

## Study Committee C6

### SPECIAL REPORT (Distribution Systems and Dispersed Generation)

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#### Special Reporters

#### Introduction

The scope of SC C6 is *to assess the technical impacts and requirements which a more widespread adoption of distributed/dispersed generation could impose on the structure and operation of transmission and distribution systems*". Rural electrification, demand side management methodologies, including management of the DG and application of storage are within the scope of this SC.

The SC decided to propose for discussion in the CIGRE 2014 General Session three preferential subjects dealing with:

- PS1. Planning of distribution networks with high penetration of DER and new loads
- PS2. Operation and control of active distribution networks
- PS3. New roles and services of distribution systems for transmission system operation

29 papers were selected for discussion in the General Session. The main issues raised in the reports are summarised hereunder, together with some questions to solicit a lively and profitable discussion.

#### **1. Preferential Subject 1 (Planning of distribution networks with high penetration of DER and new loads)**

The theme for Preferential Subject 1 is "Planning of distribution networks with high penetration of DER and new loads".

The areas dealt with are:

- Strategic planning for making distributed generation part of the TSO protection schemes
- Integration of micro generation and storage
- Experiences with demand elasticity trials and smart meter solutions
- Distribution planning with distributed energy resources

#### **The papers submitted**

Preferential Subject 1 includes 9 papers addressing various aspects of the planning and operation of active distribution networks. Authors were drawn from 12 countries reflecting the wide and international interest in the topic. The papers were regrouped under 3 subtopics.

The following aspects will be addressed:

- Subtopic 1 – Planning (Papers C6-104, C6-105 and C6-106)
- Subtopic 2 – Load and generation models (Papers C6-102, C6-103)
- Subtopic 3 – Operation of distribution systems (Papers C6-101, C6-107, C6-108 and C6-110)

***Subtopic 1 – Planning (Papers C6-104, C6-105 and C6-106)***

Papers belonging to Subtopic 1 explicitly deal with planning and highlight at what extent the distributed generation (Papers C6-104 and C6-106) can influence the development of power systems in countries that are extremely diverse for level of development, availability of natural resources and power system structure. In both cases, DG shows interesting potentialities for improving the continuity of service (TSO point of view) and the energy efficiency (DSO point of view). Paper C6-105 illustrates the impact of Micro Grids on distribution expansion plans and proposes an interesting optimization algorithm that does not consider the opportunities from Smart Grid.

**Paper C6-104** (Egypt, academia) deals with the optimal siting and sizing of Distributed Energy Resources (DER) in Egypt. The authors highlighted that with a proper integration of DER some benefits are to be expected in power systems, and investigated the impact on power losses and voltage profile. Preliminarily they proposed a simple optimization algorithm that can find an optimal position of one, two and three DER. Load flow studies were performed on bus bar by considering the combination of two or three generators and by pruning all combinations that were considered non acceptable from reactive power point of view. The main result is that with a rated DER generation equal to 25% of the slack bus capacity, energy losses can be significantly reduced with a small voltage improvement. The results of the study are in good agreement with those from the booming Literature in field, but further investigations might be necessary if renewable energy resources are used. Furthermore, the impact on voltage and power losses might be completely different with probabilistic models of DER and loads, and with a proper model of smart grid control.

**Paper C6-105** (Finland, academia) deals with the optimal expansion planning of medium voltage networks. The authors developed a heuristic algorithm that takes into due account the load growth and a more general model of prosumers. The most significant contribution given by the authors in the field of distribution planning is the integration of the Geographic-Dynamic Modeller of the Operational Environment (GDMOE) with a Network Topology Optimiser (NTO). In the proposed paper the expansion plan of a distribution network with and without the exploitation of Micro Grids is studied. The planning alternatives examined also show the impact of specific load growth and innovative fault location, isolation and service restoration systems. All planning calculations are based on worst-case scenarios (i.e., maximum demand/minimum generation and minimum demand/maximum generation) for the design of lines and conductors. In order to assess the reliability for the nodes supplied by micro grids, the probability to have enough generation for load supply is calculated. The planning procedure proposed by the authors is interesting and the inclusion of micro grids in network planning follows the path traced in few papers giving new impetus to this area. Anyway, the planning algorithm can lead to expensive solutions due to the deterministic fit and forget criterion and due to the fact that operation is not considered as a valuable option in planning studies.

**Paper 106** (Russia, Utility) deals with the contribution that the increasing DG integration can

give to the reliability enhancement in the Russian power systems. The paper offers the TSO point of view that requires DG does not cause reliability issues and do cooperate to solve typical TSO operational problems. In this context, Russian DG, essentially based on gas reciprocating engines or gas turbine generators, may be useful to avoid load shedding and even exclude this remedial action in the set of the admissible system protection actions. In order to achieve these goals, the authors proved that would be reasonable to provide DG with communication systems for fast starting and loading in order to increase the production of reactive power and, if admissible, to move towards synchronous regime. Finally, the authors specify the requirements for new DG so that it might be an active player of modern Smart Grid.

**Question 1.1** – DSO and TSO may have different goals and objectives. The definition of requirements for new DG connection is sometimes affected by this situation as well as the definition of DG duties (i.e., voltage and frequency regulation, reserve, etc.). How can such issues be successfully faced in the unbundled and liberalised power system?

**Question 1.2** – Modern distribution networks will rely upon enhanced operation. Traditional planning was not considering operation opportunities, because operation systems were not available. Is still reasonable a distribution planning process that follows the traditional path, and tries to solve operation issues at the planning stage? Is this more expensive and enough reliable with RES installed? Can the risk related to innovative planning algorithms that include operation in planning be assessed in advance?

**Question 1.3** – Distributed Generation in many countries is mostly based on Renewable Energy Sources and it is completely out of DSO control. Is it still reasonable the use of simple, single value, representation of generation and loads in planning studies? Are probabilistic, time related generation and consumption models necessary? Which is the relationship between the planning horizon and the proper time granularity for load and generation representation?

**Question 1.4** – Is the reduction of energy losses still an issue with high shares of renewable energy sources installed? Will the Smart Grid reduce losses or not?

**Question 1.5** – The communication infrastructure is essential for Smart Grid. Smart Grid features can be enhanced with the integration of multi-energy networks and storage (e.g., natural gas, heating networks, compressed air, electric vehicles, etc.). Nowadays all those systems are planned independently. Are there any examples of integrated planning? Is integrated planning important for smart cities? How can it be realised in the current fully liberalised framework?

### ***Subtopic 2 – Load and generation models (Papers C6-102, and C6-103)***

Two interesting papers belonging to Subtopic 2 deal with models for both load and DG. Paper C6-102 addresses the problem of load demand on large-scale areas in order to identify how and at what extent active demand can influence planning strategies. Paper C6-103 proposes a framework for modelling DG by taking into due account the time granularity and the detail level that are necessary for different analysis. Particularly relevant for planning applications are the models that allow the proper consideration of operation in planning studies as proposed by CIGRE WG C6.19.

**Paper C6-102** (Austria, research institution) is based on the G[e]oGreen SmartGrids ERA-NET models for describing the potentialities of demand integration. The central model of

G[e]oGreen is the Cell Structure that contains all main elements of the structure and the relations. Cells contain at least one infrastructure element (static entity), a flexible entity, and a cell manager performing local optimization. A cell in the paper coincides with a political district in Austria. Flexible and static entities represent either suppliers or consumers of electricity. A flexible entity can either be flexible in time, space or both. Electric vehicles can be considered to be flexible in the consumption of electricity in time as well as in space, if controlled charging is considered. Energy from RES, like PV Systems or wind turbines are, due to their stochastic nature, considered to be static. Flexible entities can be smart grid enabled automated functional buildings or data centres (time flexible), or electric vehicles (time and space flexible). The paper performs a high level study useful for strategic planning in Austria; since no optimization procedures have been proposed so far, the paper shows the expected demand with uncontrolled EV charge and RES installed. The simulation shows that 68% of vehicles should arrive at destination with 80% SOC, which makes EV very promising for demand side integration. Anyway, there are hours of day where RES generation can feed EV, but there are also some peaks in the morning and early evening with not enough generation for the very coincident EV demand.

**Paper C6-103** (Austria, research institution) is based on the findings and the models of the European DERri project that developed a standardised modelling scheme and exchanging format for DER modelling. The Common Reference Model (CRM) proposed by the authors for Distributed Energy resources (DER) aims at improving the portability and exchangeability of DER models for different simulation experiments, particularly in the field of real-time and Hardware In the Loop (HIL) studies. A clear categorization of models for *fast transient*, *slow dynamic*, and *quasi-dynamic* simulations as well as the time granularity necessary for each of them is clearly explained. Generally speaking, the smaller the time constant the bigger is the level of details required by CRM. The main goal in definition of CRMs was to obtain dynamic models of DERs that are open and independent from the software environment that will be used to perform simulations. A test case is proposed with an interesting comparison of two popular software packages for the fast transient simulation of grid connected PV that shows a significant difference in the transient behaviour after a voltage dip. The use of CRM with the same input data does not always guarantee the identity of results in different simulation environments because of the solver algorithms adopted. Even in this case, the use of CRM is useful to understand that differences in simulations are for sure caused by different software packages and not by different DER models.

**Question 1.6** – Will active demand play a role in distribution planning? Can the distribution system evolution be planned without considering the services that active demand might offer?

**Question 1.7** – Are there any good models for modelling EV fast charging station daily load profile?

**Question 1.8** – Can traffic and urban planning models be integrated with power distribution planning for the proper modelling of EV load behaviour and for the optimal position and siting of fast recharging stations?

**Question 1.9** – Which is the level reached by standardization of models for DER representation? And which is for active demand functions? And for distributed management systems?

### ***Subtopic 3 – Operation of distribution systems (Papers 101, 107, 108, and 110)***

The papers belonging to Subtopic 3 are focused on the operation of innovative distribution systems. Paper C6-101 shows the results of experimental studies in a dedicated facility that can simulate a Micro Grid. Paper C6-107 faces the problem of reaching LV customers and controlling LV networks with a system, tested in the field, that does not consume all available communication bandwidth. Paper C6-108 demonstrates the suppression of voltage fluctuations with an optimised coordination of Combined Heat and Power and Battery Energy Systems. Finally, interesting Paper C6-110 gives a clear overview of voltage regulation in LV networks and shows the impact of reactive power. All these papers, mainly focused on operation, offer to researchers models and information that can be included in advanced planning studies.

**Paper C6-101** (Canada, utility) deals with real-time studies of Micro Grid operative states and transitions. Researches had been carried out with the distribution test line installed at the Hydro-Quebec research centre (IREQ), a full size representative distribution feeder for testing different types of distributed energy resources, and control and measurement equipment. Islanded, transition to islanded, and transition to grid-connected operation have been investigated. Islanded mode of operation was studied with a droop power sharing control and with an isochronous generator. The authors proved that a Micro Grid can smoothly operate in all modes by maintaining both voltage and frequency. Energy Storage System (ESS) can operate as an isochronous generator with a four-quadrant power electronic interface as the authors experimentally proved. As a consequence, ESS is a viable alternative to synchronous generators for voltage and frequency regulation. The paper confirms with experimental results the simulation studies published in many papers dealing with the islanded operation of Micro Grids and the transient from/to grid-connected states. The worth of the experimental facility is clearly evident, since it allows researchers to investigate or to confirm simulation studies on real utility-scale equipment.

**Paper 107** (Spain, Utility) deals with the implementation of techniques to operate Low Voltage (LV) networks following the Smart Grid concepts. Correctly, the authors observed that the information available for LV management are often poor and limited to know which meter is connected to a certain Secondary Substation. The information about the feeder to which a meter is connected to is seldom available with enough accuracy. Since Automatic Metering Infrastructures based on Power Line Communication (PLC) are going to be widely deployed through Europe, the paper proposes a methodology to allow feeder identification by using the typical messages sent by meters to demonstrate they are alive and functioning. The system has been tested on the field (three MV/LV transformers, 13 feeders, 688 smart meters). The combination of direct and indirect detection allows identifying 100 % of smart meters in the correct feeder and phases. With the proposed technique, it was observed that four meters were erroneously assigned to the wrong feeder, confirming that distribution companies know LV with significant inaccuracies often caused by the difficulty to keep databases updated. PLC provided grid topology information (smart meter connectivity to transformer, feeder and phase) just with the information that is naturally generated during the regular operation of meters (control packets). LV grid topology information gathering based only on information naturally generated by the PLC systems ensures an efficient use of the available bandwidth, and the projection of the Smart Metering infrastructure into the Smart Grid applications.

**Paper 108** (Japan, industry) deals with application of Battery Energy Storage (BES) to help Combined Heat and Power (CHP) reduce the voltage fluctuations caused by Photo Voltaic

(PV) generation. Indeed, Japan committed itself to 25 % of CO<sub>2</sub> emission by 2020 and the resort to nuclear power is no longer considered a viable option after the 2011 Tohoku earthquake and tsunami. For these reasons, demand response is going to be exploited with energy management systems implemented in buildings and dwellings; CHP has been promoted and incentivised with the goal to reach 15% of power generation; PV is growing very fast thanks to very convenient feed-in tariffs. The Smart Energy Network (SEN) project aims at smoothing PV output fluctuation with the control of CHP, hence accelerating PV implementation to the power grid with an optimal integration of both energy resources. In the paper the authors, with the aid of 100 case simulator tests carried out with the Smart Grid Simulator – an analogue simulator which models actual components in 1/1000 scale capacity – proved the feasibility of PV fluctuation suppression by remotely controlled and distributed CHP. The authors conclude that it is possible to regulate 6.7 times the adjustment capacity of PV with a combination of CHP and BES, or with BES alone. The combination of CHP and BES reduces the BES capacity necessary to dispatch low frequency component with CHP, and high frequency component with BES.

**Paper 110** (Slovenia, academia) deals with extremely relevant issue of voltage regulation in LV networks with high shares of Photo Voltaic (PV) generation. The authors of the paper are involved in the Meta PV FP7 EU project that aims at demonstrating that PV can actively contribute to system operation, with a transition from *'fit and forget'* approach to the *'fit and rely upon'*. The paper gives a significant contribution based on both simulations and experimental studies, which are very seldom performed at LV level where it is expensive for network operator to measure consumption of individual loads and to track costumers and PV-sources phase connection. First measurement results suggest that voltage control by means of reactive power from PV sources is a viable mean for controlling voltages and preventing the voltage to exceed the maximum defined limits. However, the available data does not allow yet to compare different control strategies and to choose the most suitable one. Moreover, the results indicate that in some points along the grid the number of PV sources having voltage control capabilities is not high enough to prevent overvoltage. The authors conclude that further investigations are necessary to analyse the reactive power flows that might be necessary for voltage regulation and can significantly affect the energy efficiency of power delivery as well as reduce the network power factor. Finally, the authors propose an interesting application of On Load Tap Changer (OLTC) in MV/LV transformers in order to improve voltage regulation with a centralised voltage regulation system that can reduce the need for reactive power from PV generators.

**Question 1.10** – Is hardware in the loop simulation a good way to validate models, particularly dynamic models, and programs, which can give completely different results even though the input data are the same as proved by the authors of paper C6-103? Are full real scale data essential for developing good models and produce reliable results? Or do we have to improve the electrical consciousness of young engineers to guide simulation software in the right direction?

**Question 1.11** – Can power line communication really work in lines with high shares of photovoltaic generation? Some preliminary Italian studies highlighted the impact of harmonic pollution on the capability to communicate with automatic meters.

**Question 1.12** – How to choose the best communication system for Smart Grids and how to involve Communication Companies in the Smart Grid process outside big cities?

**Question 1.13** – Are ZEBRA batteries a good solution for voltage fluctuation suppression if coupled with CHP plants?

**Question 1.14** – Is Volt/VAR regulation effective in urban LV networks with high shares of underground cables? Are load shifting and load shaping – eventually coupled with storage - more effective or in any case necessary?

**Question 1.15** –Which type of control for voltage regulation is better suited for LV systems (decentralised or centralised)? How can LV regulation systems be integrated with MV controls?

## **2. Preferential Subject 2. (Operation and control of active distribution networks)**

The theme for Preferential Subject 2 is “Operation and Control of active distribution networks”.

The areas dealt with are:

- Voltage estimation and supervision using AMIs
- Novel methods for operation and control of distribution networks with high share of Dispersed Generation (DG)
- Energy storage and Electric Vehicles (EV)
- System interconnection requirements/standards for DG
- Wireless communication for protection

### **The papers submitted**

There are 18 papers submitted in preferential subject 2. In view of a wide variety of topics, the papers were grouped into three subtopics.

#### ***2.1 Sub Topic 1 – Novel methods for operation and control of distribution networks***

Many papers submitted aim to develop novel methods for operation and control of active distribution networks. Some of them feature the large projects utilizing a number of AMIs. The others aim to estimate and control the voltage profile in active distribution networks.

**Paper C6-202** (Australia, University and Utility) describes the evaluation results of voltage control methods on a real-world distribution network with a probabilistic type of PV model based on the actual PV measurement data. The evaluation of voltage control methods was performed on different case scenarios which were the combination of tap changer of power distribution transformers and low-voltage supply transformers, STATCOM and batteries.

It is shown that the tap changers had significant effect on voltage control. STATCOM had good effect even with small amount of capacity and even PV inverters might have the same level of performance. Batteries were also effective, however, the large effect might not be expected with batteries only.

**Paper C6-204** (China, Research Institute, Utility and University) describes the Cluster Control Strategy, which controls generation schedule of micro gas turbine (MGT) according to PV output curve and the charging and discharging pattern of a storage system for short and rapid adjustment. The effect of this cluster control strategy is confirmed by the simulation for four scenarios which consist of the combination of MGT control and storage control. The cluster control strategy is defined as the combination of MGT output schedule according to the output of PV system and the storage system to smooth the output of PV system. The

cluster control strategy is revealed to be able to respond to the randomness of PV output and resolve the voltage fluctuation problem and improve the power quality.

**Paper C6-206** (Germany, Portugal, industry) introduces ‘RiesLing’ in Germany and ‘InovGrid’ in Portugal and compares the results of these projects. The project ‘RiesLing’ deals with the development of different solutions for the stepwise automation of secondary substations and advanced grid operation functionalities. The objective of the project ‘InovGrid’ is to seek the answer to several challenges, including: the need for increased energy efficiency; reduced costs and increased operational efficiency; the integration of a large share of dispersed generation; the integration of electric vehicles and the desire to empower customers and support the development of new energy services.

**Paper C6-207** (Spain, utility) introduces the PRICE GEN project, a demonstration project in the Henares region around Madrid. The objectives of the project are to implement an advanced distribution automation system, active remote metering, and active energy management functionalities, in order to improve distribution system reliability and minimize energy losses. An important aspect of the project is the analysis and tracking of technical and non technical losses in the low voltage network. In order to carry out this activity, a state estimator algorithm has been designed to calculate the most probable status of the whole network, based on a few real measurements.

**Paper C6-208** (Spain, Belgium, Sweden, utility) introduces an Active System Management (ASM), which is a key tool for efficient and secure integration of a high share of distributed energy resources, distributed generation, flexible loads, electric vehicles and storage. In this concept, three steps towards the integration of active distribution system are considered. The first step is passive (Current situation), the second step is re-active, and the third step is active. In the third step, a close coordination between TSOs and DSOs is required.

**Paper C6-211** (UK, utility) introduces the Flexible Plug and Play project. The concept of the project is to connect distributed power generations to the constrained parts of the power distribution system cheaply and speedy in UK. The purpose is to construct a platform for connecting and cutting off freely distributed power generations. The IEC61850 is used as the communication protocol in order to maximize capacity for distributed power generation within thermal and voltage limits. As smart devices, the Quadrature-booster and Quadrature-booster Controller System are used to manage loop power flow, and the dynamic Line Rating technology is utilized to calculate the real time thermal rating of power lines. The method of calculating suitable cost is introduced considering cost of curtailment and cost of reinforcement.

**Paper C6-213** (United Kingdom, consulting firm and academia) describes the effectiveness of Power Flow Management (PFM) algorithm to alleviate branch overloads by actively controlling the generators' output. Several PFM algorithms, including those based on constraint satisfaction, optimal power flow, power flow sensitivity factors, and linear programming, are evaluated on the actual network model. It is found that no algorithm can always minimize the number of overloads while minimizing the amount of curtailment applied to the generators within the network. It is demonstrated that selecting and using the algorithm that is most effective at removing overloads and minimizing curtailment for each network state has a performance benefit than using the same algorithm for every state.



**Paper C6-215** (USA, Sweden, Canada, utility, academia, and industry) describes the IEEE project P1854. The purpose of the project is to give guidance to utilities and network operators in the use of new technology in electric power distribution. The application areas of new technology are: improving the reliability of supply, improving the power quality, improving the efficiency of distribution system operation, increasing hosting capacity for new production or for new consumption, and market functioning and participation.

**Paper C6-216** (Japan, Utility) introduces the general outline of distribution automation system of the Kansai Electric Power Company and their demonstration project. This project evaluates the voltage supervision and control methods by applying to the actual power distribution line with 500kW PV system. From the simulation results, it is found that the combination of Step Voltage Regulator (SVR) and Static Var Compensator (SVC) can reduce the voltage fluctuation caused by PV output dramatically. The actual values/parameters of power distribution network are measured and the effectiveness of the combination of SVR, SVC and Thyristor type step Voltage Regulator is evaluated.

**Paper C6-217** (Greece, University and Utility) describes the IGREENGrid project, which aims at increasing the hosting capacity of Distributed Renewable Energy Sources (DRES) in power distribution grids without compromising the reliability. In the Greek demo site, advanced functions, such as Congestion and Overvoltage Management, RES Hosting Capacity Estimation and Management, Power Quality Monitoring, etc., are under development. This is the first attempt to utilize the AMR data for the support of the power system operation and planning.

**Question 2.1-** In C6-207, a state estimator algorithm was developed and successfully implemented in a demonstration project in Spain. Is there any other example of the state estimation especially in the Low Voltage distribution system, which usually are not furnished with a number of measurement and control devices? How do you ensure the reliability of information?

**Question 2.2** - What kind of data collection method is used for automatic meter readings? What is the communication bandwidth and how long is the data collection interval?

**Question 2.3** - The voltage regulation issues are the major concerns for a power distribution network with a large penetration of renewable energy sources, such as PV system whose power output fluctuates depending on the weather conditions. What is the voltage regulation used for the distribution network operation in your country? Based on this regulation, what are the problems you are facing under current condition of renewable energy penetration level, and how difficult is it to solve such problems?

**Question 2.4-** The intermittent nature of renewable energy sources brings significant effect on power distribution networks. The prediction technology for the intermittency of renewable energy sources can enhance the performance of the distribution network operation. Do you have any projects to increase the accuracy of the prediction methods for the power output of renewable energy sources? How do you use such prediction methods in the distribution network operation?

**Question 2.5-** The curtailment of power generation, voltage and reactive power control are used as the countermeasures to manage the power distribution network with a large penetration of renewable energy sources. Are there any other countermeasures you have ever

evaluated such as reconfiguration of the distribution network sections with sectionalizing switches or so on?

## **2.2 Sub Topic 2 - Energy Storage and electric vehicles**

There is a wide interest all over the world in applying Low Carbon Technology (LTC) such as integration of renewable energy sources (RES) and electric vehicles (EV) to the distribution networks. The increasing share of LCT may lead to some challenges like how to manage a rapid change in loads and how to sustain the power quality. In these papers, the emphasis is to increase LTC applications to distribution networks, while keeping the voltage within limits.

**Paper C6-201** (Argentina, academia) proposes a methodology to solve the short-term economic dispatch (ED) problem of a smart distribution grid (SDG). The advantages of ED are evaluated with regard to the following items, Case1) Plug-in electric vehicles (PEVs) can only charge their batteries without control by aggregators and there are no PVs, Case2) The same as Case 1 plus considering PVs, Case3) PEVs can charge and supply energy, and the SDG integrates PVs and aggregators. As a result, Case3 considering peak demand has advantages in ED, and it is also shown that the development of charge-discharge system for PEVs based on energy price parameter is effective.

**Paper C6-205** (Germany, industry) describes the lighthouse project "Well2Wheel(W2W)" which is located in the supply area of the energy supply company (ESCO), HSE, Darmstadt in Germany. The project is based on the existing ICT infrastructure and the virtual power plant (VPP) established within the "Web2Energy" project. The main targets of the W2W consist of gaining experiences regarding the establishment and operation of advanced electric vehicle management (EVM) systems in practice and of investigating the user (drivers) responses on recommendations regarding the dispersion of charging periods. The first hand results of the W2W project demonstrate that the integration of the EVs in the distribution network and the consumption of regional renewable energy beyond the border of energy supply are possible.

**Paper C6-209** (Italy, utility) describes the possible uses of Energy Storage System (ESS) on MV and LV distribution networks in Italy. The large increase of Distributed Generation (DG) connected to the Italian distribution network is rapidly changing the load profile curve and dropping the power quality. The ESS is expected to improve the power or voltage quality management and to provide new system services, supporting DSO to improve voltage quality. In 2014, ENEL Distribuzione is carrying out pilot installations of ESS at primary substations in order to assess the ESS contribution to increase the network utilization factor by means of various functionalities such as peak shaving/time shifting, power balancing, power quality, voltage regulations, etc. The initial results from the field tests of the ESS connected to LV lines are shown to be quite encouraging in reducing the number voltage violations.

**Paper C6-210** (Italy, utility) describes a distribution smart-grid demonstration project in Forli-Cesena, Italy. The project involves two primary substations, more than 100 MV/LV substations and at least five MV distributed generation facilities. The main objective is the realization of an advanced control system allowing to increase the Medium Voltage network hosting capacity of Renewable Energy Sources, thus maximizing RES integration. This paper focuses on the control algorithm mathematical models and logics and the validation of the control system.

**Paper C6-212** (United Kingdom, academia) presents a framework for probabilistic LV network analysis that has been developed as a planning tool to address the challenges of

increased Low Carbon Technology (LCT) load penetration on LV networks. A case study of a real UK network with 50% EV penetration is presented to demonstrate the application of the framework. Results indicate that potential for network limit violations is concentrated during traditional peak hours.

**Paper C6-218** (Korea, industry) describes a demonstration project about the applications of Battery Energy Storage System (BESS) for energy time-shift at industrial building in Yongin-Si, Korea. In this project, 1MW/1MWh BESS has been developed based on Lithium Ion Battery technologies, and has been commissioned in 2012. The first demonstration results of BESS for electric energy time-shift application have been successfully completed. The effective operational strategies of BESS with the help of Energy Management System (EMS) can enhance the customer's peak load management and the electricity rate savings effect.

**Question 2.6-** Paper C6-218 describes the demonstration results of long term saving cost of BESS, which is used for time shift of electric energy. It seems that it is difficult to obtain the return of investment considering the current cost of BESS. What are its basic causes and what are their possible solutions (legislative & technical) to allow for this approach to become more effective?

**Question 2.7-** A large number of EVs are expected to spread rapidly worldwide. What are the most viable algorithms for EV charging/discharging in order to keep distribution network within its operational limits?

**Question 2.8-** What are ideal forms of business model to maintain a stable distribution network when a large number of EVs are deployed? Is it necessary to create a societal structure among EV owners, aggregators, and distribution network operators? What should be the relation between them?

### **3.3 Sub Topic 3 – System interconnection requirements and radio communication for protection**

The standardization of system interconnection requirements is very important for active distribution networks with a large share of DGs. Another key issue is the communication between different smart devices and its utilization in operation and control.

**Paper C6-203** (Brazil, Utility) describes the guidelines adopted by many Brazilian distribution utilities for connecting distribution generation (DG) to the HV and MV electrical networks. As a result of this study, the guidelines emerged for DG connection and all other related reviews are public and are available on utilities web pages. The main issues and related reviews/findings relating to DG connection have been discussed in detail by categorizing into (1) Connection forms of DG, (2) Access and control Criteria, and (3) Protection systems.

**Paper C6-214** (USA, Laboratory) reports the communications based solutions to address the challenges of integrating DERs at the distribution level. It discusses the several teleprotection schemes that use communication to improve protection and anti-islanding performance of a distribution network with DER penetration. Conventional communications channels are usually cost-prohibitive for applications at the distribution level. However, new technologies for wireless communication have become available recently. The wireless technologies provide economical communications options for DER applications.

**Question 2.9-** At present, it looks that the different procedures are practiced in the setting of the power system protection relays by utilities in Brazil. What are the steps implemented in order to streamline the anomalies in procedures and practices in your country? To standardize system interconnection requirements, how should we think about the relationship between the international standards such as IEEE and the local standards in each country?

**Question 2.10-** What are the legislative/technical barriers for wide spread acceptance in applying radio communication to tele-protection schemes to the distributed networks with a large penetration of DER?

### **3. Preferential Subject 3. (New roles and services of distribution systems for transmission system operation)**

The theme for Preferential Subject 3 is “new roles and services of distribution systems for transmission system operation”

The areas dealt with are:

- Provisioning of ancillary services from DG and RES
- Reactive power regulation between TSO and DSO
- Data exchanges between TSO and DSO to operate the “active grid”

#### **The papers submitted**

Although preferential Subject 3 includes only 2 papers, the quality of the items addressed is very high and the aspects covered are very relevant to the activities of TSOs and DSOs. Due to the number of the papers, one from France and the other from Germany, the subtopic addressed is:

- Subtopic 1 – Ancillary services of distribution systems for transmission system operation (Papers C6-301, and C6-302)

#### ***Subtopic 1 – Ancillary services of distribution systems for transmission system operation (Papers C6-301, and C6-302)***

**Paper C6.301** (France) deals with the proceedings of an European Project called NICE GRID aimed at testing on field the concept of a smart grid with several interactions between TSO and DSO. The project is located in France in the Nice region.

The main tasks addressed are:

- Power demand reduction and load shifting;
- Management of massive DG and PV generation;
- Islanded mode operation.

The paper focuses on the first task and in particular the management of coordinated power demand or generation reduction, requested by the TSO. The demand/generation reduction is performed in a market scheme (local transaction place) for testing the possibility to establish a market for the ancillary services to the TSO network provided by several actors at DSO level. In the proposed market scheme, a central role is played by the “Aggregator”. This figure acts as service provider in order to match TSO requests and DSO constraints in a competitive scenario. Nonetheless the DSO acts a key role to manage the network and solve local grid constraints making possible the effective provision on “services” from the MV and LV

network to the TSO grid. The paper is really up-to-date and points out a possible way to tackle with a very discussed issue in electric networks with a widespread diffusion of DG.

**Paper C6.302** (Germany) is focused on the reactive power provisioning between TSO and DSO assuming a high penetration of renewable sources at DSO level, in HV (110 kV). In this scenario, introducing DSO reactive power flexibility as a system service may be useful to help TSOs in providing the required reactive power resources. The paper focuses on a proposed scheme to indicate how the DSO can use reactive distributed renewable resources to provide services to the TSO in a reverse power flow condition. As a result, network hosting capacity could be enhanced and also economic operation could be competitive when compared to traditional methods, as for example Static Var Compensators. In the solution envisaged, the implementation scheme could be: direct access from TSO to relevant HV DER; measurement of key network parameters in “reactive zones” and optimize power flows calculations to send set points to DER units by mean of DSO or using tap changers of HV/MV transformers.

**Question 3.1** – DSO and TSO may have different goals and objectives in providing ancillary services. How to match these targets? In your opinion is this mainly a market model or a technical rule?

**Question 3.2** – What is the optimal way to deal with flexibility services from grid users (consumers, DER, storage) in order to operate the system in the most secure and economical way?