DERri
Distributed Energy Resources
Research Infrastructures

User-Project Proposal:

User-Project Acronym	**DER_management**
User-Project Title	**D**istributed **E**nergy **R**esources **management** and control in a microgrid environment
Main-scientific field	Electric Power System, Electrical Engineering, Distribution Automation
Specific-Discipline	Power system management and Control

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Position in Organization	Assistant Professor

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

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Activity type and legal status* of Organization	Higher Education Institution
Position in Organization	Ph.D. Student 3rd year

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Activity type and legal status* of Organization	Higher Education Institution
Position in Organization	PhD Student 1st year

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Activity type and legal status* of Organization	Higher Education Institution
Position in Organization	PhD Student 1st year

Date of submission	28/03/2013
Re-submission	YES_____ NO___**X**____
Proposed Host TA Facility	USTRAT, Glasgow (UK)
Starting date (proposed)	second half of October 2013

Summary of proposed research

The project is aimed at using an active MV/LV networks based on a hierarchical architecture for RES integration and intellingent load management. The work will focus on modeling RES dynamics and network communication aspects (IEC 61850, OPC). In particular the main focus will be to investigate and test medium and short term control strategies for DER and load management. The proposed control strategies are: a) Mid Term (day-ahead) strategy that, according to weather, load and generation forecasts computes the 15 minutes profile of the controllable resources (generation, load and storage). The problem is solved through an optimization process. b) Short Term strategy for which the unavoidable forecast errors are compensated implementing a control algorithm that operates on a 15 minutes horizon. This procedure is hierarchically designed and dispatches the resources/loads according to priority signals.

State-of-the-Art

By the term Smart Grid, the Smart Grids Technology Platform (www.smartgrids.eu), operating at European level, defines an "*electrical network able to intelligently integrate the actions of all the connected users – which can be represented by generators, consumers, or organizations playing both roles – in order to effectively distribute electricity in a sustainable, affordable and safe way*".

In the last few years, particularly following the market liberalizations, the actors in the electrical system scenario (specifically in distribution systems) have increased in numbers, and now include renewable generation hardly dispatchable, conventional small- and medium-sized generation, end users potentially able to participate in the market, and distributed storage systems able to integrate with the other network resources.

In order to optimize the interactions among the above mentioned entities, the supervisory systems of the distribution networks operating in presence of dispersed generation tend to incorporate optimization functions for the dispatch of available energy resources and for their coordination

with control and storage systems.

The development of the electric system, due to the strong increase of the distributed and Renewable Energy Sources (RES), is thus posing new challenges to the management and control of the power system. This new scenario in low voltage distribution networks implies control and operation issues that can be seen as opportunities to enhance new control strategies and network management operation. The resulting Microgrids composed by distributed generation, storage devices and loads could thus provide control functions and ancillary services.

The deployment of Low Voltage and Medium Voltage distribution networks, capable of operating flexibly and even autonomously in load island is one of the aspects that mostly characterize smart grid projects. In such a context, modern **Distribution Management Systems**, characterized by innovative automation, telecommunication and control architectures , allow the implementation of optimized operating strategies able to continuously adapt to the conditions of load demand and production from a renewable source.

Concerning Renewable Energy Sources (RES), one of the major issues is related to their production profiles, hardly predictable and manageable, that could cause overloading or overvoltage. The implementation of control strategies together with the presence of storage systems could help to mitigate these drawbacks, allowing the full exploitation of RES. All these strategies are meaningful while the system is in parallel with the main grid, yet the controllable devices in the Microgrid and in Active Distribution Networks can be a precious resource in keeping the system running also in islanded condition providing the regulation power needed to keep stable the voltage and the frequency without stopping up the RES generation.

References

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Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental Scientific and Technical value and interest

In the recent past the distribution networks experienced several radical changes due to the well-known liberalization share of the energy market and the more and more significant penetration of the distributed generation, in particular from renewable resources. In order to provide an efficient, secure and economical management of the distribution systems the Distribution System

Operators (DSO) need advanced application functions to improve the current capabilities of DER management.

New algorithms need to be implemented in the distribution environment to properly benefit of active networks. The presence of a new kind of customers, which can both consume and produce energy, creates the opportunity to significantly modify the power and energy profiles. This fact allows to follow desired consumption curves in order to take advantage of the best tariffs, to avoid excessive stress of the electrical infrastructure and to better monitor and control the energy usage and consumption.

In order to fully exploit these possibilities a control architecture and a communication infrastructure are of fundamental importance. A key feature is the modularity of these systems which should be distributed in the field and act in a coordinated way.

The objective of the work is to test and validate some controls and algorithms developed by the Proposing Team in a real environment dealing also with communication aspects (IEC61850, OPC).

Objectives

The proposed project will have the following objectives:

1. Validate models for DER systems and relative controllers
2. Implement and test medium term control strategies (day ahead)
3. Implement and test short term control strategies (intra day)
4. Implement and test combined operation of medium term and short term control strategies including also load management.

In Fig. 1 the single line diagram of the Strathclyde test facility is depicted in the desired configuration. The devices of interest for the proposed activity are schematically represented in Fig. 1.

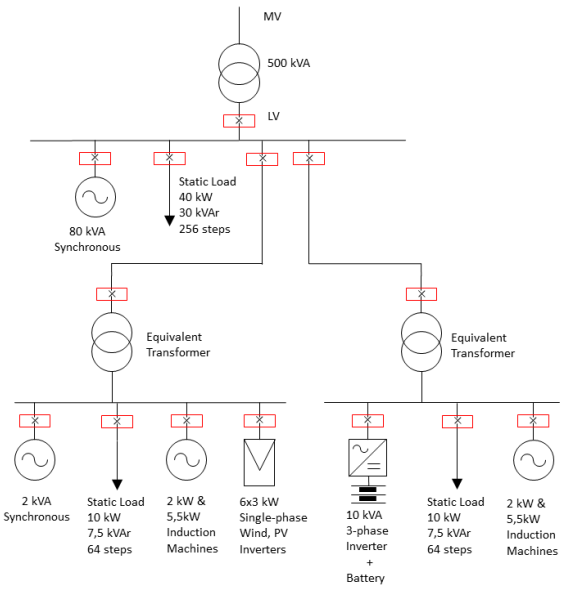

Fig. 1. Single line diagram of the Strathclyde test facility

The whole activity will be developed in DigSilent Powerfactory and interfaced to Matlab with OPC connection. The proposed mid-term and short-term control strategies, aimed to optimize the

network operation under the technical and economical point of view, will be validated in the real environment constituted by the test facility in order to gather measures and assess the actual functionality.

The proposed control strategies are.

1. **Mid Term (day-ahead)**

   A day-ahead optimization process is used to equip any controllable resource, both generators and loads, with a 15 minutes profile. The process is based on generation, load and weather forecasts which can be also simulated on the basis of available real data because they are not the main topic of the activity.

2. **Short Term (intra-day)**

   To correct the errors committed by the day-ahead forecast, which can be reduced but not avoided, an intra-day scheduler is implemented. This scheduler operates with a 15 minutes horizon and is designed on a hierarchy architecture, which induces it to dispatch the available resources/loads according to priority signals. The process needs to be constrained in order to avoid excessive changes compared to the set points provided by the day-ahead scheduler. In the context of the liberalized market, the flexibility, that the loads management gives to the system operator, assumes a great value necessary to preserve the grid from overload problems.

The two controls may be tested both independently and together as well as in different network configurations.

Expected Outcome and Value

The expected outcome is the validation of the model for the analysis of short and long term RES dynamics. Moreover the demonstration, on a laboratory scale, of the coupling between generation and loads will be measured and documented in detail. Indications are expected to be reached on the ability of an active management to effectively control microgrids.

The results and conclusions will be reported and also disseminated in the scientific community and in relevant publications.

Originality and Innovation of proposed research – Broader Impact

The proposed project addressed the issues related to DER management and active prosumers.

These experimentations also aim to verify the most critical automation strategies before implementing them in a real contest constituted by electrical distribution networks.

The proposed models are likely to become simulation instruments used to support the electric utilities in the forecasting of their grid behaviors in case of a significant DG penetration in order to promote the integration of renewable resources.

Proposed Host TA Infrastructure/Installation – Justification

As described above, the proposed project requires a micro-grid installation which includes renewable energy sources, controllable loads and local generators. The proposed host TA is USTRAT in Glasgow (UK), for the following reasons:

- presence of 2 microgrids and loads;
- the SCADA system is expected to provide all the relevant information necessary for model tuning and to make available a good architecture (Ethernet based) to test new controllers;
- the infrastructure staff has extensive experience in design, development and operation of VPP (Virtual Power Plant) controllers.

No significant additional costs would be expected, as the measuring requirements are not too much stringent and a complete SCADA system is present.

Synergy with ongoing research

A National project on smart grid (Smartgen), started on January 2011, focused on the definition of a DMS (Distribution Management System) architecture for the inclusion of renewable energy sources. Other research activities with national DSO, ICT companies and national and international research centers.

Dissemination – Exploitation of results

The results of the tests performed in TA will be disseminated in national and international appropriate peer-reviewed journals and conferences.

Time schedule

The activities are planned to be done in 4 weeks. The possible time frame can be realized within one continued month (e.g. full October) or preferably two separated weeks (e.g. second half of October and second half of November), considering the host TA availability.

1st 2-weeks round

Day	Progressive Day	Activity
Sunday	1	Arrival in Glasgow
Mon-Wed	2÷4	Setup of the infrastructure
Thu-Fri	5÷6	Mid-term (day-ahead) control
Sat-Sun	7÷8 (weekend)	
Mon-Tue	9÷10	Mid-term (day-ahead) control (continued)
Wed-Fri	11÷13	Short-term (intra-day) control
Sat	14	Departure from Glasgow

2nd 2-weeks round

Day	Progressive Day	Activity
Sunday	1	Arrival in Glasgow
Monday	2	Setup of the infrastructure
Tue-Fri	3÷6	Coupled system controller testing
Sat-Sun	7÷8 (weekend)	
Mon-Fri	9÷13	Coupled system controller testing
Sat	14	Departure from Glasgow

Description of the proposing team (as long as needed)

The **IEES** - **Intelligent Electric Energy Systems Laboratory** operates within **DITEN** (Department of Electrical, Electronics and Telecommunication Engineering and Naval Architecture). in the University of Genova. IEES is contributing in the following scientific and industrial sectors: Management and optimization of the electric system and of the energy and ancillary services markets. Power system monitoring and preventive-corrective Control. Analysis, modelling and simulation of power system components and controls. Decision support

systems and artificial intelligence (AI) applications to the planning and control of large power systems and industrial systems. Advanced technologies and methodologies for power systems protection. Electric distribution systems with distributed generation (DG). Innovative technologies for electric power microgeneration. Real time load monitoring and management for consumption rationalization and energy saving. Systemistic and design aspects of lighting engineering and domotics. The testing methodologies make use of integrated traditional simulation procedures and informatics techniques derived from AI, such as expert systems and neural networks.

The research group has well-established links with the industrial and scientific world with which it co-operates tightly in the definition and development of its own activities. Moreover **IEES** is represented in national and international normative and research coordinating Bodies in the sector. The **IEES** Lab is strongly involved into the industrial world through several and significant research contracts with sector industries and EU Frameworks.

The IEES Lab is equipped with software tools for the analysis of large power systems and of industrial electric systems through advanced calculation tools in the context of decision support systems and neural networks development (Gensym G2), of static and dynamic network studies, such as load flow, stability, short circuits, harmonics, protections coordination, electromagnetic transients and control systems analysis (DigSILENT, PSCAD/EMTDC, ATP, MATLAB). The Lab has carried out studies related to small and medium size, and renewable, Distributed Generation and their relevant validations on test grids of EU project co-partners.

The Lab has activated a real time Monitoring and Intelligent Control system of the electric consumptions of the Genova University (annual estimable consumption about 23 GWh); this system consists of 19 measurement points at MV electric energy meters and in the automatic collection of the consumptions every 15 minutes. These consumptions are transmitted to a centralized server, they are analysed and assembled into load curves aimed to operate evaluations for energy saving and for loads optimal management.

Francesco Adinolfi was born in Genova, Italy, in 1988. He received the Master degree in electrical engineering in 2012 from the University of Genova where he is currently pursuing the PhD degree in electrical engineering. His research interests regard load management and the integration of storage, DG and RES in smartgrids.

Francesco Baccino was born in Genova, Italy, in 1986. He received the Master degree in electrical engineering in 2010 and is currently on his third year of the PhD degree in electrical engineering, at the University of Genova. His research interests regard smartgrids, focusing on the optimal integration of RES, DG, storage and PEV.

Stefano Massucco received the Doctor degree in electrical engineering at the University of Genoa, Italy, in 1979. From 1979 to 1987, he had been working at the Electrical Engineering Department of Genoa University, at CREL - the Electrical Research Center of ENEL (Italian Electricity Board) in Milano, Italy, and at ANSALDO S.p.A. in Genoa, Italy. He has been Associate Professor of Power Systems at the University of Pavia and since 1993 at the Department of Electrical, Electronics and Telecommunication Engineering and Naval Architecture (DITEN), University of Genoa, as Full Professor since 2000. His research interests are in power systems and distributed generation and smartgrids modelling, control, and management. Member of CIGRE Working Group 601 of Study Committee C4 for “Review of on-line Dynamic Security Assessment Tools and Techniques”.

Andrea Morini was born in Milano in 1964. He obtained his Laurea Degree in Electrical Engineering cum laude in 1990 and his PhD in Electrical Engineering – Electric Power System in 1994. From 1994 to 1999 he had been with Gensym Corporation working on Artificial Intelligence applications to Industrial Processes. Since 1999 he has been Assistant Professor at the Electrical Engineering Dept. University of Genova. He is Regional Responsible for AIDI – Italian Association for Lighting. Scientific Responsible for National Projects, Member AEIT, IEEE – PES.

Matteo Saviozzi was born in Savona, Italy, in 1987. He received the Master degree in Mathematics in 2012 from the University of Genova where he is currently pursuing the PhD degree in electrical engineering. His research interests regard optimization algorithms, forecasting of RES and load management.

Federico Silvestro received the degree in electrical engineering from the University of Genoa in 1998 and a Ph.D. in electric power systems in 2002, with a dissertation on artificial intelligence applications to power system management and control. He is now Assistant Professor at the Department of Electrical, Electronics and Telecommunication Engineering and Naval Architecture (DITEN), University of Genoa, where he is working in distributed generation and smartgrids, dynamic security assessment, knowledge based systems applied to power systems, load management and control.