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 2010 General Session three preferential subjects dealing with:

- Planning and Operation of Distribution networks incorporating Dispersed Energy Resources (DER) and Renewables Energy Sources (RES)
- Demand Side Integration
- New Concepts and Technologies for the Electrification of Rural and Remote Areas

28 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.

1.0 Preferential Subject 1 (Planning and Operation)

The theme for Preferential Subject 1 is "Planning and operation of Distribution networks incorporating Dispersed Energy Resources (DER) and Renewables Energy Sources (RES)".
The items which will be touched upon are:

- Effect of large scale integration on reliability.
- Provision of ancillary services by DER/RES.
- Regulatory schemes to support DER/RES.
- Performance characteristics of distribution networks with high penetration of DER/RES.
- Operating experiences, demos.

1.1 The papers submitted

A total of 15 papers will be discussed under Preferential Subject 1. One paper was cancelled by the authors. The papers are split up in three groups covering different sub-topics:

A: Regulation, Reliability, Power System Evolution, Ancillary Services
C6-102 France, C6-103 Italy, C6-107 Australia, C6-114 Thailand, C6-115 USA, C6-116 Germany

B: Distribution Automation, ICT Structure, Standards
C6-101 France, C6-105 Germany, Denmark and Russia, C6-113 Switzerland and Serbia

C: Active Distribution Networks, Voltage Control, Microgrid Operation
C6-104 Japan, C6-108 Canada, C6-109 Denmark and Canada, C6-110 Japan, C6-111 Norway, C6-112 Norway

1.1.1 Sub-topic a: Regulation, Reliability, Power System Evolution, Ancillary Services

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In paper C6-102 it is stated that the new renewable energy sources, wind and solar power, are peculiar in that they are mainly connected to the distribution grids, and are also highly sensitive to meteorological conditions. This requires changes to the method usually employed by RTE to manage the electricity supply-demand balance, in order to ensure there are sufficient power reserves to guarantee system reliability and to control flows passing through national grid. For this reason, RTE has completed a setup by which it oversees the operation of its power grid, adding a new system especially dedicated to observability and forecasting wind generation. This is known as the IPES system. The system enables dispatchers to observe most of the wind generation injected into the network and to see how it will develop over the next few hours.

In paper C6-103 a software tool, developed by the authors, is employed to perform costs/benefits analysis of the active distribution network while using a Multi-Objective approach to find compromise solutions for the conflicting goals of Civil Society, DSO and DER owner. This approach is demonstrated through a simulation of five scenarios with different regulatory environments and active management implementations in a MV distribution network with RES using the evolutionary algorithm NSGA-II for optimization. As the simulation demonstrates the impact of different regulatory environment on the expected evolution of distributed system it is proposed that this procedure is employable in different market and refund mechanisms for active distribution networks.

Paper C6-107 presents a time sequential Monte Carlo simulation to investigate the impact of renewable distributed generation units on distribution system reliability. The probabilistic models for load demand, wind speed and solar radiation have been built to simulate the system uncertainties. The proposed approach has been applied to a realistic 11kV distribution feeder to evaluate the improvement of reliability in terms of System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) with consideration of different DG configurations and DG capacity factors. It is found that a hybrid system is preferable for system reliability improvement compared to the system with a single DG technology.

Paper C6-114 presents the experiences of evolution of clean energy mechanism and renewable energy regarded with the government’s policy on the sustainable and environmentally friendly development in power industry and current situation of DG in Thailand. The alteration of energy source issue and the challenge of global warming require an appropriate regulatory frameworks and technologies. The government of Thailand has set a target for clean power generation by 12% of total generation capacity by 2011. In order to achieve this goal, the power industry of Thailand is working towards the development of new and renewable energy technologies, energy management and smart power networks to meet the government’s targets by deploying and employing several tasks to strengthen power systems to support the increasing greener technologies in electricity supply industry.

Paper C6-115 concentrates on the process to develop selection criteria and strategy for planning and deployment of smart grid technology under the US Department of Energy (USDOE) and Electric Power Research Institute (EPRI) Smart Grid programs which include the USDOE Renewable ad Distributed Systems Integration (RDSI) and EPRI Smart Grid Demonstration Program. These programs include the use of responsive load to provide ancillary services such as regulation and spinning reserve. The program will also address new value-added services such as differentiated power quality and enhancing asset use. The projects will identify and address barriers for using distributed energy resources and explore business models to incorporate these technologies into capacity planning and demand-side management. In addition development of analysis tools, integration technologies, lab and field demonstrations, and technology transfer will be investigated. The paper lists nine current projects related to the integration of DER and RES into the distribution system.

In paper C6-116 it is shown that the enormous increase of the share of Renewable Energy Sources in the energy balance and the power balance requires new approaches. Without participation of the RES in the provision of ancillary services, the reliability, quality of supply and stability of the power system cannot be kept in the today’s quality. Dispersed generation with RES and CHP, storage and demand side management have a high potential to contribute in the provision of ancillary services. This participation of RES in ancillary services will become mandatory but will happen only if there is a financial benefit. Therefore this participation will require an adaptation of the current regulatory framework. Special optimization tools are developed to define the optimum energy mix and the provision of reserve power. An example demonstrates that this approach is significantly more profitable than the sum of separate market activities of the single units and plants of the VPP.

Question 1.1:
To what degree is it currently, and will it be in the near future, necessary for TSOs and grid operators, to continuously monitor and predict the operation of distributed generators? What are the goals of active distribution management?
How should the regulatory framework be changed in order to have RES participating in provision of ancillary services in the long run? What market frameworks could be applied?

Question 1.2:
The main policy to promote energy efficiency and clean energy is often based on an extra selling tariff, on top of normal tariff and financial incentives by investment subsidies and soft loans for selected types of renewable energy projects. The same effect could be reached by obliging the traditional energy producers to incorporate a certain amount of renewables and to take efficiency actions on an obligatory basis. Are there any examples of changeovers from the one regulatory regime to the other?

Question 1.3:
Are the customers willing to go along with Smart Grid concepts and exchange energy savings for the loss of some privacy? What are the main barriers encountered so far? Are they actively participating in the shaping of demonstration projects?

1.1.2 Sub-topic b: Distribution Automation, ICT Structure, Standards

In paper C6-101 it is described that EDF R&D has launched a research program to analyse the future distribution automation function requirements and the associated implementation roadmap. The first step of the distribution automation roadmap keeps the philosophy of a centralized control, but adds new functions to the Distribution Management System (DMS) of existing control centres. It is stated that the flexibility and controllability of the distribution grid is only possible if control centre tools and control engineers have a more accurate representation of the grid in real-time. The development of new Automated Metering Management (AMM) systems should enhance the observability of the network. Once the observability of the network is improved, active network management can be implemented in order to improve distribution network operation and increase distributed generation hosting capacity. Three real-time automation functions have been identified for investigation and development over the next five to seven years: Distribution State Estimation, Volt VAr Control and Network Reconfiguration.

In paper C6-105 it is stated that the distribution networks are no longer passive and require controllability. To improve the distribution network operation the practical implementation of virtual power plants (VPP) will become a reality in the future and power generation of DG&RES will be scheduled with a high accuracy. In order to realize VPP decentralized energy management, communication facilities are needed that have standardized interfaces and protocols. The correlation between IEC 61850 and 61970/68 (CIM) is: IEC 61850 gives opportunity to describe the monitoring, control and protection system of the substation; IEC 61968/70 makes it possible to describe the substation, its equipment, its condition (repairs, load schedules, asset value etc.), the measurements taken from the main equipment and, to a lesser degree, its control system. The paper deals with international activities and experiences in the implementation of a new data management and communication concept in the distribution system. Some required future work for IEC TC 57 has been identified.

Focus of paper C6-113 is on developing an ICT structure of VPP using Unified Modeling Language (UML) based modeling methodology. A VPP is considered as an instrument to aggregate DER and present them to the energy system as a single technical and commercial entity. The VPP is divided in a three layer structure: Power Flow which includes physical elements of the grid, ICT structure and Market Interface (trading agents). The ICT structure consists of monitoring and control structure, communication standards and protocols and a control center. While concluding that the multidisciplinary topics of VPP require a holistic and comprehensive approach, the UML based modeling methodology is proposed to boost mutual understanding and to facilitate mapping of users into functional requirements.

Question 1.4:
ERDF is using a simulator for distribution operation management based on MATLAB functions. The advantage is that there are no limitations in size and speed. In real time communication is essential. How is this treated in such simulations?

Question 1.5:
The standards for data on power equipment and data for monitoring and control should come closer to each other. This problem has been recognized in transmission systems already long ago but it is still not solved. What actions should be taken to make bigger steps to be ready on time for future active distribution management?
Why is UML chosen in paper 113 for modulating VPP in comparison with other modeling methodologies?

1.1.3 Sub-topic c: Active Distribution Networks, Voltage Control, Microgrid Operation

Paper C6-104 demonstrates, via a real test system, the effectiveness of the "demand side control method" in a Microgrid under islanded operation. The demonstration system uses demand side control for some loads and energy storage (batteries) to minimize the impact of the variation of a photovoltaic generation system. Voltage and frequency were measured during photovoltaic generation fluctuations and under islanding condition. Voltage and frequency deviations were well below the allowed values. The experiment also showed that the "demand side control method" increased the electric power supply due to the decrease of actual loads as well as the increase of the output of the photovoltaic generation system. Although the system is relatively simple and designed to behave within stable conditions some basic concepts for the operation of Microgrids under islanded condition have been once again demonstrated.

Paper C6-108 presents a distribution network for testing new control and operations for a better integration of renewable energies. The paper is a summary of several papers where the results of two projects were published. The test facility is equipped with different kind of DG-emulators, controllable loads and communication and monitoring tools. It is used by Hydro Quebec and also a number of governmental and non governmental entities for testing and developing new tools and devices for the integration of renewable energy sources in the distribution grids. The major benefit, of this facility, as stated in this paper is to avoid power interruptions, which would a major impediment in the tests, will be carried out in a network feeding actual customers.

A reactive power dispatching scheme in distribution networks is presented in paper C6-109. The reactive power is coming from CHP plants that are controlled in a way to maintain predefined level of reactive power exchange between transmission and distribution grid set by the TSO. A controller based on the substation measures of reactive power at the substation, receives active and reactive power measurements from a Gateway connected to SCADA system, and then calculates reactive power set point for CHP plants, to be sent via a communication (IEC 61850-7-420). The major problem encountered is the time delay caused first by the Gateway and then by the SCADA system. It was suggested to bypass the outer control loop in the excitation: the controller gives directly the excitation set point, instead of the reactive power set point, which is expected to reduce the time delay.

Paper C6-110 describes experimental studies concerning the interconnection technologies used for the high penetration of photovoltaic generation. New islanding passive and active detection methods, voltage suppression control method using storage batteries, centralized voltage suppression control method are investigated with the intention to show that a centralized voltage controller can help to maintain voltage regulation while equalizing the availability and maximizing generation for the residential PV system. The centralized control system equally suppresses the power output of each PV system to maintain a regulated voltage. As PV utilization increases verification and demonstration projects become very important and useful in obtaining useful information for grid designers.

Paper C6-111 deals with the voltage variation issues in a distribution network in Norway. The paper portrays the integration between different types of generation units and their respective voltage control settings. Field measurements and simulations were used to show how vulnerable a Hydro Power plant is to both an increase in generation and also to voltage variations in the external grid. As the wind turbine increase its production voltage would also go up at connection point of the Hydro Power plant, resulting in disconnection (reactive power used to maintain the voltage at 1.05 is exceeding the preset limit). The same thing happens when tap changers are operated to increase the voltage, during an increase in production of the wind turbine. Solutions are proposed to reduce this problem: increase the rating of the Hydro generator, increase the delay time for the reactive power tripping.

Paper C6-112 treats the voltage control in distribution grids in Norway. The main topic is to perform efficient voltage control strategies in order to increase the maximum allowable generation within a specific distribution network. Voltage control via reactive power is demonstrated in several load and generation scenarios. The most difficult scenario is the high generation low load generation case, where it is suggested to operate generators at the end of feeder in reactive power consumption mode, and generators near the substation in reactive power production mode. Additionally, reactive power import from transmission grids is significantly reduced. In the other scenarios, generators set to reactive power production mode combined with tap-changing is suggested.

Question 1.6:
How applicable are the observations of paper 104 regarding the demand control method for much higher PV penetration levels? What additional intelligence and ICT needs to be implemented to further improvement of the performance of the system?
What is the power quality impact when transitioning from grid connected to islanded operation especially when the load contains a large proportion of non-linear elements??

Question 1.7:
Paper 108 describes a distribution test system. Is it possible to divide the test facility into say two separate grids, for the aim of testing the performance of multi-agent (multi-area) systems being the key element of future smart grids? Can DC distribution grids be tested in this facility?
Can other experiences with real distribution test systems be reported?

Question 1.8:
In order to solve the voltage control problem in distribution networks it is much more effective to control the active power then the reactive power. Is this a practical option in mixed distribution systems with different DG control systems? What happens if the communication link fails in case of hierarchal control systems as proposed in paper 109?
If the advice of paper 112 is followed how to switch from one coordinated control mode to the other (for the different load en generation scenarios)?

Preferential Subject 2 (Demand Side Integration)

The theme for Preferential Subject 2 is “Demand Side Integration”. This subject is very important throughout the world as we develop the technologies, methods and standards that will facilitate integration of demand side resources with the operation of the network. Important topics that will be discussed in this session include:

- Effect of large scale integration on reliability.
- Provision of ancillary services by DER/RES.
- Regulatory schemes to support DER/RES.
- Performance characteristics of distribution networks with high penetration of DER/RES.
- Operating experiences, demos.

2.1 The papers submitted

A total of 6 papers will be discussed under Preferential Subject 2:

- C6-201 Practical experiences of demand side integration through pricing - B. FENN, D. ERMERT, H. FREY (Germany)
- C6-202 Optimal demand side response for electricity balance control in microgrid - M. KOSHIO, M. NONAKA, S. NAKAMURA, K. NAKAO, D. SATO
- C6-203 Active demand side management operator tool (SGCLOS) and new communications architecture in the XXI century electrical grid - E. GARCÍA SÁNCHEZ, A. RODRÍGUEZ APARICIO, M. GARCÍA CASADO, P. MARTÍN MUÑOZ, R. MORA, J. DIAZ GARCIA, S. FRESNILLO VELASCO, A. VALERA VÁZQUEZ, A. LÓPEZ, D. ROMÁN, M. GARCÍA, R. SANZ
- C6-204 Prospective study on the impact of electrical vehicles on the winter load peak in a village of East of France - C. BATHANY, H. BOUIA, V. MURIN, D. OSSO, J. MAIRE
- C6-205 Integration of active customers into smartgrids: experimental test facility and results - G. MAURI, D. MONETA, J. SILVA DE ASSIS CARNEIRO
- C6-206 DSM in Spain, GAD project. Aims, developments and initial results - NAVALON BURGOS, S. BANARES, L. MORENO SARRION, A. QUIJANO LOPEZ

The discussion is divided into three sections:

A: The potential for demand side resources from residential and commercial segments
C6-205 Italy, C6-204 France
B: Pricing as a basis for Demand-Side Integration
C6-201 Germany
C: Communication and information architecture and technologies for Demand Side Integration
C6-203 Spain, C6-206 Spain, C6-205 Italy, C6-202 Japan

2.1.1 Sub-topic a: The potential for demand side resources from residential and commercial segments

There are many projects evaluating the potential for demand side resources at the residential and commercial level to support demand management, energy conservation, integration of variable renewable generation, and support during system contingencies. Paper C6-205 (Italy) describes an actual test facility (see figure below) and experimental results for integrating active customers with the smart grid. The test facility can evaluate the effect of using network and price signals for demand management and to evaluate the interaction between prosumers and electric grids. The concept of Local Energy Management (LEM) applications is introduced. These applications are able to receive signals sent by energy retailers and DSOs, as well as manage generators/loads according to customer's preferences and power exchange plans with the network.

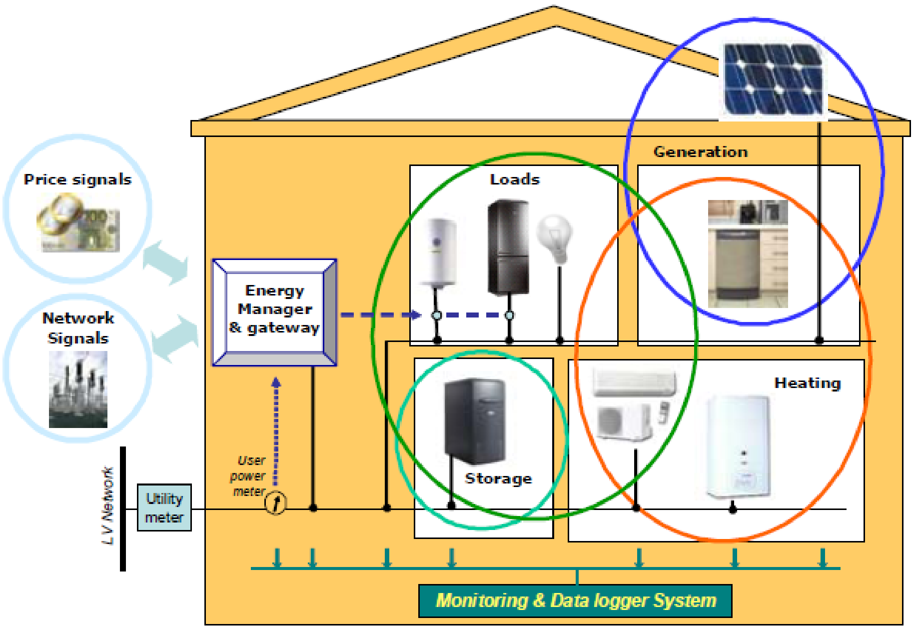
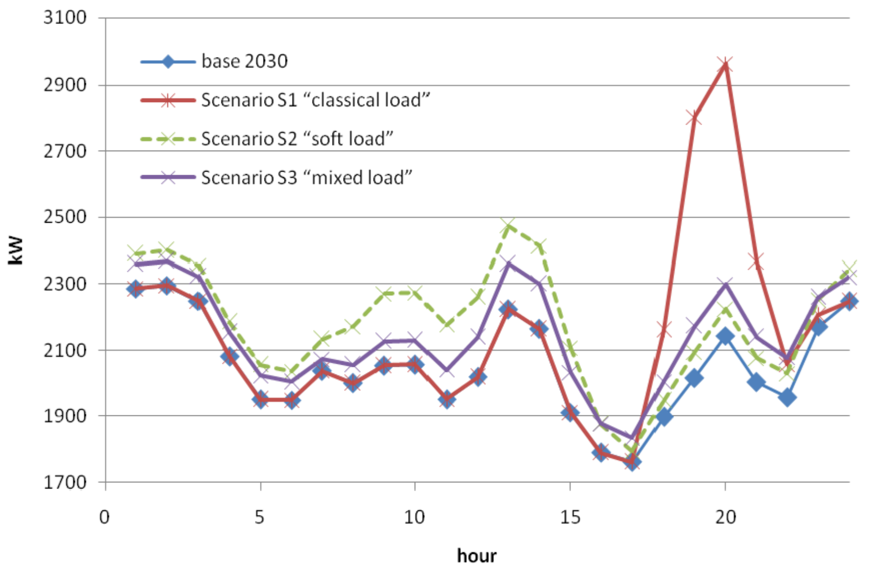


Diagram of demand side integration elements that can be evaluated in the ERSE test facility (Paper C6-205).

One resource that is likely to be particularly important in the future is the charging load of electric vehicles. In the future, it is possible that electric vehicles can even be used a dynamic storage resource for balancing of variable loads and generation, as well as demand management. Paper C6-204 (France) focuses specifically in the electric vehicle as a demand side resource, looking at the potential impact on the winter load peak in a particular village. The first step is to develop a model of the household (called EPURE) using public available data – like INSEE Statistics (French national statistic institute), residential knowledge, technology knowledge, technical data (equipment efficiency for example) and weather data from Météo France. This model is able to provide a dynamic calculation of load curve per end-uses at a national, regional or district level at hourly step and also an assessment of a demand side management or energy saving policy on the load curve and energy consumption. This tool was used to evaluate the effects of electrical vehicles with several penetration levels and with charging periods on the network placed at different times of the day and with complete or fast recharging. The study also addressed the impact of heat pumps' penetration in the same village on the winter consumption peak. The different charging scenarios resulted in dramatically different impacts on the load curves, illustrating the importance of understanding the charging scenarios for management of this load. The best scenario for this village (to reduce the impact on peak load) involved a scenario that spread the charging throughout the day. Although the results are very preliminary, the simulated load curves argue for a load management of the EVs recharge at the risk of trouble in the DSO even if such approach is not solving all problems.



Impact of electric vehicle charging scenarios on the load profile for village in France (Paper C6-204)

Question 2.1
Which demand side resources at the residential and commercial level have the most potential for integration with the grid operation, reduction of demand, and energy conservation? What are the issues with integrating these resources that must be solved.

Question 2.2
What are the different benefits that can be derived from demand side integration and what are the control time scales to achieve these different benefits? How can these different benefits be monetized across the different players?

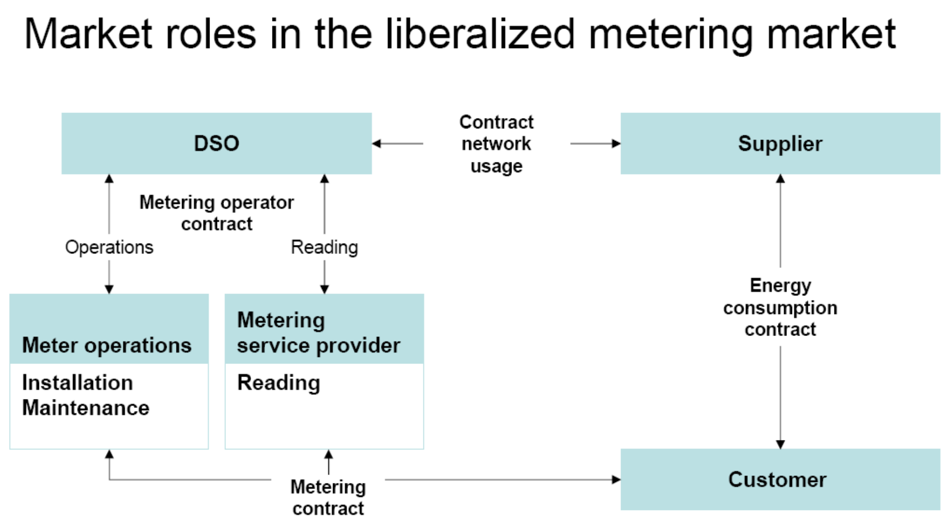
Question 2.3
What is the potential of electric vehicle charging loads as a demand side resource? What coordination will be required across the system to take advantage of this resource? What standards are required to coordinate this resource?

2.1.2 Sub-topic b: Pricing as a basis for Demand-Side Integration

There are many different ways to integrate demand side resources with the operation of the grid and electricity markets. One of the approaches that is receiving considerable attention is the use of pricing strategies to elicit a desired response from customer load and distributed generation.

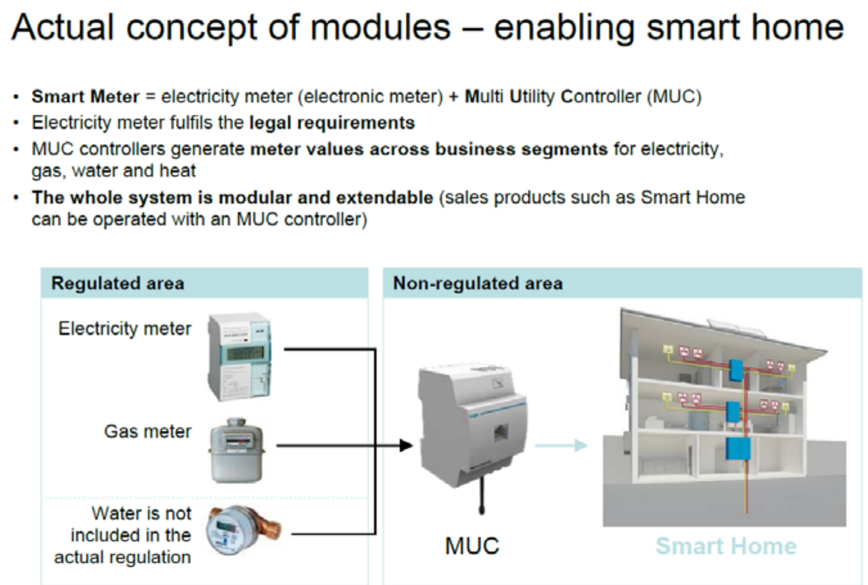
In Paper C6-201 (Germany), the general technical and organizational requirements for implementing an infrastructure to support advanced metering and the integration of customer resources is described along with the results of an extensive trial of remote reading from household meters. The paper introduces Minimum Emission Regions (MeRegio), areas possessing energy supply systems that are optimized with respect to their greenhouse gas emission. The particular focus on these regions is optimizing both electric and thermal energy using low-emission power plants as well as Smart Grid innovative functions and components. The paper provides practical knowledge gained from selected research projects in Germany that relate to the effects of new pricing models on energy conservation and demand management.

The first project involves the installation of more than 100,000 automated Smart Meters (including automatic transmission of information on energy consumption), for customers in the Mülheim power network. The German legislature has established a complicated structure for selecting these customers that involves special meter operator and meter data service providers as shown in the figure below.



Roles of different parties in advanced metering services – Paper 6-201

A key aspect of the architecture for this system as being implemented by RWE is the use of a separate communication module (multi-utility communication controller, or MUC) as the interface between the meter and various devices in the customer premise (home area network). This unit uses open standards for these interfaces (Smart Message Language SML) so that future integration with other technologies and suppliers will be possible (see figure below).



Architecture for communication modules to enable the smart home from Paper 6-201.

The Minimum Emission Region (MeRegio) – Minimum Emission Region" was set up in the areas of Göppingen and Freiamt (Baden Württemberg / Germany) as part of the overall E-Energy program in Germany. The project's approach is mainly based on three components – E-Energy marketplaces, the energy infrastructure (smart grid), and the ICT infrastructure to link the physical

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infrastructure with the marketplace. The initial project in this region involves 1,000 participants to test the concepts of efficient coordination of energy supply and demand. Marketplaces will be implemented in order to trade energy products and system services using different mechanisms to match supply and demand, such as dynamic tariffs that provide an incentive to shift loads, or auctioning mechanisms that can help establish new business models such as aggregators who bundle DERs and resell capacities. At the customer level, demand response will be achieved by dynamic tariffs and control signals for home appliances. Parallel to the development of the tariffs, control signals ("efficiency and priority signals") are being tested which enable utilities to automatically shift loads adjusting the energy consumption and generation in private households.

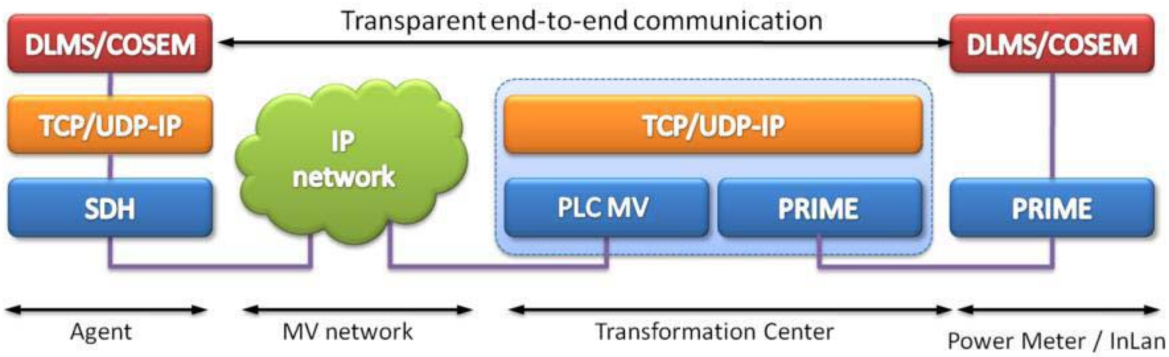
The third project described is the Web2Energy (W2E) project. This project focuses on coordination of IEC standards for the ICT infrastructure - Communication protocols (IEC 61850), ICT network security (IEC TS 62351) and Database management using CIM (IEC 61968). The W2E project focuses on interfaces between all three of these levels. Field tests are being conducted to demonstrate the 3 pillars of smart grids: customer integration, active distribution networks, and self-healing capabilities. This is accomplished by interfacing a variety of distributed resource technologies with actual distribution system control centers. The research is also evaluating the effects of special customer rate offers and analyzing the implementation of various storage types.

Question 2.4
What are examples from around the world of implementing dynamic pricing as a means of demand side integration? How are the dynamic prices coordinated between the generators, the market operators, aggregators, and the DSO? What are the limitations of using pricing as a means of demand side integration?

2.1.3 Sub-topic c: Communication and information architecture and technologies for Demand Side Integration

A critical aspect of integrating demand side resources with the grid and the marketplace is a flexible and standards-based communication and information infrastructure. Research in Germany that is addressing the ICT infrastructure requirements was described above under Sub-topic a in addition to the pricing aspects of this research. Paper C6-203 (Spain) describes a new communications architecture to enable demand side integration along with new tools for operators to manage the demand side resources. In the Spanish active demand project different system actors (TSO, DSO and Power Marketer) interact by reducing domestic demand through intelligent devices installed at the customers who have joined a contract for power limitation. A customer management system is described that involves functions distributed to each agent involved.. The part of the system corresponding to the Spanish TSO is called SGCLOS (in Spanish, Sistema de Gestión de Clientes del Operador del Sistema). SGCLOS allows the TSO to send actuation orders to the DSO so that domestic demand can be reduced according to predefined contracts. The paper describes the algorithms (demand side resource estimation and grid status monitoring), the graphical user interface, and the communication architecture developed for this application. The consortium is proposing a new communications standard for the Electrical Demand Management concept. The new standard architecture extends from the physical communication layers to the communications protocols to the applications that will use the protocols.

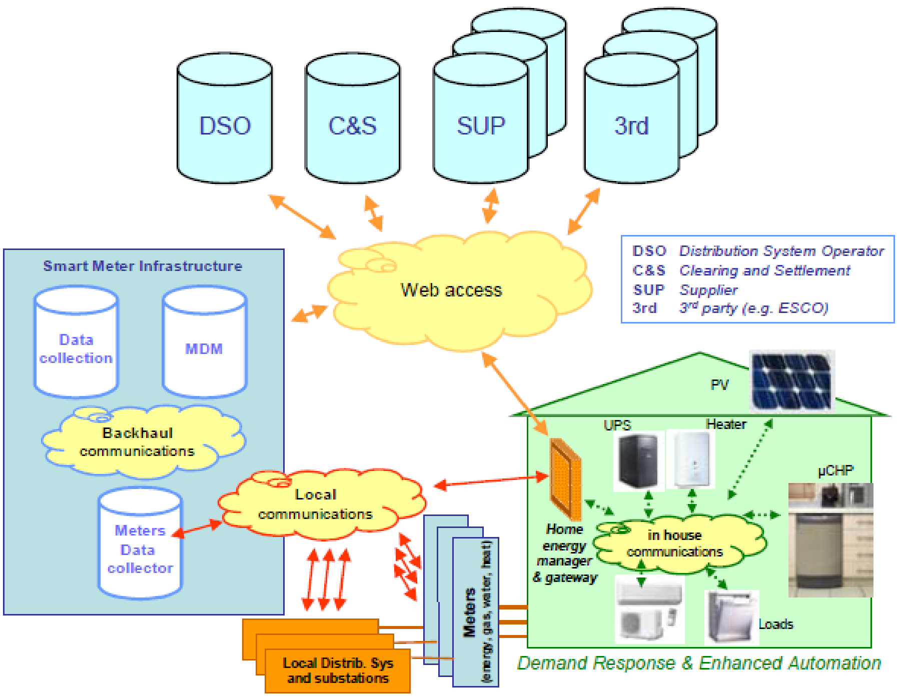
In the Spanish business model proposed, there are five main agents that support the Active Demand Management: end users, distributed energy generators, DSO, the Power Marketers and the TSO. The communication network s to support these agents are divided into a Control Area, a WAN, and LANs.



Structure and standards for communications architecture to support demand side integration (Paper C6-203)

Paper C6-206 (Spain) also addresses the GAD Project (Demand Side Resource Management) in Spain with a focus on benefits that can be derived from the demand management across all segments, a review of results from other demand side management investigations and applications around the world, the work packages of the research project, and the proposed architecture for the implementation in Spain. Specific technologies for the different levels of the architecture are described (e.g. VPN, PLC, and BPL). An actual test facility has been built to demonstrate and evaluate the technologies and the interfaces in the home.

Paper C6-205 (Italy), described above, also includes a description of how the smart metering infrastructure can be used to provide market actors with data acquisition from smart meters in order to support energy efficiency measures, enhance monitoring and management of grids, optimise market processes and improve services for prosumers. Smart meter information is available to the market players, whilst prosumers can receive price/network signals and easily access historical consumption data. Smart meters can also exchange information with both prosumers and Distribution System Operators (DSOs). One possible infrastructure for integrating advanced metering information with the different parties is outlined in the OPEN Meter project and illustrated below.



The role of smart metering in providing information for demand side integration (from the OpenMeter project, referenced in Paper C6-205).

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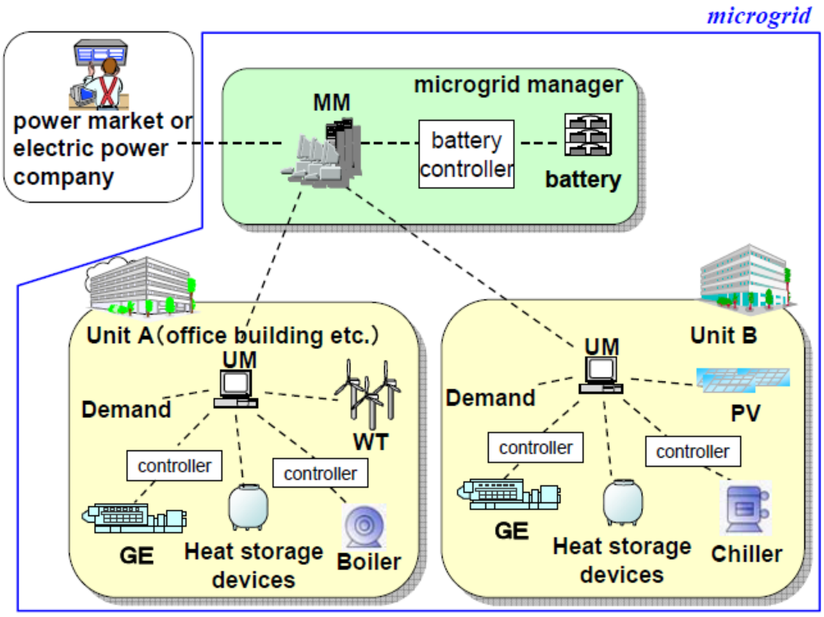
Paper 6-202 (Japan) introduces the concept of a microgrid controller that manages the operation of local generation while also controlling electricity consumption, including the effect of changing electricity prices. The basic architecture of the microgrid is shown below. Important elements include the microgrid manager (MM), the unit manager (UM) that controls each individual generating unit (combined heat and power), and individual device controllers that interface with a UM. Each UM controls generation, load, and storage based on a shadow price to determine appropriate import or export levels. An example is used to illustrate the advantage of coordinated control through a MM compared to each UM controlling local generation completely independently.



Microgrid architecture from 6-102.

Question 2.5.
What standard protocols and communication technologies are being used for communication to devices in the premise for demand side resource integration? What developments are required in these standards and protocols? What are the requirements for interoperability in these standards and protocols to allow third party application development and integration?

Question 2.6
What is the role of advanced metering in facilitating demand side integration? Will smart meters be the energy gateway into the premise? What protocols must be supported in advanced meters to make this possible?

Question 2.7
What is the role of the Common Information Model (CIM) in integration of information about customer demand side resources, flexibility of response to prices and other control signals, etc.? What are the development requirements in CIM to implement these information systems. How can tests be structured to assure interoperability between applications?

3.0 Preferential Subject 3 (New concepts and technologies for the electrification of rural and remote areas)

The theme for Preferential Subject 3 is "New concepts and technologies for the electrification of rural and remote areas".
The aspects which will be discussed are:

- Opportunities offered by Microgrids and other advanced grid based concepts and renewables
- Financing schemes, services delivery methods
- Practical experiences, including upgrading the system and connection to the grid

3.1 The papers submitted

A total of 7 papers will be discussed under Preferential Subject 3. The papers are split into three groups covering different sub-topics:

A: Opportunities offered by Microgrids
 C6-301 Korea, C6-303 Canada, C6-304 Greece, C6-306 Germany, United Kingdom, Greece
B: Rural Electrification experiences and connection to the grid
 C6-302 Argentina, C6-305 Mexico
C: Rural Electrification organisation experiences
 C6-307 The Netherlands and South Africa

3.1.1 Subtopic A - Opportunities offered by Microgrids

C6-301 Unified power quality controller for the Microgrid system: This paper describes the operation of Unified Power Quality Controller (UPQC) for application in microgrids with photovoltaic, wind, fuel cell, and conventional gas generator sources. The main focus of the work reported in the paper is on DVR (dynamic voltage regulator) and APF (active power filter) operations in grid-connected operating mode. A new voltage disturbance detection method using the neural network for the control of DVR is proposed. The proposed disturbance detection method exhibits minimum time delay in determining the occurrence of a disturbance. Moreover a new voltage regulator for single phase inverters is proposed. Results of computer simulations performed to verify the performance of proposed voltage disturbance detection method and the new voltage regulator.

C6-303 Secondary control of Microgrids: application of potential functions: This paper introduces the concept of potential functions for secondary control based on availability of communication within the microgrid. The idea underlying the proposed concept is to provide the microgrid with a high degree of control and power management which can then be exploited in the context of smart grids. The potential function associated with each DER unit of the microgrid embeds and/or regularly updates various pieces of information, e.g., current, voltage, power, and operation constraints, of the DER units. The microgrid central controller minimizes each potential function to determine the set points of the corresponding DER unit associated with the minimum of the potential function. Results of simulation carried out to demonstrate the efficacy of the proposed control system are shown.

C6-304 Distributed intelligent control of DER and LV Loads in Microgrid; This paper discusses research undertaken related to control of Distributed Energy Resources (DER) and Distributed Generation (DG) in Microgrids. The work reported is based on real test sites in Greece. The work was performed as part of EU funded R&D projects. The main focus of the paper is on intelligent distributed control via intelligent agents. The intelligent agents form a Multi Agent System with communication ability allowing the system to perform complex actions. Results presented demonstrate that the proposed control schemes are achievable. Unsurprisingly the paper concludes that the decentralised control of DER and DG is essential for the optimisation of Microgrids with increased penetration of DG and RES. The authors recommend investigation of large scale application of the proposed approaches as well as standardisation especially in the communication between the home controller and the appliances as well the home controller and the ESCO.

C6-306 European Roadmap for Microgrids: This paper presents work performed under the EU FP6 research project 'More Microgrids' which has lead to establishment of a general European platform of database and expert know-how for planning and evaluation of Microgrids. The paper introduces the experiences gained from this platform, providing some key pointers on modelling aspects required to carry out comprehensive studies on Microgrid including the main benefits that can accrue from Microgrid operation. The changes required in the commercial and regulatory frameworks in order to enable large-scale Microgrid deployment are discussed. It is argued that a Microgrid is capable of overcoming conflicting interests of different stakeholders and achieving a global socio-economic optimum in operation of distributed energy sources.

Question 3.1

As the work done focused on grid connected operation, which design aspects of DVR and APF should be taken into account to enable a smooth transition from Grid connected operation to islanded operation of the Microgrid? How applicable are the schemes in to remote mini grids tied to grid systems via weak tie-lines?

Question 3.2

What complex decision boundaries can be enabled by adopting the concept of potential functions for secondary control?

Question 3.3

In the final analysis, widespread adoption of microgrids will be based primarily on a cost benefit analysis. How should the cost of microgrids be calculated? Can the full costs of implementing microgrids be justified in developed country given that the reliability of power systems in these countries is generally very good? Under what situations is a microgrid really beneficial?

Question 3.4

Is it reasonable to conclude that for a microgrid to achieve seamless transition from grid connected to islanded operation mode, the import from the grid must be maintained as close to zero as possible? If that is the case what would be the cost implications of operating the microgrid at grid imports significantly close zero?
How could the microgrid concept be successfully deployed in rural systems with weak grid connections?

3.1.2 Subtopic B: Rural Electrification experiences and connection to the grid

C6-302 New technology for the development of economic and sustainable rural electrification systems in the vicinity of EHV power lines: This paper considers an alternative method of extracting energy from electrometric fields surrounding High voltage power lines to the use of the Overhead Ground Protection Wire (OGPW). The proposed system capable of extracting more energy is by introducing the concept of a multi-conductor composed of several sub-conductors. A software design tool for the proposed system has also been developed. The paper proposes a specific practical application of the proposed technology, by developing the complete system focused on the supply of electrical energy to consumers located in the vicinity of 500kV transmission power lines across the length and breath of Argentina. The proposed system is said to present an economical power distribution option rendering access to electrification in rural areas.

C6-305 Rural electrification project development, using auxiliary service voltage transformers: This paper discusses the successful application of an Auxiliary Services Voltage Transformer (ASVT) as a source of power for rural communities. The device doubles as an instrument transformers and a power transformer providing a cost effective solution for connecting to the high voltage lines up to 230 kV traversing rural areas. The engineering of the scheme is said to be simple and represents a real, successful and economically viable alternative, for electrification of rural communities with load requirements from 50kVA single phase, up to 1MVA three phase.

Question 3.5

The practical limit of the proposed scheme for extracting power through electromagnetic fields around the power is stated as 1500W. Though this is claimed to an improvement on Overhead Ground Protection Wire (OGPW) it still seems rather limited; how scalable is the proposed system and what are the main limiting factors to scalability?

Question 3.6

At one third of a conventional solution, the proposed scheme using auxiliary service voltage transformers is very attractive, what are the main down sides to this approach? What is the loss performance of the device compared to conventional power transformers?

3.1.3 Subtopic C: Rural Electrification organisation experiences

C6-307 Small-scale rural electricity providers: Opportunities and challenges: Drawing on the results of ongoing initiatives, this paper discusses the principles, opportunities and challenges faced by governments, electric utilities, local entrepreneurs, and other actors in the provision of electricity to rural communities. Examples are of drawn from the activities of ESMAP "Energy Small and Medium Enterprises (SME)" programme, Global Partnership on Output-Based Aid (GPOBA), EdF Access Program, Alliance for Rural Electrification (ARE), Enabling Access to Sustainable Energy (EASE) and Netherlands/German programme Energizing Development as well as other joint activities.

The paper suggests that one of the opportunities to relieve the national budget from the high cost of providing the electric infrastructure is to "unleash" rural financial resources and entrepreneurial capacity with the support from the donor community.

It is concluded that the most significant constraints on developing small-scale providers include the lack of a sound legislative and regulatory environment, poor entrepreneurial capacity, lack of knowledge and skills, and limited access to financing for both entrepreneurs and end-users. Pointedly the paper suggests that rural electrification should be seen as a component in rural development plans indicating support for integrated rural development. For small-scale electrification projects to be successful, assistance to project developers and the engagement of the local community are needed. The papers also reiterates the well known fact that rural electrification projects are perceived by Bankers as high risk and advocates risk assessment that addresses local political circumstances, expected load factor, revenue collection, tariff setting and the affordability and willingness to pay of the population.

Question 3.7

What practical steps can/should be taken to encourage world Governments to adopt a more holistic approach to rural development which includes provision of safe, sustainable energy sources including electricity? Should Energy service companies be promoted rather than electricity service companies? Given the diverse nature of challenges and lack of "one size fits all" solution how should recommendations be framework to achieve widespread relevance? How feasible are feed-in tariffs in developing countries?