seritan, Evolution of smart buildings. A Romanian case, IEEE Universities' Power Engineering Conference - UPEC 2015, 1 – 4 September, Stoke – on – Trent, UK

[WP6.15] O. Ceaki, R. Vatu, M. Mancasi, R. Porumb, G. Seritan, Analysis of electromagnetic disturbances with or without SVC device, IEEE Universities' Power Engineering Conference - UPEC 2015, 1 – 4 September, Stoke – on – Trent, UK.

Power quality assessment

[WP6.16] G. Chicco, F. Corona, R. Porumb, F. Spertino, Experimental Indicators of Current Unbalance in Building Integrated Photovoltaic Systems, IEEE Journal of Photovoltaics, vol. 4, no. 3, May 2014, pp. 924-934, doi:10.1109/JPHOTOV.2014.2307491 (published in open access mode).

Deviations (from the project workprogram):

The research activities performed for the development of deliverables 6.1 aimed at performing a complete assessment of the islanded electrical power systems. This task proved to be very challenging due to the large array of parameters, which must be taken in consideration, ranging from geographical position, dimensions, local legislation, all the way to the voltage levels, consumption and generation profiles. This complexity proved to be bourdensome for the overall research activity, leading it to delays in completing the final deliverables. Regarding Deliverable 6.2, the deviation from the initial scheduled completion date was induced by the two factors:

- Late deployment of the Deliverable 6.1, for reasons presented above
- Sheer complexity of the task at hand, which was increased by the large amount of data regarding islanded power systems, which must be assesed, filtered and used in order to extract useful

information. The amount of data to be filtered was underestimated, due to the current availability of data loggers and advanced SCADA systems deployed into the electrical power systems, far beyond the initial expectations. This activities delayed the initial planning, leading to a time-deviation which could not be overrun.

1.3.6 WP7 - Planning Procedures And Tools For Distribution Grid Integration

Work package objectives:

The objectives of WP7 are the following:

- Development of robust mathematical models and software tools to address the integration of RES into the planning of European insular distribution systems.
- The effect of RES planning and distribution network planning is addressed as follows: First, the effects of the addition of RES are studied independent of distribution planning. Then, the development of the distribution network is analyzed alone, assuming that RES are fixed. Finally, the effect of both new RES and distribution network expansion are jointly studied. In the last model, the overall social welfare is optimized instead of total costs, considering demand response, reliability issues, hybrid technologies and EES, among others.

Progress towards objectives:

Summary: In order to meet the aforementioned objectives, since the beginning of the project the associated work was organized in four distinct tasks (Tasks 7.1-7.4). The partners involved in WP7 did not encounter substantial problems to fulfill the prescribed activities and complete the relevant deliverables. The work progress in all Tasks is briefly summarized as follows:

Progress towards objectives detailed for each task

Task 7.1: RES generation expansion model for insular networks

This task is devoted to the formulation of a mathematical model that is able to obtain the optimal expansion of RES in an insular distribution network. The mathematical model contains an objective function for the minimization of all operation and expansion costs of the RES resources. In particular, we consider wind, hydro and solar technologies, among others. The technical constraints related to all these technologies are incorporated into the model. The problem is formulated as a multi-stage RES expansion model and a comprehensive set of scenarios is deployed to account for all sources of uncertainty in the model. Among them, demand, solar irradiation, water inflow and wind speed are the main variables that are considered as stochastic variables for the model. The creation of plausible scenarios that are the result of the combination of all stochastic variables is validated with real data coming from the insular companies of the consortium. The model is programmed in GAMS and MATLAB and both the objective function and the constraints are linearized to attain a stochastic mixed-integer linear programming model (SMILP), whose robustness guarantees to obtain a set of optimum solutions for different scenarios.

Task 7.2: Reliable distribution network expansion model for insular networks

This task models how to expand the distribution network adding new assets (lines and substations) so that the current and future energy supply for the island customers is served at minimum cost and with the quality required. The objective function to minimize is the net present value of the investment cost to add, reinforce or replace feeders and substations, losses cost, and operation and maintenance cost. The model considers several levels of load in each node and investment alternatives for each resource to be added, reinforced or replaced. The nonlinear objective function is approximated by a piecewise linear function, resulting in a mixed integer linear model that is solved using standard mathematical programming. The model allows us to find multiple solutions to analyze from a pool of solutions. In addition to the optimization problem, reliability indices and associated costs are computed for each solution. The implemented model considers that there are several alternatives for each line expansion asset available depending on the size of the conductors or the transformer's capacity. The model is multi-stage and each stage has several load levels, described by a typical daily load curve occurring in each node at different times. The load is represented as a constant current so that the planning model becomes a mixed-integer linear programming problem (MILP). Quadratic losses in lines and transformers are handed by piecewise linearization so that the problem becomes a mixed-integer linear one, solved by using GAMS/CPLEX. The utilization of MILP techniques ensures fast and efficient solutions for large-size problems.

Task 7.3: Joint RES generation and distribution network expansion model for insular networks

This task is the result of combining the models resulting from the previous tasks, 7.1 and 7.2. In task 7.1, we only assume the expansion of RES in an insular distribution system. In task 7.2, we consider the expansion of distribution assets of an insular distribution system. In this task we put together the previous two models for a complete expansion of the distribution system assets and RES. In addition, we consider reliability in the joint model.

The impact of reliability on the expansion cost is significant. It is essential to know the reliability level to predict the evolution of the most important performance indices before and after distribution network expansions. Therefore, we aim to determine the long-term behavior of the distribution system considering: failure rates of system components, which are known for existing components and estimated for future additions along the time horizon and duration of the interruptions as a function of the repair time, service recovery, switching, or isolation states. The reliability indices studied are system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI), average system availability index (ASAI), and customer interruption duration (CID), customer interruption frequency (CIF), and expected energy not supply (EENS). These data were provided to the consortium by the industrial partners.

The difficulty to incorporate all these reliability indices into distribution expansion is that it is necessary to know the network topology in order to calculate the reliability indices that characterize the system as well as the failure and repair rates, and the placement and response of the protective devices. To solve this problem, the most relevant reliability indices are computed for each solution selected from the pool of solutions (see task 7.2) and, thereafter, the associated costs of these solutions. With this information, it is possible to identify how individual nodes or consumers are affected by every plan of the pool of solutions, as well as the associated impacts on costs.

Task 7.4: Joint RES generation and distribution network expansion planning with demand response, reserves, hybrid storage and plug-in vehicles

Finally, the model developed in task 7.3 is completed by adding other issues relevant to planning in insular distribution systems. First, we take into account demand response, depending on the type of customer: industrial, commercial or residential. Each one of these customer types has its own demand response that is provided by the industrial partners of the consortium. Another important aspect is the treatment of the reserves of the system that is directly linked to the demand data. These reserves also have a direct connection with the reliability indices obtained in task 7.3. The consideration of hybrid technologies as part of RES is also addressed, as well as the possibility of plugging electric vehicles to the system. The latter allows for a flatter demand profile, since vehicles' charging happens during the night. Finally, due to the presence of demand response, a new objective function is used. In this case, social welfare maximization that considers both generation and demand, replaces cost minimization. This, together with the reliability indices, quantifies the goodness of adding new RES and distribution assets in a long-term planning framework.

Significant results:

At the end of November 2015 (End of the project), Tasks 7.1, 7.2, 7.3 and 7.4 have been completed, while deliverables D7.1, D7.2 and D7.3 have been submitted with no dely. UCLM has undertaken the development and deployment of robust mathematical models and software tools to address the integration of RES into the planning of European insular distribution systems. It encompasses the effect of RES planning and distribution network planning. In D7.1 a distribution expansion planning algorithm has been presented from a centralized point of view. In this algorithm, an optimization model calculates three expansion solutions, among, which is the optimal one. The reliability indexes and their associated costs have been calculated for the previous set of solutions. Finally, an investment decision has been adopted through a comparative analysis. In D7.2, a joint generation and distribution network expansion planning has been presented. The installation of feeders, transformers, substations, and generators has been considered and adequately described in the expansion planning algorithm. This allows a distribution company to obtain the optimal strategy to meet a rise in demand. In D7.3, the activities previously performed have been enhanced The including DR and hybrid storage. DR has been introduced in the model considering elastic demand functions calibrated by load levels. Demanded energy in every load level has been expressed as a function of the elasticity, demand and prices for the incumbent load levels included in the load-shifting horizon and average price.

During the grant agreement period, the measurable results yielded by the activities of WP7 led several submissions to a peer-reviewed scientific journal and four announcements in forthcoming energy-related international conferences, listed as follows:

Books and Book Chapters

[WP7.1] M. Asensio, P. Meneses de Quevedo, J. Contreras, C. Monteiro, R. Porumb, I. Triştiu, and G. Seriţan, “Electric Price Signals, Economic Operation, and Risk Analysis,” Chapter 6 in Book: "Smart and Sustainable Power Systems: Operations, Planning and Economics of Insular Electricity Grids ", CRC Press, Taylor and Francis Group, Jun. 2015.

[WP7.2] G. Muñoz-Delgado, S. Montoya-Bueno, M. Asensio, J. Contreras, J. I. Muñoz, and J. M. Arroyo, "Renewable Generation and Distribution Grid Expansion Planning," Chapter 7 in Book: "Smart and Sustainable Power Systems: Operations, Planning and Economics of Insular Electricity Grids ", CRC Press, Taylor and Francis Group, Jun. 2015.

[WP7.3] M. Asensio, P. Meneses de Quevedo, G. Muñoz-Delgado, J. Contreras, "Joint RES and Distribution Network Expansion Planning under a Demand Response Framework", ELSEVIER S&T Books, 2015

Journal papers:

[WP7.4] N. Neyestani, M. Y. Damavandi, M. Shafie-Khah, J. Contreras, J. P. S. Catalão, "Allocation of Plug-in Vehicles' Parking Lots in Distribution Systems considering Network-constrained Objectives", IEEE Transactions on Power Systems, Digital Object Identifier 10.1109/TPWRS.2014.2359919, 2014

[WP7.5] E.M.G. Rodrigues, R. Godina, S.F. Santos, A.W. Bizuayehu, J. Contreras, J.P.S. Catalão, "Energy storage systems supporting increased penetration of renewables in islanded systems", Energy (ELSEVIER), Vol. 75, pp. 265-280, October 2014.

[WP7.6] A.A.S. de la Nieta, J. Contreras, J. I. Muñoz, J.P.S. Catalão, "Optimal wind reversible hydro offering strategies for midterm planning", IEEE Transactions on Sustainable Energy, Vol. 6, No. 4, pp. 1356-1366, October 2015. http://dx.doi.org/10.1109/TSTE.2015.2437974

[WP7.7] F. Barati, H. Seifi, M.S. Sepasian, A. Nateghi, M. Shafie-khah, J.P.S. Catalão, "Multi-period integrated framework of generation, transmission and natural gas grid expansion planning for large-scale systems", IEEE Transactions on Power Systems, Vol. 30, No. 5, pp. 2527-2537, September 2015. http://dx.doi.org/10.1109/TPWRS.2014.2365705

[WP7.8] G. Muñoz-Delgado, J. Contreras, J. M. Arroyo, "Joint Expansion Planning of Distributed Generation and Distribution Networks", IEEE Transactions on Power Systems, vol. 30, no. 5, pp. 2579–2590, Sep. 2015.

[WP7.9] M. Asensio, J. Contreras, "Risk-Constrained Optimal Bidding Strategy for Pairing of Wind and Demand Response Resources", IEEE Transactions on Smart Grid, Digital Object Identifier 10.1109/TSG.2015.2425044, 2015

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1.3.7 WP8 – Implementation of DSM

Workpackage objectives:

The objectives of WP8 for the full project duration are the following:

- Install specific HAN web smart meters to selected pilot users that will support the DSM services, offer real-time energy data gathering from pilot sites and feed the cloud MDM system with energy raw data.
- Develop advanced models that allow the integration of real-time information streams of the smart power grid with diverse information pulled from online services, in order to translate the veritable explosion of data that becomes available, into a comprehensive knowledge repository supporting demand response decisions.
- Develop user interfaces and interaction methods that communicate energy-saving opportunities and price / dynamic incentives in an optimized way.

- Develop advanced consumer prioritization methods that continuously consider consumer's potential for load curtailment and allow utilities to efficiently select the appropriate consumers to apply DR in a given time.
- Develop an innovative cloud-based Meter Data Management system that will support and manage the proposed DSM / DR services to the energy consumer.
- Develop a platform, which will be different for the administrator (utility) and different for the user (consumer) that will participate in the DR programs.
- Develop the DSM strategy, which will include Energy Efficiency tips for savings and DR programs.
- Enhance the developed innovative cloud-based Meter Data Management system that will support and manage the proposed DSM / DR services to the energy consumer in the Crete pilot
- Enhance the platform, which will be different for the administrator (utility) and different for the user (consumer) that will participate in the DR programs.
- Finalize and adapt the DSM strategy, which will include Energy Efficiency tips for savings and DR programs.
- Deploy various DSM signals to the Crete pilot and measure various KPIs and effectiveness level
- Develop various DSM scenarios and measure the Key Goal Indicators and other relevant metrics
- Assess and rate the DSM effectiveness and the ability to expand the service to the commercial Utility market

Progress towards objectives:

Summary: In order to meet the aforementioned objectives for the full period, the work in WP8 was including the involvement of the four tasks below:

- Task 8.1: Smart Meter HAN devices installation and networking (M13-M18)
- Task 8.2: Development of the core cloud Meter Data Management System (M13-M18)
- Task 8.3: Development of Demand Response strategy roadmap and services catalogue (M13-M18)
- Task 8.4: Implementation of DR / DSM events in Real-time (M19-M30)

Task 8.1 faced a delay due to some difficulties that we encountered during the installations of the smart meters (defective data loggers and CTs)

In Task 8.1 of WP8 the installation of specific metering devices has been carried out in Crete (Heraklion). The energy meter selected to be installed in home consumers for the needs of the Demand Response pilot in Crete was a low cost smart meter and a data logger (i-meter) suitable for residential use, which empowers users with full utility monitoring.

The energy meter (Figure below) consists of the following parts:

- Battery Supplied wireless Transmitter with CT jaws

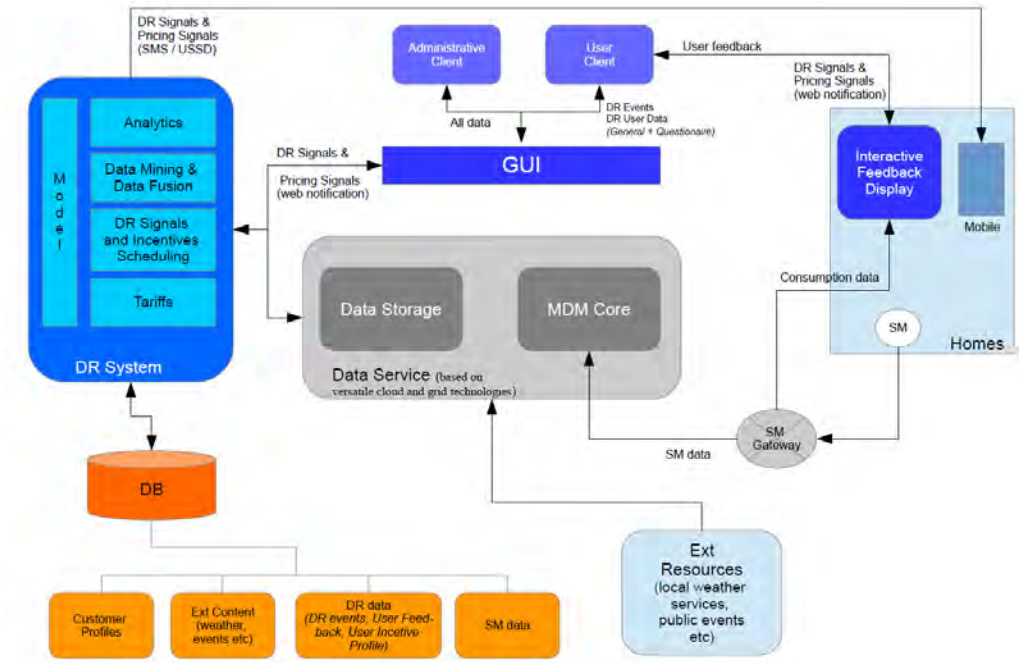
- Monitor Display (with variety of information regarding power consumption on real-time, energy consumption for the previous 1-7 or 30 days. Graphical representation of energy consumed within pre-determined periods of the time and information on temperature).
- Power adapter for the display
- Communication cable between the display and a USB stick.

With the electricity meter, an additional data logger was also installed, the i-meter

Intelen's iMeter is a smart device that acts as a data bridge between the meter and the Internet and is capable for a series of services, including the following:

- It performs basic calculations in order to translate the raw data that are collected by the specific energy meter to information that can be handled by Intelen centralised (cloud) infrastructure.
- It acts as memory storage (buffer) so that in case of a network or other error, data are not lost, but are stored for transmission as soon as network connectivity is re-established.
- It extracts the appropriate key performance indicators (KPIs) from the raw data received by the energy meter.
- It receives instructions for extra KPIs from Intelen Meter Data Management (MDM) System.
- It performs error handling concerning the energy meter, the connectivity of the system and the iMeter itself.

Tasks 8.2 and 8.3 were successfully completed according to the initial workplan. In Task 8.2 a Meter Data Management System has been developed and deployed along with relevant applications that implement DR and DSM services and supported the communication in between the platform and the consumers.



Task 8.3 was successfully completed according to the initial work plan and was adapted in order to meet the Dry-run requirements and the pilot objectives. There was a 7-9 months delay for the pilot deployments and dry-run implementation due to some difficulties that we had encountered during the installations of the smart meters (defective data loggers). In Task 8.3 of WP8 the development of Demand Response Strategy roadmaps and services catalogue were analysed and designed. Firstly, the Demand Side Management tools and techniques were studied as part of the state-of-the-art analysis conducted within this task. Secondly, in this Task the requirements for the technical and the functional core platform that has been developed have been set up. The analysis and specification of the core platform requirements were based on the DSM/DR strategies that have been designed and assessed in this Task.

Task 8.4 was run successfully and many DR events (21) were scheduled in two Phases for the Crete pilot site to test several behavioral motivational patterns for DR efficiency, as shown below, based on Task 8.4 for the preparation of D8.4 Deliverable:

DR Event	Time of Event	Duration	Scope	Status	Outcome
1	20:00-21:00	1 hour	Reduction	DR was successful	-2.88%
2	19:00-20:00	1 hour	Reduction	DR was not successful	0.37%
3	20:00-22:00	2 hours	Reduction	DR was successful	-3.89%
4	21:00-00:00	3 hours	Reduction	DR was not successful	10.88%
5	12:00-17:00	5 hours	Reduction	DR was not successful	15.45%
6	00:00-02:00	2 hours	Increase	DR was successful	70.47%
7	14:00-18:00	4 hours	Increase	DR was successful	3.37%
8	20:00-22:00	2 hours	Reduction	DR was not successful	7.90%
9	21:00-22:00	1 hour	Reduction	DR was successful	-0.67%
10	19:00-22:00	3 hours	Reduction	DR was not successful	25.14%
11	20:00-21:00	1 hour	Reduction	DR was not successful	1.85%
12	20:00-21:00	1 hour	Reduction	DR was not successful	32.78%
13	20:00-21:00	1 hour	Reduction	DR was not successful	22.09%
14	20:00-21:00	1 hour	Reduction	DR was successful	-14.72%

DR	Day of Event	Time of Event	Motivational factor	Control Group	Condition Group

Event					
1	10/09/2015	20:00-21:00	Personalization	15 invitees	15 invitees
2	24/09/2015	20:00-21:00	Notice in advanced	15 invitees	15 invitees
3	01/10/2015	21:00-22:00	Competition	15 invitees	15 invitees
4	13/10/2015	21:00-22:00	Feedback (without savings)	15 invitees	15 invitees
5	15/10/2015	21:00-22:00			
6	30/10/2015	20:00-21:00	Feedback (with savings)	15 invitees	15 invitees
7	04/11/2015	20:00-21:00			
8	26/11/2015	20:00-21:00	Set a certain goal for savings	15 invitees	15 invitees

The pilot execution required support for the smart meter installations to solve any issues regarding the proper functionality of the metering equipment and the communication with the central system. The support is organized in three levels. The first level support is responsible for the daily monitoring of the smart meter status to identify smart meter failures and telco support activities to solve minor issues with the help of end-users. The second level support performs remote support actions through iMeter's remote support functionalities such as rebooting the equipment and updating the network settings among others.

A dedicated web application was developed for Singular installers, which simplifies the installation process by providing troubleshooting information regarding the communication of iMeter with the smart meter and the central MDM system.

Progress towards objectives detailed for each task:

Task 8.1: Smart Meter HAN devices installation and networking (M13-M18)

This task was responsible for the installation of specific smart energy meters that would be used for the implementation of the DSM strategies that took place in Task 8.4. First, Intelen in collaboration with the partners that are involved in WP8, has decided on the model of the smart meter that was going to be used. The energy metrics that the meter could provide and the easiness in the installation of this specific meter were the two most significant criteria that have been taken into consideration during the phase of its selection. The energy meter that was finally selected to be installed for the needs of the DSM services pilot, is a low cost smart meter suitable for residential use which empowers users with full utility monitoring. Then the whole smart metering infrastructure was designed by Intelen in order to fulfill the requirements that have been set during the design of the DSM roadmaps. Next step was the order and purchase of the respective equipment. The installation of the meters and simulation of potential DR programs have taken place on one of the pilot islands, the island of Crete in Greece.

Task 8.2: Development of the core cloud Meter Data Management System (MDM) (M13-M18)

In this task the development of the core cloud MDM system that used in SiNGULAR has been designed and deployed along with relevant applications that implement DR and DSM services. The MDM system was designed to receive and send the measurements from the smart energy meters that have been installed under the Task 8.1. Functionalities and services for data validation, integration / storage, consolidation and access have also been implemented within the framework of the MDM system design.

Except for the design and the development of the MDM system, in this task the whole SiNGULAR platform design where the DSM strategies took place has been carried out. The platform was designed based on a distributed, service-oriented approach: it consists of several components that are designed and have been implemented as a set of interoperable services. The results of this implementation documented in D8.4. The four main functionalities of the SiNGULAR platform are the following:

- **Data Service:** Main functionalities of the Data Service are:
  - Communication with Smart Meters.
  - Data retrieval cleansing and storage.
  - The exposure of stored electric energy data to other components. .
- **DR System:** Main functionalities of the DR systems are the following:
  - User/Household Clustering of the home users that participated in.
  - Savings estimation per DR program.
  - Tip Recommender for the energy efficiency tips.
  - Typical usage profile for each user.
- **External Data Sources:** An integration system has been implemented in order to retrieve data from external data sources, for example electric energy tariffs files.
- **User Interface:** The user interface consists of an end-user web application and an administrative web application. Both applications support electric energy tariffs for up to 6 tariff periods, which can change in daily basis.

Task 8.3: Development of Demand Response strategy roadmap and services catalogue (M13-M18)

The scope of this task was to design and develop DSM strategy roadmaps and services catalogues. In this task the specification of relevant DSM/DR strategy metrics and Key Performance Indicators (KPIs) were defined. In this Task the requirements for the technical and the functional core platform that has been developed in Task 8.2 have been set up. The analysis and specification of the core platform requirements were based on the DSM/DR strategies that have been designed and assessed within the framework of this task. A state of the art analysis of the common technologies that are used in the DR program has been conducted.

Within task 8.3 different DSM policies were studied extensively which include both energy efficiency tips/ commitments and Demand Response (DR) programs. Initially a detailed study of the most common passive DR policies a specific DR roadmap has been designed for the needs of the SiNGULAR platform. The DR roadmap could contain 4 DR programs that can be found below:

- Real Time pricing (RTU).
- Time of Use (ToU).
- Critical Peak Pricing (CPP).
- Demand Bidding Program (DBP).

Because there was not the possibility to have actual variable or adaptive pricing due to DSO regulations, we decided to focus on emulating the ToU and RTU pricing and focusing a lot on social

and behavioral DR in order to measure the effectiveness. Actually we used the proposed DR strategies in a virtual mode with real energy mix data, enhancing a lot the behavioral part to increase motivations for people to follow the DR signals. Also many of the social KPIs were not used because of low (almost zero) use of social networks (Facebook) from the users not the mobile API (lack of smartphones available). Many KGI that are presented in DOW were adapted and re-adjusted in Deliverable 8.4, in order to focus more on the behavioral side of the DR and the various behavioral patterns

Task 8.4: Implementation of DR / DSM events in Real-time (M19-M30)

In average 1-2 DR events were scheduled/week in a real-time mode (immediate emails/platform messages), based on the pricing information and on the consumer profiling, since the DR signals are being sent on different time slots, according to the profiling. The DR events are scheduled and sent through the DR Admin panel of Intelen (see below). The emails are sent before the event and based on the real-time measurements Intelen verifies the DR drop and automatically estimates the consumer's potential and DR acceptance. Initially the Behavioral DR method was followed, where we sent to the consumers general tips and information about the RES mix; in other words we have informed them to use more "clean energy" in specific time slots (ToU) The behavioral method is actually combined with the Time Of Use (ToU on pricing info) where we inform the consumers of the specific electricity rates in daily slots or weekly slots (ToU and Dynamic Pricing / slot) and additionally we are informing them about the RES mix

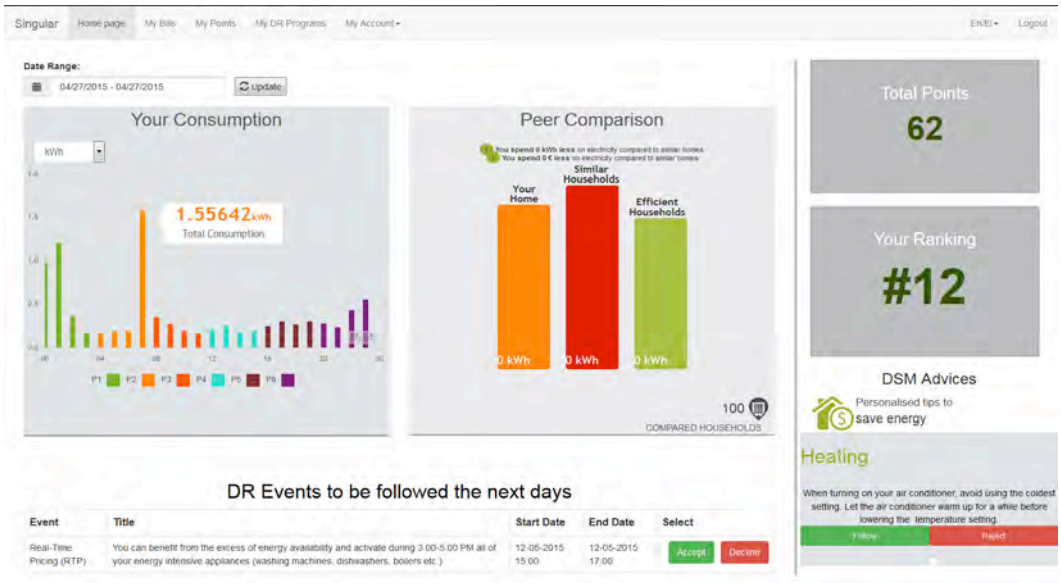


Figure 7: Homepage of end users' Demand Response platform

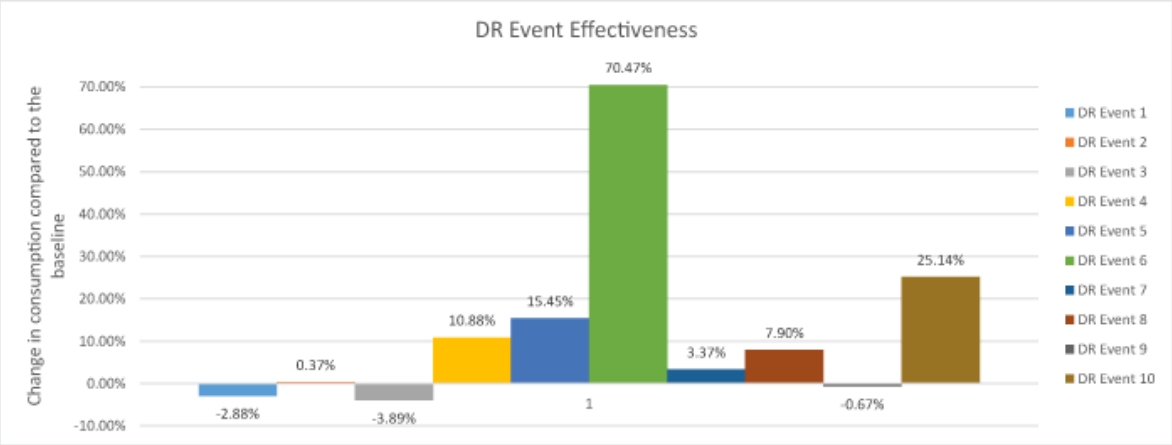


Figure 8: DR Events' progress

Significant results:

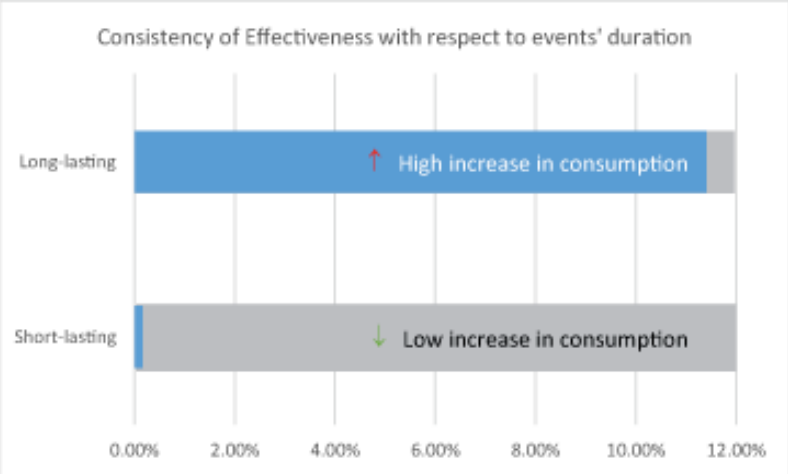
At the end of May 2014 that the first reporting period had also finished, tasks 8.1, 8.2 and 8.3 have been completed and the respective deliverables have been submitted to EU. The design of the smart metering infrastructure has been carried out and the installation of the 100 smart energy meters has finished in the home users of the Crete island that the pilot took place. Intelen's iMeter the data logger that has been used to extract the energy data from the energy meters to the SiNGULAR platform is sending regularly measurements every 15' minutes. Moreover, the design and implementation of the MDM system and the SiNGULAR platform for the execution of the DSM roadmap has been completed successfully within this first reporting period. Extensive surveys in the state of the art of the DSM strategies and the technologies that are used in them have taken place. After this detailed study, we were in the position to design our own DSM roadmaps for the users of the pilot site. Within task 8.3 different DSM policies were studied extensively which include both energy efficiency tips/ commitments and Demand Response (DR) programs. An energy tariff system and a point system have also been created for the scope of the pilot.

Within task 8.3 different DSM policies were studied extensively which include both energy efficiency tips/ commitments and Demand Response (DR) programs that served as the basis for the Task 8.4 for the Dry-run pilot execution and the extraction of many statistics about the DSM strategies. In Task 8.4 the DR events were scheduled successfully and executed on time with some great KPI and statistics results.

In particular, we found that given the framework of our research, DR events with energy consumption increase objective are more effective. Not necessarily with respect to participation but in terms of percentage results. Moreover, we found that for the 8 energy consumption reduction DR events there was a pattern of savings between the clusters of low, medium and high consumers. More specifically, the medium consumption cluster indicated the higher stability of savings over the DR events, having produced savings in the 4 out of 8 DR events. The group of medium consumers that included different number of participants each time and different user IDs, had an average of -6.54% energy consumption when requested with maximum reduction touching the -49.85% and maximum increase being 31.31%.

The low consumption group indicated savings in 3 out of the 8 DR events with an average of 19.73% increase of energy consumption over the DR events, a maximum reduction of -18.78% and a maximum increase in consumption of 83.00%. Lastly, the high consumption group that traditionally included the least number of participants and these participants were not residential consumers, reached the target of savings the 3 out of the 8 DR events, indicating a maximum reduction in consumption of -4.59%, while the maximum increase rocketed at the 55.06% increase compared to the baseline. The average increase was 15.46%.

Lastly, findings showed that shortest in duration DR events (up to 2 hours) were much more effective than long lasting DR events (more than 2 hours). Particularly, the performance of shortest DR events was almost to a "no effect" situation and of course significantly lower than longer DR events. Taking into account all short DR events, the outcome was 0.17% increase in consumption with 3 out of the 5 DR event being successful, while the increase of longer DR events was significantly higher, i.e. 11.41% on average, with no successful DR results at all. Figure below shows the difference in effectiveness between the short and the long lasting DR Events.



To that point, we should clarify that such sharp upward differences in energy consumption during the DR events compared to the baseline might be due to inefficiencies of the baseline model utilized. Nevertheless, the trends observed are important and provide insights. Of course, further research should take place in order to reject the hypothesis that DR events might lead, in majority, to the opposite of the desired behaviors direction.

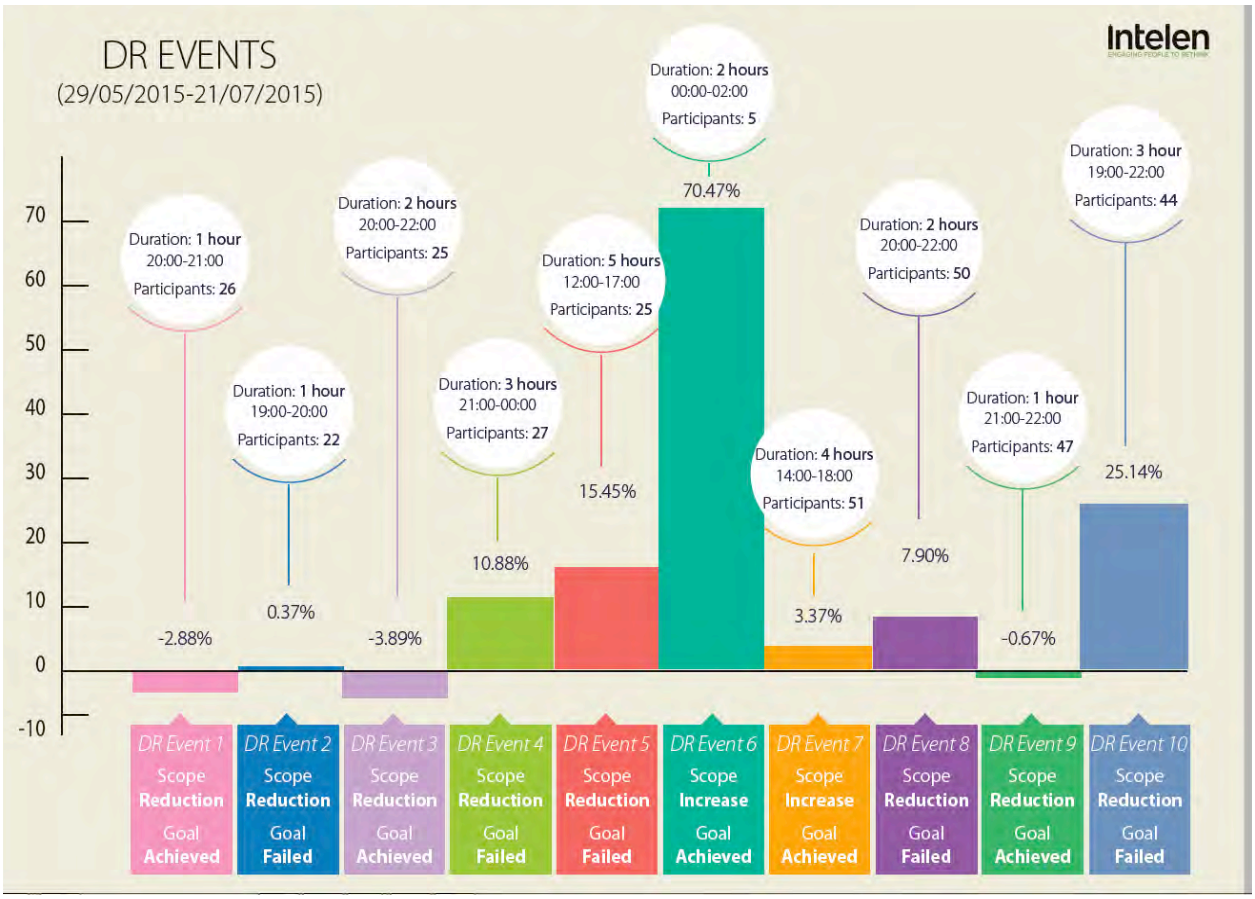


Figure 9: Overall stats of the initial DR events

Also, valuable insights about the behavioral DR design were gained through the course of the 8 DR events realized during the 2nd phase of the analysis. In total, 6 different motivational factors were studied and most of them proved to improve the effectiveness of DR events.

More specifically, personalization, competition, feedback (both with and without savings being referred) and setting a certain goal, were found to have a significant impact on energy savings. Table 27, summarizes the DR events deployed and the effectiveness per event.

DR Event	Effect	Outcome	Baseline 1	Baseline 2
1	Personalization	Improved DR effectiveness	-24.71%	-29.63%
2	Notice in advance	Did not improve DR effectiveness	50.38%	21.99%
3	Competition	Improved DR effectiveness	-15.13%	-23.23%
4	Feedback (without savings)	Improved DR effectiveness	16.44%	8.53%
5	Feedback (without savings)	Improved DR effectiveness	-45.19%	-50.70%
6	Set a certain goal	Did not improve DR effectiveness	26.62%	33.10%

Table 1: Effectiveness per DR event

When intrinsic motives stop driving effective DR events, exploiting other motivational factors to improve the DR effectiveness and boosts energy savings is a good strategy. However, since the

effectiveness of the studied motivational factors was not tested in the long term, their impact should not been taken for granted. Because it might be possible that the more participants are getting exposed to the effect, the least will be the perceived impact to lead to energy savings. Then, it might be necessary for monetary incentives to enter the game aiming to enhance the long-term savings.

Journal Papers

[WP8.1] M. Shafie-khah, E. Heydarian-Forushani, G.J. Osório, F.A.S. Gil, J. Aghaei, M. Barani, J.P.S. Catalão, "Optimal behavior of electric vehicle parking lots as demand response aggregation agents", IEEE Transactions on Smart Grid, 2016 (forthcoming). http://dx.doi.org/10.1109/TSG.2015.2496796

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[WP8.3] N.G. Paterakis, O. Erdinc, A.G. Bakirtzis, J.P.S. Catalão, "Optimal household appliances scheduling under day-ahead pricing and load-shaping demand response strategies", IEEE Transactions on Industrial Informatics, Vol. 11, No. 6, pp. 1509-1519, December 2015. http://dx.doi.org/10.1109/TII.2015.2438534

[WP8.4] O. Erdinc, N.G. Paterakis, T.D.P. Mendes, A.G. Bakirtzis, J.P.S. Catalão, "Smart household operation considering bi-directional EV and ESS utilization by real-time pricing-based DR", IEEE Transactions on Smart Grid, Vol. 6, No. 3, pp. 1281-1291, May 2015. http://dx.doi.org/10.1109/TSG.2014.2352650

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[WP8.7] M. Shafie-khah, F.A.S. Gil, J.P.S. Catalão, J. Aghaei, M. Barani, "Impacts of participating in different demand response programs on operational behavior of plug-in electric vehicle parking lots", in: Proceedings of the 2015 International Symposium on Smart Electric Distribution Systems and Technologies — EDST 2015 (technically co-sponsored by IEEE), Vienna, Austria, USB flash drive, September 8-11, 2015. ***Best Paper Award*** http://dx.doi.org/10.1109/SEDST.2015.7315190

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Deviations (from the project workprogram):

According to DOW the installation of 200 meters should have taken place in the Crete island that the DSM roadmap would take place. In a past plenary meeting, though, the consortium and especially the involved partners have decided not to proceed in the installation of the 200 meters due to limitations in the budget and the difficulties that is being faced during the selection of the end users and installation phase. The installation of the 100 smart energy meters that would be used for the pilot, had not been completed on time, since we encountered many unexpected problems during these 6 months of installation. The delays were mainly concerning the following issues:

- Home Area Network.
- Failure in some cases of the hardware equipment that had to be replaced after having about 35% of the installation made.
- Difficulties in finding the home users
- Technical issues with some of the electrical installations, so that they seem exactly the same as before, that prolonged the installation time

Hence, Intelen changed many defective CTs and data loggers and that resulted in a 6-7 month delay for the start of Task 8.4 (DSM implementation of pilot)

This was the main delay for the Task 8.4 that was started 7 months later but executed to the maximum degree and resulted into some great KPIs and analysis. During the execution of Task 8.4 there were no delays and all DR signals and schedule were on target.

1.3.8 WP9 – Testing and Validation

Workpackage objectives:

The main objectives of the Work Package 9, on Testing and Validation activities are mainly (i) to implement and evaluate the results of the tools developed during the previous work packages. To achieve the aforementioned objective the development of integrated simulations tools (ii) is needed. These tools will allow simulating the behavior of the insular electricity systems to analyze the performance of each scenario (iii). Finally, the project tries to make a real-life implementation, as far as possible, at the selected pilot islands.

Progress towards objectives:

Summary: SiNGULAR developed during the first half of the project (WP2-WP8) different software tools that were implemented in the pilot sites selected in order to evaluate the tools' performance. Each tool was framed in a specific work package but with a robust relationship between them, particularly those tools which aims to support the power system operation: probabilistic forecasting

(RES and Load), stochastic power flow and advanced scheduling algorithms. Other tools, like optimal planning stochastic algorithms that take into account RES penetration, electrical mobility and demand side management were implemented in some pilots to analyze the performance. The islands selected to implement the solutions developed in a greater or lesser degree were:

- Crete (Greece)
- São Miguel (Portugal)
- Brăila (Romania)
- Pantelleria (Italy)
- La Graciosa (Spain)
- El Hierro (Spain)

To achieve the objectives proposed in this work package a detailed planning was implemented to facilitate the way towards the objectives achievements.

Progress towards objectives detailed for each task:

Task 1: Development of integrated software tools for the simulation of the insular systems

Achievements made with reference to planned objectives

To analyse the performance of the different tools developed in SiNGULAR, it was necessary to integrate the tools according to the needs of each pilot site and theirs specific characteristics.

The integrated tools have been implemented as stand-alone applications, receiving data from the SCADA systems directly or 'manually' by email or FTP. The most complete integration was implemented in the island of Crete, where the application STEPS runs in parallel with the actual control center operations in HEDNO's headquarters.

a) Crete

In Crete four tools have been tested and validated: (i) Load and RES Forecasting, (ii) Power Analysis, (iii) Scheduling, and (iv) Demand Response. Load forecasting, power analysis and scheduling tools were integrated within a single stand-alone software application, called STEPS. RES forecasting (as well as an alternative load forecasting procedure) are performed via a Web-based Forecasting Platform. Finally, the demand response tool has been developed as an external application but with a strong connection with STEPS. In any case, all aforementioned tools communicate with each other by consistently exchanging useful data for their efficient implementation. Full detailed description about the integration of the tools in Crete was made in the deliverable 9.1.

b) São Miguel

In the island of São Miguel four tools were validated: (i) Risk-based Power Scheduling Tool (RiSch), (ii) Renewables Generation and Load Forecast, (iii) Planning and (iv)Power Analysis.

Similar to the other pilots, a web platform to share the Forecasting results has been developed. This platform allows an easy integration with other tools, which requires the information supplied by the

forecasting algorithms developed in the Work Package 2. In the case of São Miguel the platform send the information to the Risk-based analysis tools, developed specifically for São Miguel.

A specific tool to run the Schedulling in the island was developed, named RiSch. This tool receives the information supplied by the RES and Load predictions directly thanks the PHP/Python interfaces, interfaces that capture the forecasting from the MySQL databases.

The third tool, planning, was applied using the information about the distribution network provided by EDA. This algorithm was executed with two planning approaches: deterministic and stochastic but there is no way to compare the results with a "real situation" because there is not an existing planning for the distribution network in the island. For this reason, the "validation" was made comparing between all cases simulated.

Regarding Power Analysis, the software DERMAT (developed in the framework of the WP4) has been executed with the information of the Distribution Network supplied by EDA and the probabilistic forecast supplied by the Forecasting Web Platform. Thanks to the different interfaces created during this task, the communication of data between tools is completely reliable, mainly FTP and manual downloading available in the website. DERMAT is prepared to use that information thanks to its flexible interface through configuration files.

c) La Graciosa

In La Graciosa, finally the microgrid is not available yet. For that reason the decision taken was emulation of the microgrid. During this task the information collected by ITC thanks to the measurement stations installed was sent to the forecasting tools through FTP or email, in the format supported by the forecasting algorithms.

For the development and validation of the storage management in this pilot, an emulation of the microgrid was implemented in the framework of this task. The emulator, described in the deliverables 9.1 and 9.2, allowed to run different storage management approaches. The application, developed in MATLAB/Simulink has the interfaces to use the information provided by the measurements stations or the RES and Load forecasting.

d) El Hierro

In the case of EL Hierro island, only forecasting tools were validated. For this purpose, GORONA del VIENTO (power plant owner and operator) and SiNGULAR project signed an agreement in May 2015. From that date GORONA send files collected from the Wind Farm control supplying the theoretical power that the wind farm should produce in case that no curtailment and other technical restrictions are applied.

The files were received weekly in the binary format supplied by the wind turbines manufacturer (ENERCON). ITC processed the file to calculate the hourly average and to convert it to "csv/text" file, according to the requirements requested by the forecasting tool. Finally the files processed were sent to the Forecasting platform by FTP.

For load forecasting, the process followed was different. The information daily collected from the REE (System Operator) servers was sent, after processing, to the forecasting tool by FTP.

e) Pantelleria

In this it pilot makes no sense to talk about integration, since there is no any available data of RES generation real values. The forecast presented in the platform is only for virtual RES generation: Virtual Wind Power, Virtual Photovoltaic and Virtual Wave Power.

Regarding Power Analysis, the software DERMAT (developed in the framework of the WP4) has been executed with the information of the Distribution Network supplied by the DSO. DERMAT is prepared to use that information thanks to its flexible interface through configuration files.

f) Brăila

In this pilot, the power analysis tool and the forecasting tools were applied for testing and validation. DERMAT and the WEB FORECASTING PLATFORM were used to do it. As was mentioned above, the information of the distribution grid was formatted according the DERMAT configuration files and the information needed to train the forecasting models was sent by FTP manually to the Web Forecasting Platform, because the direct connection with the SCADA was not possible.

Task 2: Demo Planning and Preparation

Achievements made with reference to planned objectives

During this task, executed in parallel with the task 9.2, the demo planning was developed and the report included in the 2nd Common deliverable (D9.5) with IGREENGRID and SUSTAINABLE projects described the process to demonstrate the solutions implemented in SINGULAR.

During this task, as was planned, the final decisions about how the tools were to be implemented in the sites selected were taken and reported and the issues that limited their implementation were identified. It is important to bear in mind that the project consortium is composed by several utilities that have the responsibility of operate insular power systems guarantying the power supply to their customers and, at same time, test and validate some of the tools developed. It means, that some tools would not be applicable directly on the real dispatching, but in parallel avoiding a direct integration on the actual dispatching processes implemented in the power system control.

All objectives were achieved during this phase.

Task 3: Performance of demo scenarios

Achievements made with reference to planned objectives

During this task the experimental activities to test the tools developed in SINGULAR were developed according to the planning implemented in the previous task. The main objective was to parametrize each tool developed for each island and this objective was achieved. For each island, as reported in the deliverable 9.1, each tool tested was parametrized and adjusted to train the models or configure the tools. All the activities were made according the local specificities.

Task 4: Real-life implementation of the SINGULAR tools at the selected pilot facilities

Achievements made with reference to planned objectives

The main objective of this task was to implement in real-life, as far as possible, the tools developed on each island. Finally, six (6) islands have been included in the SiNGULAR project to implement, test and validate the different algorithms developed. El Hierro was the last island to enter the list of application sites. Not all tools were tested and validated in all pilots. Difficulties to access to island

operator SCADA systems and to access to information where utilities are not involved in the project restrict the implementation of some tools in the selected islands.

There are not any pilots where the tools have been implemented in the control centers and "in real operation" conditions, but some of them are running in parallel in order to compare the actual operation with the results achieved by the new tools proposed. Crete is the best example, where one integrated application, named STEPS, integrates, in an efficient way, several tools developed in SiNGULAR. This integrated application runs in parallel with the control center of HEDNO in Crete.

During this task the validation results have been obtained. The analysis of the values calculated for the different KPIs used to evaluate the performance was made also, presenting acceptable results. (Results reported in the deliverable 9.2).

Some tools have been difficult to validate, due to the lack of any reference to compare the results. As an example, the RES forecast evaluation could be assessed thanks to the real information gathered from the different pilot sites, but the Storage Management in La Graciosa or the Planning tools was only able to be compared with simulations under different scenarios.

Significant results:

The more significant result obtained in this work packages is that the tool developed during the first period were fully tested and validated in different islands with very good results and transferability opportunities to other insular regions around the world. The reasons is that the pilots used have different sizes in terms of peak loads, voltage levels and generation mixes, trying to have a wide range of different insular power systems.

The tests developed in the six islands, once all the KPIs have been analyzed show the following results:

- The forecasting tools developed for Load and RES generation has demonstrated high level results ensuring the replicability of the algorithms developed once the models have been trained. These results are presented in D2.3 and D9.2.
- Regarding the Planning tool, although a "real" validation could not be performed due to the lack of real planning of the DSOs involved, and the results presented were compared with a Base Case with simulations, the work performed in the WP 7 and validated in the WP9, shows a great potential to optimize the extension of the Distribution network (and not only in islands) taking into account not only the Distribution Generation, but also the Distributed Storage and Demand Response Programs. These results are available in the deliverables reported in the framework of the WP7 and in the deliverable 9.2. The results shows a very flexible tool that need the current grid data and RES
- The tool developed in WP4, named DERMAT, has been used for power analysis in the pilot sites. This tool, as show the validation works performed, is quite replicable and scalable thanks to its interface to configure the tool.
- Regarding Scheduling, two distinct approaches have been developed: (i) an advanced probabilistic unit commitment based on risk analysis, validated in Sao Miguel, and (ii) a second approach based on Mixed-Integer Linear Programming (MILP), validated in Crete. Those approaches have led to

the development of two integrated software tools as already mentioned, namely RiSch and STEPS, respectively. It has been shown that their use can reduce the operation costs of the islands. The results also show that:

- RiSch is replicable in small islands with a limited number of fast conventional generation units.
- STEPS approach is more suitable for large islands, where both slow and fast conventional generating units operate.
- Both can be applied to different power systems with moderate effort.

Deviations (from the project workprogram):

There are not major deviations during this work package according to the Plan designed during the beginning of the WP9, and in any case on the available resources:

a) The main deviation, or difficulty, was the problem to connect the SCADA systems of the Control Center of the pilot islands in "real time" with the tools' interfaces, mainly for security reasons imposed by the Operators. Only in the case of the island of Crete, a connection with the SCADA was made feasible.

b) Another deviation is that finally, during the project execution period, the ISWEC system could not be connected to the power grid of Pantelleria due to administrative issues. The impact in the project was the difficulty to validate the forecasting tool developed with real power production.

c) The inclusion of the new pilot island of El Hierro, is the main 'positive' deviation from the original project proposal. The forecasting tool has been finally tested in the island, but, the Power Plant Operator was interested in very short-term forecast as well. The reason to accept the research on Short-Term forecast is due to the problem that they have to manage the Wind Farms curtailments. An extra-effort in WP2 and WP9 was made to start to develop the short- term prediction.

Corrective actions taken/suggested

The actions taken have not inflicted any injury on the available resources in the WP9:

a) To solve the problem due to the difficulty to connect the SCADAs with the tools in real time, other procedures were implemented to send the information periodically. Mainly 'manually' by email or FTP.

b) To validate the Wave Forecasting tool, an extra-effort was made in WP9 to validate the waves against satellite data and the data collected by buoy installed close to the ISWEC system.

1.3.9 WP10 – Development of Grid Codes

Workpackage objectives:

The objectives of WP 10 are:

- The development of generalized guides of procedures specific for future generation of smart insular electricity grids,

- The incorporation of effective solutions and information so that the integration of insular and highly variable energy resources is maximized, and
- The description of hands-on rules/guidelines that could act as state-of-the-art and could be easily incorporated in the future Network Codes of such insular electricity grids.

Progress towards objectives:

Summary: In order to provide generalized guides for procedures for the management of insular electricity grids, a review of the Grid Codes already issued for various insular grids was necessary. Therefore, at the beginning of this Work Package, a review of existing Grid Codes for insular grids has been performed. Input from various insular networks Grid Codes, such as the Greek Islands, the Canary Islands, the Azores, the Italian islands, the Hawaii state in the US, the French overseas territories and Island countries such as the Caribbean Sea islands (e.g. Jamaica, the Barbados, the St. Lucia), Malta, Cyprus, Mauritius, the Faroe islands and the Pacific Ocean Islands were used in order to identify best practices. These inputs were then combined with the key outcomes of the R&D WPs of SiNGULAR (i.e. WP 2-8 and 11) to meet the objectives of this WP.

In this framework, an extended 200-page document (Deliverable 10.1) was prepared to provide recommendations (hands-on rules and guidelines) for various insular systems (IS) operational procedures, requirements and functionalities. These recommendations could be further incorporated in existing or future Grid Codes allowing for the maximization of RES integration in non-interconnected IS.

In brief, this document:

- Summarizes the progress in Grid Codes and common management practices from various Insular Grids that can be used as paradigms for other countries as well.
- Provides hands-on-rules and guidelines based on the SiNGULAR project results that can be incorporated in revised Grid Codes. Emphasis was given on Storage Devices Management and Demand Response.

The main sections of this document are as follows:

- Key issues/challenges in insular power systems.
- Common practices currently followed by DSOs in insular power systems.
- Best practices for large-scale RES integration in insular power systems.

The last section is the most extended one, since it provides the aforemetnioned hands-on rules and guidelines that could be characterized as best practices for the large-scale RES integration in non-interconnected IS.

The topics addressed in the document are as follows:

- Definitions of the roles of the participants and the Operator of the Insular System
- Typical system requirements in a variety of fields (typical values and deviations, telecommunications, short circuit levels, etc.)
- Technical and tecno-economic data that the should be requested for the Units connected to the IS for the effective management in smart insular networks.

- Forecasting procedures for various random system parameters (e.g. load, RES production)
- Scheduling procedures (Unit Commitment and Economic Dispatch)
- Ancillary services
- Expansion planning
- Functionalities of energy storage
- Pricing Schemes

Progress towards objectives detailed for each task:

Task 1: Definition of the basic structure of the grid codes

This task was essential in order to identify the general structure of the deliverable and the necessary bibliography required to be gathered. This has helped us so that the sections of the deliverable could be defined along with the corresponding bibliography. During the internal SiNGULAR meeting that took place in Iraklion, Crete, in April 2015, a very concrete implementation plan for the deliverable was presented to the partners.

Task 2: Definition of specific rules

Based on the results of the bibliographic survey, the outline of the document as described in Task 1 and the inputs from other work packages specific rules regarding a variety of operational and planning procedures were suggested. The main part of the document was prepared, while some adjustments and additions to the structure of the document were also made.

Task 3: Integration of Grid Codes

In this Task, the key findings of our research were highlighted. Based on the document as compiled until the month 32 along with the remarks from the partners, we focused on:

- Compiling an homogenous document
- Highlighting the suggested topics that the compilers of Grid Codes should take into account when creating or updating a Grid Code document based on the gathered experience from other DSOs and the findings of the WPs of SiNGULAR.
- Creating an executive summary of the document (about 20 pages). This was deemed necessary to give a concise outline of the document aiming mainly at the key findings of the research. This allows the reader to obtain the key findings of the analysis performed and, if interested, reach a more in-depth analysis in the specific chapters or paragraphs of the deliverable.

Significant results:

Common practices currently followed by DSOs in insular power systems

From the performed analysis, few island territories have implemented sophisticated Grid Codes in terms of Market Complexity. Many of the Grid Codes focus mainly on technical requirements for RES interconnection and operation and, thus, they resemble what is called Distribution Management System Code of the Interconnected Power Systems. Cyprus is the IS, which has planned to make structural changes in the Market Operation similar to large interconnected power systems.

Most of the IS have higher values of voltage and frequency deviations compared to the mainland power systems.

A common practice, on most of these IS, is the use of persistence or advice of weather web-sites for forecasting and the use of a simple merit-order list for scheduling. Very few IS, mainly the largest ones, e.g. Crete, have more sophisticated tools for scheduling and forecasting. Thus, the use of tools developed within SiNGULAR and installed at the pilot sites is expected to provide significant aid for the management of the IS.

Regarding Energy Storage, the Canary Islands and the Greek islands have some type of legislation on Energy Storage, while the Hawaii State has already implemented Storage projects as well as the residents have started using Electric Vehicles (EVs).

In some of the islands, e.g. Jamaica, Crete, Rhodes, Cyprus, a common practice that is followed is the use of under-frequency (automatic) load shedding.

One key finding from these common practices is that the networking and co-operation of the insular DSOs facing similar technical challenges can bring about significant benefits on the effective management of these systems. This is the example of the Caribbean Electric Utility Service Corporation (CARILEC) and the Pacific Power Association (PPA).

Hands-on Rules and Guidelines

This was the heart of our efforts and covered the largest part of the Deliverable 10.1. The analysis performed addresses the following topics:

Definitions of the roles of the participants and the Operator of the Insular System and necessary classifications

The outcome of our research is that the classification of IS is essential when preparing Grid Codes, especially for countries with a variety of sizes of islands. This will help in: a) implementing specific rules for larger and simpler islands, and b) the simplification of the market procedures for smaller islands; increased complexity of the market structures in smaller island systems may create adverse results regarding the development of RES and the adoption of smarter approaches. Additionally, as discussed in the section of D10.1 regarding storage, very high penetration levels have been currently reached for small islands.

The recommended classification is either based on their size (e.g. peak demand), or their generation mix and network characteristics. Such a distinction is crucial, since a Grid Code should explicitly define which of the specific operational procedures, requirements and standards should be mandatory for an IS or could be regarded as optional, depending on the size and/or generation and network characteristics of the IS. A typical classification may be on the peak size as follows:

- *Very Small IS,* when the average peak demand of the previous five (5) years does not exceed 2 MW.
- *Small IS*, when the average peak demand of the previous five (5) years is between 2 MW and 10 MW.
- *Medium IS*, when the average peak demand of the previous five (5) years is between 10 MW and 100 MW.
- *Large IS,* when the average peak demand of the previous five (5) years exceeds 100 MW

A clear definition of the main IS participants (e.g. IS Operator, Producers, Load Representatives, Demand Aggregators, Users, etc.) as well as their typical responsibilities and obligations is of utmost importance. In many islands the IS Operator may currently be at the same time the owner of all the Generation Units, including RES, Grid Operator and the sole market player. If extended market participation is foreseen, the IS Operator role may have to change but in any case an IS Operator should monitor and ensure the reliable, efficient and secure operation of the power system, carry out the generating units scheduling and dispatch, manage the provision of reserves, compile the power system planning studies, prepare and implement emergency plans and make market transactions. Therefore, before applying market policies the roles of the participants should be clearly defined.

Typical system requirements

Most of the Grid Codes contain detailed information on technical issues on how to earth facilities, what are the interconnection requirements etc. In our approach, the Grid Code should contain generic guidelines on technical issues that should be further described in the fields of:

- Frequency and Voltage levels
- Short Circuit Ratio
- Protection Schemes
- Flicker emissions
- Earthing
- Communication infrastructure

However, detailed ways of calculations should be described in a separate more detailed Manual. This approach is followed also in interconnected Power Systems where Market Operator and Distributed System Operator are different entities. Three key-findings on the system requirements are the following:

- For smaller islands, somewhat larger voltage and frequency deviations should be allowed. This should be made known to the DG producers, so that their equipment is accordingly adapted.
- The acceptable rate of change of frequency (RoCoF), which is a very critical aspect for ensuring the reliability in fully autonomous systems, should be provided. Such rates are expected to be much higher as the islands become smaller.
- As the complexity (number and diversification of participants) of the IS increases, more detailed telecommunication infrastructure requirements should be prescribed.

Technical Requirements for Units connected to the Grid

Connection requirements may resemble to those prevailing in the interconnected power systems, but some modifications may be required in order to provide frequency stability and voltage stability, which are usually of high significance to the IS. For instance, for the same installed capacity, mainly in smaller IS, the connection requirements may be stricter than in mainland grids.

It is strongly recommended that the IS Operator creates a Database with the typical technical and techno-economic parameters of the IS. Even if no market exists at all, this may significantly improve the performance of the IS and can help the IS Operator more effectively integrate software tools that have already been developed or are under development.

The Grid Code (and/or the respective Manuals), should also provide information of the desired behavior in case of faults even single-phase ones, especially for DGs. Some of these typical requirements have been provided in the Deliverable but, in any case, recommendations from international organizations should be also taken into account.

For any other technical requirements such as black start capability, reserve provision, etc., it should be taken into account that smaller-scale DGs compared to larger interconnected power systems may be requested to provide aid or services to the IS Operator.

Forecasting

The common outcome of the review of the current practices is that few references in few existing Grid Codes exist on forecasting procedures for IS. In most of the IS, load and RES forecasting is empirical and very few islands -mainly the largest ones- use more sophisticated tools for load or wind power forecasting. Therefore, in D10.1, apart from the little experience on other Grid Codes about forecasting, the results of WP2 were also taken into account. The suggestions made by this document were about the following:

- The type of forecasting necessary for the operation and management of insular networks (i.e. load, wind and PV forecasting).
- The forecasting horizons and their applicability for various operational procedures (Maintenance scheduling, Unit Commitment, Economic Dispatch and Real Time scheduling).
- The input data (e.g. historical time series, historical and forecasted weather and climate data, time/calendar data, etc.) and the output data (e.g. forecasted values).
- Forecasting models should also be able to deliver probabilistic forecasts instead of single-valued (point) forecasts.
- The forecasting error values and types of evaluation of forecasting errors. More specifically focus was given not only on the Mean Average Percentage Errors (MAPE) but also on how often and how large the forecasting errors should be. Different forecasting horizons require different values of accuracy. This information may be used not only for Grid Codes but also on Tenders for obtaining forecasting tools from the DSO, as already done for HEDNO case.
- The forecasting tools should be able to integrate manual interventions related to Network Operations, e.g. when part of the Grid is under maintenance.

Scheduling

The various levels and operational horizons for Generation scheduling should be defined in a Grid Code. These procedures may include:

  - Day-Ahead Unit Commitment or Rolling Day-Ahead Unit Commitment
  - Real Time Unit Commitment and
  - Real-Time Economic Dispatch

For all these functions and for various time horizons, the procedures, the typical algorithms that may be used as well as the contents of exchanged information among all the stakeholders have been described in the D10.1 document. This information is the outcome of the gathered experience in

HEDNO, the outcome of the results of WP9 available during the preparation of the deliverable and the results of WP 5. Such information should be defined in a Grid Code document.

The latest advance in operations practices, which is expected to be very useful for IS, is the incorporation of Rate of Change of Frequency (RoCoF) constraints in unit commitment and economic dispatch models. These constraints ensure that, if a credible contingency occurs, the system frequency does not drop so quickly that under-frequency load shedding is activated before generators are able to respond. This way, undesirable load shedding or even black-outs can be avoided.

Ancillary Services

The lack of interconnections and the fact that not many units operate in parallel may increase the requirements for Ancillary Services provision from units of smaller size and of different technology than in an interconnected power system. Load-frequency reserves are of paramount importance for the containment and restoration of the IS frequency in case of a major event (i.e. unit or line outage) or/and the conservation of the system frequency in acceptable margins under normal operating conditions.

For each category and reserve type, potential providers should be specified. For instance, Frequency Containment Reserve (FCR) could be provided by thermal and dispatchable RES units and loads equipped with a droop control system (wind turbines with power converters may also fall in this category). Demand response (including load-shedding) as well as variable speed pumped turbines may also contribute to the provision of FCR.

It is important that calculations on the Reserve requirements or for any other Ancillary Services provisions, take into account load and RES variability and uncertainty, so that the most efficient dimensioning is obtained. These calculations may take into account either deterministic or probabilistic criteria.

The quantification of the flexible ramping requirements should be performed based on the forecasted load and non-firm renewable generation, for all scheduling intervals, in order to take explicitly into consideration the possible appearance of steep ramps, due to the volatile and unpredictable nature of renewable energy sources.

Expansion planning procedures

In some Grid Codes there are generic references on what is required for both generation and Grid Expansion planning. The typical approach is N-1 Criterion or the largest Single Infeed (LSI) loss. In D10.1, the approach suggested by the SiNGULAR project in WP 7 has been considered. The main scope of the specific chapter was to provide an insight of which data should be provided and hence should be systematically stored by the DSOs, if such studies are to be implemented. Additionally, the request of typical outputs and the answer to specific questions when considering such studies has been pinpointed.

Various important issues have been identified as of particular interest for the Insular Networks. The first one is the low min/max ratio, which may require as an alternative the rental of the production units for generation expansion. The second one is that the RES capacity to be installed should be limited in order to avoid potential stability issues, i.e. definition of ‘electrical space’ for RES. Thirdly, expansion planning studies should also provide potential solutions that could lead to the relaxation of

RES installed capacity limitations and, therefore, allow for considerable increase of the respective RES capacity. Such solutions include interruptible production contracts for RES capacity, introduction of storage systems, demand response actions, installation of flexible conventional units, etc. Finally, it is recommended that in case of proposals for the interconnection of one IS with another or the mainland grid in order to usually exploit the high RES potential or increase the system reliability, the potential benefit as compared to the independent operation of such systems should be properly quantified (e.g. through a cost/benefit analysis).

Demand response

Currently, very few examples of very limited Demand Response in insular Grid Codes exist. For instance, in Cyprus specific loads shall be disconnected in case of emergency, (e.g.. frequency excursion), while for the Greek islands, a specific paragraph referring on the common management of Desalination plants and RES dedicated to the Desalination plant and interconnected at the same island network with application on the island of Milos, was identified.

Therefore, a Grid Code should first define the roles and responsibilities of the participants that are involved in the provision of DR services. Communication and coordination between the involved participants (e.g. IS Operator, load aggregators, consumers) should be robust with clear distinction of the various assignments.

The specifications of each DR product should cover, at least, a list of elements, such as the activation time, the price of the bid, the minimum and maximum quantity, the duration of the event, the mode of activation, the frequency of activations, the penalties for non-compliance, etc.

Since there is no "one-size-fits-all" best approach, baseline methodologies should balance accuracy, simplicity and integrity and produce consistent results that are unbiased in either over-predicting or under-predicting the actual performance. Additionally, brief information on the necessary communication infrastructure in order to implement the DR actions is also provided. Advanced metering infrastructure (AMI) could provide substantial aid to the implementation of such actions.

A special paragraph on specific code requirements for Electric Vehicles (EV) has been incorporated. The IS Operator should also determine if high-capacity charging stresses the IS and, thus, whether EV Charging Systems should be restricted at low-capacity charging.

Since the integration of EVs in IS is an innovative project, for the sake of simplicity, it is proposed that the Grid Code should first foresee and specify the implementation of unidirectional interaction between EVs and the Grid.

Storage

International practice with IS presenting very high RES penetration, exceeding 60%, has shown that storage is essential to achieve such penetration levels. However, an IS Operator is not generally allowed to retain facilities that can produce electricity and generally participate in the energy markets. Thus, installation and management of storage facilities by the IS Operator to make profit is hardly acceptable by the Regulatory Authority.

However, storage can provide substantial aid towards the efficient management of IS by:

- Enhancing local reliability and, especially, response to contingencies.

- Smoothing the demand; this is more important in IS, since such systems usually present extremely low minimum/maximum ratio with significant cost difference from season to season.
- Giving the opportunity to absorb excess electricity from RES units that otherwise would have been curtailed. Thus, the installed RES capacity and penetration may increase.

The following guidelines should be considered:

- Single installation of energy storage facilities without additional production capacity. The most simplified approach is either to use storage as a service, or face it as a producer during high-cost hours and as a consumer during low-cost hours, or when RES production is expected to be curtailed.
- Combined operation of RES and storage facilities to formulate Hybrid Power Stations (HPS). In such a case: i) RES capacity and penetration can be increased and the HPS is the sole responsible to provide inputs to the energy scheduling performed by the IS Operator. ii) RES units (especially wind and PV) can become more dispatchable and less volatile in their production providing aid for the Ancillary services provision and participate in market operation.

The typical precautions for management of Storage Devices combined with RES along with a detailed analysis of the scheduling procedures were provided in the document.

Additionally, typical signals that should be exchanged between storage devices and the DSO Control Centers were also suggested. This may help both the owner of the storage devices and the DSO to set up the necessary measurements and communications.

A special form of Storage is the Thermal Storage in Solar Thermal Power Stations. Since such Power Stations are of high capacity compared to the peak demand of the islands, operational precautions should be taken into account. A list of questions that the compilers of an updated Grid Code should be able to answer in their updated Grid Codes has been provided in the document. Some typical commitment rules for STP stations combined with thermal storage were also provided based on the Greek Experience.

Market Organization and Pricing Schemes

The Grid Code should be able to implement transparent pricing and operations mechanisms, applicable independently of generation ownership and demand representation.

Four types of remuneration may exist for insular networks, listed as follows:

A) Remuneration for electricity injected to the grid (€/MWh)
B) Remuneration for Capacity Availability (€/MW)
C) Remuneration for Ancillary Services
D) Remuneration on Emergency plans

There may be variations depending on the dispatchability of the Units and the use of fuel or RES. Additionally, especially for RES, any incentives or feed-in tariffs should be also taken into account so that the DG unit is neither over-remunerated nor under-remunerated.

Regarding, demand side participation, energy and capacity charges should be defined either by national or regional tariff system.

Additionally there should be clauses for the payments for the absorption of electricity for charging the storage devices of either single storage devices facilities or as part of Dispatchable Hybrid Power Stations.

Moreover, suggestions on how to take into account imbalances, deviation and sanctions should be provided. It is our opinion that such clauses should be outlined in a Grid Code and further elaborated in the Manuals of the Grid Code. In the Grid Code however, the variety of Accounts that should be established for the market operation should be defined.

Finally, some parameters for pricing may be requested to be regulatory defined such as values for Regulatory Asset Base or additional Variable Operation and Maintenance Cost mainly of Conventional Units.

During the full duration of the project, the measurable results yielded by the activities of WP10 led to two (2) publications in peer-reviewed scientific journals and one (1) announcement in energy-related international conference, listed as follows:

Journal papers

[WP10.1] O. Erdinc, N.G. Paterakis, J.P.S. Catalão, "Overview of insular power systems under increasing penetration of renewable energy sources: opportunities and challenges", *Renewable and Sustainable Energy Reviews*, Vol. 52, pp. 333-346, Dec. 2015.

[WP10.2] E.M.G. Rodrigues, G.J. Osório, R. Godina, A.W. Bizuayehu, J.M. Lujano-Rojas, J.P.S. Catalão, "Grid code reinforcements for deeper renewable generation in insular energy systems", *Renewable and Sustainable Energy Reviews*, Vol. 53, pp. 163-177, Jan. 2016

Conference paper

[WP10.3] E.M.G. Rodrigues, A.W. Bizuayehu, J.P.S. Catalão, "Analysis of requirements in insular grid codes for large-scale integration of renewable generation", in: *Proceedings of the 2014 IEEE PES Transmission & Distribution Conference & Exposition — T&D 2014*, Chicago, Illinois, USA, 14-17 April 2014.

Deviations (from the project workprogram):

A short delay in the submission of D10.1 (about 35 days) was inevitable, due to the fact that the 200-page document had to be homogenized, but mainly due to the fact that a summary of the document was sent to experts of the Regulatory Authority of Energy in Greece for their feedback. However, this delay did not affect at all the progress and successful completion of the remaining WPs. In addition, at the same period, the HEDNO personnel had to prepare the tenders for the new SCADA/Energy Management System and Market Management Systems, not initially scheduled at the planning phase of SiNGULAR. However, for the preparation of this tender, some of the ideas and results of the SiNGULAR project and specifically of the work done in WP10 were also considered as very useful.

1.3.10 WP11 – Evaluation, recommendations and roadmapping

Workpackage objectives:

- To evaluate the outcomes of the project, elaborating recommendations and a roadmap for futures developments;
- To analyze the effects of large-scale integration of renewables and DSM on the planning and operation of insular electricity grids;
- To develop an overview of the different methodologies, procedures, tools, services and grid codes proposed for the efficient short-term operation and long-term planning of insular electricity grids.

Progress towards objectives:

Progress towards objectives detailed for each task

Task 11.1: Evaluation (M19-M24):

This task defined the assessment criteria and the evaluation mechanism that was applied. An important aspect of the work carried out was the definition of the evaluators that participated in the assessment process, along with the evaluation tools (mainly peer reviews, on-line questionnaires, feedback, and discussion groups) that were incorporated. In any case, the use of web technologies had a primary role in the assessment of SINGULAR results.

Task 11.2: Recommendations (M31-M36):

Work synthesized findings from the results of all previous WPs in order to provide an orchestrated report on new solutions and their impact at European level.

Task 11.3: SINGULAR Roadmapping (M31-M36):

Roadmap analysis was based on the results of previous WPs. The roadmap identified new research and technology development areas within and beyond the domains defined by SINGULAR with the aim of contributing to the research and development priorities of HORIZON 2020.

Significant results:

- On December 12th, 2013, SiNGULAR organized the 1st External Advisory Board (EAB) meeting that took place in Las Palmas de Gran Canaria (Canary Islands, Spain), and was hosted by Canary Islands Institute of Technology. A technical visit to El Hierro Wind-Hydro Power Plant was also scheduled for the second day. Overall, all reviewers were impressed with the progress of the project at this early stage, just finishing the 1st year of activities, and their comments and recommendations were useful for the subsequent steps of the research.
- From November 2014 till February 2015, a detailed on-line questionnaire was implemented in order to evaluate SiNGULAR from the point of view of the research community, companies and other experts (institutions, entities, etc.). SNGULAR was considered innovative and interesting by a large majority (81% on average) of the participants. Six New Market Products were developed.
- On June 25th, 2015, SiNGULAR organized the 2nd EAB meeting that took place in Ponta Delgada, Azores, Portugal, and was hosted by EDA – Electricidade dos Açores (Island DSO). A technical visit to a Geothermal Power Plant was also scheduled for the second day. This Meeting focused on Partners coming from the "Family of Projects", namely SuSTAINABLE and iGREENGRID. As mentioned by the EAB members, "R&D in SiNGULAR was made from

scratch. A large amount of work has been done, which is excellent. Validations is proven by the many results obtained". From the on-line feedback, the aggregated conclusions are as follows (in short): "The project SiNGULAR is of significant depth and shows an impressive array of research activities centered on the development of sustainable insular electricity grids. The sequence of WPs is very coherent and structured. The consortium profile makes a project like this possible. There is presence from all type of entities on wide scale sectors of activity. Congratulations for the extensive dissemination activities and publications." – including a book published by CRC Press in Florida, USA (http://www.crcpress.com/product/isbn/9781498712125).

- Finally, regarding the "Short report on exchanged experiences on demonstrations and validation of the proposed solutions", based on the 3rd IGREENGrid-SiNGULAR-SuSTAINABLE Global Joint Conference that occurred on 26-27 November 2015 in Caparica, Lisbon, Portugal, involving the 3 FP7 projects alongside 6 H2020 projects as guests, six topics of high interest were presented and discussed: 1) energy storage, 2) forecasting, 3) generation curtailment, 4) demand side management, 5) voltage control, and 6) scalability & replicability. The benefits from storage applications were described, identifying promising and innovative applications and some conclusions of energy storage. The use, applications, types and frameworks of forecasting were addressed, as well as its value and evaluation. Generation curtailment was also addressed regarding the situation in some EU countries. Demand Side Management and Voltage Control were also specifically addressed, regarding technical approaches, architectures, and regulatory issues. Finally, the objectives and challenges of the Scalability and Replicability analysis were debated. Overall, a great common experience, with shared knowledge and know-how from different but complimentary perspectives.

1.3.11 WP12 – Dissemination and Exploitation

The objectives of the WP12 were the following, already gathered regarding the major concept of each one, and according the Dissemination Plan.

Strategy And General Concerns

- To develop SINGULAR dissemination and communication strategy;
- To develop and carry out a concrete set of activities that will ensure the success of the communication strategy.
- To monitor and contribute to standardization activities in wireless standards under development.
- To widely disseminate SINGULAR concept, developments and findings to all key actors in the field in an interactive way, integrating their feedback at key points of the specification, design, development and evaluation work;

Constant Communication

- To develop an interactive and user friendly web site to inform the general public and relevant stakeholders about SINGULAR.

Scientific Achievements

- To organize and / or publish results in international conferences and workshops to inform the scientific community about SINGULAR goals and achievements and to gather valuable information on related issues;

Specific and presential Networking Actions

- To plan and realise key workshops and events and administer a User Forum, to support the wide diffusion of the above and guarantee proper input and feedback by key stakeholders;
- To collaborate and exchange knowledge and results with relevant projects to be implemented under task 7.1.1 i.e., SuSTAINABLE, iGREENGRID and coordination actions such as the GRID+ project and the EEGI and to participate in events and concertation activities organized by such projects and coordination activities.
- To cooperate with national projects currently being held in the countries (or in the specific islands, if applicable) involved in SINGULAR, which are relevant with the objectives of SINGULAR in terms of participating in/organizing joint events and activities for knowledge sharing and dissemination.

Exploitation and IPR

- To issue exploitation plans for key project results and oversee IPR management within SINGULAR and beyond.

Progress towards objectives:

Summary: The goal of WP12 is to ensure that the project and its outcomes were widely disseminated. The exploitation potential of results were explored. The objective is to guarantee the wider promotion of SINGULAR outcomes. The SiNGULAR general strategy regarding the three years of the project can be summarized in the following major issues:

- YEAR 1. Communication tools. Collaboration procedures. First scientific results
- YEAR 2. Scientific Results. Networking with other projects. First analysis exploitation results.
- YEAR 3. Scientists final results. Exploitation Plan Results.

Progress towards objectives detailed for each task:

Task 12. 1: Dissemination plans and activities (M1-M36)

- Communication tools. The existence of tools that ensure continued communication of SiNGULAR: logo, website, leaflet (two sets), forum, continuous feedback and permanent availability of information, always according to the Project, especially those relating to family projects. All communications tools done were running regularly.
- Dissemination of current state of the work done by SiNGULAR on schedule and produced results. This action is the life of the project already in its continued development. Is guaranteed by the communication between partners, and its main reflection in the news that are loaded into the project website. Also in attendance own or organized by Grid + events. During the second period,

Concepto Sociológico created a great data base[1] with more than 9.000 international energy experts who receive periodically information about SiNGULAR achievements and progress. Few newsletters and other dissemination documents were created and sent to this data base.

- Organizing own events. A total of 10 internal meetings had taken place during the three years of the project, as well as, Global Joint Stake holders Conferences (SuSTANABLE and iGREENgrid).
- Scientific publications. The project has showed great results and scientific publications, which were in its highest level during the second mid-term, reaching a cruise speed according to the relevance of the project achievement. They both, public deliverables and scientific publications (papers accepted in journals and international conferences) have been uploaded to SiNGULAR website, being available to everybody.

Task 12.2: Business models (M19-M30)

Its implementation has been carried on during this second period. Firstly, by a market analysis and then, elaborating a feasibility plan.

The elaboration of a market survey for the final business plan was necessary. Its objectives were to identify the project's results thoroughly, to understand the importance they could have in the market and to elaborate a clear scheme for every single result in order to identify its viability in the market. A double work has been done in which, firstly, the target to which the results could be directed towards international experts has been segmented identifying three important different groups, industry companies, academic and scientific community, and experts in general (other institutions, governments, etc.): international experts as members of companies, organisations and governments, private and state corporations, universities and institutes, all of them related in the broadest sense with the main objective of SiNGULAR, with a view to identifying the Singular principal fields of interest. They have been subjected to a market survey as comprehensive as possible in order to understand the whole value scene of research and results achieved to date by the project.

SURVEY. Data Sheet

Universe: international experts specialized in areas related to Singular fields with the following occupations:

- Academic and research universities, institutes
- Industry, DSOs, and Power generation
- Others experts as governments and No Governmental Organizations,

Geographic scope: international
Population register: 9.230 international experts
Level of reliability: 95%
Sampling error: ± 3'4 %
Sample size: 759 international experts
Sampling: no sampling has been achieved
Timing of survey: 20/11/2014 – 10/02/2015 (2 months and 10 days)

[1] Protection of personal data. Directive 95/46/EC

Secondly, once their opinions were known with a representative sample, we have proceeded properly and, in consequence, we have analysed each result within its specific market future forecast.

Feasibility Plan. Thanks to the previously Market Analysis we have better understood which are the handicaps or barriers that SiNGULAR's results would have to take into consideration when elaborating a new business plan. In fact, the ecosystem of products for large-scale integration of renewable and demand side management (DSM) in the planning and operation of insular (non-interconnected) electricity grids, proposing efficient measures, solutions and tools towards the development of a sustainable and smart grid that SINGULAR undertook, required the creation of a novel business model, in which few companies and energy providers can offer a set of products.

Task 12.3: Standardization issues (M6-M36)

This task ensures the orderly and recorded communication among partners. Very simple procedures are established for monitoring the dissemination of each partner was doing, home and abroad. The main mechanisms are: **check list**[2] (9 during all the project), personalized follow up email, bilateral discussions at each meeting, especially for future actions would produce and be able to track (attendance at congress, preparation of scientific articles, etc.).

Task 12.4: Clustering with other projects (M1-M36)

- Networking with other relevant projects: The primary relationship with other projects, for meetings, works and events has been with the so called Family Projects, which includes SiNGULAR, SuSTAINABLE and IGREENgrid. Since the first meetings celebrated during first quarter, which designed a joint work program, the normal organization of events, meetings and regular participation in the committees, and joint events of each one, the network run normally with full collaboration.
- SiNGULAR has been communicated to the national representatives of EEGI as well as the technical secretariat located in Brussels (Zabala Consulting), and it was properly documented. Similarly, SiNGULAR obtained in November 2013 the ranking EEGI Labelled Support Project.
- Joint dissemination activities with SuSTAINABLE and iGREENGRID have been organized during this period. International Workshop in Canary Islands and Athens.
- SiNGULAR has been communicated to the European Energy Research Alliance (EERA) during first six months and currently we are waiting the first scientific results to reinforce technical interaction. Meanwhile SiNGULAR and EERA exhange news and communications.
- Networking with National projects, produced have been done with Italy, Portugal and Spain:
  - National project "Evaluation of Effective productivity of Floating System for Energy Generation from Mediterranean Saw Wave" (2011-2012) (Pantelleria, Contact Entity: POLITO).
  - Regional project PROMO - Produzione di energia da Moto Ondoso - Regione Piemonte (2012-2014) (Pantelleria, Contact Entity: POLITO)
  - Smart Microgrid in La Graciosa Island (Jan 2012 – Dec 2014) (Contact Entity: ENDESA, ITC)

[2] More information about check list in Annex I

- PV Forecasting Tools in Canary Islands (Jan 2009 – Dec 2013) (Contact Entity: REE, ITC)
- El Hierro Wind-Pumped-Hydro Power Station (Jan 2002 – Dec 2012) (Contact Entity: GORONA, ENDESA, ITC) Visited by SiNGULAR Dec-2013.
- Representatives of new six European projects were invited to present them during SiNGULAR final meeting in Caparica (Lisboa, Portugal) 26·27 November 2015.

Significant results:

SiNGULAR logo was created in the first month.

Figure 10: SiNGULAR white logo

Figure 11: SiNGULAR black logo

Figure 12: SiNGULAR green logo

Two Flyers Sets: SiNGULAR Flyers were in SiNGULAR website and printed to use in several conferences, as well as they were sent to our expert data base. First set. January 2014 (M2). Summary of the project, its deliverables and its objectives.

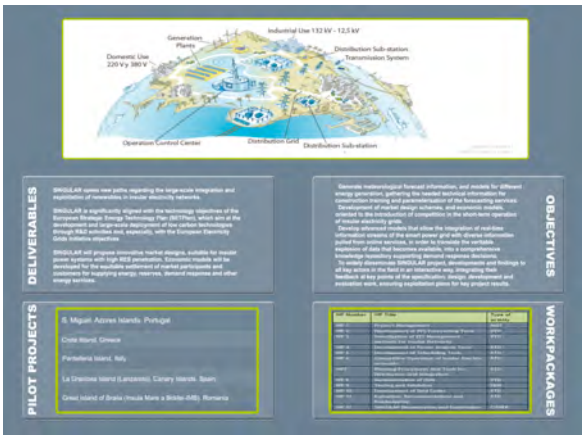


Figure 13: First Set. Side A; Figure 14: First Set. Side B

Second Set. March 2015 (M28). This second set included a list of products capable of being launched into the market, resulting for the electronic survey information.

Figure 15. Second Set. Side A; Figure 16. Second Set. Side B

Roll ups

Three different models have been designed as a dissemination and communication tool for SiNGULAR's presentations in the international conferences, congresses and meetings.

Photo 1. INNOGRID 2020+ (31March · 1 April 2015. Anastasios Bakirtzis (AUTH); Photo 2. Global Joint Stake holders Conf. (26·27 November 2015. Joao Catalao (UBI))

Website

SiNGULAR website is uploaded daily with SiNGULAR progress (partners dissemination actions, new scientific publications, presence in international conferences…) as well as with current news and opinions about SiNGULAR research fields, in order to get a continuous feedback and permanent availability of information.

SiNGULAR website has had 461,259 visits during these three years!

Figure 17. SiNGULAR website. Home

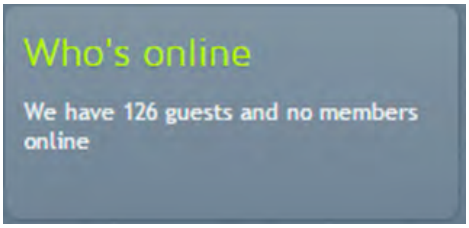


Figure 18. SiNGULAR website. Who's online

Communication and Dissemination Plan made on the website: detailed categories of the different acts:

Table 2. SiNGULAR website cathegories

ISSUE	NUMBER
Communication and Dissemination	1.131
- News & Opinion	927
- Activities	174
- Publications	30
Home	206
Events	342
Articles	119
TOTAL	**1.798**

SiNGULAR website has obtained an average of 3,45 articles/day.

New sections in Communication and Dissemination: Papers / Deliverables:

SiNGULAR has presented 56 papers in the most important and international relevant publications (18) and world Conferences and Congress related with smart grid (38). In this second period, a new section were designed where all they are showed (Tittle, kind of publication, date, author..) and, the public ones, could be download from "Communication and Dissemination/ Papers" section.

At the same time, another new section were created in order to show all SiNGULAR deliverables (wp leader, tittle,..). Equally the public ones could be downloaded from "Communication and Dissemination/Deliverables" section.[3]

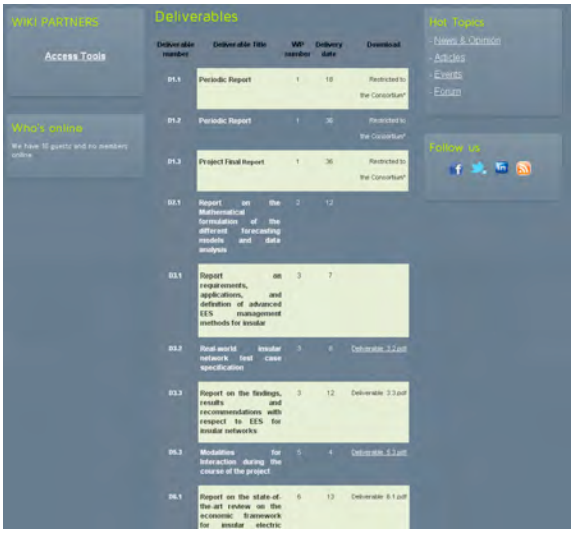


Figure 19. SiNGULAR website (deliverables section); Figure 20.SiNGULAR website. Papers section

Table 3. Top Downloads Ranking

Deliverable/Paper	Number of downloads
D.2.1. "Report on the mathematical formulation of the different forecasting models and data analysis" - SMARTWATT	923
"Energy storage systems supporting increased penetration of renewables in islanded systems" – UCLM and UBI	423
"Advanced distribution system modelling and analysis: making it SiNGULAR" - POLITO	251
D.4.1. "Report on the definition of the data structures, component models and mathematical formulation of the developed power flow and fault analysis tools" - POLITO	234
"Allocation of Plug-In Vehicles' Parking Lots in Distribution Systems Considering Network-Constrained Objectives" – UCLM and UBI	222
"Energy storage systems supporting increased penetration of renewables in islanded systems" - UCLM and UBI	192
D.5.3. "Modalities for interaction during the course of the project". Common Deliverable with SuSTAINABLE and iGREENGrid – AUTH and CS (SiNGULAR)	191
"Hardware-In-the-Loop test rig for the ISWEC wave energy system" – POLITO	173
D.6.2. "Report on the scenario analysis for the insular electricity grids and development completed for risk analysis tools" - UCLM	168
"Impact of Demand Response in an Isolated System with High PV Penetration" - UCLM	166

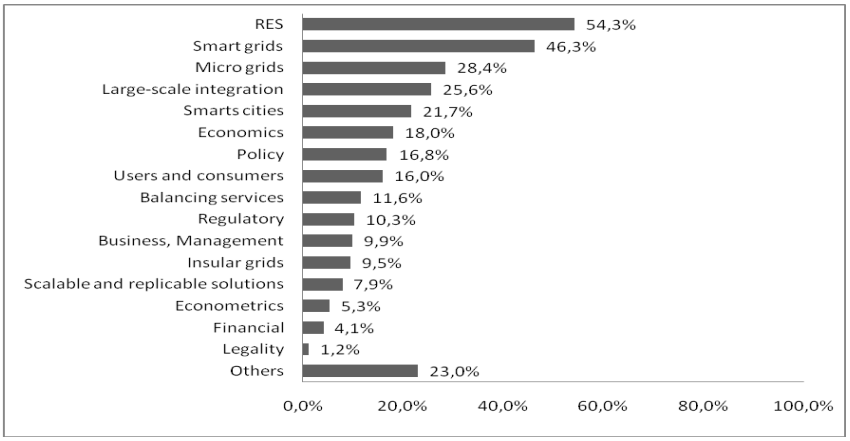
[3] More info in Annex II: Scientific publications.

Other communication tool: data base

Concepto Sociologico has created a data base with more than 9.000 contacts: international experts in SiNGULAR research fields (academics, DSOs and other experts)[4].

Thanks to this data base, Concepto Sociológico opened another channel for further dissemination. These experts have received information about the progress and the results achieved by SiNGULAR periodically, such as newsletters.

Figure 21. Data Base. Areas specialized



Networking + Events:

Contribute to GRID+ and to the implementation of EEGI,

- CIEM 2013 – 7 November 2013 – Bucharest (Romania) – represented by POLITO
- Meeting with EEGI national representative – 11 November 2013 – Madrid (Spain) – represented by CS
- GRID+ / EEGI – 9 April 2014 – Madrid (Spain) – represented by CS

Smart Grids Programme

- Smart Grids in Europe – the Case of Islands – 15/16 May 2014 - Athens (Greece) – represented by HEDNO.

*Family Projects (SiNGULAR, **SuSTAINABLE and iGREENgrid)***

- Stakeholders Committee – 29 September 2013 – Paris (France) – organized by iGREENgrid.
- Advisory Board – 10 December 2013 – Porto (Portugal) – organized by SuSTAINABLE.
- Stakeholders Committee – 12 December 2013 – Canary Islands (Spain) – organized by SiNGULAR.
- Public International Workshop Family Project – 12 December 2013 - Canary Islands (Spain) – organized by SiNGULAR.

[4] List of institutions of the data base is available in Deliverable 12.5. First version. Annex I. (companies, DSO, universities and other academic institutions, research and training centres, public entities, associations, NGOs, press, blogs, journals and experts).

- 1st Global Joint Stakeholders Conference – 11 April 2014 - Athens (Greece) – organized by SiNGULAR.
- 2nd Global Joint Stakeholders Conference – 18·19 February 2015 – Paris (France) – organized by iGREENgrid.
- 3rd Global Joint Stakeholders Conference - 26·27 November 2015 – Costa da Caparica, Lisboa (Portugal) – organized by SiNGULAR.

Other events that Concepto Sociológico attended.

- Presentation of SiNGULAR in XI Congreso Español de Sociología -12 July 2013-. Madrid.
- HORIZON 2020 – 20 February 2014– Toledo (Spain) – SiNGULAR presented by CS and UCLM
- Innogrid 2020+ - 25·26 March 2014– Brussels (Belgium) – attended by AUTH and CS
- Innogrid 2020+ - 31March ·1 April 2015 – Brussels (Belgium) - attended by CS and AUTH

Survey results[5]:

According to this survey achieved results, we can conclude that:

- The project is considered highly interesting and innovative.
- Our practices are praised.

Survey: Main findings.

The target to which the results could be directed towards international experts has been segmented identifying three important different groups, industry companies, academic and scientific community, and experts in general (other institutions, governments, etc.): international experts as members of companies, organisations and governments, private and state corporations, universities and institutes, all of them related in the broadest sense with the main objective of SiNGULAR, with a view to identifying the Singular principal fields of interest.

Fields of international experts specialized in areas related to SiNGULAR.

From the following fields, please mark any area in which you are specialized:

Answer Options	**Response Percent %**	**Response Count**
Smart grids	46,3%	348
RES	54,3%	408
Insular grids	9,5%	71
Large-scale integration	25,6%	192
Scalable and replicable solutions	7,9%	59
Balancing services	11,6%	87

[5] Survey model in Annex III

Micro grids	28,4%	213
Smarts cities	21,7%	163
Users and consumers	16,0%	120
Legality	1,2%	9
Regulatory	10,3%	77
Business, Management	9,9%	74
Economics	18,0%	135
Econometrics	5,3%	40
Financial	4,1%	31
Policy	16,8%	126
Other areas non mentioned before related to renewable energy	23,0%	173
answered question		**751**

Do you know or could you identify "Best Practices" in their sector in order to achieve the following SINGULAR objectives of...:

Figure 22: ***Question 22: ...studying the effects of large-scale integration of RES and DSM on the planning and operation of insular (non-interconnected) power grids?;*** **Question 24: …in their sector in order to achieve the following SINGULAR objectives of Developing and Validating Operation and planning procedures and tools in pilot sites? Question 26:…recommending Scalable and Replicable Solutions for regulatory, technical and economic challenges of integrating very large shares of RES in insular electricity grids?**

Possible market competition is analysed.

Figure 23. Question 20: Do you know or could you identify any other services or products operating already in the market which are similar to those that SiNGULAR is currently researching?

- SiNGULAR products and services are positively valuated.
- All results are graded and the five best products and services are identified, or the most interesting results for companies, researchers and institutions.

Being: 1-Very interested / 2-Somewhat interested / 3-Neutral / 4-Not very interested / 5-Not at all interested

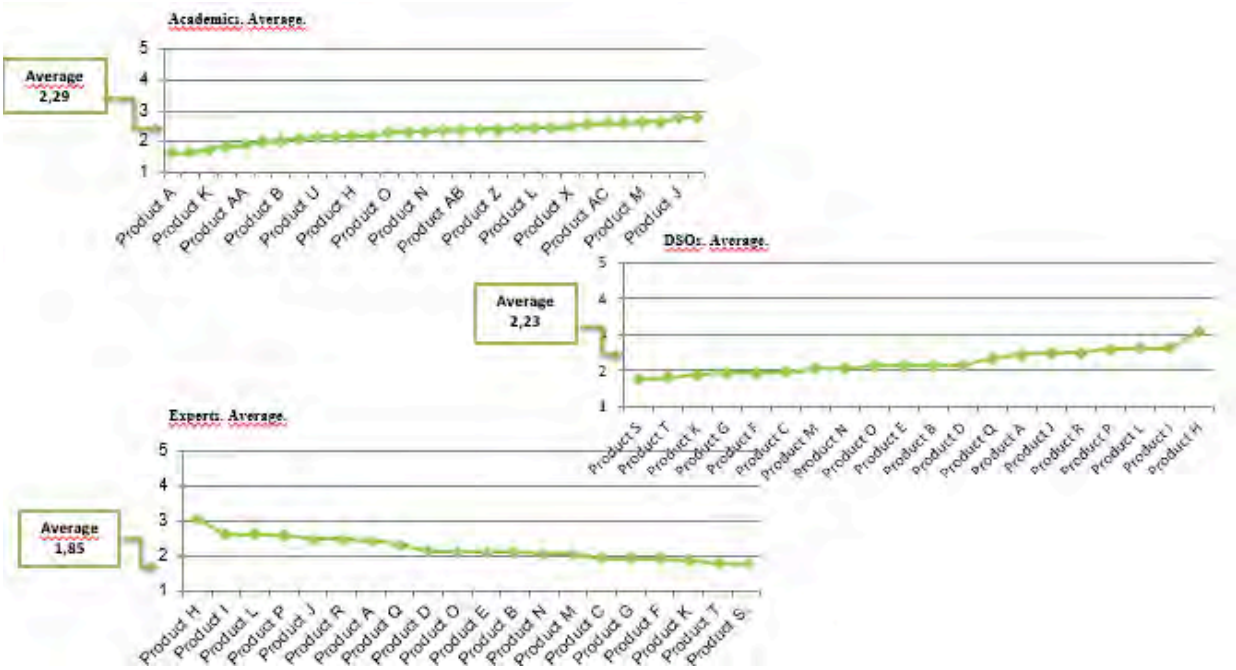
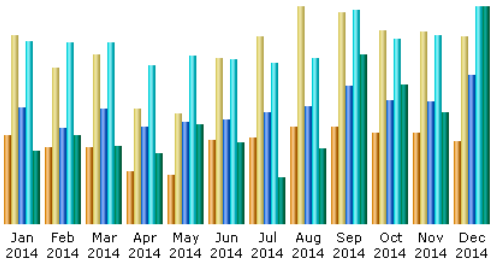


Figure 24. Experts valorations

This study also has allowed:

- To increase project diffusion and dissemination[6].
- To increase visits in our web site. The months which the diffusion emails presenting the project were sent have more "unique visitors" and "number of visits"
- To open a new diffusion procedure: periodic deliveries were done to our **data base** showing our SiNGULAR progresses.

[6] More information about the diffusion via email in Annex IV



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2014	9,798	20,795	51,746	81,231	1.19 GB
Feb 2014	8,438	17,162	42,415	80,913	1.45 GB
Mar 2014	8,403	18,686	51,217	80,717	1.27 GB
Apr 2014	5,829	12,712	43,321	70,584	1.15 GB
May 2014	5,353	12,169	45,467	74,949	1.62 GB
Jun 2014	9,264	18,296	46,287	73,471	1.33 GB
Jul 2014	9,503	20,587	49,416	71,444	766.78 MB
Aug 2014	10,749	23,894	52,240	73,538	1.23 GB
Sep 2014	10,675	23,351	61,549	95,453	2.77 GB
Oct 2014	10,041	21,256	54,812	82,244	2.28 GB
Nov 2014	9,966	21,168	54,365	84,161	1.83 GB
Dec 2014	9,067	20,595	66,118	96,547	3.54 GB
Total	107,086	230,671	618,953	965,252	20.40 GB

Figure 25. Monthly history 2014

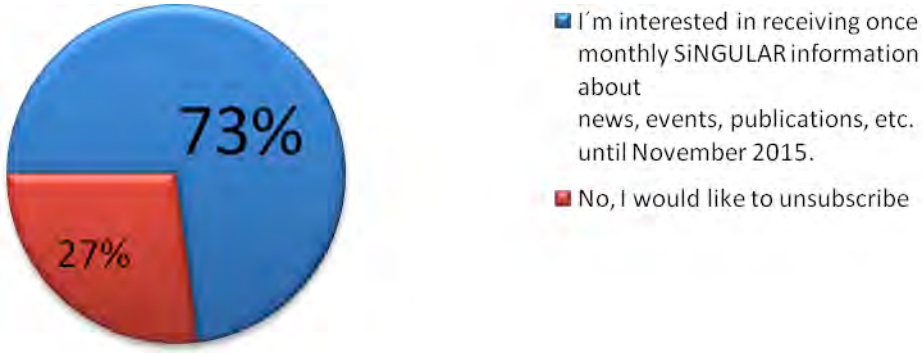


Figure 26. Question 30: Finally, SiNGULAR would like to keep you updated about those products and services, which could be interesting to you. Please tell us which of the following means could be used for communication purposes. Choose the most appropriate by marking one of these options:

Other results for SiNGULAR:

- **Prizes.** At the IEEE Powereng conference (Riga, 11·13 May 2015), SiNGULAR got the following awards:
    - Integration of Renewable Energy for the Harmonic Current and Reactive Power Compensation, which won the BEST PAPER AWARD.
    - Uncertainty Characterization of Carrier-Based Demand Response in Smart Multi-Energy Systems, which won the BEST PRESENTATION AWARD.
    - A New Methodology for Solving the Unit Commitment in Insular Grids Including Uncertainty of Renewable Energies, by Gerardo, Juan, Matias et al., won an additional BEST PRESENTATION AWARD.
- **Distinctions:** in the same way, SiNGULAR partners' merits in their researches have been recognised:

- Our partners Javier Contreras (UCLM) and Anastasios Bartzis (AUTH) were promoted to IEEE Fellow members, where SINGULAR, with no doubt, contributed to their both long and prestigious professional career.
- SiNGULAR publishable summary research has been approved by the European Commission and it is the basis for the "Result in Brief" written by CORDIS science editors.

Deviations (from the project workprogram):

Minor deviations from the project workprogram have taken place in WorkPackage 12, always justified with an improvement of the information showed and as well as the coherence in the results achieved.

Milestone M32: Exploitation Plan expected by Month 12. Voluntary delayed to month 26. Partner involved Concepto Sociológico. At month 12 there was not clear perception of results that can be exploited. Date rethinks because in September 2014, after mid-term evaluation of the project and once obtained clearly the first results and validated internal reports, we may estimate its value according to the market rivalry, and write a realistic exploitation plan about what can be exploited (including IPR), price, who has researched and who may be the target and customers. Even because the Delivery, 12.6 (Business feasibility and exploitation report) must be ready at month 36 and the Exploitation Plan is seen as a natural consequence before this Deliverable, so proximity to both produce greater general coherence about real exploitation results and the business plan about it. This deviation has no effect on the rest of the project, do not incur any deviations on the available resources and planning of the remaining activities included in WP12, even help to understand it from market approach. The corrective action taken was planned to produced the Milestone 33 according a realistic approach to results by month 26.

Deliverable 12.1: Dissemination of Support Material (including Project web site and leaflet) and Deliverable 12.2: Dissemination and promotion activities report: another version for each deliverable was sent in M19 – June 2014 in order to improve the information given in the first one.

Deliverable 12.5: Market analysis report expected by Month 24. Voluntary delayed to month 29. Partner involved Concepto Sociológico.

It showed the electronic market survey, its results and the main conclusions obtained according to the products and researches achieved by SiNGULAR, and, at the same time, it helps to understand the effect that the project could have in the real market. It had the following temporal tasks sequence:

- M19 – M23 (June - October 2014): creation of a database of international companies and DSO, public and private institutions, NGOs in relation to the goals of this Project and experts – around 3000 contacts.
- M23 (October 2014): development of the questionnaire.
- M24 (November 2014): first deliveries through the available data base.

First, the survey was designed to obtain a 10% margin of error. The questionnaires obtained have been enough to carry out with the survey as it had been designed. Nevertheless, due to the complexity of the products and the necessity of them to be evaluated by a bigger number of companies, research centres and other entities, Concepto Sociológico increased the number of questionnaires in order to achieve a

3,5% margin of error. Therefore, this is the main reason of the slight delay in delivery of this Deliverable 12.5.

- M25 -26 (December 2014 – January 2015): rest of deliveries and collection of the results.

Survey data was sent to a current database with the result of the currently 9.196 expert contacts. As a result, 759 questionnaires were completed: in this way, the initial 10% survey margin error decreased until the current 3,4%. This fact gives more trustworthiness to the final results and allows making a better analysis of them.

- M27 (February 2015): analysis results.
- M28 (March 2015): draft review
- M29 (April 2015): final version submission.

The following months, Concepto Sociológico elaborated a questionnaire for all SiNGULAR partners. Thanks to their collaboration, we were available to improve even more D.12.5 (June 2015 M31), identifying six different products capable of being launched into the market in the short term and short/ medium term. For each one, we included a Product information sheet (brief description, specific characteristics, pictures, market added value and SWOT analysis) and a Market information sheet (market description, expected global market growth, market trends, overview of the competitive landscape, strengths and weakness of the market competition, customers target, distribution Channels, sales channel and price).

1.4 Deliverables and Milestones table

1.4.1 Deliverables

Deliverables Table									
Del No	**Deliverable name**	**WP No**	**Lead Beneficiary**	**Nature**	**Dissemination level**	**Delivery date (Annex I)**	**Delivered Yes/No**	**Actual/ Forecast delivery date**	**Comments**
D1.1	Periodic report	1	UBI	R	CO	M18	YES	M18	N/A
D1.2	Periodic report	1	UBI	R	CO	M36	YES	M36	N/A
D1.3	Final report	1	UBI	R	CO	M36	YES	M36	N/A
D2.1	Report on the mathematical formulation of the different forecasting models and data analysis	2	SMARTWATT	R	PU	M12	YES	M12	N/A
D2.2	Operational forecasting services in a web platform	2	SMARTWATT	R	PU	M24	YES	M24	N/A
D2.3	Report on the analysis of the performance of the continuous forecast services	2	SMARTWATT	R	PU	M36	YES	M36	N/A
D3.1	Report on requirements, applications, and definition of advanced EES management methods for insular	3	ALSTOM	R	PU	M7	YES	M7	An updated version of the deliverable submitted on M36
D3.2	Real-world insular network test case specification	3	ALSTOM	O	PU	M8	YES	M8	N/A
D3.3	Report on the findings, results and recommendations with respect to EES for insular networks	3	ALSTOM	R	PU	M12	YES	M12	N/A
D4.1	Report on the definition of the data structures, component models and mathematical formulation of the developed power flow and fault analysis tools	4	POLITO	R	PU	M6	YES	M9	Refinement of the writing by incorporating the partners' suggestions and the results of the final testing of the tools
D4.2	Power flow analysis tools (restricted to the Consortium)	4	POLITO	O	CO	M6	YES	M9	Extended testing of the tools and addition of comments to the code

Deliverables Table									
Del No	**Deliverable name**	**WP No**	**Lead Beneficiary**	**Nature**	**Dissemination level**	**Delivery date (Annex I)**	**Delivered Yes/No**	**Actual/ Forecast delivery date**	**Comments**
D4.3	Report on the mathematical formulation of the developed reliability, power quality and security assessment tools	4	POLITO	R	PU	M12	YES	M13	Refinement of the writing by incorporating the partners' suggestions and the results of the final testing of the tools
D4.4	Reliability, power quality and security assessment tools (restricted to the Consortium)	4	POLITO	O	CO	M12	YES	M13	Extended testing of the tools and addition of comments to the code
D5.1	Report on the state-of-the-art on scheduling tools and the mathematical formulation of the proposed scheduling models	5	AUTH	R	PU	M12	YES	M12	N/A
D5.2	Ready-to-use scheduling tools	5	AUTH	R	CO	M21	YES	M21	D5.2 was also revised after the clarifications and comments received during the 1st review (although it did not officially fall within the first reporting period). Revised version was submitted in M26.
D5.3	Modalities for interaction during the course of the project (Joint report with SuSTAINABLE and iGREENGrid)	5	AUTH	R	PU	M4	YES	M7	Extended discussions on the scheduling of the common activities of the three family projects
D6.1	Report on the state-of-the-art review on the economic framework for insular electric networks	6	UPB	R	PU	M13	YES	M15	N/A
D6.2	Report on the scenario analysis for the insular electricity grids and development completed for risk	6	UPB	R	PU	M18	YES	M18	N/A
D7.1	Reliable distribution network planning model report	7	UCLM	R	PU	M15	YES	M15	N/A
D7.2	Joint RES and distribution network planning model report	7	UCLM	R	CO	M18	YES	M18	N/A

Deliverables Table									
Del No	**Deliverable name**	**WP No**	**Lead Beneficiary**	**Nature**	**Dissemination level**	**Delivery date (Annex I)**	**Delivered Yes/No**	**Actual/ Forecast delivery date**	**Comments**
D7.3	Enhanced joint RES and distribution network planning model report	7	UCLM	R	PU	M24	YES	M24	N/A
D8.1	HAN and Smart Metering Technical Installations Report	8	INTELEN	R	PU	M18	YES	M18	N/A
D8.2	Meter Data Management Full Deployment System Report	8	INTELEN	R	PU	M18	YES	M18	The platform and the MDM system were ready and implemented, but the document was not ready on May, 31st.
D8.3	DSM / DR Services and Deployment Plan Report	8	INTELEN	R	PU	M18	YES	M18	N/A
D8.4	Dry-run and Pilot execution Progress Report	8	INTELEN	R	PU	M22	YES	M36	The dry-run pilot execution was delayed because of defective data loggers that were replaced by Intelen
D9.1	Report on analytical description of simulation tools and demo planning	9	ITC	R	PU	M27	YES	M35	Some difficult to integrate the tools in each island and inclusion of the new pilot
D9.2	Report on integration of tools at the pilot facilities	9	ITC	O	CO	M35	YES	M36	N/A
D9.3	Short general description of use cases and process for demonstration of the proposed solutions	9	ITC	R	PU	M24	YES	M29	Time needed to discuss the final planning according the reality of each pilot site. It needed specific discussions with the islands operator. For example in the specific case of El Hierro. This is a common deliverable, and more time was needed to coordinate the three

Deliverables Table									
Del No	**Deliverable name**	**WP No**	**Lead Beneficiary**	**Nature**	**Dissemination level**	**Delivery date (Annex I)**	**Delivered Yes/No**	**Actual/ Forecast delivery date**	**Comments**
									projects involved
D10.1	Completed Grid Codes for insular electricity grids: Completed Grid Codes for insular electricity grids	10	HEDNO	R	PU	M33	YES	M35	Homogenize text, Feedback from the Regulatory Authority of Energy, Greece
D11.1	SiNGULAR evaluation, recommendations report and roadmap	11	UBI	R	PU	M36	YES	M36	N/A
D11.2	Short report on exchanged experiences on demonstrations and validation of the proposed solutions	11	UBI	R	PU	M36	YES	M36	N/A
D12.1	Dissemination of Support Material (including Project web site and leaflet)	12	CS	R	PU	M3	YES	M13	Updated version
D12.2	Dissemination and promotion activities report	12	CS	R	PU	M12	YES	M19	Improved version
D12.3	Dissemination and promotion activities report	12	CS	R	PU	M24	YES	M24	N/A
D12.5	Market analysis report	12	CS	R	PU	M24	YES	M31	Increasing the number of questionnaires in order to achieve a minor margin of error, which gets more realistic results. Improved version with the information given by partners.
D12.6	Business feasibility and exploitation report	12	CS	R	CO	M36	YES	M36	N/A

1.4.2 Milestones

Milestones Table							
Milestone No	**Milestone Name**	**Workpackage No**	**Lead Beneficiary**	**Delivery Date form Annex I**	**Achieved Yes/No**	**Actual / Forecast achievement date**	**Comments**
MS1	Project kick-off meeting	1	UBI	M1	YES	M1	N/A
MS2	Project Initiation Milestone	1	UBI	M1	YES	M1	N/A
MS3-8	Six-monthly Milestones	1	UBI	M6, M12, M18, M24, M30, M36	YES	M6, M12, M18, M24, M30, M36	N/A
MS9	Project completion milestones	1	UBI	M36	YES	M36	N/A
MS10	Data and models ready to start implementation	2	SMARTWATT	M6	YES	M6	N/A
MS11	Models operational in 50% of the target locations	2	SMARTWATT	M12	YES	M12	N/A
MS12	Models operational in 100% of the target locations	2	SMARTWATT	M18	YES	M18	N/A
MS13	Requirements and application of the EES management methods defined	3	ALSTOM	M7	YES	M7	N/A
MS14	EES management methods tested and validated in the insular network test case(s)	3	ALSTOM	M12	YES	M12	N/A
MS15	Data structures and component models defined	4	POLITO	M4	YES	M4	N/A
MS16	Power flow analysis tools tested and validated	4	POLITO	M6	YES	M6	Extended testing of the tools and addition of comments to the code
MS17	Reliability and security assessment tools tested and validated	4	POLITO	M12	YES	M12	Extended testing of the tools and addition of comments to the code
MS18	Performance evaluation of the core scheduling models and tools	5	AUTH	M12	YES	M12	N/A
MS19	Design and performance evaluation of the state-of-the-art and new methods for the efficient and reliable operation of the insular power systems	5	AUTH	M15	YES	M15	N/A

Milestones Table							
MS20	Installation and performance evaluation of the integrated software tools	5	AUTH	M21	YES	M21	N/A
MS21	Scenario regarding market models and risk analysis models completed, tools developed and ready to use	6	UPB	M18	YES	M18	N/A
MS22	Reliable distribution network planning model	7	UCLM	M15	YES	M15	N/A
MS23	Joint RES and distribution network planning model	7	UCLM	M18	YES	M18	N/A
MS24	Enhanced joint RES and distribution network planning model	7	UCLM	M24	YES	M24	N/A
MS25	HAN Smart metering Installations to pilot users	8	INTELEN	M18	YES	M18	The problems that we have encountered have been reported previously in this document.
MS26	Meter Data Management final system deployment	8	INTELEN	M18	YES	M18	The development of the platform has been slightly delayed duo to some last minutes enhancements.
MS27	Final run and full deployment of DR/DSM pilot to specific pilot users	8	INTELEN	M22	YES	M36	Delayed due to defective data loggers that needed to be changes in order to have access to real-time energy data
MS28	Installation and performance evaluation of the integrated simulation tools	9	ITC	M36	YES	M36	N/A
MS29	Integration of Grid Codes for the efficient operation of the insular networks	10	HEDNO	M36	YES	M36	N/A
MS30	SINGULAR Recommendations and Roadmap	11	UBI	M36	YES	M36	N/A
MS31	Plan for dissemination	12	CS	M6	YES	M6	N/A
MS32	Plan for exploitation of results	12	CS	M12	YES	M12	N/A
MS33	Successful project closure, verification of SINGULAR value results and valid business propositions	12	CS	M36	YES	M36	N/A

1.5 The potential impact and the main dissemination activities and exploitation of results.

1.5.1 Summary of dissemination Activities

1 YEAR	2 YEAR	3 YEAR
SiNGULAR WEBSITE ALWAYS RUNNING / DAILY UPLOADED / INFORMATION ABOUT PROJET PROGRESS AND RESULTS / PARTNERS ACTIVITIES		
INTERNAL FAMILY **MEETINGS**/ SUSTANAIBLE-iGREENGrid / NETWORKING WITH OTHER PROJECTS		
SCIENTIFIC PUBLICATIONS/ RESULTS INCREASE		
Creation of Initial Communication Tools (logo, flyers, website, posters,…)	Presentations in conferences and workshops. Survey: first market analysis.	Market Analysis Report and Business Plan
Dissemination to civil society (local, regional, national and international). Dissemination to Scientific Community. (first two papers)	Dissemination to Scientific Community and Industry (european and international). Creation of a data base.	Dissemination to Scientific Community, Industry and Policy makers (european and international).
Articles in press, websites and social networks.	Articles in energy magazines.	Scientific results submited and accepted in prestigious journals and international conference (availables in website)
Deliverables D.12.1, D.12.2	Deliverables D.12.3 D.12.5	Deliverables D.12.6

1st YEAR

Therefore, early communication impacts and interviews were published in the local and regional press and other media just since the kick-off meeting, celebrated on January 24, 2013 in Covilha, Portugal. The first months were entirely dedicated to the development of graphic materials, organization and corporate identity handbook to be used as material support for the subsequent dissemination and communication of the project. These materials have been operating since week 6, that is, 6 weeks before the expected time for implementation -12 weeks-. Further information about SiNGULAR Communication Tools can be found in Deliverable 12.1 and 12.2.

In this phase, our social responsibility was to widely inform the civil society about the SiNGULAR project social benefits, several articles were published in press, websites and social networks.

During the first months, the project had not already produced enough results even scientific publications. For this reason, only initial presentations explaining summary and objectives could be done. Approximately in month 9 – August 2013-, its first scientific results were already starting to be seen: the two first papers were received last year. Therefore the most important element of this aspect is that the project could be presented at international forums and organizations in month 11 -October

2013 – when the project was presented for the first time in an international research conference held in Romania.

Also in the 11th month of development, *Concepto Sociológico* had a meeting with Borja Izquierdo, EEGI (European Grid Initiative) National Representative. Few months before, SiNGULAR was labelled.

Image 1. SiNGULAR logos

Image 2. SiNGULAR website

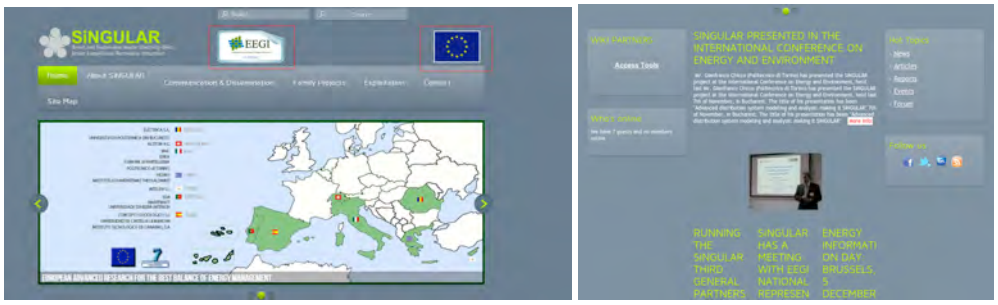


Image 3. First set of flyers

Image 4. SiNGULAR posters

Image 5. Digital 'AlbaceteCapital.es'; Image 6. - Digital 'Ecoticias' ; Image 7. 'Structuralia': Image 8. Digital 'Innovallcluster.com

Image 9. Digital; 'Image10. Digital 'En Castilla-La Mancha'; Image 11. 'Noticiero Mendoza'; Image 12 Journal 'La Tribuna de Albacete.

Image 13. Group images

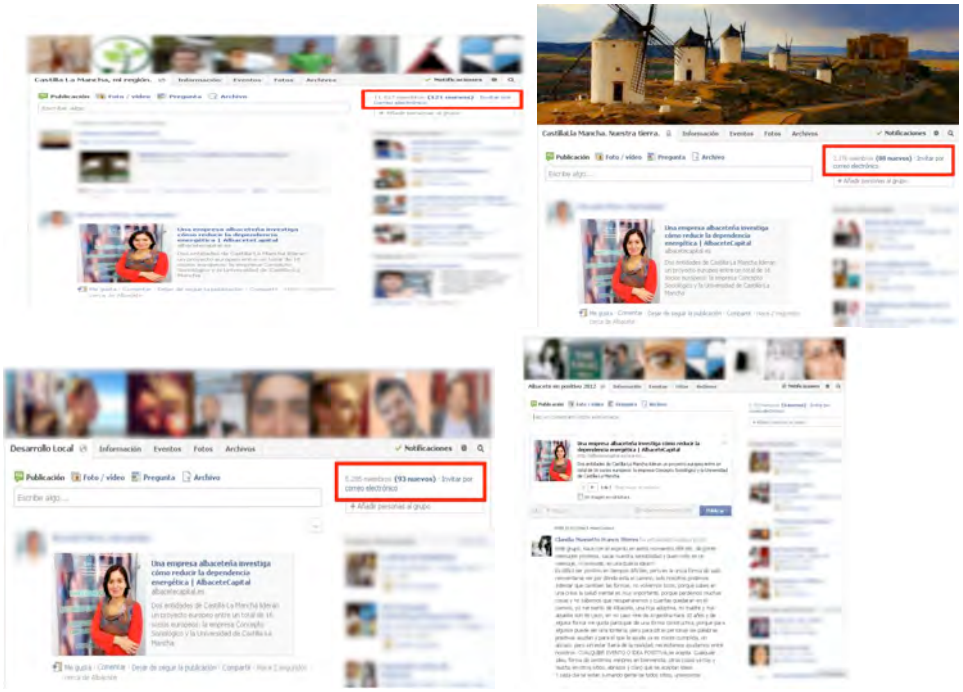


Image 14. – Facebook images

2nd YEAR

Concepto Sociológico prepared key specific presentations of SiNGULAR for EU entities and relevant institutions, monitoring the relationship with each other. In addition to this, it has participated in the development of Common Deliverables with the family projects -iGREENGRID & SusTAINABLE- collaborating with partners like UBI and AUTH for its realization.

During this year the market research was carried out as the start-up of the business opportunity; the analysis of the market research is detailed in Deliverable 12.5. A large database was created containing a total number of 9.230 international companies and DSO, public and private institutions, NGOs, journals and personal information of experts in this field in relation to the goals of this project. This has been carefully made with two main objectives. On the one hand, they have been subject to a market survey as comprehensive as possible in order to understand the whole value scene of research and results achieved to date by the project. Once their opinions were known, with a representative sample, we proceeded properly and, in consequence, analysed each result within its specific market future forecast. On the other hand, we could carry out a massive communication and diffusion action about the SiNGULAR project and to provide monthly information, from October 2014 until the end of the project, to all of these experts, companies and institutions about its progress.

Image 15. HORIZON 2020 Workshop; Image 16. 2nd INNOGRID 2020 Interaction Workshop; Image 17. GRID+; Image 18. 2nd IGREENGrid Public Workshop

Image 19. "SiNGULAR: Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration" Grid Innovation-on-line Platform

Image 20. Diffusion Emails: Presentation of the project

SiNGULAR

Dear Sir/Madame,

We are writing to present you the SiNGULAR European project. SiNGULAR –"SMART AND SUSTAINABLE INSULAR ELECTRICITY GRIDS UNDER LARGE-SCALE RENEWABLE INTEGRATION- is an European Union 7th Framework Programme, and its main objective is the **investigation of the effects of large-scale integration of RES and DSM on the planning and operation of insular (non-interconnected) electricity grids.**

Our research company, *Concepto Sociológico*, as responsible for communication and dissemination tasks, puts at your disposal the SiNGULAR flyers and a summary pdf document. You can find all the information about the project in our website:

http://www.singular-fp7.eu/home/

Also, as SiNGULAR website administrators, we are always open to publish news, events or articles related to it. We also cooperate with other projects for knowledge sharing, feedback activities and information dissemination. For this reason, **do not hesitate to send us any information you may consider of interest in this field and we will upload it in our website!**

You may also contact us at our email address.

Best regards.

Isabel Colmenero Herreros

Director, 'Concepto Sociológico' SL

SiNGULAR

Dear Sir/Madam

Once again, we are writing to inform you about the development of the SINGULAR- "SMART AND SUSTAINABLE INSULAR ELECTRICITY GRIDS UNDER LARGE-SCALE RENEWABLE INTEGRATION- project, which belongs to European Union 7th Framework Programme and whose main objective is the investigation of the effects of large-scale integration of RES and DSM on the planning and operation of insular (non-interconnected) electricity grids.
Our research company, *Concepto Sociológico*, as responsible for communication and dissemination tasks, puts at your disposal SiNGULAR newsroom:

- **Second leaflet set:** SiNGULAR flyers summarize our objectives and workpackages. Second set also includes new results and future products. Please find them attached.
- **Scientific publications:** SiNGULAR has been notably focused on scientific results and on networking with other projects: adding up to 41 papers in internationally prestigious journals and world conferences and events. Please find them in the following link:

http://www.singular-fp7.eu/home/index.php/comdis/papers

- **Deliverables**: public SiNGULAR deliverables are available to download in our website:

http://www.singular-fp7.eu/home/index.php/comdis/deliverables

In addition, in academic world, there is a wide demand for documentation and technical research related to smartgrids. Here, it should be noted that SiNGULAR has produced "*Smart and Sustainable Power Systems: Operations, Planning, and Economics of Insular Electricity Grids*", book written by João P. S. Catalão -partner from Universidade da Beira Interior and project coordinator- as a result of its first exploitation of project results. It is already available in the following link:

http://www.crcpress.com/product/isbn/9781498717373

Also, as SiNGULAR website administrators, we are always open to publish news, events or articles related to it. We also cooperate with other projects for knowledge sharing, feedback activities and information dissemination. For this reason, do not hesitate to send us any information you may consider of interest in this field and we will upload it in our website!

You may also contact us at our email address: singular@singular-fp7.eu

Yours sincerely,
Isabel Colmenero Herreros
Director, 'Concepto Sociológico' SL
http://www.conceptosociologico.com/

Image 21. Market Survey

3rd YEAR

In this final phase, SiNGULAR goals have been achieved and its results are clearly defined thanks to the high scientific level achieved by all the SiNGULAR's publications and presentations. According to all these scientific results, some of them have been able to become commercial products, services or results available to be exploited by SiNGULAR. After a detailed market analysis, where six different products were defined as well as its market components, we analysed the different possible options for bilateral and multilateral cooperation agreements and propose a suitable model to show us the way forward to exploit SINGULAR results. This can be found in Deliverable 12.6.

SiNGULAR has added up to 56 papers more, 18 of them have been submitted in internationally prestigious journals; the other 38 have been destined to world conferences and events. *Concepto Sociológico* uploaded this information to SiNGULAR website, and the public ones could be download; as well as Partners Deliverables.

Image 22. Deliverables section; Image 23. Papers section

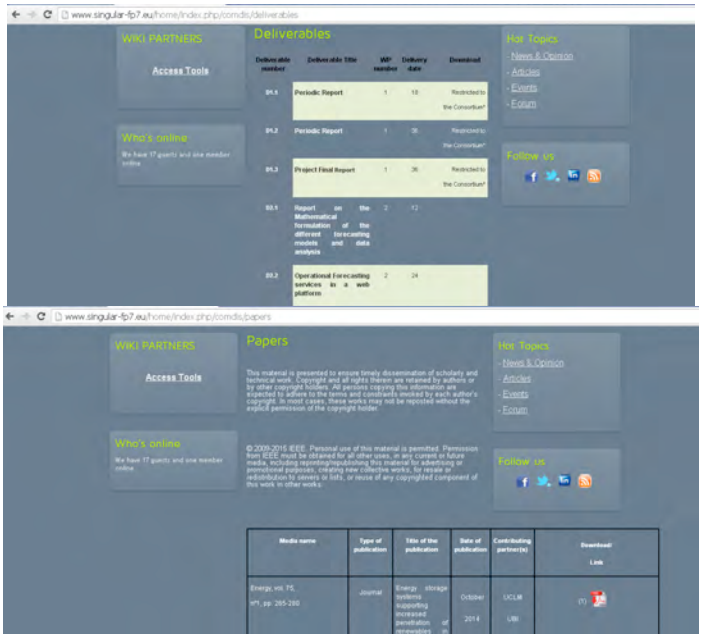
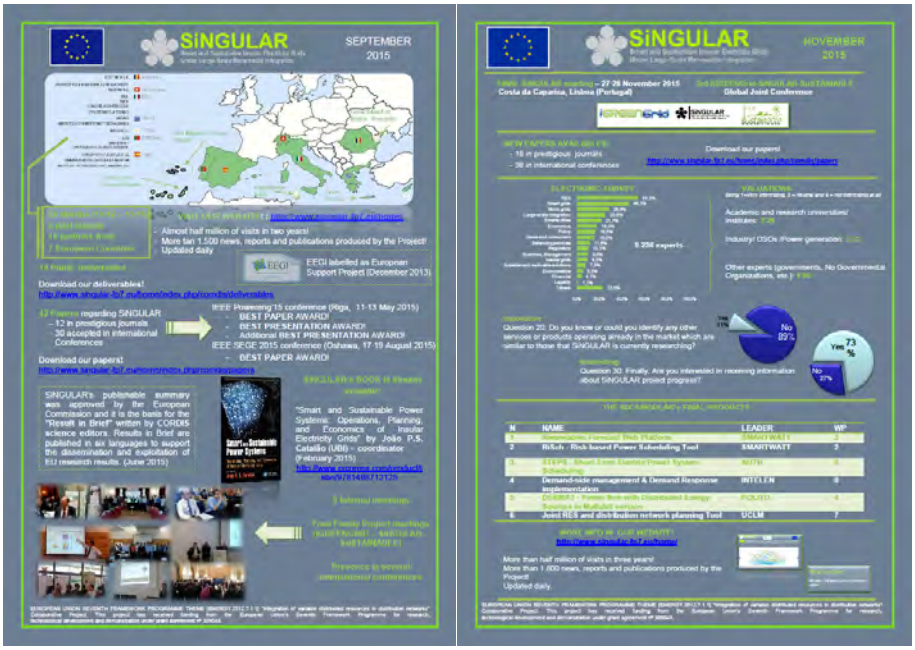


Image 24. Second set of flyers

Image 25. Newsletters; Image 26. "*SiNGULAR, integración de renovables en smart grids*" SMARTGRIDSINFO.es



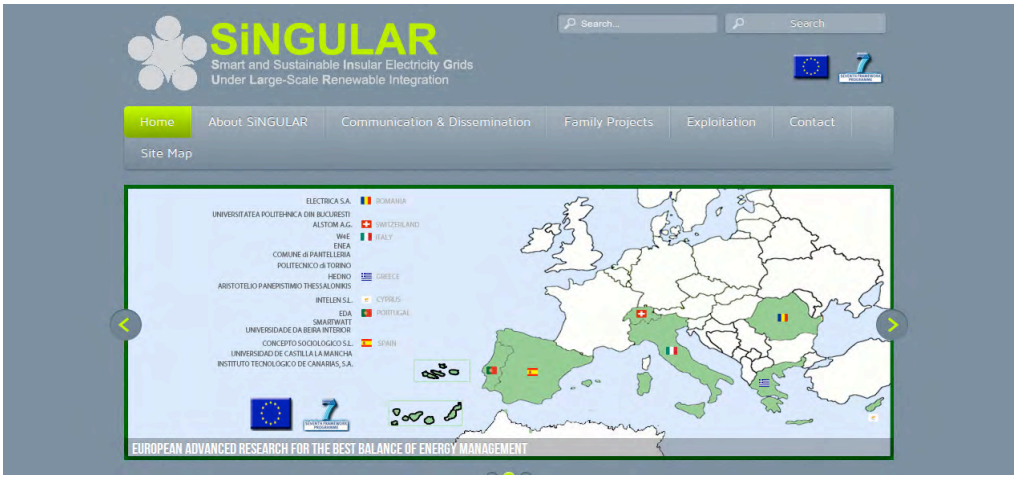
1.6 SiNGULAR website

The SINGULAR website incorporates a structure suitable for inclusion of all current and progressively developed information regarding the project. A special section for secure access to the project's restricted area for internal workflow is available.

The World Wide Web offers a wide range of possibilities for dissemination of SINGULAR. For this reason, the project website has been developed and will be maintained (after the end of the project) by making information related to SINGULAR available to the wide audience for dissemination of the project. It is intended to provide an overview of the project goals, an introduction to the SINGULAR consortium, and a gateway for discussing SINGULAR-related issues. The SINGULAR website is considered as one of the most effective dissemination channels, since it is a global medium which can be accessed anytime from any interested party. The SINGULAR website offers general information on the project, such as its rationale, the project progress, expected results and partners. Since it serves as a promotional tool, it was enriched during the project with attractive presentations of expected benefits, related reference information (e.g. studies, news, papers) and access to other promotional material such as brochure and poster.

The SINGULAR website contains the project's identity (logo, colour scheme, etc.), developed as part of the work in WP5, and has been designed in order to provide both the general public as well project partners with useful information concerning SINGULAR.

The idea behind the site is twofold. Firstly, to provide a point of reference for people interested in learning more about the project (with information such as SINGULAR objectives, the expected benefits, participating partners, etc.) and, secondly, as a place from which to distribute documents and information addressed strictly to the partners. Therefore, the SINGULAR website is divided to two sectors, one intended for public access and another for authorized users only. SINGULAR Web site can be found at: http://www.singular-fp7.eu



The structure of the web site is quite standard and at the onset of its operation contains the following basic sections (the public area):

– Home page, which is the main page of the website and shows its structure.

- Motivation.
- Project, which includes information on
    - Partners.
    - Technical Approach.
    - Objectives.
    - Workpackages.
    - Public deliverables.
- Dissemination, which included all publications and publicity material available.
- Info, which includes information on
    - News.
    - Events.
    - Related Websites.
    - Contact.

2. Use and dissemination of foreground

2.1 Section A

Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
No	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[7] (if available)	Is/Will open access[8] provided to this publication?
1	*Book Chapter* *Chapter 4:* Scheduling Models and Methods for Efficient and Reliable Operations	E.A. Bakirtzis	*Book* Smart and Sustainable Power Systems: Operations, Planning and Economics of Insular Electricity Grids (ISBN 9781498712125)	Jun. 2015	CRC Press, Taylor and Francis Group	-	2015	155-224	https://www.crcpress.com/Smart-and-Sustainable-Power-Systems-Operations-Planning-and-Economics/Catalo/9781498712125	NO
2	An advanced model for the efficient and reliable short-term operation of insular electricity networks with high renewable energy sources penetration	C.K. Simoglou	Renewable & Sustainable Energy Reviews	vol. 38	Elsevier	-	2014	415-427	http://www.sciencedirect.com/science/article/pii/S1364032114004523	NO

[7] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[8] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

3	Optimal operation of insular electricity grids under high RES penetration	C.K. Simoglou	Renewable Energy	vol. 86	Elsevier	-	2016	1308-1316	http://www.sciencedirect.com/science/article/pii/S0960148115303438	NO
4	Stochastic scheduling of hybrid power stations in insular power systems with high wind penetration	A.V. Ntomaris	IEEE Transactions on Power Systems	*in press*	IEEE	-	2016	-	-	NO
5	ANN-based scenario generation methodology for stochastic variables of electric power systems	S.I. Vagropoulos	Electric Power Systems Research	*in press*	Elsevier	-	2016	-	-	NO
6	Assessment of the impact of a battery energy storage system on the scheduling and operation of the insular power system of Crete	S.I. Vagropoulos	49th Universities' Power Engineering Conference - UPEC2014	2-5 Sep. 2014	IEEE	Cluj Napoca, Romania	2014	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6934746&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6934746	NO
7	Integration of a hybrid power station in the insular power system of Crete	A.V. Ntomaris	2014 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)	12-15 Oct. 2014	IEEE	Istanbul, Turkey	2014	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7028875&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7028875	NO
8	Reserve quantification in insular power systems with high wind penetration	A.V. Ntomaris	2014 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)	12-15 Oct. 2014	IEEE	Istanbul, Turkey	2014	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7028907&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7028907	NO
9	Optimal bidding strategies of a mixed RES portfolio by stochastic programming	E.G. Kardakos	2014 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)	12-15 Oct. 2014	IEEE	Istanbul, Turkey	2014	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7028801&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7028801	NO
10	Hydrothermal Producer Offering Strategy in a Transmission-Constrained Electricity Market - An MPEC Approach	E.G. Kardakos	2014 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)	12-15 Oct. 2014	IEEE	Istanbul, Turkey	2014	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7028772&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnu	NO

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11	Benefits of demand response on a wind power producer bidding strategy	C.K. Simoglou	2015 IEEE Eindhoven PowerTech Conference	29 Jun.–2 Jul. 2015	IEEE	Eindhoven, The Netherlands	2015	1-6	http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=7232621	NO
12	Assessment of load shifting potential on large insular power systems	S.I. Vagropoulos	2015 IEEE Eindhoven PowerTech Conference	29 Jun.–2 Jul. 2015	IEEE	Eindhoven, The Netherlands	2015	1-6	http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=7232654	NO
13	Stochastic day-ahead scheduling of thermal and hybrid units in insular power systems with high wind penetration	A.V. Ntomaris	2015 IEEE Eindhoven PowerTech Conference	29 Jun.–2 Jul. 2015	IEEE	Eindhoven, The Netherlands	2015	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7232658&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7232658	NO
14	Artificial neural network-based methodology for short-term electric load scenario generation	S.I. Vagropoulos	2015 18th International Conference on Intelligent System Application to Power Systems (ISAP)	11-16 Sep. 2015	IEEE	Porto, Portugal	2015	1-6	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7325540&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7325540	NO
15	Robust scheduling of variable wind generation by coordination of bulk energy storages and demand response	E. Heydarian-Forushani	Energy Conversion and Management	Vol. 106, pp. 941-950	ELSEVIER	-	2015	-	http://dx.doi.org/10.1016/j.enconman.2015.09.074	
16	Modelling and sizing of NaS (sodium sulfur) battery energy storage system for extending wind power performance in Crete island	E.M.G. Rodrigues	Energy	Vol. 90, pp. 1606-1617	ELSEVIER	-	2015	-	http://dx.doi.org/10.1016/j.energy.2015.06.116	
17	New control strategy for the weekly scheduling of insular power systems with a battery energy storage system	G.J. Osório	Applied Energy	Vol. 154, pp. 459-470	ELSEVIER	-	2014	-	http://dx.doi.org/10.1016/j.apenergy.2015.05.048	
18	Probabilistic harmonic power flow calculations with uncertain and correlated data	G. Chicco	book J.P.S. Catalão (ed.), "Smart and Sustainable Power Systems: Operations, Planning, and	June 18, 2015	CRC Press	Boca Raton, FL, USA	2015	95-154	ISBN 9781498712125	no

			Economics of Insular Electricity Grids"							
19	Experimental Indicators of Current Unbalance in Building Integrated Photovoltaic Systems	G. Chicco	IEEE Journal of Photovoltaics	Vol. 4, No. 3, May 2014	The IEEE	Piscataway, NJ, USA	2014	924-934	doi:10.1109/JPHOTOV.2014.2307491	yes
20	Hardware-In-the-Loop test rig for the ISWEC wave energy system	G. Bracco	Mechatronics	Vol. 25, February 2015	Elsevier	Amsterdam, The Netherlands	2015	11–17	doi:10.1016/j.mechatronics.2014.10.007	no
21	Probabilistic generation of time-coupled aggregate residential demand patterns	I.A. Sajjad	IET Generation Transmission and Distribution	Vol. 9, No. 9	IET	London, UK	2015	789–797	doi: 10.1049/iet-gtd.2014.0750	yes
22	Stochastic Modelling of Multienergy Carriers Dependencies in Smart Local Networks with Distributed Energy Resources	N. Neyestani	IEEE Transactions on Smart Grid	Vol. 6, No. 4, July 2015	The IEEE	Piscataway, NJ, USA	2015	1748 - 1762	doi: 10.1109/TSG.2015.2423552	no
23	Multi-Objective Reconfiguration of Radial Distribution Systems using Reliability Indices	N.G. Paterakis	IEEE Transactions on Power Systems	in press	The IEEE	Piscataway, NJ, USA	2015	to be defined	doi:10.1109/TPWRS.2015.2425801	no
24	Contingency Assessment and Network Reconfiguration in Distribution Grids Including Wind Power and Energy Storage	P. Meneses de Quevedo	IEEE Transactions on Sustainable Energy	Vol. 6, No. 4, October 2015	The IEEE	Piscataway, NJ, USA	2015	1524-1533	doi: 10.1109/TSTE.2015.2453368	no
25	Islanding in Distribution Systems Considering Wind Power and Storage	P. Meneses de Quevedo	Sustainable Energy, Grids and Networks	in press	Elsevier	Amsterdam, The Netherlands	2015	to be defined	doi:10.1016/j.segan.2015.12.002	no
26	Error Assessment of Solar Irradiance Forecasts and AC Power from Energy Conversion Model in Grid-connected Photovoltaic Systems	G. Chicco	Energies	in press	MDPI	Basel, Switzerland	2016	to be defined	to be defined	yes
27	Power Flow Calculations for Small Distribution Networks under Time-Dependent and Uncertain Input Data	A. Mazza	Proceedings of the IEEE PES Transmission & Distribution Conference & Exposition Chicago, IL, USA	14-17 April 2014	The IEEE	Piscataway, NJ, USA	2014	1-5	doi: 10.1109/TDC.2014.6863395	no
28	Data Pre-Processing and Representation for Energy Calculations in Net Metering	G. Chicco	Proceedings of the IEEE EnergyCon 2014, Dubrovnik,	13-16 May 2014	The IEEE	Piscataway, NJ, USA	2014	paper 262		no

	Conditions		Croatia							
29	Weather forecast-based power predictions and experimental results from photovoltaic systems	G. Chicco	Proceedings of the 22nd International Symposium on Power Electronics, Electrical Drives, Automation and Motion (Speedam 2014), Ischia, Italy	18-20 June 2014	The IEEE	Piscataway, NJ, USA	2014	342 - 346	doi:10.1109/SPEEDAM.2014.6872086	no
30	A Probabilistic Approach to Study the Load Variations in Aggregated Residential Load Patterns	I.A. Sajjad	Proceedings of the 18th Power Systems Computation Conference (PSCC), Wroclaw, Poland	18-22 August 2014	The IEEE	Piscataway, NJ, USA	2014	paper 546	doi: 10.1109/PSCC.2014.7038105	no
31	A Novel Optimization Algorithm Solving Network Reconfiguration	A. De Bonis	Proceedings of the 18th Power Systems Computation Conference (PSCC), Wroclaw, Poland	18-22 August 2014	The IEEE	Piscataway, NJ, USA	2014	paper 449	doi:10.1109/PSCC.2014.7038421	no
32	A new approach for solving DAE systems applied to distribution networks	F. Torelli	Proceedings of the 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania	2 - 5 September 2014	The IEEE	Piscataway, NJ, USA	2014	1-6	doi:10.1109/UPEC.2014.6934736	no
33	Characterization of solar irradiance profiles for photovoltaic system studies through data rescaling in time and amplitude	G. Chicco	Proceedings of the 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania	2 - 5 September 2014	The IEEE	Piscataway, NJ, USA	2014	paper 52	doi:10.1109/UPEC.2014.6934619	no
34	Multi-objective optimization of radial distribution networks using an effective implementation of the ε-constraint method	N. Paterakis	Proceedings of the 24th Australasian Universities Power Engineering Conference —	28 September - 1 October, 2014	The IEEE	Piscataway, NJ, USA	2014	1-6	doi :10.1109/AUPEC.2014.6966505	no

			AUPEC 2014, Perth, Australia							
35	A review on the dynamic analysis of weak distribution networks	A. De Bonis	Proceedings of the 49th International Universities' Power Engineering Conference (UPEC 2014), Cluj-Napoca, Romania	2 - 5 September 2014	The IEEE	Piscataway, NJ, USA	2014	1-5	doi:10.1109/UPEC.2014.6934820	no
36	Uncertainty characterization of carrier-based demand response in smart multi-energy systems	N. Neyestani	Proceedings of the 5th International Conference on Power Engineering, Energy and Electrical Drives (PowerEng 2015), Riga, Latvia	11-13 May 2015	The IEEE	Piscataway, NJ, USA	2015	366-371	doi: 10.1109/PowerEng.2015.7266344	no
37	Supraharmonics: Concepts and Experimental Results on Photovoltaic Systems	G. Chicco	Proceedings of the XII Conference-Seminar International School on Nonsinusoidal currents and compensation, Lagow, Poland	15-18 June 2015	The IEEE	Piscataway, NJ, USA	2015	1-6	doi:10.1109/ISNCC.2015.7174705	no
38	Sea-wave power converter modeling for fault conditions analysis	F. de Bosio	Proceedings of the IEEE PowerTech 2015, Eindhoven, The Netherlands	29 June - 2 July 2015	The IEEE	Piscataway, NJ, USA	2015	1-6	doi: 10.1109/PTC.2015.7232703	no
39	Advanced Control of Inverter-interfaced Generation Behaving as a Virtual Synchronous Generator	S. Rubino	Proceedings of the IEEE PowerTech 2015, Eindhoven, The Netherlands	29 June - 2 July 2015	The IEEE	Piscataway, NJ, USA	2015	1-6	doi: 10.1109/PTC.2015.7232753	no
40	Demand Flexibility Time Intervals for Aggregate Residential Load Patterns	I.A. Sajjad	Proceedings of the IEEE PowerTech 2015, Eindhoven, The Netherlands	29 June - 2 July 2015	The IEEE	Piscataway, NJ, USA	2015	1-6	doi: 10.1109/PTC.2015.7232760	no
41	Multi-Objective Distribution System Reconfiguration for Reliability Enhancement and Loss	N. Paterakis	Proceedings of the IEEE Power & Energy Society	July 26-30, 2015	The IEEE	Piscataway, NJ, USA	2015	1-5	doi: 10.1109/PESGM.2015.7286524	no

	Reduction		General Meeting, PESGM 2015, Denver, Colorado, USA							
42	A two-way coupling CFD method to simulate the dynamics of a wave energy converter	M. Bergmann	Proceedings of the MTS/IEEE OCEANS'15, Genoa, Italy	18-21 May 2015	IEEE	Piscataway, NJ, USA	2015	1-6	doi:10.1109/OCEANS-Genova.2015.7271481	no
43	Use of wave forecast for the regulation of ISWEC	G. Bracco	Proceedings of the 11th European Wave and Tidal Energy Conference (EWTEC 2015), Nantes, France	6-11 September 2015			2015			no
44	Optimal wind reversible hydro offering strategies for midterm planning	A. Sánchez de la Nieta	Transactions on Sustainable Energy	Vol. 6, No. 4, pp. 1356-1366,	IEEE		October 2015.		http://dx.doi.org/10.1109/TSTE.2015.2437974	No
45	Multi-period integrated framework of generation, transmission and natural gas grid expansion planning for large-scale systems	F. Barat	Transactions on Power Systems	Vol. 30, No. 5, pp. 2527-2537	IEEE		September 2015		http://dx.doi.org/10.1109/TPWRS.2014.2365705	No
46	Optimal wind reversible hydro offering strategies for midterm planning	A.A.S. de la Nieta	Proceedings of the 2016 IEEE PES Transmission & Distribution Conference & Exposition — T&D 2016,	2-5 May, 2016	IEEE	Dallas, Texas, USA	2016		http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7128390	No
47	DG investment planning analysis with renewable integration and considering emission costs	D.Z. Fitiwi	Proceedings of the IEEE Region 8 International Conference on Computer as a Tool — EUROCON 2015,	8-11 September, 2015.	IEEE	Salamanca, Spain	2015		http://dx.doi.org/10.1109/EUROCON.2015.7313735	No
48	An integrated generation, transmission and natural gas grid expansion planning approach for large scale systems	F. Barati	Proceedings of the 2015 IEEE Power & Energy Society General Meeting — PESGM 2015	July 26-30, 2015.	IEEE	Denver, Colorado, USA	2015		http://dx.doi.org/10.1109/PESGM.2015.7286535	No

49	Optimal Expansion Planning in Distribution Networks with Distributed Generation	G. Muñoz-Delgado	Proceedings of the PSCC 2014.	August 18-22, 2014		Wroclaw, Poland	2014		Digital Object Identifier 10.1109/PSCC.2014.7038423	No
50	Optimal Expansion Model of Renewable Distributed Generation in Distribution Systems	S. Montoya-Bueno	Proceedings of the PSCC 2014.	August 18-22, 2014		Wroclaw, Poland	2014		Digital Object Identifier 10.1109/PSCC.2014.7038348	No
51	Joint Expansion Planning of Distributed Generation and Distribution Networks	G. Muñoz-Delgado	IEEE Transactions on Power Systems	vol. 30, no. 5, pp. 2579–2590	IEEE		September 2015		Digital Object Identifier 10.1109/TPWRS.2014.2364960	No
52	Joint Expansion Planning of Distributed Generation and Distribution Networks	G. Muñoz-Delgado	Proceedings of the 2015 IEEE Power & Energy Society General Meeting — PESGM 2015	July 26-30, 2015.	IEEE	Denver, Colorado, USA	2015		Digital Object Identifier 10.1109/PESGM.2015.7285602	No
53	Joint RES and Distribution Network Expansion Planning under a Demand Response Framework	M. Asensio	El Sevier Monograph Series		ELSEVIER S&T Books		2016 (expected date of publication)			No
54	Multistage Generation and Network Expansion Planning in Distribution Systems Considering Uncertainty and Reliability	G. Muñoz-Delgado	IEEE Transactions on Power Systems		IEEE		2015		Digital Object Identifier 10.1109/TPWRS.2015.2503604	No
55	Technical and Economic Impact of Integrating EV in an Insular System	P. Meneses	CIRED Europe 2015	June 2015		Lyon, France	2015			
56	Distribution system short-term operation loss analysis with stochastic wind integration	A.W. Bizuayehu	2015 IEEE Eindhoven PowerTech	June 29, July 2, 2015	IEEE	Eindhoven, The Netherlands	2015		Digital Object Identifier: 10.1109/PTC.2015.723240	
57	Distribution system reconfiguration in Economic dispatch with high wind penetration	A.W. Bizuayehu	2015 IEEE Power & Energy Society General Meeting	July 26-30, 2015.	IEEE	Denver, Colorado, USA	2015		Digital Object Identifier: 10.1109/PESGM.2015.7286251	
58	An economic and regulatory framework for insular grids: The case of the Canary Islands	P. Meneses	2015 12th International Conference on the European Energy Market (EEM)	19-22 May 2015		Lisbon, Portugal	2015		Digital Object Identifier: 10.1109/EEM.2015.7216684.	
59	Optimal Bidding of a Group of Wind Farms in Day-Ahead Markets Through an External Agent	V. Guerrero-Mestre	IEEE Transactions on Power Systems	Volume:PP , Issue: 99 Page(s): 1 - 13	IEEE		September 2015		DOI: 10.1109/TRWRS.2015.2477466	

60	Stochastic Unit Commitment and Economic Dispatch in Isolated Systems with Renewable Penetration under CVaR Assessment	M. Asensio	IEEE Transactions on Smart Grid		IEEE		2015		DOI: 10.1109/TSG.2015.2469134	
61	Risk-Constrained Optimal Bidding Strategy for Pairing of Wind and Demand Response Resources	M. Asensio	IEEE Transactions on Smart Grid		IEEE		2015		10.1109/TSG.2015.2425044	
62	Allocation of Plug-in Vehicles' Parking Lots in Distribution Systems considering Network-constrained Objectives	N. Neyestani	IEEE Transactions on Power Systems	Volume:30 , Issue: 5) Page(s): 2643 - 2656	IEEE		October, 2014		10.1109/TPWRS.2014.2359919, 2014	
63	Energy Storage Systems Supporting Increased Penetration of Renewables in Islanded Systems	E. M. G. Rodrigues	Energy	vol. 75, nº1, pp. 265-280,			October 2014		doi:10.1016/j.energy.2014.07.072	
64	Unit Commitment with Wind Generation and Reversible-Hydro System in Islands	V. Guerrero	IFAC 2014,				Cape Town, South Africa, August 2014			
65	Short-Term Effects of Optimal Wind-Pumped Hydro Storage Energy Offers in Day-Ahead Electricity Markets	A. Sánchez de la Nieta	IFORS 2014				Barcelona, Spain, July 2014			
66	Effects of Optimal Grouping of Wind Farms in Day-Ahead Markets through an External Agent	V. Guerrero	IFORS 2014				Barcelona, Spain, July 2014			
67	Assessment on Baseline and Higher Order Grid Security Criteria: Prospects for Insular Grid	E.M.G. Rodrigues	IEEE PES General Meeting 2014				Washington DC, USA, July 2014			
68	A Stochastic Investment Model for Distributed Generation in Distribution Systems	S. Montoya-Bueno	IEEE Transactions on Sustainable Energy	Volume:6 , Issue: 4 Page(s): 1466 - 1474			July 2015		Digital Object Identifier DOI 10.1109/TSTE.2015.2444438, 2015	
69	A heuristic methodology to	A.	Renewable Energy	Vol. 87			March 2016	pp. 731-	http://dx.doi.org/10.1016/j.r	Yes

	economic dispatch problem incorporating renewable power forecasting error and system reliability	Tascikaraoglu,	(ELSEVIER)					743	enene.2015.11.011	
70	Electricity price forecast using combinatorial neural network trained by a new stochastic search method	O. Abedinia	Energy Conversion and Management (ELSEVIER)	Vol. 105			November 2015	pp. 642-654	http://dx.doi.org/10.1016/j.enconman.2015.08.025	Yes
71	Short-term wind power forecasting using adaptive neuro-fuzzy inference system combined with evolutionary particle swarm optimization, wavelet transform and mutual information	G.J. Osório	Renewable Energy (ELSEVIER)	Vol. 75			March 2015	pp. 301-307	http://dx.doi.org/10.1016/j.renene.2014.09.058	Yes
72	Electricity prices forecasting by a hybrid evolutionary-adaptive methodology	G.J. Osório	Energy Conversion and Management (ELSEVIER)	Vol. 80			April 2014	pp. 363-373	http://dx.doi.org/10.1016/j.enconman.2014.01.063	Yes
73	An EMD-ANN based prediction methodology for DR driven smart household load demand	A. Tascikaraoglu	Proceedings of the 18th Intelligent Systems Applications to Power Systems Conference and Debate — ISAP 2015 (technically co-sponsored by IEEE)	September 11-17, 2015		Porto, Portugal	2015		http://dx.doi.org/10.1109/ISAP.2015.7325544	Yes
74	Including forecasting error of renewable generation on the optimal load dispatch	G.J. Osório	Proceedings of the IEEE Power Tech 2015 Conference	29 June - 2 July, 2015		Eindhoven, Netherlands	2015		http://dx.doi.org/10.1109/PTC.2015.7232495	Yes
75	Hybrid evolutionary-adaptive approach to predict electricity prices and wind power in the short-term	J. Osório	Proceedings of the 18th Power Systems Computation Conference — PSCC 2014 (technically co-sponsored by IEEE)	August 18-22, 2014		Wroclaw, Poland	2014		http://pscc.ee.ethz.ch/uploads/tx_ethpublications/pscc2014_072_01.pdf	
76	Optimal behavior of electric vehicle parking lots as demand	M. Shafie-khah	IEEE Transactions on Smart Grid,	2016	IEEE		2016		http://dx.doi.org/10.1109/TSG.2015.2496796	No

	response aggregation agents		2016 (forthcoming)							
77	Optimal behavior of responsive residential demand considering hybrid phase change materials	M. Shafie-khah	Applied Energy (ELSEVIER)	2016	Elsevier		2016	81-92	http://dx.doi.org/10.1016/j.apenergy.2015.11.013	no
78	Optimal household appliances scheduling under day-ahead pricing and load-shaping demand response strategies	N.G. Paterakis	IEEE Transactions on Industrial Informatics	2015	IEEE		2015	1509-1519	http://dx.doi.org/10.1109/TII.2015.2438534	No
79	Smart household operation considering bi-directional EV and ESS utilization by real-time pricing-based DR	O. Erdinc	IEEE Transactions on Smart Grid,	2015	IEEE		2015	1281-1291	http://dx.doi.org/10.1109/TSG.2014.2352650	No
80	Introduction to the special section on real-time demand response	J.P.S. Catalão	IEEE Transactions on Smart Grid	2013	IEEE		2013	1841-1841	http://dx.doi.org/10.1109/TSG.2013.2291699	No
81	Enhancing home appliances energy optimization with solar power integration	D. Oliveira	Proceedings of the IEEE Region 8 International Conference on Computer as a Tool	2015	EUROCON	Salamanca, Spain	2015		http://dx.doi.org/10.1109/EUROCON.2015.7313798	Yes
82	Impacts of participating in different demand response programs on operational behavior of plug-in electric vehicle parking lots	M. Shafie-khah	Proceedings of the 2015 International Symposium on Smart Electric Distribution Systems and Technologies	2015	EDST	Vienna	2015		http://dx.doi.org/10.1109/SEDST.2015.7315190	Yes
83	Optimal operational and economical coordination strategy for a smart neighborhood	N.G. Paterakis	Proceedings of the IEEE Power Tech 2015 Conference	2015	IEEE	Eindhoven	2015		http://dx.doi.org/10.1109/PTC.2015.7232511	Yes
84	Distribution system operation enhancement through household consumption coordination in a dynamic pricing environment	N.G. Paterakis	Proceedings of the IEEE Power Tech 2015 Conference	2015	IEEE	Eindhoven	2015		http://dx.doi.org/10.1109/PTC.2015.7232424	Yes
85	Smart and energy-efficient home implementation: wireless communication technologies role	T.D.P. Mendes	Proceedings of the 5th International Conference on Power Engineering,	2015	PowerEng	Riga	2015		http://dx.doi.org/10.1109/PowerEng.2015.7266346	Yes

			Energy and Electrical Drives							
86	Optimal daily operation of a smart-household under dynamic pricing considering thermostatically and non-thermostatically controllable appliances	N.G. Paterakis	Proceedings of the 5th International Conference on Power Engineering, Energy and Electrical Drives	2015	PowerEng	Riga	2015		http://dx.doi.org/10.1109/PowerEng.2015.7266348	Yes
87	Smart households and home energy management systems with innovative sizing of distributed generation and storage for customers	O. Erdinc	Proceedings of the 48th Hawaii International Conference on System Sciences	2015	HICSS	Kauai, Hawaii	2015		http://dx.doi.org/10.1109/HICSS.2015.178	Yes
88	Coordination of smart-household activities for the efficient operation of intelligent distribution systems	N.G. Paterakis	Proceedings of the 5th IEEE PES Innovative Smart Grid Technologies Europe Conference	2014	ISGT Europe	Instabul	2014		http://dx.doi.org/10.1109/ISGTEurope.2014.7028977	Yes
89	Impact of electric vehicle V2G operation and demand response strategies for smart households	O. Erdinc	: Proceedings of the 2014 IEEE PES Transmission & Distribution Conference & Exposition	2014	T&D 2014	Chicago	2014		http://dx.doi.org/10.1109/TDC.2014.6863277	Yes
90	Electric Price Signals, Economic Operation and Risk Analysis	J. Contreras	book J.P.S. Catalão (ed.), "Smart and Sustainable Power Systems: Operations, Planning, and Economics of Insular Electricity Grids"	June 18, 2015	CRC Press	Boca Raton, FL, USA	2015	95-154	ISBN 9781498712125	no
91	Analysis of storage technologies within smart grid framework	R. Vatu	Proceedings of the IEEE Universities' Power Engineering Conference - UPEC 2014	2-5 September 2014	The IEEE	Cluj, Romania	2014	11–17	10.1109/UPEC.2014.6934823	no

92	Analysis of the grid-connected PV plants behavior with FACTS influence	O. Ceaki	Proceedings of the IEEE Universities' Power Engineering Conference - UPEC 2014	2-5 September 2014	The IEEE	Cluj, Romania	2014		10.1109/UPEC.2014.6934822	yes
93	Competitive electricity market schemes within smart grids framework	R.Vatu	Proceedings of the IEEE International Symposium on Fundamentals of Electrical Engineering – ISFEE	28 – 29 November	The IEEE	Bucharest, Romania	2014	1-5	doi:10.1109/ISFEE.2014.7050602	no
94	Analysis of SVC influence on the power quality for grid – connected PV plants	O. Ceaki	Proceedings of IEEE International Symposium on Fundamentals of Electrical Engineering – ISFEE	28 – 29 November	The IEEE	Bucharest, Romania	2014	1-5	doi: 10.1109/ISFEE.2014.7050604	no
95	Load profiles definition for the electrical distribution operator	R.Porumb	Proceedings of IEEE International Conference on Modern Power Systems – MPS	17 – 20 May 2015	The IEEE	Cluj, Romania	2015	280-284		no
96	Continuity of supply, a key parameter for smart grids' resilience evaluation,	G.Seritan	Proceedings of IEEE International Conference on Modern Power Systems – MPS	17 – 20 May 2015	The IEEE	Cluj, Romania	2015	314-320		no
97	Power quality measurements and analysis for a Romanian WPP	G. Sava	I Proceedings of IEEE PowerTech	29 June - 2 July 2015	The IEEE	Eindhoven, Holland	2015	1-6	doi: 10.1109/PTC.2015.7232598	yes
98	Loss minimum reconfiguration through deterministic iterative improvement and simulated annealing	V. Boicea	Proceedings of IEEE International Conference on Optimization of Electrical & Electronic Equipment (OPTIM 2015)	02 - 04 September 2015	The IEEE	Antalya, Turkey	2015	1-8		no

99	Smart grids reliability indices assessment using sequential Monte Carlo method	M. Mancasi	Proceedings of IEEE International Conference on Environment and Electrical Engineering	10 – 13 June	The IEEE	Rome, Italy	2015	2066 - 2071	doi: 10.1109/EEEIC.2015.7165495	no
100	Analysis of ancillary services within smart grid framework	R. Vatu	Proceedings of IEEE Modern Electric Power systems Conference – MEPS	6-9 July	The IEEE	Wroclaw, Poland	2015	11.21		no
101	Analysis of electromagnetic disturbances for grid – connected PV plants	O. Ceaki	Proceedings of IEEE Modern Electric Power systems Conference – MEPS	6-9 July	The IEEE	Wroclaw, Poland	2015	11.22		no
102	Power quality issues produced by embedded storage technologies in smart grid environment	R. Vatu	Proceedings of IEEE Universities' Power Engineering Conference - UPEC	1 – 4 September	The IEEE	Stoke – on – Trent, UK	2015	paper 449	doi: 10.1109/UPEC.2015.7339797	no
103	Evolution of smart buildings. A Romanian case	M. Mancasi	Proceedings of IEEE Universities' Power Engineering Conference - UPEC	1 – 4 September	The IEEE	Stoke – on – Trent, UK	2015	paper 449	doi: 10.1109/UPEC.2015.7339802	no
104	Analysis of electromagnetic disturbances with or without SVC device	O. Ceaki	Proceedings of IEEE Universities' Power Engineering Conference - UPEC	1 – 4 September	The IEEE	Stoke – on – Trent, UK	2015	1-5	doi: 10.1109/UPEC.2015.7339817	no

Template A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[9]	Main leader	Title	Date	Place	Type of audience[10]	Size of audience	Countries addressed
1	*Press Release*	*AUTH*	*Smart and Sustainable Insular Electricity Grids with the contribution of Aristotle University of Thessaloniki*	*5/3/2013*	*Thessaloniki, Greece*	*Scientific Community, Medias*	*N/A*	*Greece*
2	*Articles published in the popular press*	*AUTH*	*SiNGULAR: Smart grids for the development of RES in islands*	*5/3/2013*	*Greece*	*Scientific Community, Industry, Medias*	*N/A*	*Greece*
3	*Oral Presentation*	*AUTH*	*3rd Annual Conference Innogrid2020+*	*25-26/03/2014*	*Brussels, Belgium*	*Scientific Community, Industry, Policy Makers*	*~ 400*	*EU*
4	*Workshop*	*AUTH*	*REServices Final Event*	*30/09/2014*	*Brussels, Belgium*	*Scientific Community, Industry, Policy Makers*	*~ 100*	*EU*
5	*Poster Presentation*	*AUTH*	*4th Annual Conference Innogrid2020+*	*31/3 – 1/4/2015*	*Brussels, Belgium*	*Scientific Community, Industry, Policy Makers*	*~ 400*	*EU*
6	*Oral Presentation*	*AUTH*	*Presentation in the "Fuel Cells and Hydrogen Joint Undertaking" Workshop*	*21/5/2015*	*Athens, Greece*	*Scientific Community, Industry, Policy Makers*	*~ 80*	*Greece*
7	*Oral Presentation*	*AUTH*	*Presentation of SiNGULAR in the FP7 INCREASE Technical Workshop*	*16/9/2015*	*Thessaloniki, Greece*	*Scientific Community, Industry,*	*~ 100*	*Greece*

[9] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[10] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias ('multiple choices' is possible.

						Policy Makers		
8	*Conference*	*AUTH*	*IEEE European Summit*	*10/11/2015*	*Brussels, Belgium*	*Scientific Community, Industry, Policy Makers*	*200*	*EU*
9	*Creation of Initial Communication Tools*	*CS*	*SiNGULAR Logo*	*February 2013*				
10	*Creation of Initial Communication Tools*	*CS*	*First set of flyers*	*February 2013*	*Published in SiNGULAR WEBSITE For following conferences and meetings*			
11	*Creation of Initial Communication Tools*	*CS*	*SiNGULAR Posters*	*February 2013*	*For following conferences and meetings*			
12	*Creation of Initial Communication Tools11*	*CS*	*SiNGULAR website*	*February 2013 - Presently*	*http://www.singular-fp7.eu/ Daily uploaded with SiNGULAR information and renewable energy news. Articles average: 3,45 per day during the whole project.*	*All*	*Total visits: 461.259*	*International*
13	*Articles published in digital newspapers*	*CS*	*"Una empresa albaceteña investiga cómo reducir la dependencia energética" AlbaceteCapital.es*	*17/June/2013*	*http://albacetecapital.es/una-empresa-albacetena-investiga-como-reducir-la-dependencia-energetica/*	*Civil Society*	*Local*	*Spain*
14	*Articles published in websites*	*CS*	*"Castilla – La Mancha lidera innovador proyecto europeo de energía sostenible" Econoticias.com*	*18/June/2013*	*http://www.ecoticias.com/energias-renovables/80028/Castilla-Mancha-lidera-innovador-proyecto-europeo-energia-sostenible*	*Scientific Community, Industry, Civil Society*	*International*	*Spain, Colombia, Perú, EEUU, Uruguay, Argentina, Bolivia, Brasil, Panama, Chile, Paraguay, Costa Rica,*

[11] Further Information in Deliverables 12.1. and 12.2

								Venezuela,
15	*Articles published in websites*	*CS*	*"Castilla – La Mancha lidera innovador proyecto europeo de energía sostenible" Structuralia*	*18/June/2013*	*http://www.structuralia.com/es/component/k2/item/101909-castilla-%E2%80%93-la-mancha-lidera-innovador-proyecto-europeo-de-energ%C3%ADa-sostenible?tmpl=component&print=1*	*Scientific Community, Industry, Civil Society*	*International*	*Chile, Colombia, Costa Rica, Panama, Peru, Mexico and Spain*
16	*Articles published in websites*	*CS*	*"Castilla – La Mancha lidera innovador proyecto europeo de energía sostenible" Innovallcluster.com*	*18/June/2013*	*http://www.innovallcluster.com/noticia.aspx?id=ab44204b-4cd9-4f2a-93a6-f3849c6041fc*	*Scientific Community, Industry, Civil Society*	*International*	*International*
17	*Articles published in websites*	*CS*	*"SiNGULAR: innovador proyecto europeo de autoconsumo energético insular" Instituro Superior de Medio Ambiente*	*18/June/2013*	*http://www.comunidadism.es/actualidad/singular-innovador-proyecto-europeo-de-autoconsumo-energetico-insular*	*Scientific Community, Industry, Civil Society*	*International*	*Spain*
18	*Articles published in digital newspapers*	*CS*	*"SiNGULAR, un proyecto europeo liderado desde Castilla-La Mancha" Encastillalamancha.es*	*19/June/2013*	*http://encastillalamancha.es/noticia/25848/Singular,%20un%20proyecto%20europeo%20liderado%20desde%20Castilla-La%20Mancha*	*Civil Society*	*Regional*	*Spain*
19	*Articles published in digital newspapers*	*CS*	*"Castilla La Mancha lidera innovador proyecto europeo de energía sostenible" Noticiero Mendonza*	*24/June/2013*	*http://noticieromendoza.com.ar/castilla-%C2%96-la-mancha-lidera-innovador-proyecto-europeo-de-energia-sostenible/*	*Civil Society*	*Argentina. International*	*International*
20	*Presentations, Conferences*	*CS*	*Presentation SiNGULAR in XI Congreso Español de Sociología*	*12/July/2013*	*XI Congreso Español de Sociología*	*Scientific Community*	*National*	*Spain*
21	*Media Briefings: Promotional video*		*SiNGULAR*	*17/July/2013*	*https://www.youtube.com/watch?v=ejA9zzwnG8E*	*Scientific Community, Industry, Civil Society*	*International*	*International*
22	*Articles published in the popular press*	*CS*	*"Una empresa albaceteña lidera un proyecto europeo en el que colabora la UCLM" La Tribuna de Albacete*	*18/August/2013*	*Albacete (Spain)*	*Civil Society*	*Local*	*Spain*
23	*Media Briefings: Articles in social networks*	*CS*	*"Castilla – La Mancha, mi región" Facebook group*	*August/2013*	*https://www.facebook.com/groups/miregion/*	*Civil Society, Scientific Community*	*Potential impact: 12.000 users*	*Spain*
24	*Media Briefings:Articles in social*	*CS*	*"Castilla-La Mancha, nuestra tierra" Facebook group*	*August/2013*	*https://www.facebook.com/groups/418537494895088/*	*Civil Society, Scientific Community*	*Potential impact: 2.200 users*	*Spain*

	networks							
25	Media Briefings:Articles in social networks	CS	"Desarrollo Local" Facebook group	August/2013	https://www.facebook.com/groups/128254754069/	Scientific Community, Industry, Civil Society	Potential impact: 8.648 users	Spain
26	Media Briefings:Articles in social networks	CS	"Albacete en Positivo" Facebook group	August/2013	https://www.facebook.com/groups/374500892619553/	Civil Society	Potential impact: 2.500 users	Spain
27	Media Briefings:Articles in social networks	CS	"MiCiudadAlbacete" Facebook page	August/2013	https://www.facebook.com/MasAlbacete	Civil Society	Potential impact 2.856 users	Spain
28	Media Briefings:Articles in social networks	CS	"Instituto Superior de Medio Ambiente" Facebook page	August/2013	https://www.facebook.com/ismedioambiente	Scientific Community, Industry, Civil Society	Potential impact: 7.771 users	Spain
29	Media Briefings:Articles in social networks	CS	"Albacete en Transición" Facebook page	August/2013	https://www.facebook.com/pages/Albacete-en-transici%C3%B3n/234544919944398	Scientific Community, Industry, Civil Society	Potential impact: 1.091 users	Spain
30	Presentations, meetings	CS	Meeting with Borja Izquierdo, EEGI National Representative.	11/November/2013	Madrid, Spain	Scientific Community	International	International
31	Presentations, Conferences	CS and UCLM	SiNGULAR presentation in HORIZON 2020	20/February/2014	Toledo, University of Castilla – La Mancha, Spain	Scientific Community, Civil Society	Regional	International
32	Presentations, Conferences	CS and AUTH	2nd INNOGRID 2020	25-26/March/2014	Brussels, Belgium	Scientific Community	International	International
33	Presentations, Conferences	CS	Participation in GRID+/EEGI INTERACTION EVENT	09/April/2014	Madrid, Spain	Scientific Community	International	International
34	Media briefings	CS	Diffusion Emails: Presentation of the project's scientific results	09/October/2014	Data base of international experts	Scientific Community, Industry, Policy makers	9.230 experts (companies, academic researchers, analysts, politics)	International
35	Articles published in websites	CS	"SiNGULAR: Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration" Grid Innovation-on-line Platform	13/October/2014	http://www.gridinnovation-on-line.eu/Articles/Library/SiNGULAR-Smart-And-Sustainable-Insular-Electricity-Grids-Under-Large-Scale-Renewable-Integration.kl	Scientific Community	International	International

36	Media briefings	CS	Diffusion emails: invitation to complete the electronic survey	November/2014	SurveyMonkey	Scientific Community, Industry, Policy makers	9.230 experts	International
37	Presentations, Conferences	CS and UCLM	2nd IGREENGrid Public Workshop	04/December/2014	Madrid, Spain	Scientific Community	International	International
38	Website changes:	CS	New sections in SiNGULAR website: information about SiNGULAR scientific results, public papers and deliverables availables to download - Communication and Dissemination/Papers - Communication and Dissemination/Deliverables	March/2015	Published in SiNGULAR website			
39	Creation of communication tools	CS	Second set of flyers	March/2015	Published in SiNGULAR website For following conferences and meetings			
40	Media briefings	CS	Diffusion Emails: project's scientific results and progress	March/2015	Data base of international experts	Scientific Community, Industry, Policy makers	9.230 experts	International
41	Presentations, Conferences	CS and AUTH	4th INNOGRID 2020	1/04/2015	Brussels, Belgium	Scientific Community	International	International
42	Media briefings	CS	Agenda with photos - Creta meeting	27-28/04/2015	Published in SiNGULAR website http://www.singular-fp7.eu/home/downloads/Agenda%20with%20Photos.pdf	All	International	International
43	Media briefings	CS	Agenda with photos - Azores meeting	25-26/06/2015	Published in SiNGULAR website http://www.singular-fp7.eu/home/downloads/AZORES.pdf	All	International	International
44	Media briefings	CS	Agenda with photos - Porto meeting	17-18/09/2015	Published in SiNGULAR website http://www.singular-fp7.eu/home/downloads/9.pdf	All	International	International
45	Media briefings	CS	September newsletter (project progress and scientific publications)	September/2015		Scientific Community, Industry, Policy makers	9.230 experts	International
46	Articles published in	CS	"SiNGULAR, integración de renovables en smart grids"	13/11/2015	https://www.smartgridsinfo.es/articulos/singular-integracion-	Scientific Community	National	Spain

	websites		*SMARTGRIDSINFO.es*		*de-renovables-en-smart-grids-insulares*			
47	*Media briefings*	*CS*	*November newsletter (survey results and SiNGULAR products)*	*November/2015*		*Scientific Community, Industry, Policy makers*	*9.230 experts*	*International*
48	*Media briefings*	*CS*	*Agenda with photos - Caparica meeting*	*26·27/11/2015*	*Published in SiNGULAR website http://www.singular-fp7.eu/home/downloads/Final%20meeting%20Agenda%20with%20photos.pdf http://www.singular-fp7.eu/home/downloads/Final%20meeting%20Agenda%20with%20photos%202.pdf*	*All*	*International*	*International*
49	*Conference*	*IEEE*	*IEEE Energy Summit*	*10th November*	*Brussels*	*Research Institutions*	*100*	
50	*Conference*	*UCLM*	*Proceedings of the 2015 IEEE Power & Energy Society General Meeting — PESGM 2015*	*July 26-30, 2015.*	*Denver, Colorado*	*Research Institutions*	*200*	
51	*Conference*	*UCLM*	*Proceedings of the PSCC 2014.*	*August 18-22, 2014*	*Wroclaw, Poland*	*Research Institutions*	*200*	
52	*Conference*	*UBI*	*Proceedings of the IEEE Region 8 International Conference on Computer as a Tool — EUROCON 2015,*	*8-11 September, 2015.*	*Salamanca, Spain*	*Research Institutions*	*200*	
53	*Conference*	*UCLM*	*http://cienciaes.com/entrevistas/2014/08/07/sistemas-de-energia-electrica-hablamos-con-javier-contreras/*	*9 August, 2014*		*General Public*	*1000*	
54	*Website*	*HEDNO*	*Creation of separate section on the HEDNO Website (www.deddie.gr) referring to the European Projects that HEDNO participates. Preparation for the SiNGULAR project description*	*March 2013*	*Athens,Greece*	*All Possible*		
55	*Conference*	*HEDNO*	*Reference to the SiNGULAR project at the presentation Gigantidou, A.: 'Renewable energy sources in Crete'. Bulk Power System Dynamics and Control-IX Optimization, Security and Control of the Emerging Power Grid (IREP Symp. 2013), Crete, Greece, pp. 1–3*	*25 Aug - 30 Aug 2013*	*Rethimno,Crete, Greece*	*Scientific Community*	*100*	*Greece,UK,USA,Brazil,France,Italy,Switzerland,Denmark, etc*
56	*Conference*	*HEDNO*	*Reference to the activities of the SiNGULAR*	*12th*	*Athens, Greece*	*Scientific*	*50*	*Greece*

			project at the presentation of Ms Gigantidou at The Hellenic Committee of the CIGRE "Renewable Energy Sources on the island of Crete".	*December 2013*		*Community, Industry*		
57	*Workshop*	*HEDNO*	*Presentation to the Executive Board of HEDNO regarding the benefits from the SINGULAR project by Dr. Emm. Thalassinakis*	*April 2014*	*Athens, Greece*	*Industry*	*20*	*Greece*
58	*Conference*	*HEDNO*	*Hosting the SuSTAINABLE-SiNGULAR-iGREENGrid Global Joint Stakeholders Conferences*	*11-12 April 2014*	*Athens, Greece*	*Scientific Community,*	*60*	*Greece,Spain ,Italy,Austria, UK,Portugal, Romania,Cyp rus*
59	*Letter*	*HEDNO-Associati on of Electrical and Mechanic al Engineer s on Eastern Crete*	*Information Letter on the activities of WP 8 of the project in order to create interest on the project and the installation of the Home Area Meters.*	*January 2014*	*Crete, Greece*	*Civil Society*	*50*	*Greece*
60	*Flyer Distribution*	*HEDNO*	*Flyers provided to the persons participating in the SmartKye Meeting hosted in Iraklio.*	*15th-16th September 2014*	*Crete*	*Scientific Community (research)*	*15*	*Spain, Greece, Germany*
61	*Conference Presentation*	*HEDNO*	*Reference to the activities of the SiNGULAR project at the presentation "HEDNO and the Development of RES on Crete" by Ms. A. Gigantidou presented at the day –conference "The energy Future of Crete"*	*1st November 2014*	*Orthodox Academy Colymvari,Crete,Greece*	*Scientific Community (research)*	*50*	*Greece*
62	*Other*	*HEDNO*	*Stickers on the Home Area Meters for the project*	*December 2014-April 2015*		*Recidents of homes*	*80 individuals*	*Greece*
63	*Flyer*	*HEDNO*	*Informative flyer on the purposes of the project and the specific targets of the WP 8 to the recipients of the smart logging system*	*February-April 2015*	*Crete island*	*Recidents of homes*	*80 individuals*	*Greece*
64	*Conference Presentation and Flyer Distribution*	*HEDNO*	*Reference to the aid that the SiNGULAR project has provided in management of PVS on the island of Crete-Presentation at the Presentations of the Final PV-NET Conference, 8 May 2015*	*08th May 2015*	*Nicosia. Cyprus*	*Scientific Community, Policy Makers*	*60*	*Italy,France, Cyprus,Spain ,Slovenia*
65	*Other (meeting)*	*HEDNO*	*Information on the SINGULAR project to a*	*July 2015*	*HEDNO premises in Iraklio,*	*Industry*	*1*	*Sweden*

			visitor from a Swedish DSO		*Crete*			
66	*Other (meeting)*	*HEDNO*	*Internal meeting with Japanese and Greek representatives. Presentation of the STEPS tool.*	*13-14 July 2015*	*HEDNO premises in Iraklio,Crete*	*Industry*	*4*	*Japan, Greece*
67	*Conference Presentation*	*HEDNO*	*Reference to the aid that the SiNGULAR project has provided in management of the Cretan Power System in Ms. Gigantidou presentation "Current Situation in Energy Balance on the island of Crete" in the Conference "Energy Autonomous Islands and Conmunities with up to 100% RES use"*	*14- 15th November 2015*	*Orthodox Academy, Colymvari, Crete, Greece*	*Scientific Community, Industry, Policy Makers*	*40*	*Greece*
68	*Other (e-mail)*	*HEDNO*	*E-mail to HEDNO personnel on the activities on the project*	*30th November 2015*		*Industry*	*40*	*Greece*
69	*Conference*	*A.A.S. de la Nieta*	*Optimal coordinated wind and generic storage system bidding in electricity markets*	*27-30 September, 2015*	*Wollongong, Australia*			
70	*Conference*	*E.M.G. Rodrigues*	*Comparison of battery models for energy storage applications on insular grids*	*27-30 September, 2015*	*Wollongong, Australia*			
71	*Conference*	*E.M.G. Rodrigues*	*Assessing lead-acid battery design parameters for energy storage applications on insular grids: a case study of Crete and São Miguel islands*	*8-11 September, 2015*	*Salamanca, Spain*			
72	*Conference*	*E. Heydarian-Forushani*	*Optimal coordination of battery energy storages and demand response programs with application to wind integration*	*August 17-19, 2015*	*Oshawa, Canada*			
73	*Conference*	*E.M.G. Rodrigues*	*New schedule management approach of energy storage system in insular power system*	*29 June - 2 July, 2015*	*Oshawa, Canada*			
74	*Conference*	*A.A.S. de la Nieta*	*Optimal generic energy storage system offering in day-ahead electricity markets", in: Proceedings of the IEEE Power Tech 2015 Conference*	*May 11-13, 2015*	*, Eindhoven, Netherlands*			
75	*Conference*	*E.M.G. Rodrigues*	*An innovative technique for energy storage system management based on vanadium redox batteries"*	*28 September - 1 October, 2014*	*Riga, Latvia*			

76	*Conference*	*E.M.G. Rodrigues*	*NaS battery storage system modeling and sizing for extending wind farms performance in Crete*	*13-18 July, 2014*	*Perth, Australia*			
77	*Conference*	*P. Medina*	*Electrical energy storage systems: technologies' state-of-the-art, techno-economic benefits and applications analysis*		*Big Island, Hawaii*			
78	*Workshop*	*Prof. Cláudio Monteiro - Smartwatt*	*Presentation on Scheduling and Forecasting Platforms*	*25-10-2013*	*EDA Headquarters, São Miguel Island, Azores*	*Industry*	*7 persons*	*Portugal*
79	*Community Event*	*W4E*	*Energia Green e Agricoltura: Pantelleria inizia dal Wave Pawer*	*25-10-2015*	*Pantelleria*	*General Public (citizens of Pantelleria to which the demonstration project of the ISWEC converter has been presented and where also Singular project has been introduced)*	*100 persons*	*Italy*
80	*Conference - Exhibition*	*Intelen*	*European Smart Metering Week 2015*	*3-5 November 2015*	*Vienna*	*Scientific, Industry, Policy makers, Medias*	*thousands*	*Europe*
81	*Conference*	*Singular*	*IGREENGrid-SiNGULAR-SuSTAINABLE*	*26 November 2015*	*Caparica*	*Scientific*	*tens*	*Europe*
82	*Press Release*	*Intelen*	*Singular Kick off*	*October 2012*	*New York and Athens*	*Global*	*Global*	*Global*
83	*Web site material*	*Singular*	*Web site content material*	*2012*	*Global*	*Global*	*Global*	*Global*
84	*Presentation*	*R.Porumb*	*Competitive Operation of Insular Electric Networks*	*2 September 2014*	*Cluj, Romania*	*Scientific Community*	*150*	*25*

						(higher education, Research), Industry		
85	*Presentation CIRED 2015*	*Dumitru FEDERENCIUC / Ioan SILVAŞ Dorel STĂNESCU*	*Electrica S.A.– Romania Nicolae GOLOVANOV Universitatea Politehnica Bucuresti - Romania*	*15-18 June 2015*	*Lyon*	*Scientific Community (higher education, Research), Industry*	*180*	*90*
86	*Presentation WEC –NC 2015*	*Dumitru FEDERENCIUC, Ioan SILVAŞ*	*Electrica S.A.– Romania Nicolae GOLOVANOV Universitatea Politehnica Bucuresti - Romania*	*12-15June 2014*	*Bucharest*	*Scientific Community (higher education, Research), Industry*	*60*	*20*
87	*Oral presentation*	*POLITO*	*Advanced distribution system modelling and analysis: making it SiNGULAR, invited presentation by G. Chicco at the 6th International Conference on Energy and Environment (CIEM 2013)*	*07/11/2013*	*Bucharest, Romania*	*Scientific Community, Industry*	*~ 50*	*many*
88	*Oral presentation*	*POLITO*	*Voltage Control Architecture (centralized vs. decentralized), presentation by G. Chicco at session 3 of the 1st Global Joint Stakeholders Conference (iGreenGRID, SiNGULAR, SuSTAINABLE) Interactive Sessions*	*11/04/2014*	*Athens, Greece*	*Scientific Community, Industry*	*~ 50*	*many*
89	*Oral presentation*	*POLITO*	*Demand flexibility for load aggregations, presentation by G. Chicco at the IEEE SmartGridComm Conference, workshop on "Integrating Renewables and Exploiting Customer Flexibility", available online at http://sgc2014.ieee-smartgridcomm.org/content/ws3*	*03/11/2014*	*Venice, Italy*	*Scientific Community*	*~ 150*	*many*
90	*Oral presentation*	*POLITO*	*Characterization and flexibility of the electrical demand in smart grids, presentation by G. Chicco at the 7th International Conference on Energy and Environment (CIEM 2015)*	*23/10/2015*	*Iasi, Romania*	*Scientific Community*	*~ 20*	*many*
91	*Oral presentation*	*POLITO*	*SiNGULAR - Smart and sustainable insular electricity grids under large-scale renewable integration, presentation by F. Spertino at the*	*08/09/2015*	*Torino, Italy*	*Scientific Community, Industry*	*~ 20*	*many*

			Research and Technologies for Society and Industry Conference (RTSI 2015), session "EU projects dissemination: smart grid and smart energy"					
92	*YouTube link*	*ENEA, POLITO*	*ENEA WebTV - Energia dal Mare: ISWEC, un progetto Mediterraneo*	*04/08/2014*	*https://www.youtube.com/watch?v=pV_sqUmbnDU*	*All*	*> 1400 visualizations*	*Italy*
93	*YouTube link*	*W4E*	*ISWEC Technology Presentation*	*16/09/2014*	*https://www.youtube.com/watch?v=YXwuRp5-8Xw*	*All*	*> 4000 visualizations*	*many*
94	*YouTube link*	*POLITO, W4E*	*Energia Pulita Dal Mare - Inertial Sea Wave Energy Converter*	*06/04/2015*	*https://www.youtube.com/watch?v=-ImNuosIvbk*	*All*	*> 3000 visualizations*	*Italy*
95	*YouTube link*	*POLITO, W4E*	*ISWEC video*	*18/11/2015*	*https://www.youtube.com/watch?v=CoKz2DHXq40*	*All*	*> 200 visualizations*	*many*
96	*Report presentation*	*POLITO, W4E*	*Presentation of the Report "100% renewables: a new future for the small islands" (in Italian)*	*22/07/2015*	*Palermo, Italy*	*Industry, Policy makers, Civil Society*	*~ 50*	*Italy*
97	*Media briefings*	*POLITO, W4E*	*"100% rinnovabili: un nuovo futuro per le piccole isole", convegno a Palazzo delle Aquile*	*22/07/2015*	*http://www.palermotoday.it/green/energia/energia-sostenibile-greenpeace-convegno-22-luglio-2015.html*	*All*	*web*	*Italy*
98	*Media briefings*	*W4E*	*Image of the day: ISWEC ready for deployment*	*27/07/2015*	*http://tidalenergytoday.com/2015/07/27/image-of-the-day-iswec-ready-for-deployment/*	*All*	*web*	*many*
99	*Media briefings*	*POLITO, W4E*	*Greenpeace e Anci Sicilia elaborano per le piccole isole progetto per un futuro di energie rinnovabili*	*03/08/2015*	*http://trinacrianews.eu/greenpeace-anci-sicilia-elaborano-per-piccole-isole-progetto-per-futuro-energie-rinnovabili/*	*All*	*web*	*Italy*
100	*Media briefings*	*POLITO, W4E*	*New Inertial Sea Wave Energy Converter Deployed to Produce Electricity in Pantelleria Island*	*07/08/2015*	*http://www.azocleantech.com/news.aspx?newsID=22277*	*All*	*web*	*many*
101	*Media briefings*	*W4E*	*Wave for Energy: ISWEC device ready for production*	*10/08/2015*	*http://tidalenergytoday.com/2015/08/10/wave-for-energy-iswec-device-ready-for-production/*	*All*	*web*	*many*
102	*Media briefings*	*W4E, POLITO, ENEA*	*Wave Energy Device Installed off Italy*	*11/08/2015*	*http://www.offshorewind.biz/2015/08/11/wave-energy-device-installed-off-italy/*	*All*	*web*	*many*
103	*Media briefings*	*POLITO, W4E, ENEA*	*New Wave Energy Device Placed Offshore Italy*	*10/10/2015*	*http://subseaworldnews.com/2015/08/10/new-wave-energy-device-placed-offshore-italy/*	*All*	*web*	*many*
104	*Media briefings*	*POLITO, W4E, PANTEL*	*Wave power a Pantelleria con il Politecnico di Torino*	*02/11/2015*	*http://www.civiltadelbere.com/wave-power-a-pantelleria-con-il-politecnico-di-torino/*	*All*	*web*	*Italy*

		LERIA						
105	*Media briefings*	*POLITO, W4E, ENEA, PANTEL LERIA*	*Passitaly 2015, un work in progress a Pantelleria*	*03/11/2015*	*http://www.gamberorosso.it/it/vini/1023170-passitaly-2015-un-work-in-progress-a-pantelleria*	*All*	*web*	*Italy*
106	*Media briefings*	*W4E*	*Gallery: ISWEC awaits January connection*	*09/11/2015*	*http://tidalenergytoday.com/2015/11/09/gallery-iswec-awaits-january-connection/*	*All*	*web*	*many*

Section B

Part B1

The applications for patents, trademarks, registered designs, etc. shall be listed according to the template B1 provided hereafter.

The list should, specify at least one unique identifier e.g. European Patent application reference. For patent applications, only if applicable, contributions to standards should be specified. This table is cumulative, which means that it should always show all applications from the beginning until after the end of the project.

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[12]:	Confidential (YES/NO)	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)
N/A					

[12] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

3. Report on societal implications

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	309048
Title of Project:	Smart and Sustainable Insular Electricity Grids under large-scale
Name and Title of Coordinator:	Prof. Joao Catalao

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	NO
• Did the project involve patients?	NO
• Did the project involve persons not able to give consent?	NO
• Did the project involve adult healthy volunteers?	NO
• Did the project involve Human genetic material?	NO
• Did the project involve Human biological samples?	NO
• Did the project involve Human data collection?	NO
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	NO
• Did the project involve Human Foetal Tissue / Cells?	NO
• Did the project involve Human Embryonic Stem Cells (hESCs)?	NO
• Did the project on human Embryonic Stem Cells involve cells in culture?	NO
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	NO
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	NO
• Did the project involve tracking the location or observation of people?	NO
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	NO
• Were those animals transgenic small laboratory animals?	NO
• Were those animals transgenic farm animals?	NO
• Were those animals cloned farm animals?	NO
• Were those animals non-human primates?	NO
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	NO
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	YES
DUAL USE	
• Research having direct military use	NO
• Research having the potential for terrorist abuse	NO

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator		3
Work package leaders	4	11
Experienced researchers (i.e. PhD holders)	7	38
PhD Students	5	23
Other	23	42

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**32**
Of which, indicate the number of men:	26

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	○ X	Yes **No**

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○

○ Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

X No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[13]: 2.2

○ Associated discipline[13]: 5.2 ○ Associated discipline[13]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ X	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No

○ Yes- in determining what research should be performed

○ Yes - in implementing the research

○ Yes, in communicating /disseminating / using the results of the project

[13] Insert number from list below (Frascati Manual).

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- X Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- X Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture		Energy		Human rights	
Audiovisual and Media		Enlargement		Information Society	
Budget		Enterprise		Institutional affairs	
Competition		Environment		Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		Regional Policy	
Development Economic and Monetary Affairs		Food Safety		Research and Innovation	
		Foreign and Security Policy		Space	
Education, Training, Youth		Fraud		Taxation	
Employment and Social Affairs		Humanitarian aid		Transport	

13c If Yes, at which level?

- ○ Local / regional levels
- X National level
- X European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**29**
To how many of these is open access[14] provided?	**23**
How many of these are published in open access journals?	**7**
How many of these are published in open repositories?	**11**
To how many of these is open access not provided?	**22**
Please check all applicable reasons for not providing open access:	
X publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[15]: ……	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		**0**

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

X	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	X	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

[14] Open Access is defined as free of charge access for anyone via Internet.
[15] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:* ***9***
Difficult to estimate / not possible to quantify	❑

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	X	Coverage in specialist press
X	Media briefing	X	Coverage in general (non-specialist) press
❑	TV coverage / report	X	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
❑	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	X	English
X	Other language(s)		

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES
1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]
1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)
1.3 Chemical sciences (chemistry, other allied subjects)
1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY
2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]