Towards a Smarter Network Management by Europeans DSOs

A technological outline of selected Smart Grids functionalities for a more optimal management of Europe's distribution networks

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A EURELECTRIC Report

MARCH 2011

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D/2011/12.205/15

Towards a Smarter Network Management by Europeans DSOs

A technological outline of selected Smart Grids functionalities for a more optimal management of Europe's distribution networks

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WG Smart Grids / Network of the Future

Per HALLBERG (SE) Chair

Konstantinos ANDREADIS (GR); Josep BALLART (ES); Christer BERGERLAND (SE); Aurelio BLANQUET (PT); Ignacio CASTRILLON (ES); Alan CLAXTON (GB); Han J. DAMSTE (NL); Ensari DURMAZ (TR); Tomas GLEICH (CZ); Frederic GORGETTE (FR); Robert GRAGLIA (LU); Kenneth HÄNNINEN (FI); Jörg JASPER (DE); Ole HAUGEN (NO); Henrik HORNUM (DK); Ikuo KURIHARA (JP); Marina LOMBARDI (IT); Michael LASKOWSKI (DE); Pierre MALLET (FR); Arunas MARKEVICIUS (LT); Adam OLSZEWSKI (PL); Jerry O'SULLIVAN (IE); Adrian PETER (CH); Paola Lucia PETRONI (IT); Mirko RISTEVSKI (MK); Margus SIREL (EE); Milan SPATENKA (CZ); Walter TENSCHERT (AT); Andelco TUNJIC (HR); Edvard TURK (SI); Milan VALJASEK (SK); Donald VANBEVEREN (BE); Doru VOICU (RO);

Contact:

Pierre SCHLOSSER, Advisor Networks Unit – pschlosser@eurelectric.org
Gunnar LORENZ, Head of Networks Unit – glorenz@eurelectric.org

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1. Executive Summary

Upgrading the current European electricity grid with 'smarter' technologies is a strong contribution to overcome the system implications stemming from the newly-adopted EU energy and climate package. Indeed, the EU's commitment to reduce CO2 emissions by 20%, reach a 20% share of renewables sources in its total energy consumption (transport, heating & lighting and electricity) and improve energy efficiency by 20% - by 2020 - represents a considerable challenge for the energy sector of today.

For the electricity industry, this triple commitment is even more demanding as it foresees that approximately 33 % of all electricity will be generated from renewable sources which need to be integrated in the grid/system. Moreover, new electricity applications will appear in the future, such as broad usage of heat pumps and electrical vehicles. This will have a considerable impact on the electricity grid.

Besides, we observe that the European Union has been moving towards deregulation of the electricity markets for the past decade, with the consequent need to ensure the reliability and quality of energy supply while adapting the structure and processes to take on board the new market approach and new legal obligations, integrating renewable energy sources (RES) into the system and increasing the efficiency of electricity transmission and distribution in order to limit grid tariffs increases.

EURELECTRIC is pleased to see that the European Commission and ERGEG have recognised the role of 'smart grids' in reaching the goals of the energy-climate package in its recent Green Paper on Energy Networks. European electricity networks will have to cope with the ambitious sustainability targets set by the EU policy makers, adding new items to the mission of Transmission System Operators (TSOs) and Distribution System Operators (DSOs), which has traditionally been to secure network reliability and quality and, more recently, to act as market facilitators.

Investments in Europe's distribution grids will need to be incentivised by national energy regulators. Once this critical condition is met and DSOs dispose of favourable investment conditions, they will face two options:

1. They can follow the **"fit and forget approach",** often referred to as the "copperplate scenario". This approach entails heavy investments in additional distribution lines in order to prepare distribution grids for a large intake of RES electricity. This means over-sizing the distribution grid to avoid congestion during the few periods of strong wind or sunshine – comparable to building four- or five-lane automobile highways to avoid potential congestion hours.

2. Alternatively, DSOs can follow the **"smart grids approach"** which consists of investing in Information and Communication Technologies (ICT) that will help them to better manage the electricity flows and limit the need for new lines. By using ICT (including smart metering) to monitor, control and automate the distribution grid, DSOs can optimise the use of current assets.

While the “smart grids approach” provides a better allocation of resources in the long run, it is very likely to result in higher capital expenditures (mainly in ICT) in the short and medium term, compared to the “fit and forget approach”. However, the “smart grids approach brings value across the energy supply chain, which ultimately and importantly, benefit customers.

EURELECTRIC is strongly convinced that Smart grids are a way to equip Distribution System Operators with the necessary tools to contribute to the 2020 objectives. We are convinced that with the current infrastructure, it will not be possible to integrate all the renewable and other distributed power generation to the grid, as it was not built for this purpose.

The purpose of this paper has been to outline the potentialities and system implications of a first group of Smart Grids functionalities which fall under the umbrella of what we call “Smarter Network Management” and which are able to deliver, once incrementally implemented, a more efficient management of distribution networks.

We determined that 4 main functionalities will be defining elements of the future Smart Grids concept in the short term from the point of view of European DSOs:

- **Conventional Grid Development, Improvement and Optimisation** investments will improve the operation of distribution grids using available technologies. These investments – some of which could be considered ‘smart investments’ will consist of enhancement and addition of lines, transformers, switch components and other power equipment alike.

- **Grid Automation** investments will make a significant contribution to effective grid operation in the changing environment and will be essential to provide the network with: reduced duration of interruptions, enhance voltage control, auto-reclosing or auto-opening systems, remote controlled switches and remote monitored fault indicators and will equip distribution networks with more intelligence

- **Advanced Network Operation** and investments in Control centres will be needed to cope with an increasing share of RES DG being connected to the distribution grid and with more unpredictable loads such as EVs. DSOs will need advanced systems and control solutions to be able to face the challenges of the future.

- Essential functionalities (from a DSO perspective) of **Smart metering** will help DSOs to operate their network better. Remote meter readings, detection of both fault and frauds (among others) will bring value to the DSO business and help to improve customer service.

The support of policymakers and regulators will be needed to design the pathway to a smarter network management and encourage investments. Smart Grids will indeed require significant capital expenditure on the part of European DSOs. According to figures from the International Energy Agency, the investment needs in the European distribution network will amount to **480 bn euros** up to 2035[1].

- **To outline the appropriate economic incentives** that will allow DSOs to conduct the investments needed for a smarter DSO network management. Incentives should depend on the maturity of the technology used. This would encourage the large-scale implementation of untested technologies.

- **To prepare the future and make sure that a large pool of (both IT and power) engineers will be available in the future** to implement and operate these technological changes within DSOs, our industry being in a chronic shortage of qualified workforce.

[1] Projected investment in the EU 27 distribution network. IEA World Energy Outlook 2010 – New Policies Scenario (655 bn $).

2. Introduction

Energy security and climate change are becoming increasingly prominent on political agendas across all sectors of the world economies and ranks highest among the EU's priorities. The EU has committed itself to expanding the use of renewable energies and reducing greenhouse gas emissions by 2020. The EU is also aiming for a 20% increase in energy efficiency by 2020. The Commission has notably acknowledged that, by enabling substantial gains in energy efficiency, ICT-based innovations may provide one of the potentially most cost-effective means to help Member States achieve the 2020 targets.

EURELECTRIC sees the implementation of more intelligent/smart transmission and distribution systems in the form of Smart Grids as central to the development of the internal market for energy. There is a clear need in the drive for lower-carbon generation, combined with greatly improved efficiency on the demand side, to stimulate consumers to become active participants on retail markets and increasingly interact with the electricity supply system.

The newly adopted 3rd Electricity Directive, the European Union specifies that it expects Member States to ensure the implementation of intelligent metering systems that shall assist the active participation of consumers in the electricity supply market. Moreover, Member States are encouraged to modernise their distribution networks, for example through the introduction of Smart Grids, which should be built in a way that encourages cleaner decentralised generation and energy efficiency. More recently, the European Commission launched an ad-hoc advisory body called 'Task Force Smart Grids' in order to gather advise on policy directions at EU level and to coordinate the first steps towards the implementation of Smart Grids under the provision of the Third Energy Package.

In EURELECTRIC's understanding, a Smart grid is an electricity network that can intelligently integrate the behaviour and actions of all users connected to it -generators, consumers and those that do both - in order to efficiently ensure sustainable, economic and secure electricity supply[2].

A smart grid, involving a combination of software and hardware allowing better power monitoring and control and enabling consumers to manage their demand, is an important part of the solution for the future. Smart grids will function bi-directionally, thus enabling the integration of small and large scale renewable and distributed energy production and will also show self healing capabilities. Smart Grids will lead to a paradigm shift in the way the electricity is distributed. As stressed in a European Commission document: "Smart Distribution network solutions will embrace the changing structure of generation, market and use of electricity, and improve the efficiency, reliability, flexibility, accessibility and cost-effectiveness of the end-to-end system"[3].

The purpose of this paper is to outline the potentialities and system implications of a first group of Smart Grids functionalities which fall under the umbrella of what we call

[2] Other definitions are available (eg. ERGEG's position paper on Smart Grids, 2009).

[3] ICT for low carbon economy: Smart Electricity Distribution Networks, European Commission, July 2009.

"Smarter Network Management" and which are able to deliver, once incrementally implemented, a more efficient management of distribution networks.

This paper will form the first contribution of a wider forward-looking analysis of the challenges and opportunities posed by Smart Grids functionalities in the run-up to 2020. **The structure of this trilogy** is based on the different functionalities that should be implemented in a Smart Grid. **We decided to classify these different functionalities into three main groups**, depending on the maturity and complexity of the functionalities' implementation, as illustrated in the following graph:

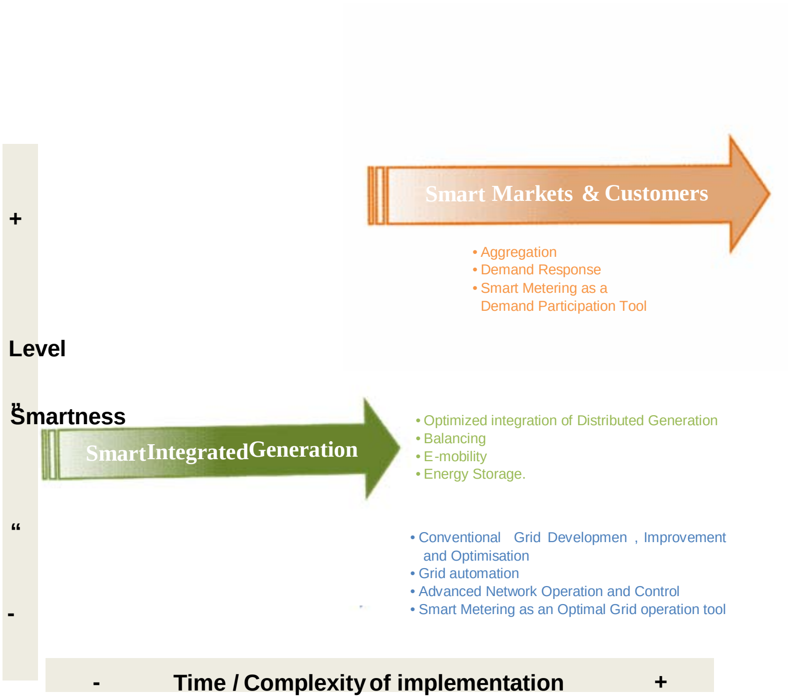

Figure 1. Groups & Levels of Smart Grids Functionalities.

1. Smart network management: As networks are the enablers for these functionalities, they are more likely to be the first to be implemented, in parallel with the functionalities related with Smart integrated generation. Main functionalities in this group include: conventional grid development, improvement and optimisation, grid automation, advanced network operation and control, and smart metering as an optimal grid operation tool

EURELECTRIC deliverable: this paper, by Q3/2010

2. Smart integrated generation: integrating a large scale of Decentralised Generation capacities in the distribution network holds key to a low-carbon society and will be essential to deliver on the EU 20/20/20 objectives. This will however lead to increased challenges to balance the power grid and various technologies (DSM, storage, V2G) could help in this undertaking. Main functionalities include: Distributed Generation, Balancing, Energy Storage.

EURELECTRIC deliverable: paper on Smart integration of RES DG, Smart Grids, flexible loads and storage, by Q3/2011

3. Smart markets & customers: These functionalities are considered the most difficult to deploy, due the number of stakeholders involved and the need of awareness and participation of the customers. Main functionalities include: flexible load & load control and demand response, aggregation, e-mobility

EURELECTRIC deliverable: paper on market models for Smart Grids, by Q3/2011
The classification of Smart Grids functionalities in 3 main Groups stems from the belief that Smart grids implementation will be implemented in a continuous process, which will answer specifically to new challenges and the requirements of the various actors involved. As described below, we believe that this first layer of Smart grids functionalities which will be implemented will help to improve the operation of the DSO network. Once the Smart grid infrastructure is installed however, it will act as a market platform for new services and new interactions on the retail markets, to the benefit of both customers and electricity retailers (see graph in Annex).

3. Functionalities leading to a Smarter Network Management

Part 3 outlines the potentialities and system implications of a first group of Smart Grids functionalities which fall under the umbrella of what we call *"Smarter Network Management"* and which are able to deliver, once incrementally implemented, a more efficient management of distribution networks.

We determined that 4 main functionalities will be defining elements of the future Smart Grids concept in the short term from the point of view of European DSOs:

Conventional Grid Development, Improvement and Optimisation	**Grid Automation**
Advanced Network Operation and Control	**Smart metering as an Optimal Grid Operation tool**

3.1 Conventional Grid Development, Improvement and Optimisation

Investments in grid development and optimisation are all conventional investments to the power system that improve the operation of distribution grids using available technologies.

These investments consist of enhancement and addition of lines, transformers, switch components and other power equipment alike. The main target is to give all users of the grid the quality that users expect and that are in accordance with valid technical specifications, the regulatory requirements and state of the art.

At present, the main challenges are the embedding of distributed generation of any size and number, while keeping the voltage profile and power flow inside the operational constraints, as well as improved requirements in respect to quality.

Future challenges might be the charging of electrical vehicles and integration of energy storage devices.

- **Players Involved – Roles and Responsibilities**

DSOs as grid operators have to carry out and finance the investments. Because investment budgets are restricted, system operators try to fully utilise the existing grid and develop it in the necessary manner.

Maintaining reliability and security of supply, inside the regulatory framework, push grid operators towards the implementation of new technologies, methods and processes in order to exploit the possible advantages of the new elements (as distributed and dispersed generation), further to being able to face the challenges they pose.

They are playing a key role in achieving successful smart grids.

Regulators have the target to optimise the fees for grid usage network in order to achieve reasonable prices for the customers. Yet, these methodologies care not always allowing enough commercial space for investing in future technologies that can improve the network. In respect to smart grids they are requested to introduce incentives in the frame of the regulation scheme to promote and enable the necessary investments. They might use performance indicators to identify the most beneficial tools.

Generators are interested in feeding all the produced or surplus energy into the grid without restrictions to get maximum return of the investment. Feed-in from renewable sources enjoys priority grid access in most countries which gives additional burdens for the grid.

Already today additional requirements are coming up, like a need for involvement in voltage regulation or peak cutting at extreme points in time. The present evolving scenario sees also consumers taking the role of producers, with the same expectations and future responsibilities.

Consumers want to receive electrical energy at any time up to the contracted amount at best quality. A future responsibility, considering also their new role of producers and users of e- mobility, will be the provision of a flexible demand trough the participation to demand side management programs. They will also have to be more and more engaged into energy efficiency measures. They might request technical support from the grid to realise this engagements.

Suppliers would like to be able to offer and sell a range of products and services tailored to meet requirements of specific customers. These could be special incentives for customers to support energy efficiency measures and more intensive participation in the market e.g. flexible and load depending prices.

ICT-Companies: telecommunication and information technology had in the past a rather restricted role in grid investments. This position is evolving towards a situation which will enable network operator to face the new requirements mentioned above. There will be possibilities where DSO and ICT providers through supply of equipment and procedures exploit together the possible advantages

Manufacturers of electricity grid equipment have the responsibility to provide reliable and long-living devices and equipment at acceptable costs. Already today more sense is coming up in developing “more intelligent” devices that are able to communicate with other devices and allow automatic operations and control of the grids. There is also a need to develop material for improved voltage control and for the management of bidirectional flows.

- **Technology Required**

The technology for conventional grid investments exists already, but there is always a continuous process of improvements. Additional requirements are coming up with the need for communication with other devices to perform automatic processes (see Grid Automation). Conventional grid equipment has low or no communication requirements. This will change, with the grid automation and remote control that is being introduced more and more in the network.

- **Financial Implications (for DSOs)**

Components of a power grid are durable and expensive. Commercial balance takes place after several decades and the components require – beside the construction costs – considerable operating and maintenance costs over the whole lifetime period. At the end of their lifetime the components are usually replaced by new components. It is therefore important to the grid operators, the grid users and the society that grid development is chosen carefully and no stranded investments are undertaken.

The upcoming new technologies are comprising to a large extent equipment and components, which have a much smaller lifetime. New methods in asset management will be necessary in order to decide about the lifetime cycle of this technology and how to fully exploit the investments.

The decision as to how to further develop smart grid function after its lifetime is in many cases dependent not only on DSOs but also on grid users and their individual preferences and business plans. This causes additional risks to the investments of grid operators.

Corresponding regulative or financial incentives are required to persuade grid operators to do investments and to avoid stranded investments.

3.2 Grid Automation

Under grid automation, we understand all automated processes during normal system operating, after faults or during improper system status, which are performed without explicit activities of persons. The objective of grid automation is to keep or to improve the technical quality of grid services and to avoid negative implications to grid users in the case of faults. It is an important functionality to be associated with remote control system. In fact remote control systems do not guarantee a fast reaction in case of concurrent faults, when the operators at the control centre receive a quantity of information. Automation can significantly reduce the duration of interruptions, which is a very common indicator used by regulators to evaluate the performances of network operators.

The cooperation of fault detectors along the network and substations' devices as protections and switches, provides to the network **self healing capabilities**: localisation of faults and restoration of supply even in large portion of the grid can be performed even before the personnel in control centre gets alarms from remote control units, as to say that even if the central system is down the faults are managed. Currently grid automation is usual for the transmission grid, while is now increasing in the distribution MV networks.

- **Players Involved in this functionality – Roles and Responsibilities**

All **Grid Users** (consumers, producers, suppliers) are beneficiaries of well functioning grid automation.

DSOs and TSOs have to technically implement and finance automated measures to meet the required quality standards set by regulators and reduce operating costs. Additional motivations may be image improvement or commercial benefits. Regulation systems with quality incentives or penalties are key drivers for grid automation.

Regulators have to develop an adequate quality regulation scheme as an important measure to promote grid automation investments.

Research Organisations increasingly embark on management of consumption and of decentralised production as a field of research and development. By means of public funded projects research organisations will have an important role to develop theoretical and practically applicable solutions.

Manufacturers provide reliable, durable and robust technical solutions for grid automation.

ICT-Companies will have to provide powerful, reliable and secure data connections.

- **Technology Required**

The required technology for enhanced grid automation is more or less available but in some fields practical experience is required to develop generally applicable solutions and test the technologies on a large-scale. Moreover, increasing standardisation will help to get commercially reasonable products.

Most advanced grid automation processes require communication services. Depending on the task of the process narrow or broad band is needed. Critical is the availability of communication services during outages of the electricity system, which might last over several hours. However, the use of open communication protocols increases indeed the danger of unintended influence by third parties. Appropriate security measures will hence be required, to make them "cyber secure".

Extensive data functionalities are an inherent part of dispersed system control and data acquisition. Increasing number of automation devices will boost the demand on data.

- **Financial Implications** (for DSOs)

As all other grid investments, enhanced automation installation has to be financed by the network tariffs. Well-balanced commercial incentives for quality improvements by means of grid automation will be necessary.

3.3 Advanced Network Operation and Control

The evolution towards the smart grids introduces new functionalities for the SCADA (Supervisory Control And Data Acquisition) systems. In particular the presence of distributed generation and the implementation of demand side management programs may require new functionalities to be implemented in the management systems of the Distribution Control Centres:

- *New network operation applications* (forecasting tools for load and generation profiles, active systems instead of reactive operation based on the alarm system)
- *Ground force management systems* (fully integrated with the Distribution Management System, capable to interact by receiving orders or updating topological connections according to the ground field manual actions)
- *Automatic load management* (for example to accommodate the demand to the technical requirements of the network in those pro-sumers MV/LV involved in a load management program)

- *Digital mapping/Geographical Information Systems* (the development in cartography: e.g. Google Maps, Google Earth, etc.)
- *Information Technologies PDA (Personal Digital Assistant) and mobile computing and Communications* in general.
- *Interactions with the other information systems, as Automated Meter Reading, Geographic Information System, Computer Information Systems (CIS).*

The challenge will also be to understand the degree of decentralisation of functions convenient for the network operation and for the costs. Some functionalities may be performed at the level of the substations, but these will probably imply more installation costs, and communication links to be properly designed, while offering scalability and systems managing a lower amount of data.

Decentralized autonomous control centres are very likely to be established in the future (autonomous agents installed in transformer stations).

- **Players Involved**

DSOs: understand and define the requirements of the new functionalities, invest in development and training of employees of the control centres who will have to use the new functionalities.

Regulators should recognise the investments in the development of these new functionalities.

ICT providers and manufacturers: new functionality to develop and sell.

- **Technology required**

Sensor and auxiliaries in order to get the required measures from the field, local intelligence to perform algorithms, controllers, remote units. The level of decentralisation of functions determines also the degree of communication links that will be necessary.

In the network operation, automation and e-mobility applications communications are going to have an important role. In most countries public operators don't have the reliability that utilities need to integrate communications in the critical path. In some cases a cascade problem appears when there is an outage in a zone where mobile phone functionality is lost. One of both, or public operators improve there reliability or utilities will have to assume a deployment of digital communications (for example digital radio) to develop its smart grid. There is still a dilemma that must be solved about the use of the MV and LV power cable to solve the communication requirements for smart grids. Radio communications are likely to have more impact in the solution.

- **Financial implications**

Under static conditions there is a business case to justify the deployment of advanced operation systems in network operation and generally the utilities have improved technical systems. Additional costs which have to be covered by grid fees are appearing with the need for additional "intelligent functionalities" requested from customers and/or generators

The investments in the technical system must be considered as part of the essential investment of the business and must have the same consideration as all the investment carried out in electrical assets in the grid fee calculation.

- **Interrelations with data functionalities**

The more decisions are taken based on a virtual representation of reality through systems, instead of on reality itself (having less presence on the field and looking and touching the assets for example), the more we need to be confident that the information on which these decisions are based is of the necessary quality. From the organizational point of view utilities will have the need to define a new 'speciality' within the Organisation: the 'Data Manager', to work hand in hand with the Control Centre as a specialist in information management.

3.4 Smart metering as an Optimal Grid Operation tool

The following Smart Meter essential functionalities will to an optimized distribution grid operation:

- remote reading
- detection of faults
- detection of frauds
- connection contract management (e.g. changing the contracted available power, new connections, disconnections)
- when requested by suppliers (and in accordance with the relevant national legislation) management of bad payers such as reduction of contracted available power, disconnection, etc.

Once smart metering is fully implemented, the whole set of these functionalities can lead to savings in operational costs of DSOs, substantially for the possibility to perform remotely functions which formerly required field crew intervention and to detect frauds with the energy balance system. However this potential saving will differ strongly between countries.

The evolution of this scenario might bring the smart meter linked to appropriate devices at home which make available the consumption information to consumers, through different interfaces as displays, PC monitors, TV, or to devices used to manage the energy at home (EMS). Furthermore smart metering infrastructure is also very important for the realization of the recharging infrastructure of electric vehicles[4].

[4] These potentials are however outside of the scope of this paper and will be dealt in other EURELECTRIC publications.

- **Players involved in this functionality – role and responsibilities**

DSOs: in many countries DSOs are responsible for the installation, management, reading and provision of metering data to the other system players. Even in that case some DSOs outsource metering to a separate meter operator. In other market setups it is compulsory that metering is unbundled from distribution, so the above described functions are performed by meter operators However data from smart meters will be necessary and be a key part of the future smarter grid operation.

Generators: they need to be able to measure the energy injected in the grid. Requirements for metering increase with decentralised generation and different remuneration of power for self usage and for feed-in in the grid.

Suppliers: they need metering data for settlement and billing purposes, in future also for dynamic pricing offers and further provision of consumption information (e.g. through displays and web applications) to enhance customer participation on the demand side.

Consumers: with smart meters they can count on billing based on actual consumption, more frequent readings, fast contract management, information about the energy consumed in the billing period. Additionally, Smart Grids will provide them with an intelligent platform for more active participation in power markets.

Technology required

- the electronic meter replacing the electromechanical one
- the communication infrastructure
- the concentrator which is usually installed in secondary substations collecting data from the meters installed in the LV feeder

Standardised information architecture will be a key prerequisite for an efficient usage of the system. In Europe some communication protocols are already open and associations have been created also in some cases (e.g. Meters and More, Prime).

The communication network between the smart grid and metering devices and distribution systems allows collection and distribution of information to customers, suppliers, distribution network companies, utility companies and service providers.

The technology used for communications vary. A good overview of pros and cons of the different solutions can be found in [L1].

Interrelations with data functionalities
Smart meters will allow interactions with other data bases and communication systems such as the meter Communication System, the meter Data Management System, the work Order Management System, the Meter Inventory System and the Customer Billing and Invoicing System.

- **Financial Implications**

Since Smart Meters will not only bring benefits to the whole length of the electricity value chain, and will also carry externalities to society as a whole, EURELECTRIC calls on EU Member States' National Regulatory Agencies to make the commitment that Smart Meter roll-out will be tariff-financed. One interesting regulatory policy is to recognise depreciation costs for electromechanical meter, even if they are replaced with the new electronic ones.

4. Conclusions and Policy Recommendations

The purpose of this paper has been to outline the potentialities and system implications of a first group of Smart Grids functionalities which fall under the umbrella of what we call "Smarter Network Management" and which are able to deliver, once incrementally implemented, a more efficient management of distribution networks.

We determined that 4 main functionalities will be defining elements of the future Smart Grids concept in the short term from the point of view of European DSOs:

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- **Advanced Network Operation** and investments in Control centres will be needed to cope with an increasing share of RES DG being connected to the distribution grid and with more unpredictable loads such as EVs. DSOs will need advanced systems and control solutions to be able to face the challenges of the future.

- Essential (from a DSO perspective) functionalities of **Smart metering** will help DSOs to operate their network better. Remote meter readings, detection of both fault and frauds (to name a few) will bring value to the DSO business and help to improve customer service.

The support of policymakers and regulators will be needed to design the pathway to a smarter network management. Their action will be critical:

- **To outline the appropriate economic incentives** that will allow DSOs to conduct the investments needed for a smarter DSO network management. Incentives should depend on the maturity of the technology used. This would encourage the large-scale implementation of untested technologies

- **To prepare the future and make sure that a large pool of (both IT and power) engineers will be available in the future** to implement and operate these technological changes within DSOs, our industry being in a chronic shortage of qualified workforce.

5. List of references

There are a lot of documents and definitions. Below are some examples and links.

[L1] The smart grid in 2010: Market segments, applications and industry players; David J.
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[L2] Definition of Smart Metering and Applications and Identification of Benefits

http://www.esma-home.eu
Project: European Smart Metering Alliance (ESMA)
Authors: Pekka Koponen (ed.), Luis Diaz Saco, Nigel Orchard, Tomas Vorisek, John Parsons, Claudio Rochas, Adrei Z. Morch, Vitor Lopes, Mikael Togeby.
Lead author: Pekka Koponen, VTT Technical Research Centre of Finland
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[L4] IEC - Report of SMB/SG 3, Smart Grid after the meeting held on 2009-11-19..20 in Denver, US - (page 82)

[L5] Cost Benefit Analysis of Smart Metering and Direct Load Control Overview Report for consultation, NERA

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Union of the Electricity Industry - EURELECTRIC aisbl
Boulevard de l'Impératrice, 66 - bte 2
B - 1000 Brussels • Belgium
Tel: + 32 2 515 10 00 • Fax: + 32 2 515 10 10
VAT: BE 0462 679 112 • www.eurelectric.org