ICT for a Low Carbon Economy
Smart Electricity Distribution Networks

JULY 2009

Findings
by the High-Level Advisory
Group on ICT
for Smart Electricity
Distribution Networks
On the Energy sector

European Commission
Information Society and Media

Interested in Information and Communication Technologies for Energy Efficiency?

Please visit the dedicated area of our website at http://ec.europa.eu/ictforsg and participate in the annual High Level Event on ICT for Energy Efficiency Further information at http://ec.europa.eu/ict4ee

European Commission
Directorate-General Information Society and Media
ICT for Sustainable Growth Unit
B-1049 Brussels
Merce.Griera-I-Fisa@ec.europa.eu
INFSO-ICTforSG@ec.europa.eu

ICT for a Low Carbon Economy

Smart Electricity Distribution Networks

JULY 2009

European Commission
Information Society and Media

LEGAL NOTICE

By the Commission of the European Communities, Information Society & Media Directorate-General, ICT for Sustainable Growth Unit.

Neither the European Commission nor any person acting on its behalf is responsible for the use which might be made of the information contained in the present publication.

The European Commission is not responsible for the external web sites referred to in the present publication.

The views expressed in this publication are those of the authors and do not necessarily reflect the official European Commission's view on the subject.

Office for Official Publications of the European Communities — Luxembourg, 2009
ISBN 978-92-79-13347-3
doi 10.2759/19105

Table of **content**

Foreword by the European Commission

Energy security and climate change are becoming more and more prominent on political agendas worldwide and across all sectors of the economy, so that it 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, both in its energy and climate package announced on 10 January 2007 as well as in its 20/20/20 vision from the spring summit of the same year. This commitment has been confirmed by two energy policy papers: "The Second Strategic Energy Review" published in November 2008 and the Green Paper "Towards a Secure, Sustainable and Competitive European Energy network", published in March 2009.

The EU is also aiming for a 20% increase in energy efficiency by 2020. The Commission has 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.

From an ICT policy perspective, two Communications to the Institutions have already been adopted by the Commission. While the first Communication of May 2008 identified the many ways in which ICT can contribute to energy efficiency gains, the second Communication adopted by the Commission in March 2009 identified concrete actions for the ICT industry, for EU Member State governments, and their regional and local administrations. It highlighted the importance of close working partnerships between policy actors and stakeholders from both sectors: ICT and energy.

To set up this new and ambitious environment we have been assisted by a High-level Advisory Group from leading companies and research institutions that worked during the second half of 2008. Their visions were discussed and enriched during the ICT for Energy Efficiency event in March 2009.

This booklet, prepared by the Smart Distribution Network Working Group, is a compilation of the main findings focusing on the development of ICTs to deliver more efficient management of networks, more commonly known as SmartGrid. The grid becomes "smart" because it will not only transport electricity but also information that will become an active part of the electricity supply system. This shall be considered as a paradigm shift in the way the electricity distribution grids are today and how they will become in the future: user and customer centric, service oriented, accommodating all needs and providing adequate solutions, supporting the migration towards and shaping of the low-carbon economy and society. Smart Distribution network solutions 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.

The Working Group concluded that ICTs have a major role to play, not only in reducing losses and increasing efficiency, but also in managing and controlling the ever more distributed power grid to ensure stability and reinforce security.

Without advanced communications capabilities, consumers will not be able to exploit real-time electricity pricing and become active players in the electricity retail market. Smart metering has been subject to discussion as Member States invest in trials and wider roll-out. Smart metering, which essentially introduces ICTs into traditional energy-metering, can be deployed in many ways, taking advantage of ICTs to a greater or a lesser extent. Information can flow between the meter and the energy provider and between the meter and the consumer. The so-called "one-way" implementation, that only serves the energy supplier, is often favoured over the 'two-way' implementation which serves both supplier and consumer. However, data collected from field trials of smart meters with two-way information flows in a number of Member States have indicated that consumers reduce their consumption by as much as 10% or more, depending on the context and quality of the information provided.

The Working Group also concluded that the innovations based on ICTs not only improve the energy efficiency and the way today electricity is traded and used, but also stimulate the development of a wide leading-edge ICT market that will foster the European industry competitiveness and will create new business opportunities according to the European Economic Recovery Plan.

The findings of the Working Group have provided valuable input to our policy process and have the potential to contribute to national policies and to reinforce cooperation between the energy and the ICT research and industrial communities.

I would like to thank all members of stakeholder associations, industry and research who have given their contribution to this publication and I wish you an interesting and enjoyable reading.

Zoran Stančič

Zoran Stančič
Deputy Director-General for Information Society and Media, European Commission

1 Executive **Summary**

European SmartGrids will promote the Intelligent Energy Supply Chain that will optimize, control, secure and sustain the procurement and supply of cleaner distributed energy anticipating increased demand till 2020 and beyond (Figure 1).

The adopted approach has been to investigate the ICT impact across the whole energy value chain from generation to retailing and end consumers (Figure 2).

The required ICT investments cover:

Generation

Portfolio and virtual power plant management, emission management, predictive maintenance, adaptive generation and demand side management.

Transmission and Distribution

Interoperable Supervisory Control and Data Acquisition (SCADA) systems and Virtual Power Plant (VPP) monitoring power flow management (FACTS, WAMS, WAPS), Integration of large DG, predictive maintenance, capacity planning and energy data management.

Retail

Demand side and response management, competitive customers multi-channel management, bundling of products and services, customer intelligence and energy capital management.

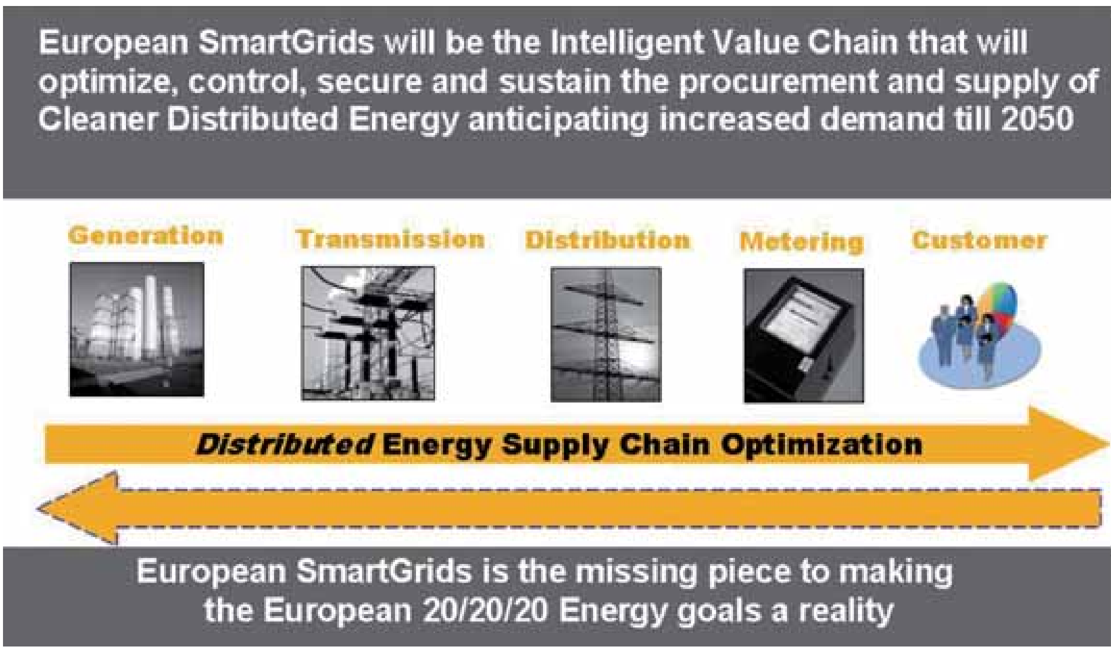


Figure 1:
European SmartGrids energy supply chain is the missing intelligent piece — intensively requiring ICT- to achieving the European 2020 energy goals.
Source : SAP (2009)

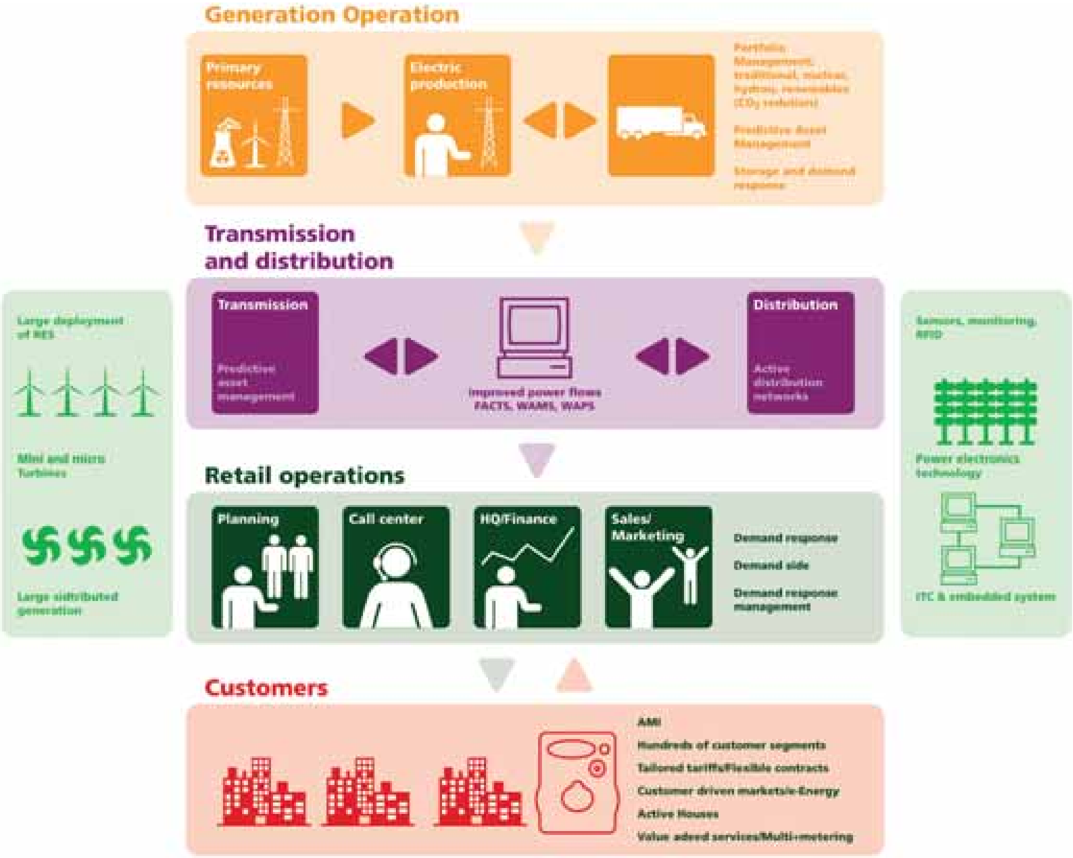


Figure 2:

Innovation areas across the SmartGrids value chain

Source : ETP SmartGrids

Customers

Smart Homes (smart meters, smart boxes, smart services), home energy management systems, customer active participation (demand response), customer empowered buying and switching in eEnergy.

These requirements have been grouped in 5 areas as follows:

Area 1: Present socio-economic drivers and challenges
Area 2: ICT for smart utility processes
Area 3: ICT for smart energy consumption
Area 4: ICT for grid infrastructure readiness
Area 5: ICT for breakthrough industry transformation

In order to put ICT at the core of the energy networks, it is recommended:

- To invest in ICT studies, business cases, surveys, and best practices, considering success stories per country/region.

- To invest in automated customer communications (smart metering) to reach 100% smart metering penetration in Europe by 2015 (Time of use to become mandatory).

- To invest in demand side management, demand response management and real time pricing as key processes for peak load shaving and energy efficiency.

- To invest in home energy controlling hubs (similar to an Internet hub that could be linked to smart meters or directly to the distributor or retailer) that will collect real time energy consumption from smart household appliances. This real time energy consumption information will lead to smarter energy consumption.

- To invest in "loss free" and the readiness of infrastructure networks to enable the connection of large scale distributed generation and renewable energy sources (share of 20% by 2020).

- To invest in ICT readiness for "mobile electricity consumers" (e.g. plug hybrid electrical vehicles that will become customers of electrical distributors and retailers rather than the traditional oil companies — this could include any electricity charging/discharging of mobile devices).

By implementing these recommendations, peak load can be 50% shaved and energy consumed by end users can be reduced by 20%. The actual benefits will depend on the commitment of each EU country as well as on the success to combine smart processes (e.g. successful implementation of demand response) with smart technologies (e.g. 100% deployment of smart meters).

This report is structured following the five areas defined before. It has an initial chapter which includes the views from key stakeholders and a final chapter on conclusions where the previous recommendations are more detailed.

2 Keynote Messages

The road towards a society without energy waste

By Livio Gallo

The EU targets on energy efficiency can only be achieved with the contribution from many different sources, coming from all the energy system stakeholders, mainly customers, utilities, manufacturers, industries, governmental actors and regulators.

One of the most important contributions comes from the Information and Communication Technology sector. In fact, the road towards a society without energy waste can be made easier thanks to the availability and the management of large amount of information on energy consumption for all the actors.

The Enel experience shows that Information and Communication Technologies are an enabling factor in developing innovation in the whole energy sector.
The main initiatives implemented by Enel in the past years to reach the Italian energy efficiency targets are:

- increased efficiency in generation plants
- reduction of network losses (technical and non technical losses)

Livio Gallo,
Chief Executive Officer, Enel Distribuzione and Managing Director, Infrastructure and Network Division, Enel

- distribution of more than 20 Mln of energy savings kits (lamps and water economizers).

In addition to these activities, ENEL has implemented the "Telegestore" System, an automatic meter management system that is unique worldwide in terms of scale and functionalities, based on bidirectional electronic meters, installed at all our 32 Mln customers. This system (meters + central management control) allows all energy stakeholders involved, as suppliers, DSOs, Transmission System Operator (TSOs), generators, and national regulators to benefit from the enormous quantity of data generated at the consumption points.

In the EU Directive 32/2006 the role of information on energy consumption through the presence of an automatic meter management system is strongly supported. The digital meters allow us to give more services to our customers such as:

- Automatic commercial operations (activations, change of contract, switching between suppliers in real time with a real remote reading etc)
- Tailored tariffs (benefit on peak load and total energy system consumption)
- Increase in quality of service (local balance, more effective verification of technical and commercial losses etc)
- Enabling demand side management
- Billing on real consumption.

ICT is also beneficial in the automation of operations in the field, as the automated self healing capabilities of the network (Medium Voltage Lines and Substations remotely monitored and managed) and thanks to the workforce management systems (6000 laptops to our workers "always on" with the central system).

All these technologies are the basis of the development of the future intelligent networks: the SmartGrid.

The challenges deriving from the integration in the network of: large scale renewable sources, electric vehicles, systems for multidirectional flows management, new equipments and power electronics and real time information devices can be faced only with a strong, reliable and fast ICT infrastructure.

The sustainable development of the energy value chain in the future will be more and more based and supported by ICT innovation and improvement.

Do we really need "smartgrids" for energy efficiency only?

By Yves Bamberger

ICT is definitely an enabler of energy efficiency, even without building a SmartGrid.

Once your home is correctly insulated, you might replace the fossil fuel heater or water heater by biomass or electric systems like heat pumps. Then, in order to manage all your equipments, including the «white products» (washing machine etc.), you may use in a near future an «indoor smart energy system»: it needs communication (wireless, PLC, etc.) between the domestic apparatus (PC, TV set, heaters…) and an «energy box» inside your home, in such a way that you, as citizen-customer-user, may tune the apparatus, either when installing it or whenever you wish to do it. Your apparatus also could be monitored by a service provider directly through Internet or through your energy box, depending on the contract you may have signed. These service providers may have some contracts to sell peak shaving, partial load reduction to the supplier of electricity. All that practically is needed to transform your home into a smart energy building with sensors, PLC, etc.

At this stage, energy efficiency does not need a SmartGrid to be developed, since a deployment of such systems could be achieved independently from putting intelligence into the network. The demonstrations realised in California by Southern Continental Edison showed that thermostats could be directly monitored for demand response purposes. Another example is a demonstration project deployed in the Provence Alpes Cotes d'Azur region in France.

But energy efficiency systems implemented at a large scale would need a "smarter" grid!

On one hand, distribution system operators have to make sure that the automatic energy efficiency systems, demand side management systems, etc. when implemented at a large scale will not decrease the quality and the reliability of power supply, all the more if you add PV panels,

Yves Bamberger,
Head EDF Research & Development. Member of the French Academy of Technologies.

dispersed energy sources, storage systems and PHEVs (plug-in hybrid vehicles), transforming the distribution grid into a circulation grid. Intrinsically the network efficiency is high (95%), but it must ensure the quality of supply while enabling demand side management and energy efficiency at the customers' home. This will be achievable through real time state and load estimation, by locating Medium Voltage (MV) and Low Voltage (LV) faults and reconfiguring automatically the network, through dispatchability of renewable energy sources and storage.

On the other hand, Automatic Meter Management systems, with the right functionalities, may also play a central role in this infrastructure, particularly to ensure that energy efficiency services can be deployed on a region- or nation-wide scale, giving the opportunity to every citizen to contribute to CO_2 emissions reduction and energy efficiency objectives.

At this stage the DSOs have to implement a SmartGrid, which means a grid with a certain level of intelligence provided by ICT adapted to the specific objectives mentioned above, where state estimation, observability and a monitoring closer to real margins are needed.

The deployment of these technologies and their optimisation will naturally depend on the consistency of the regulations and on the costs decrease due to standardisation.

We also clearly see here that, depending on the roles and responsibilities devoted to the different stakeholders: DSOs, retailers, aggregators in the deployment of energy efficiency, the solutions (the way to use ICTs), their return on investment and their impact on the customers' behaviour could differ quite significantly; the speed of generalisation could also vary from one solution to another.

In this context, the rules adopted by the regulatory authorities will have a decisive influence on the different scenarios and on the effective deployment of energy efficient solutions. For example, an approach solely focused on metering to drive cost reduction at the DSOs' level does not give a positive signal to use the opportunity of AMM systems for energy efficiency at the customers' home.

Transforming the grid into a "SmartGrid" is not only enabling energy efficiency and deployment of dispersed renewable resources but it provides to the DSOs many other opportunities: improving the business of the in outage management, asset management, reducing operational costs and supplying several services to different vendors of electricity and aggregators.

Finally, it means that we surely need ICTs and "SmartGrids" for energy efficiency, but not only for energy efficiency!

To conclude, the combined development and deployment of ICTs/ energy efficiency/ SmartGrids consists of a virtuous circle, which needs:

- a right level of standardisation for ICT
- smart and stable regulations
- incentives to develop exciting demonstration projects for all stakeholders
- effective investments in the networks

which gives the opportunity to create jobs, services and a leadership on ICT industry in Europe.

ICT is also part of the solution to climate change

By Maher Chebbo and Miguel A. Sánchez Fornié

The Information and Communication Technologies (ICT) sector currently accounts for 2% of global emissions. The real gain from green ICT will come from the development of energy efficient solutions that impact the other 98% of global emissions. ICTs are considered as a contributor to global warming, but more importantly they are the key to monitoring and mitigating its effects. ITU stressed that ICT is also part of the solution to climate change, and could help curb emissions approximately 15 to 40%. The Smart 2020 Study estimates that smart technology could reduce global emissions by 15%.

If ICT is directed to sustainable uses, it could yield an increase of energy efficiency in all areas of the economy while continuing to account for 40% of Europe's productivity growth.

Global energy demand is predicted to increase by 60% over the next 30 years. Without any action, the EU's energy consumption is expected to rise as much as 25% by 2012: a significant increase of EU emissions despite renewable energy targets. EU energy dependency could rise by as much as 50 to 70% by 2030.

Getting from the energy inefficient present to the energy-optimised future will be a major challenge. According to the IEA, 1000 b€ will be invested to deploy power networks by 2030 (an average of 45 b€ a year representing a Capex of 11% based on 400 b€ annual turnover of the power sector), 50% spent on generation, and another 50% on transmission and distribution. Utilities allocate 2% to 6% of their turnover for IT spending (average of 4% when investing intensively in market liberalisation and SmartGrids deployment representing an additional investment of 176 b€ by 2030 to reach 352 b€ of total ICT spending by 2030).

Energy generation and distribution uses one third of all primary energy. ICT could make electricity generation more efficient by 40% and its transport and distribution by 10%. In addition ICT could facilitate the integration of renewable energy sources as well as electric vehicles.

Dr Maher Chebbo

VP EMEA Utilities & Communications SAP;
EU SmartGrids Council

Miguel A. Sánchez Fornié

Director Iberdrola, Chair EUTC;
EU SmartGrids Council

3 Present **socio-economic drivers** and **challenges**

The power sector in the EU in 2007 has an annual turnover of about 400 b€, with growing energy consumption to almost the same level as EU GDP growth. As already mentioned in page 13, global energy demand is predicted to increase by 60% over the next 30 years and getting from the energy ineffi cient present to the energyoptimised future will be a major challenge.

Utilities allocate 2% to 6% of their turnover for IT spending, representing 8b€ in IT investment per year (2% of turnover) and 188b€ by 2030 (2% of turnover), an increase of 12b€ based on 6.7% CAGR compared to 2008.

The accelerated usage of ICT to improve energy effi ciency will require more aggressive ICT investments by 2030 for markets and regulations estimated at 40b€ (based on 200€ per connection) or 36b€ (based on 6% of turnover IT spending).

Figure 3

Source : SAP (2009)

According to IDC Energy Insights forecasts, total IT spending (hardware, services and software) for 2009 in Europe will be 12.5$US billion and will reach 15.6$US billion in 2012. During these 3 years CAGR will be 7.7%, slightly above the market average. Spending in the electricity sub-industry will be approximately 7.5 $US billion in 2009.

Source: JRC

Figure 5 shows the distribution of IT spending in 2009 across the segment of the utilities value chain. Distribution and retail representing 29% of total IT spending is due to customer focus and market communication following the opening of the market of July 2007.

ICT, if directed to sustainable uses, could increase energy efficiency in all areas of the economy while continuing to account for 40% of Europe's productivity growth.

The ICT sector at present accounts for 2% of global emissions (in the UK, ICT is responsible for up to 20% of carbon emissions generated by government offices). This is as much as civil aviation. The real gains from green ICT will come from developing energy efficient solutions that impact the other 98% of global emissions. ICT is a contributor to global warming, but more importantly is the key to monitoring and mitigating its effects. Since the Kyoto protocol was adopted in late 1997, the number of ICT users has tripled globally. ITU stressed that ICT is also part of the solution to climate change, and could help reduce emissions between 15% and 40%, depending on the methodologies used to derive these estimates.

The Smart 2020 study has estimated that Smart Technology could reduce global emissions by 15%.

Energy generation and distribution uses one third of all primary energy. Electricity generation could be made more efficient by 40% and its transport and distribution by 10%. ICT could make not only the management of power grids more efficient but also facilitate the integration of renewable energy sources.

In the near future new applications can be easily added into home and building automation to save energy. A bioclimatic house may provide energy savings up to 80% — 90% compared to a conventional building. VTT Technical Research Centre of Finland has, in collaboration with its European partners, launched a thee-year project to develop a platform which might make it possible to add energy saving applications into one's home "almost as simple as putting a sticker on a door". Heating, cooling and lighting of buildings account for more than 40% of European energy consumption. ICT could, provide consumer with real-time updates on their energy consumption to stimulate behavioural changes. In Finland smart metering encouraged consumers to increase energy efficiency by 7%.

According to the French regulator CRE, with the implementation of smart metering, they estimate an increase in supplier switch capability by factor of 10, decrease residential consumption by 5% and decrease CO_2 emissions by 5%.

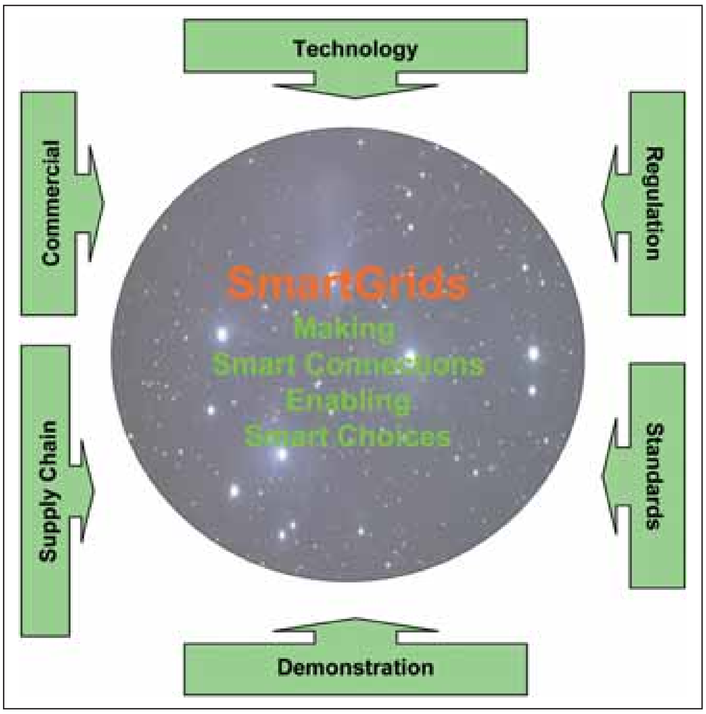


Figure 4 :

Key success factors for the European SmartGrids deployment

Source : SAP (2009)

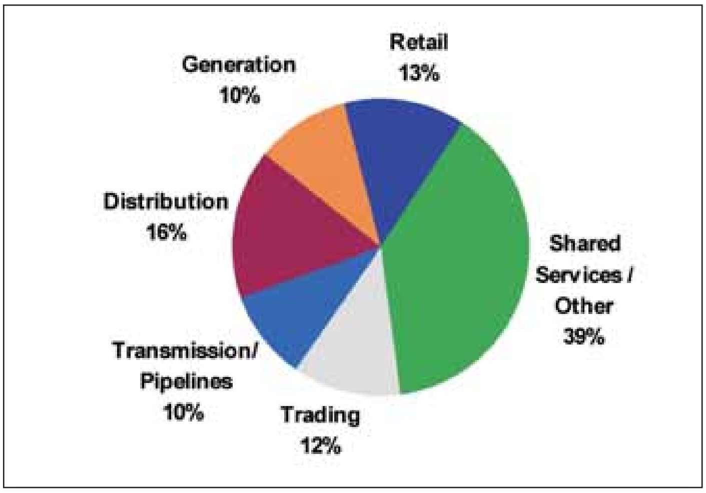


Figure 5 :

Total IT spendings in utilities 2009 by line of business.

Source: IDC Energy Insights, 2009

About 20% of world electricity is used for lighting. Changing to energy efficient light bulbs could halve today's energy consumption for lighting by 2025. Intelligent light bulbs, which automatically adjust to natural light and people's presence, will have an even greater effect.

Cities are considered a priority as they consume over 75% of the world's energy and produce 80% of its CO_2 emissions. Thus they should be treated with high priority.

U.S. Pacific Northwest National Laboratory teamed up with regional utilities and industry partners in the year-long demonstration project (112 homeowners who participated in the Olympic Peninsula project received new electric meters) that found advanced technologies that enable consumers to be active participants in improving power grid efficiency and reliability. The power use reduced 15% during key peak hours. In the future, a nationwide deployment would deliver important savings in building power plants and transmission lines. In addition, consumers saved on average approximately 10% on their electricity bills.

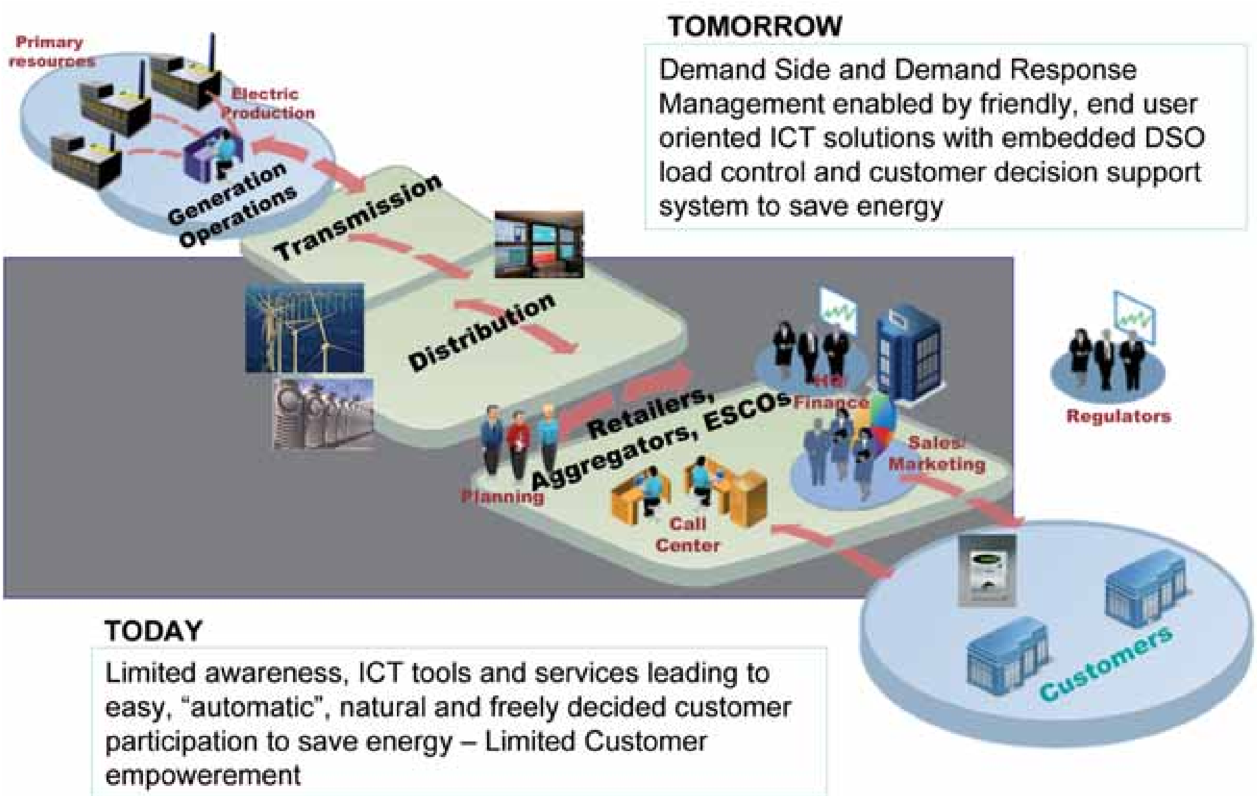
A combination of demand response and distributed generation reduced peak distribution loads by 50% over the long term. Over the duration of the study, participants who responded to real-time prices reduced peak power use by 15%.

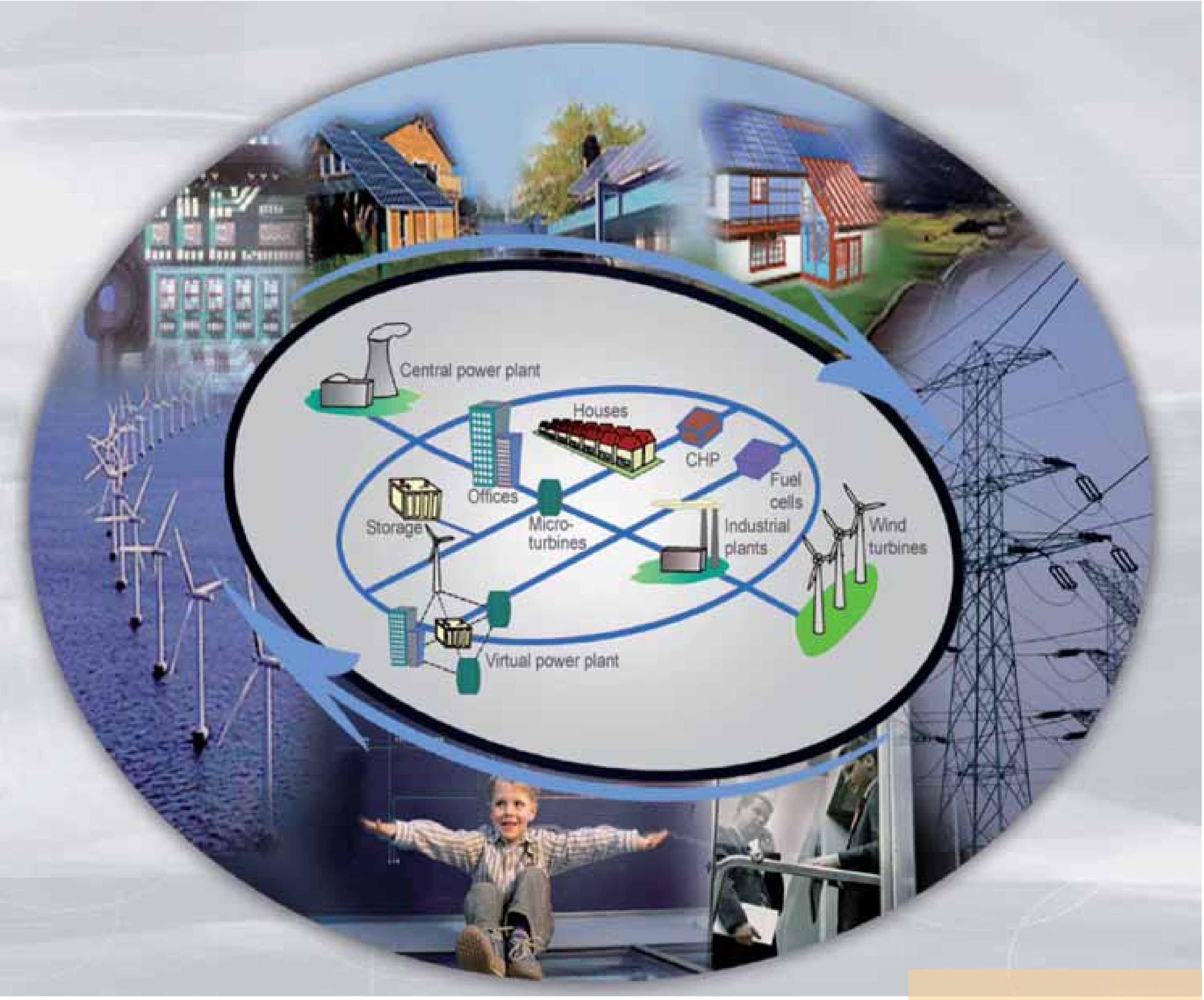
It is easier to save energy if one can monitor the consumption as accurately and quickly as possible.

Consumers need information that helps them to make more sensible use of energy. If we can save energy, we can see the benefit directly as lower energy bills. Moreover, we will slow down the climate change, according to the Finnish Environment Institute (SYKE) who launched HEAT (Household Energy Awareness Technologies), a joint project of a team of energy, environment and technology experts, which is developing a new method to measure electricity consumption and new user services for households that want to improve their energy efficiency.

Figure 6:

Today's gap and tomorrow's ICT investment in Demand Side Management.
Source : SAP (2009)





Source:SAP (2009)

According to Smart 2020 report, reducing T&D (technical and non technical) losses in India's power sector (SmartGrids like) by 30% is possible through better monitoring and management of electricity grids, first with smart meters and then by integrating more advanced ICT into the so-called energy internet. SmartGrid technologies were the largest opportunity found in the study and could globally reduce 2.03 $GtCO_2e$, worth $124.6 billion.

4 ICT for Smart Utility Processes

ICT for Smart metering operations

End to end integrated value added services from utilities to customers through smart metering

In Europe, system standards for meters are determined by a number of over-arching directives and industry specifications. Of particular importance, the Measuring Instruments Directive (MID, 2004[1]) aims to regulate metering products through harmony of technical standards based on the 'essential requirements', which cover areas such as accuracy, durability, and security. The directive will allow compliant goods to be awarded the 'CE marking', giving them free movement throughout the European Community. As far as smart meters are concerned, MID sets the baseline for required quality standards and regulations, but it does not mandate specific technologies or the functionality to be included within the meter.

The meter functionality and the related applications have a major impact on the cost of the meter and the communication infrastructure required to support large scale deployments.

Smart meters and AMI Systems provide a much higher level of precision with respect to the electricity/gas/heat/water consumption and in a timely manner. The collected information e.g. measurements is available in electronic form and can be either acquired by an external entity or forwarded by the meter itself to the energy company e.g. (Figure 7). This is expected to happen via a gateway at customer premises that will also feature a display for visualisation of data and/or be equipped with the necessary communication technologies to feed data into an onsite Energy Management System (EMS) that optimizes energy consumption on the premise.

The same data will be also fed to the energy company that will now have a complete overview on the consumption and behaviour/profiles of all connected customers. The exact frequency of information flow will depend on the needs and could be daily, hourly or even down to minutes. In any case data is acquired in real time and exchanged in a timely manner and in fine grained form (Figure 8).

Several benefits are foreseen. Providing the customers with real-time information on electricity prices or consumption advices, it is expected that the customer will adjust his consumption behaviour. This will be further reinforced by controlling the use of certain appliances at the customers site; provided that a Home Automation Network and electronic interfaces at the appliance allow for bidirectional communication access e.g. via the meter that connects wirelessly with the appliance or a gateway connected to the appliance. Partial management of the devices will provide the capability also to disconnect or partially reduce load at the customer premises depending on the needs in the grid.

According to the Commission de Regulation de l'Energie[2]. The competition will improve through more competitive tariffs. Supplier switching where smart metering is deployed (50% instead of 5% without smart

1 Measuring Instruments Directive (2004/22/EC), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0022:EN:NOT

2 http://www.cre.fr

Figure 7:

Customer energy consumption optimization using advanced technologies such as smart metering, sensing, energy controlling, Grid friendly appliances and portal load benchmarks.
Source : SAP (2009)

meters) is expected. Decrease of non technical losses i.e. non technical losses avoided is estimated to be 50% instead of 2.5% without smart meters.

An up to 5% decrease of residential consumption is expected. Peak shaving will result in avoiding unnecessary investments, avoiding use of non optimal resources and decrease CO_2 emissions from 0.5% (without smart meters) to 5% (with smart meters)

The UK Government BERR report (Impact Assessment of Smart Metering Roll Out for Domestic and Small Businesses, April 2008[3]) indicates smart metering solutions can provide further benefits e.g. : via accurate billing of customers for energy used, improved energy network management allowing better informed investment decisions, facilitation of wider policy goals such as policy on energy efficiency measures, improved customer services and reducing complaints and reduction in costs of pre-payment meters.

For residential and small businesses, the benefit from radical reform would lead to 3.4% in energy/capacity savings and 1% carbon savings (British Gas cost benefit — undertaken for British Gas by Frontier Economics).

The Market Based Demand Response Project[4] (2005-2008) performed by SINTEF Energy Research with the Norwegian TSO (Statnett) as a responsible partner, demonstrated that customers with the new power product reduced their consumption by 24.5% in Q1 of 2006, while customers with spot price power products and standard power products increased their consumption by 10.4% and 7.7% respectively in the same period.

The SmartHouse/SmartGrid project[5] led by SAP and co-financed by the European Commission sets out to validate and test how Information Communication Technology (ICT) enabled collaborative technical-commercial aggregations of Smart Houses provide an essential step to achieve the needed radically higher levels of sustainability and energy efficiency in Europe.

It develops a holistic concept for smart houses situated and intelligently managed within their broader environment. Intelligent networked ICT for collaborative technical-commercial aggregations enables Smart Houses to communicate, interact and negotiate with both customers and energy devices in the local energy grid so as to achieve maximum overall energy efficiency as a whole.

The project will also define a roadmap to mass application adoption. Only by considering the aggregated network level of smart houses managed by intelligent networked ICT for scale and flexibility, one is able to achieve the quantum leap in energy efficiency and sustainability that the EU's "20% by 2020" objectives call for.

3 http://www.berr.gov.uk/files/file45794.pdf

4 http://www.sintef.no/Home/Petroleum-and-Energy/SINTEF-Energy-Research/Project-work/Market-Based-Demand-Response/

5 http://www.smarthouse-smartgrid.eu

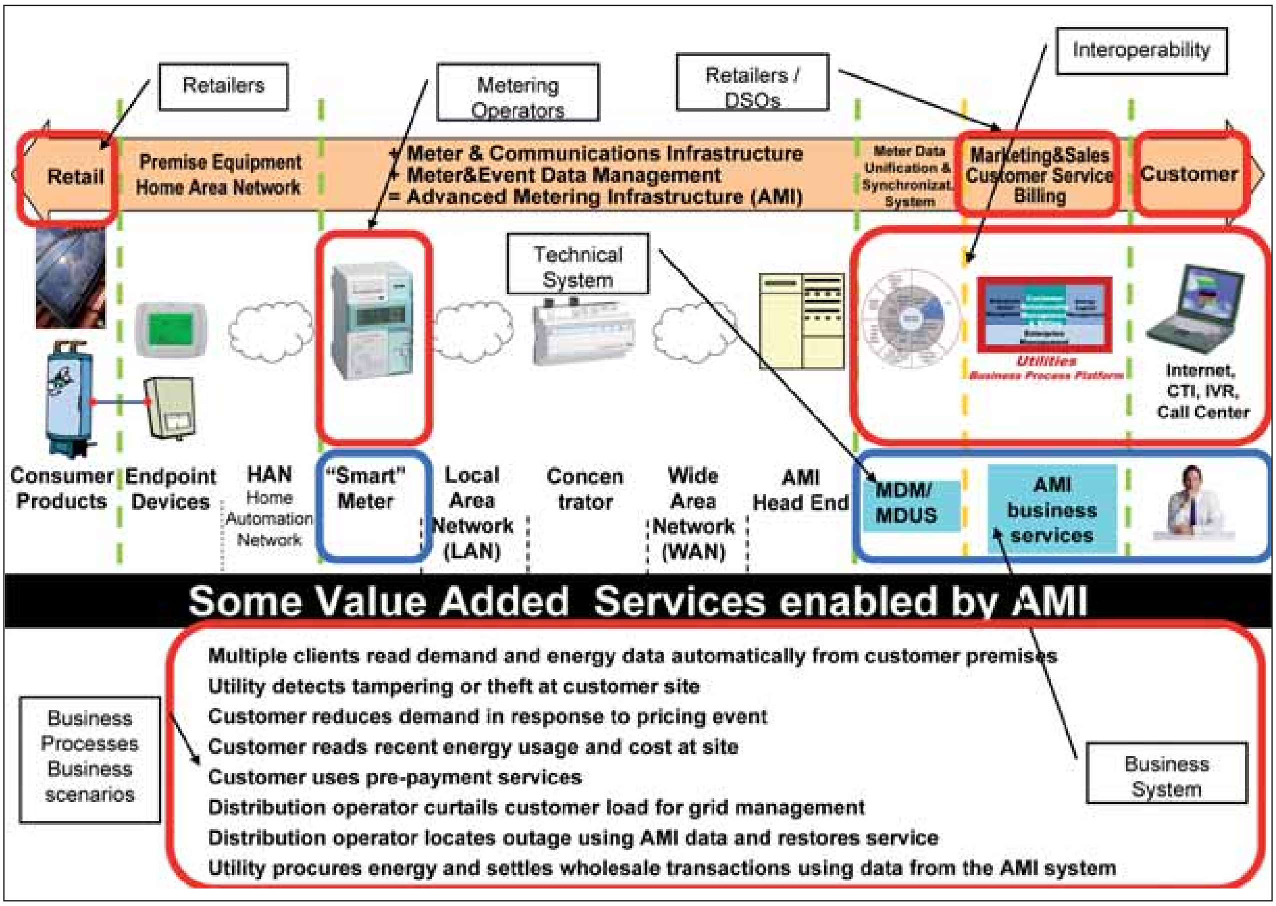


Figure 8:

End to End integrated value added services delivered by Utilities to end customers through smart metering.
Source : SAP (2009)

RECOMMENDATIONS

There are many business cases available, per utility or metering operator. What is missing is a **European typical business case** for smart metering that could be a benchmark of a significant number of business cases focusing on "energy savings achieved due to the large deployment of smart meters in Europe". Real-world deployment evaluations and analysis are needed and these related to key indicators for mass-market acceptance.

Regulation: "We cannot manage what we cannot frequently measure": A decision for mandatory Time of Use metering and billing (calculated by IT systems) by the regulating authorities is needed.

Research: Demand side and demand response management research algorithms combined with AMI taking into account the majority of countries and cases in EU member states for residential and commercial/ industrial customers.

Multi-disciplinary Value Added Services (including Multi-media) benefiting from the technology deployment of smart meters.

Development: of advanced standard AMI scenarios (for instance pre-payment and multi-metering energy saving decision support) that communicate and integrated seamlessly in the end-to-end value chain.

Go-to-market: Large scale deployment of end-to-end AMI solution across EU member states with a dynamic scenario leading to 100% smart metering deployment by 2020.

Interoperability of smart metering solutions

While many energy network operators are interested in deploying ICT primarily for operational cost savings, they also try to ensure that they capture the full potential of the strategic and regulatory benefits in order to cover the cost of this technology. Technology advancements and the availability of infrastructure features at lower prices create opportunities for expanded deployment, value-added services and potential new revenue streams for stakeholders such as network operators, suppliers, value added service providers and consumers.

In order to offer open, flexible and future oriented metering solutions, new integration standards for components of the ICT infrastructure to ensure interoperability among these components have to be developed. The large scale adoption of smart metering solutions, potentially covering electricity, gas and any other network service and commodity, is today hampered by the lack of widely accepted open standards, capable of guaranteeing the interoperability of systems and devices in the metering systems produced by different manufacturers.

BENEFITS

Interoperability will create new opportunities and reduce cost in the IT infrastructure that enables the applications that finally will lead to energy savings. Data available about AMI communication standards can be found on DLMS User Association[6], Energy business Information eXchange[7], IEC TC57[8], BDEW/MUC[9], ENBIN NTA8130 and DSMR[10].

RECOMMENDATIONS

Interoperability standards between metering suppliers to facilitate supplier switch and the quick deployment of smart meters across EU Member States must be considered and evaluated. The relation between metering solutions must be investigated as well as the possible gaps such as interfaces where no standards or initiatives yet exist.

It is very important that all stakeholders involved in the standards participate in this harmonisation activity. The EC call "ENERGY.2008.7.1.1: Open-access Standard for Smart Multi-Metering Services" is a first step, but the projects resulting from that call must still result in unique international solutions and furthermore the scope of standardisation should be wider than Smart Multi-Metering systems.

A European harmonisation effort should be initiated to come to unique international standards to solve the interoperability problem. In this effort major players in the utility industry, the IT manufacturers and research/test institutes will work together on these standards.

The work already undertaken on standards and interoperability has to be disseminated and its applicability in the energy domain via real world cases.

ICT for Smart metering communications

Smart metering communication brings its own challenges in the effort to provide cost effective, reliable and secure services to millions of premises within a country or region. Europe has been successful in promoting competition in the telecommunications sector which has resulted in numerous competing telecommunications operators and equipment vendors offering an increasing range of fixed and mobile technologies and services. The same needs to be applied for the SmartGrids and the smart metering.

Smart metering will involve the routine collection of usage and system data from individual customer homes. Solutions will need to consider the cost and benefits of using specific technologies and third party networks for each part of the communications path.

It is clear from the many smart metering trials that are taking place around the world[11] that there is no single technology or service mechanism that can deliver large scale implementation of smart metering. Most probably there will be a mixture of technologies, approaches and models involved.

Key technologies include Internet based technologies e.g. the Internet Protocol (IP) based services through public service broadband access, power line communication (PLC) for direct access to the electricity meter, wireless technologies e.g. GSM/GPRS, 3G and beyond, optical fibre in enabling increased broadband capability and providing wide area networking etc. At customer premises WiFi, Bluetooth, Zigbee, Homeplug etc. will be providing connectivity for control of appliances and connection to gas and water meters

There are several key influential factors for future communication solutions. The level of telecommunications competition in the region of implementation is important since effective competition increases choice and reduces prices. The roll out mechanism for the smart metering solution and the functionality requirements of the meter are key since more complexity in the application means higher bandwidth communications. The ability to have future compatible communication technologies is important for the smart meter business case as it is built with a long term view in mind (10 – 15 years) whilst communication technologies are changing very rapidly and may have a much shorter lifecycle.

6 http://www.dlms.com
7 http://www.ebix.org
8 http:// www.iec.ch
9 http://www.m-u-c.org
10 http://www.energiened.nl

11 http://tinyurl.com/ami-worldwide

BENEFITS

The communication solution used in any large scale implementation of smart metering should be transparent with respect to the metering data or any value added services. By addressing the recommendations outlined above it will be possible to drive 'best value' in the development of a business case and allow introduction of 'best practices' for the communication technologies to be used for any specific implementation. Such actions will speed up the introduction of smart metering and the subsequent energy and environmental benefits whilst ensuring that solutions can be open enough to accommodate future developments and continue to deliver value across the lifetime of the metering assets.

RECOMMENDATIONS

A research and regulation initiative should focus on the cooperation between the utility and telecommunication sectors in order to make mutual use of all available communication capabilities for TV, radio, Internet, telephone and smart metering solutions.

It is recommended an investigation of the general cost savings and specific energy savings by sharing multi-purpose communication networks among several content providers (service bundling). For the energy industry for example, the benefits of avoiding specific utility smart metering solutions for wireless (e.g. GPRS) or wired (e.g. PLC) by making use of a publicly available infrastructure should be identified.

Work should be instigated in developing common open standard physical and electrical interfaces in the energy meter to enable the use of any telecommunication technology. The meter has a long asset life compared to the shorter service life of communication technologies and should be capable of taking advantage of any future technical solution.

Interoperability standards between metering suppliers should facilitate supplier switch and the quick deployment of smart meters across EU member states must be considered and evaluated. Interoperability will help billing, commercial and asset management systems being independent of metering suppliers and will help investments to focus on the development of value added services rather than duplication of effort due to proprietary "fat" metering systems.

ICT for Demand Side Management

Evidence in support of the use of ICT comes from the research project run by GridWise[12] in the Olympic Peninsula project, USA. The project ran during 2007 and the results were published in January 2008. GridWise is an organization sponsored by the US Department of Energy (DoE). It is developing a number of trials and research projects to test technologies and the applicability of products, services and processes in support of SmartGrid. The Olympic Peninsula project ran for 12 months and investigated the impact of 5 minute energy price signals combined with smart in-home appliances, "intelligent agents" and network operations in 112 residential energy homes.

Some of the results from the project include a 15% peak demand reduction over a 12-month period, 50% peak reduction over "significant" periods, and technology integration proof.

RECOMMENDATIONS

Investment needs to be made for ICT, research and development and focus should be given to open standards for interoperability across multiple platforms and device types.

ICT for targeted contracts, tariffs and offers

The Ontario Time of Use tariffs (ToU) trials, Canada 2006/07 project trialed Interval Metering with ToU tariffs with 375 residential customers. The objective was to investigate the impact of variable energy rates throughout the day on energy consumption. This included the definition of critical peak periods. The results demonstrated 6% average energy conservation effect and critical peak load shifting (summer) 5.7% — 25.4% (indicative).

12 http://gridwise.pnl.gov/docs/op_project_final_report_pnnl17167.pdf

RECOMMENDATIONS

With smart meters now being installed in many European countries the use of ToU tariffs on a large scale should be investigated.[13]

ICT for portfolio management, forecasting and balancing

Source: JRC

Applications for portfolio management, forecasting and balancing do not contribute directly to the reduction of energy consumption and CO_2, but they are seen as some of the basic infrastructure tools for the management of SmartGrids and a liberalised energy market. Therefore they act as enablers for SmartGrids.

With the deployment of SmartGrids energy data management will have to cope with a tremendous growth of data communication, data storage and (new) processing.

Some examples for the growth of data and communication:

At a German DSO (about 3.5 mio metering points of electricity, about 10% supplied by external retailers) the amount of datastorage for market communication today is approximately 2 terabytes per year, with up to 50.000 communication processes in peak per day. This amount will rise times 5-10 only due to unbundling legislation (process identity) not even considering the growth due to smart metering. The above figures comprise the processes of supplier switching, grid usuage billing, meterdata and masterdata exchange.

The overall datavolume for metering will rise in maximum up to the factor 100 by the future use of time series data from smart meters instead of yearly measurements for residential customers (depending on the used time interval). This is due to the fact that e.g. DR-programmes, DSM as a way to reduce balancing power, customer individual products etc. in a net of highly volatile generation can not be handled any longer with only a few standard profiles as it is the case today. (The factor is derived from the ratio 1:100 for industrial to residential customers in terms of numbers).

A finding from Gardner Group for energy data management in the future: "SmartGrid will be the largest increase in data any utility has ever seen; the preliminary estimate at one utility is that the SmartGrid will generate 22 gigabytes of data each day from their 2 million customers. Just collecting the data is useless — knowing tomorrow what happened yesterday on the grid does not help operations. Data management has to start at the initial reception of the data, reviewing it for events that should trigger alarms into outage management systems and other real-time systems, then and only then, should normal data processing start. Storing over 11 gigabytes a day per million customers is not typically useful, so a data storage and roll off plan is going to be critical to managing the flood of data. Most utilities are not ready to handle this volume of data. For a utility with 5 million customers, they will have more data from their distribution grid, than Wal-Mart gets from all of their stores and Wal-Mart manages the world's largest data warehouse."

Example requirements energy data management will have to face with smart distribution networks:

13 http://www.oeb.gov.on.ca/documents/cases/EB-2004-0205/smartpricepilot/OSPP%20Final%20Report%20-%20Final070726.pdf

Source: JRC

Portfolio management in the future has not only to take care of midterm and longterm requirements but has also to consider short term (at least day ahead) prognosis due to the high volatile generation of Renewable Energy Sources (RES) especially windenergy and photovoltaic (PV) to adjust their scheduling (also considering weather prognosis).

EDM-systems have to visualize the possibilities for load shedding or the possibilities for microstorage to reduce the amount of balancing energy. This has to be done in a regional context and also has to consider commercial/contractual data.

The potential for load shedding today (Germany) is rarely used and not transparent. There is a very costly prequalifying process in place.

The potential in Germany in the chemical, paper and metal-industry is 2 Gigawatt (GW); in other industries 1,5 GW (cold storage, food, retail, household…). There is only one virtual balancing energy power plant in place so far: Saar Energie AG.

In terms of virtual power plants (generation and balancing energy) and virtual storage facilities (microstorage) there are a lot of requirements for data communication and aggregation and also the relation to commercial/contractual data. This includes requirements for logical and technical communication standards, as well as a common datamodel and a common understanding of the relevant (interoperable) business processes.

The requirements for the use of EDM for forecasting rise due to the high volatility of esp. wind-, PV- and microCHP-energy. To improve forecasting also the weather forecasting has to be involved.

As an example there is already a statistical online-model (based on 111 representative wind-parks in Germany) from ISET/Kassel in place that supports the TSO's in Germany with realtime data on windenergy.

With Plug-in hybrid electrical vehicles (PHEV) there are also a lot of new requirements for balancing and forecasting with a regional impact.

In the meantime there are several studies and pilot projects in place that to a certain extent cover individual ICT requirements related to energy data management e.g. SmartGrids, SmartGrids/SmartHouse, eEnergy and the 6 model-region-projects, CRISP, microgrids, BUSMOD, EU-Deep, Fenix and smart2020.

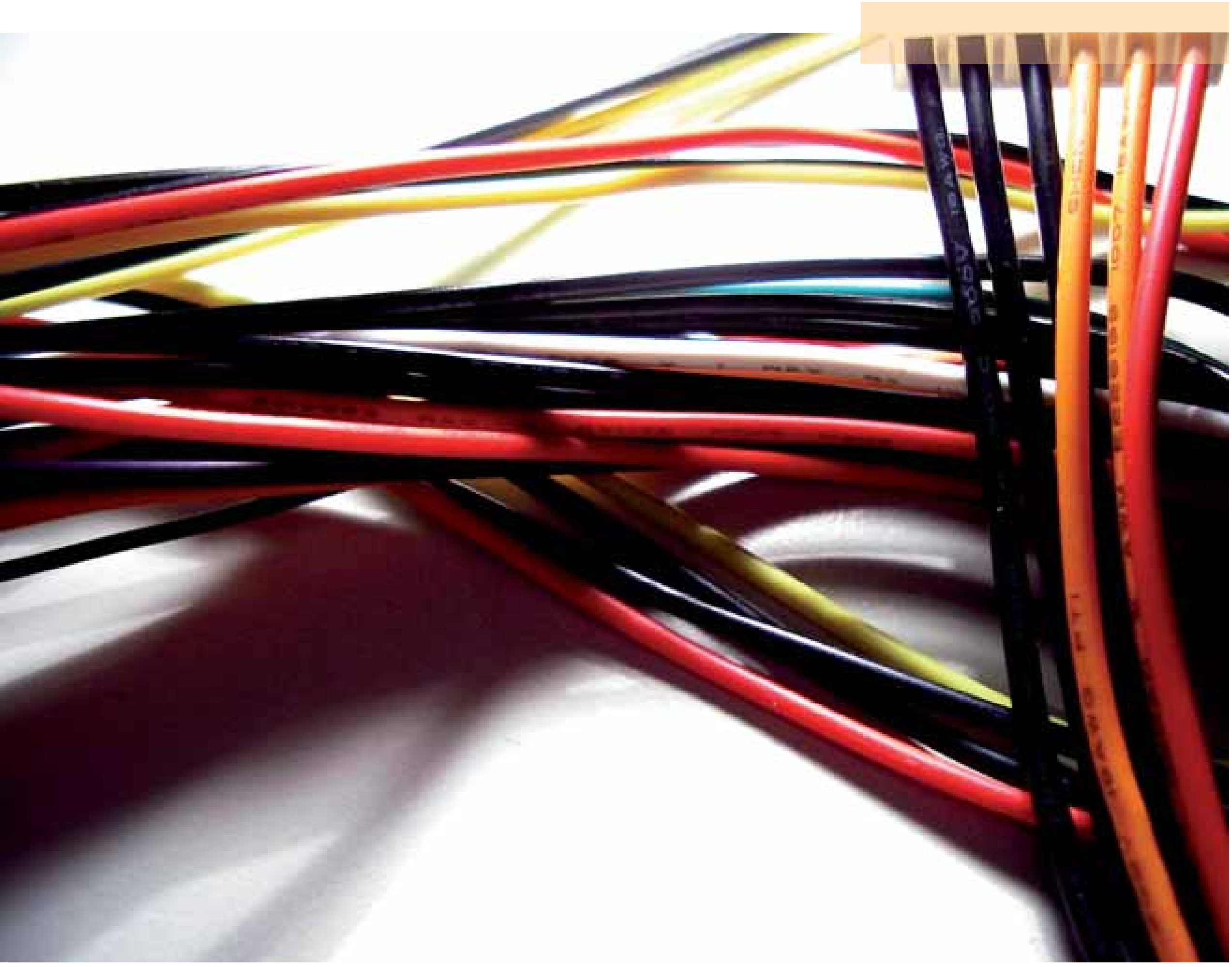
But there is no comprehensive view of the overall requirements related to energy data management topics to show the software vendors the roadmap to follow.

RECOMMENDATIONS

So the suggestion is to do an additional study to collect all these requirements from existing studies/thematic networks and to complete it with new requirements to set up a model and roadmap for portfolio management, EDM/balancing and forecasting in terms of:

- market model (roles, participiants and their relations, relevant business processes)
- communication model (technical and organisational)
- interoperability
- future IT-storage capacities, communication volume and processing power
- functional requirements
- system integration (to reduce interfaces, guarantee consistency and also to integrate commercial/contractual data)
- data model
- required (additional or harmonised) standardisation and regulation
- data aggregation and data lifecycle.

Source: JRC



5 ICT for Smart Energy Consumption

ICT for Small User Behaviour Management

Evidence in support of use of ICT for small and medium user behaviour management comes from the IBM Research report — Plugging in the Consumer (2007). This includes a survey of 1894 energy consuming households from six countries: Germany, the Netherlands, the UK, USA, Japan, and Australia.

The results include a number of points relevant to SmartGrid and the future use of energy.

- There is growing demand for security of supply (energy always available).
- Energy consumers are moving toward a more participative model for energy consumption (import and export).
- Price and environment are the main factors in changing consumption patterns.
- 62% of respondents would like to generate their own power if they could sell it back to the grid.
- 57% would like to generate their own power if it resulted in cost reductions of 50% — this drops to a 32% share if energy price difference is below 10%.

Recommendations

To invest in open, agreed standards for integration of devices across the value chain.

ICT for medium and large user behaviour management

Energy users can contribute to make distribution electricity grids smart by becoming "reactive" and participate to demand-response (DR) programmes, i.e. respond in real-time to grid conditions by shedding loads (lights, machines, air conditioning…) or start on-site generation in response to an emergency condition (reliability based DR or "contingency programmes") or to wholesale market conditions (market-based DR). Two types of DR exist: Price-based DR (Real-Time pricing (RTP), critical-peak pricing (CPP) and Time of Use Tariffs (ToU) and Incentive based DR (pay participating customers to reduce their loads).

Very large customers (industrial or commercial) have been participating in DR for 15-20 years. Response is typically "manual" and can only be afforded when resulted shed capacity is significant.

More recently, ICT has been developed to the point of allowing larger portions of the demand to function as an integrated system element, with technologies to automate the process of DR (detect the need for load shedding, communicate the demand to participating users, automate load shedding, and verify and measure compliance with DR programmes). More specifically, technologies "beyond the smart meter" that can support interactive customers include (Figure 9):

- **Energy management tools** to understand one's consumption patterns in substantial details, to support awareness capability to shift curtail usage, to enable load prioritisation schemes (non automated demand-response).

- **Integrated platforms for demand-response,** which integrates external environmental factors (pricing signals, weather data, curtailment requests, etc.) with electrical equipments in a facility (lighting system, HVAC system, machines, distributed generation, etc.). Typically, internet standards are required to connect to external data sources, while building automation and metering integration provide connectivity with electrical equipment within the premises. Intelligence — e.g. if/then rules — can be implemented on top of this platform to automate equipment reaction to external signals.

- **Intelligent equipment and appliances** that are designed once and manufactured ready to respond autonomously to DR signals. This model would be particularly suitable for appliances that are manufactured in high number and where significant economies of scales could be achieved.

DR benefits are well documented i.e. cost reduction (RTP programmes achieve load reductions equal to 12-33% of participants' peak demand; incorporating demand response into the US market with dynamic pricing would lead to $10 billion to $15 billion savings per year), electricity price reduction and reliability benefits.

Less data exists regarding the benefits of ICT-based tools to support DR. In RTP pilots, substancial fragments does not participate because they lack flexibility and technical expertise, and there is a tendency to forget about electricity prices, which support the case for energy management systems and automated DR.

Linking lighting and air conditioning systems to RTP achieved cost and demand reduction up to 42% during peak hours (Lawrence Berkeley Labs Pilot).

Integrated Demand-Response Platform for lighting in an industrial facility enabled 20-30% shedding during peak usage in some areas of the facility and 50% on second-shift and weekends without adversely affecting operations at all.

Technical feasibility of frequency responsive appliances (i.e. that adjust automatically when local measured grid frequency fell below a given threshold) has been established with residential customers (but should be applicable to commercial & industrial customers as well) with no inconvenience perceived by the customers.

RECOMMENDATIONS

To promote large scale pilot involving medium size industrial and commercial customers to fully demonstrate the benefits of DR.

Figure 9:

Web portals will be the fastest way to enable active consumer energy management

Source : Source Energy Insights predictions 2009 (Lixar SRS)

6 ICT for Grid Infrastructure Readiness

SmartGrid aims to increase the security of supply and reliability of the (European) electricity transmission, distribution systems and the competition of the retail market while contributing to favour investment in interconnections and cleaner energy technologies, effective internal market integration and competitiveness of the European electricity industry.

Present barriers to SmartGrid deployment are largely of regulatory nature as well as standardisation, which will ensure the requested interoperability. To a lesser extent these barriers are influenced by research and development issues and the lack of suitable demonstration pilot projects. Some pilot projects are on the table, but implementation has been fragmented and slowed. The main reasons are the current uncertainty regarding the new market models, the global investments and the technology needed.

ICT for Asset Management

The biggest force for changes since last century in the European electricity system has been the changing of economics of the power industry. Central power plants stopped being more efficient in the 1960s, bigger in the '70s, cheaper in the '80s, and almost ended their progress in the '90s when distributed generation was confirmed as an efficient solution. By that time they had become so reliable that nearly all power failures originated in the grid.

After the large electrification investments during the '60s and '70s, the European transmission network is rapidly ageing. It has been estimated that within the next 30 years more than 1000 b€ will need to be invested for the European power sector, of which more than 120 b€ should be dedicated to the transmission system and more that 413 b€ to the distribution sectors. Today a great majority of the population lies in the range of equipment age across the design technical end-of-life.

Managing an ageing system with increased requirements in terms of system response to perturbations, system flexibility and robustness is a challenge which cannot be effectively addressed without the extensive use of modern technologies, such as ICT.

ICT PROCESS AND TECHNOLOGY DESCRIPTION

The large improvements in management of the assets of transmission and distribution systems already rely on the wide use of ICT.

Telemeasures and telecontrol of voltages, currents, frequencies, active and reactive power, topology etc. are available, normally for high voltage networks, in central and local control centres for the online management of the system configuration. Very often these systems — based on SCADA technologies — are equipped with operation aid decision tools, such as state estimation, power flow calculation, static security analysis and simulation of emergencies, voltage stability analysis and calculation of collapse margins, power exchange capabilities calculations, congestion forecasts, voltage profiles optimisation, calculations of short circuit levels at substation and line levels, verification of protection settings and coordination etc.

Systems are also available for the data collection and analysis — often off-line — for the condition monitoring of main equipment and for the planning and control of condition assessment and maintenance operations.

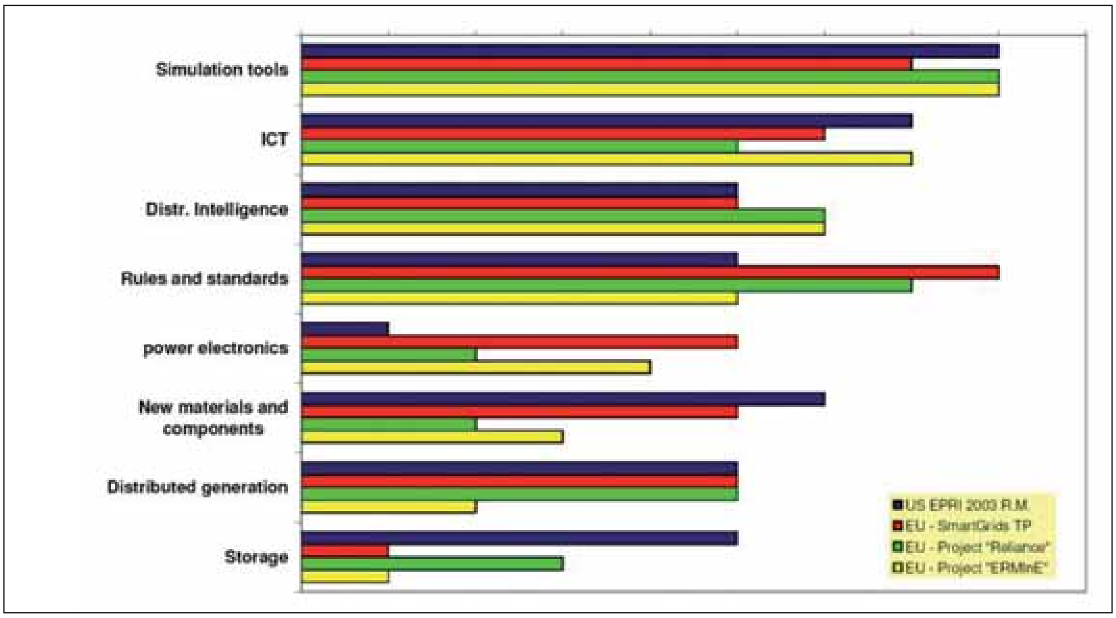


Figure 10: comparison of the roadmap for R&D priorities on transmission and distribution grids between severalinitiatives
Source: ERMInE

These are based on local sensors (e.g. oil temperature, gas pressure, leakage currents) that measure physical quantities called diagnostic indicators that can be related, by means of adequate ageing models, to the state of degradation of the components and which are used to trigger maintenance operations, possibly before any failure occurs.

CURRENT ICT PROJECTS FOR NETWORK AND ASSET MANAGEMENT

In cooperation with research centres, nearly all TSOs and DSOs worldwide are developing their own projects related to the use of ICT for the network and asset management, but with poor coordination and wider dispersion of resources.

Among the presently on-going most important projects, the following paragraphs describe a representative selection in some countries:

US–Initiatives: An open-standard based architecture is adopted for integrating the data communication networks and intelligent equipment needed to support the power delivery system of the future. This provides methods, tools, best practices and recommendations for specifying "intelligent" systems in such a way, as to promote interoperability, flexibility, effective security and data system management, expandability. Specific projects deal with e.g. integration of substation systems by means of the IEC 61850 protocol, set up of station monitoring systems (antenna array) to locate concentrated defects in the substation, use of low-cost distributed sensors for equipment monitoring and problem identification, etc. The extensive use of phase monitoring units to enhance the system visibility and to anticipate the effects of system disturbances as well as the development of monitoring systems for the automatic fault detection are also investigated.

JP–Initiatives: R&D initiatives in Japan are focusing on several topics e.g. collection and data sharing from substation on all voltage levels (EHV, HV, MV), adaptive protection, wide area protection & monitoring, and security assessment. Application of tools to minimise the transmission losses based on real time SCADA is also in the focus.

IN-Initiatives: the Indian initiatives for the enhancement of the HV network intelligence are focusing on the use of the PMU (Phasor Measurement Unit) technology. This includes the installation of PMUs in strategic locations and specification for a continuous up-to-date approach, use of PMUs to validate off-line power system models used at present, etc. The development of visualisation software for better visibility of the network and on-line disturbance monitoring, design and implementation tools for data storage, retrieval and analysis and enhancing of system observability and understanding are also investigated. Furthermore a development of remedial action scheme based on adaptive islanding, self-healing approach and improved protection is also part of the initiatives.

BR–initiatives: the Brazilian initiatives, in view of the implementation of a SmartGrid approach, are focusing on information management i.e. integration of databases, upgrading of EMS systems, etc.

Advanced protection and monitoring tools are developed i.e. adaptive protection by using logical functions, wide area protection, wide area monitoring with steady state and dynamic security assessment. Furthermore focus is also on systems for the on-line observability of the system state: detection of power swings and analysis of counter-measures, dynamic load flow control, stability observation, line utilisation increase and fault analysis.

European Initiatives: the recent European Coordination Action ERMInE (Electricity Research Road Map In Europe) has put great emphasis on the role of ICT on power grids. Figure 10 compares the roadmap for R&D priorities on transmission and distribution grids of ERMInE with the corresponding roadmaps of Reliance (Coordination Action of the European transmission network research activities); the SmartGrids European Technology Platform and finally the American EPRI (Electric Power Research Institute) 2003 (Source: ERMInE).

As it can be seen, most of the top-priority R&D subjects are directly or indirectly linked with ICT in all the roadmaps.

More specifically, the European Technology Platform SmartGrids has pointed out the top priorities for the transmission and distribution systems that are completely in line with the approach presented here; among them, the priorities which are more closely linked with the use of ICT are the following:

- real time condition monitoring
- flow control devices
- loss optimisation
- investment decision tools
- carbon-cost & asset management
- new protection principles
- cyber security protection

RECOMMENDATIONS

To promote coordination among the current research projects and to continue supporting research on ICT for Grid Assets Management.

ICT for Observability and Monitoring of the Distribution Network, Ageing Infrastructure and Outage Management

Use of ICT can be evidenced in monitoring and control in real time of the MV and LV networks as well as integration of new devices with existing SCADA, GIS, asset repositories, outage management, etc.

The networks which are mostly totally observed are the transmission ones. In distribution systems the status is quite different coming from the 100% in the high voltage parts up to a certain degree in medium voltage and almost nothing in low voltage. There is a vast field for improvement in observability in distribution networks

The implementation at DONG Energy, Denmark has undergone a benefits analysis in 2006. Design and implementation of the solution began in 2007 and initial functions are now live in parts of the Distribution network. Expected projections for the solution currently being implemented include 25%-50% reduction in Non Delivered Energy (NDE), 35% reduction in fault search time, up to 90% reduction in network reinforcement costs, improved operations (safe overloading), improved network planning, and improved customer service.

Non Delivered Energy (NDE) and Customer Minutes Lost (CML) are measurements of the availability of supply. CML is the average number of minutes that end customers were without energy supply over a 12 month period. NDE puts a value on the time that energy was not available to the customer base. That value is a combination of several factors, including CMLs and the value to the economy of the kWh not delivered. This can help show the value of SmartGrid to society and the European / National economy.

RECOMMENDATIONS

Open, agreed standards for integration of devices are needed. Enablement for investment across the value chain — this may require harmonisation of some regulatory frameworks (e.g. benefits realised by distribution and retail)[14].

ICT for Network Stability

Some possible developments expected at distribution system level may have a major impact on the network stability of the whole system. Active networks, micrograms, and virtual power plants may represent a possibility towards which today's distribution systems might evolve in presence of distributed generation. Also a hybrid combination of these might result. The scope of these developments is related to the need for ensuring adequate levels of reliability and security of supply in presence of increased DG penetration.

In all three system developments, modern control technologies may be very useful.

Particularly, soft controllers based on ICT and hard controllers based on power electronic devices like FACTS (Flexible AC Transmission System) can support the DSOs to control the system as this technology has

14 Additional information is available at ftp://ftp.software.ibm.com/software/solutions/pdfs/ODC03017-USEN-00.pdf

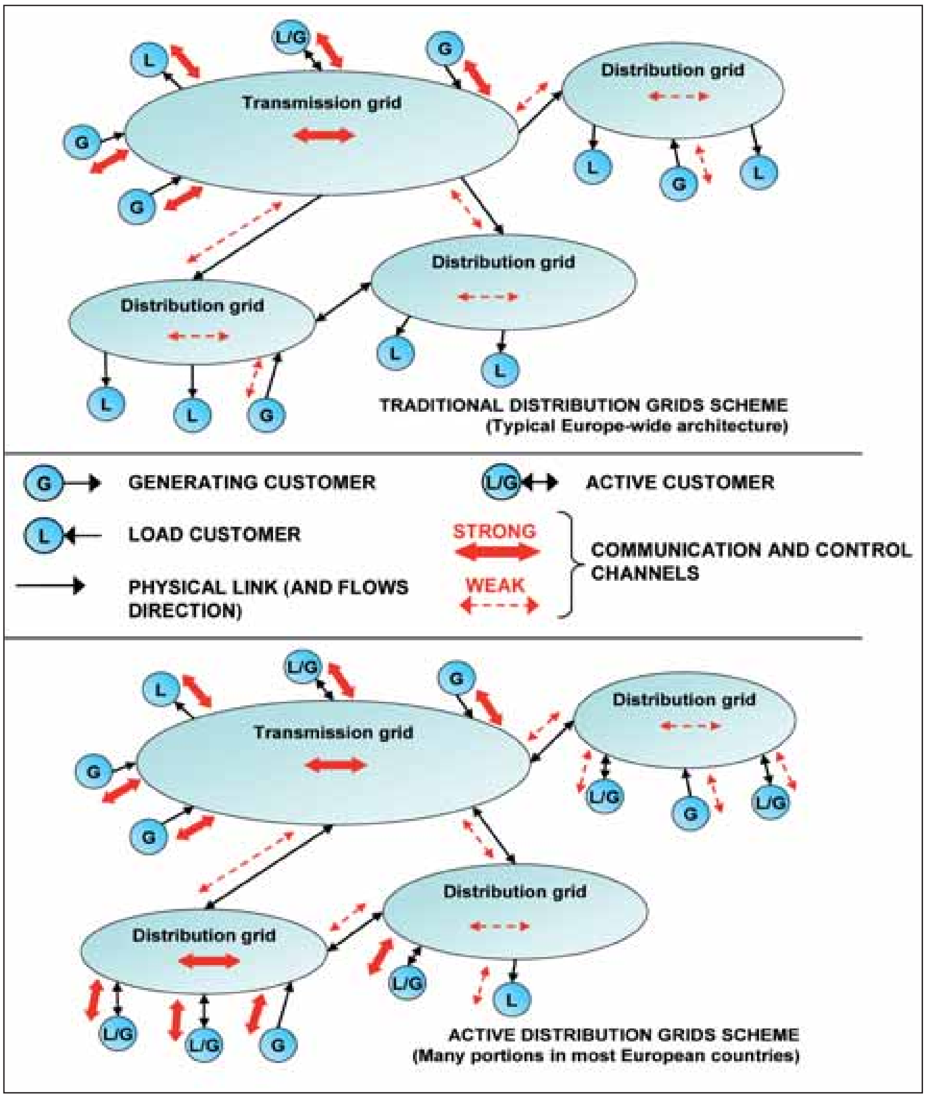


Figure 11:

Evolution of the distribution network towards a more meshed network.

Source: JRC

been proven helpful for TSOs. In distribution networks the soft controllers have a very promising use. Analytic tools which will react in real time isolating a part of the network may be very useful.

ICT can be used to improve the communication between a DSO and a TSO and provide the DSO with more advanced monitoring tools, like SCADA. Power electronics-based devices like FACTS are able to control electrical parameters like the real and reactive power flows and the voltage amplitude at network nodes in a very smooth, fast way. FACTS devices are proven technologies for a flexible transmission system control. At distribution level the equivalent devices are known as D-FACTS and may be useful for a better control of power flows, voltage level, power quality issues in distribution grids.

Other advanced network controllers are given by WAMS (Wide Area Measurement System). These technologies include software (ICT) and hardware PMU (Phasor Measurement Unit) tools. PMUs are devices able to remotely monitor phase voltages and currents and the corresponding angles at network nodes. Each phasor is measured and coupled with a very precise time stamp derived from a GPS (Global Positioning System) satellite. WAMS systems are already used to control transmission systems.

ICT for Active Networks

Active networks are foreseen as probable evolution of today's distribution networks. These systems, which are passive in a large portion, can evolve to be structured and operated similarly as the transmission systems, which are active managing bi-directional power flows. This change of the distribution design may be triggered by the connection of an increased amount of small generating units.

This evolution shall be accompanied by an upgrade of the protection schemes, along with the introduction of new software and hardware technologies for a more flexible system control. The distribution network (Figure 11) will then be more meshed (currently it has a radial structure or it is operated mainly as radial) and more controllable by means of ICT and power electronics-based devices.

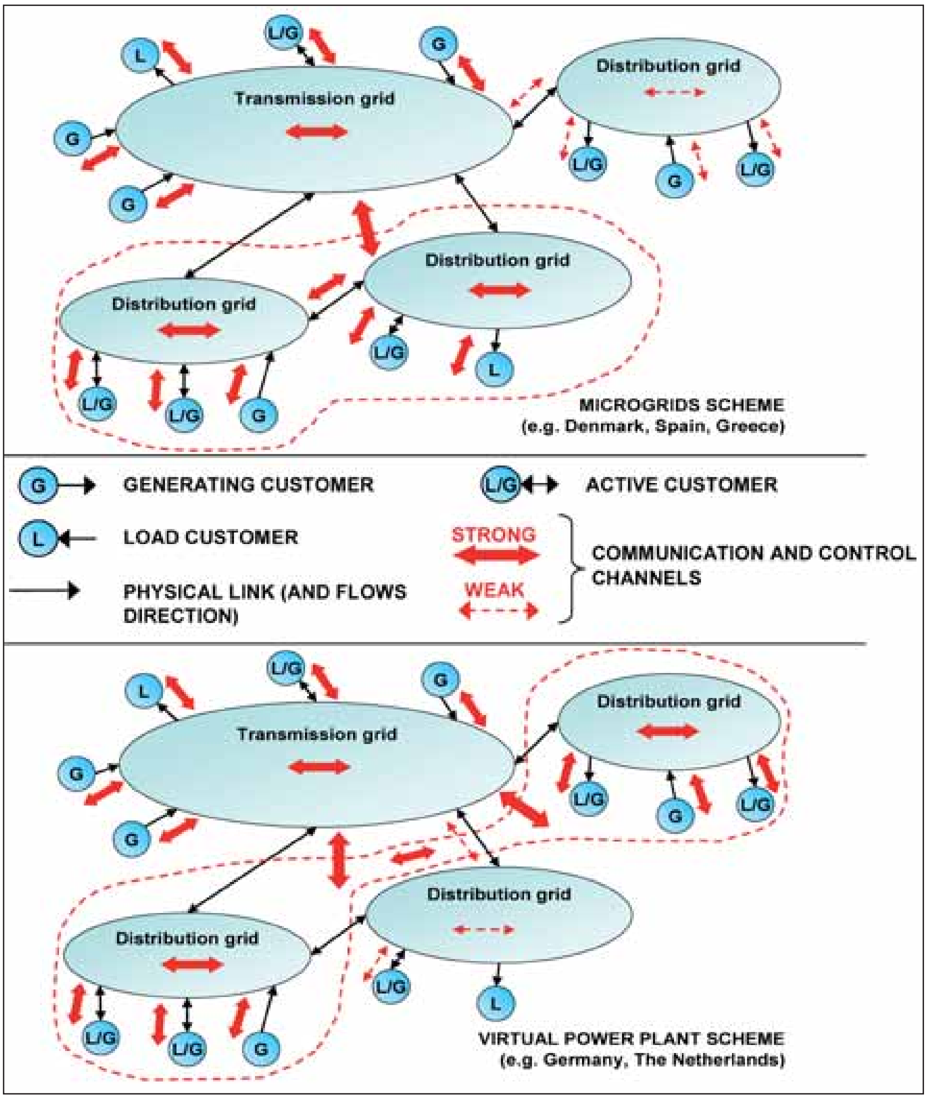


Figure 12:

Microgrids operating mostly connected to the distribution network with the capacity to be automatically transferred to islanded mode in case of faults in the upstream network.
Source: JRC

The active distribution network may then deliver power to users and/or transfer it to the transmission system as well. This first big transformation is already ongoing in some European countries, like Denmark.

ICT for Microgrids

The European Technology Platform SmartGrids defines microgrids as medium-low voltage networks with DG sources, together with local storage devices and controllable loads (e.g. water heaters and air conditioning). The main feature of microgrids is that, although they operate mostly connected to the distribution network, they can be automatically transferred to islanded mode in case of faults in the upstream network (Figure 12). After the fault has been resolved and the upstream network operation restored, they can be resynchronised to the rest of the system. Intentional islanding mechanisms can protect clusters of customers against power outages occurring on bordering and/or upstream networks. In case of disruptions affecting a nearby network, by disconnecting a microgrid (having sufficient generation and storage resources) from the faulted network, power supply to local customers can be maintained. Additionally, the islanding procedure could be implemented at a less sophisticated level, more simply allowing that a microgrid is able to 'black start' in case of a widespread system outage.

Pilot projects of microgrids are present in Greece, Germany, the Netherlands, Italy, Portugal, Spain, and in Denmark.

ICT for Virtual Power Plants

The Virtual Power Plant (VPP) is a decentralised energy management system tasked to aggregate different small generators either for the purpose of energy trading or to provide system support services. The VPP concept is not itself a new technology but a scheme to combine decentralised generation and storage and exploit the technical and economic synergies between system's components. This aggregation is not pursued by physically connecting the plants but by interlinking them via ICT applications. For this reason the result is a Virtual Power Plant, which may then be a multi-fuel, multi-location and multi-owned power station. A virtual power station balances required and available power in identified areas, based on off-line schedules for distributed energy sources, storage, demand side management capabilities and contractual power exchanges. For a grid operator or energy trader, buying energy or ancillary services from a VPP is equivalent to purchasing from a conventional station. Virtual power stations using DG, RES and energy storage can potentially and gradually replace conventional power stations.

Several European projects could be the basis for further ICT developments for efficient distribution networks:

The MICROGRIDS and MORE MICRO-GRIDS projects[15] comprise low-medium voltage distribution systems with distributed energy sources, storage devices and controllable loads, operated connected to the main power network or islanded, in a controlled and coordinated way.

Their main goal was to increase penetration of microgeneration in electrical networks through the exploitation and extension of the microgrids concept, involving the investigation of alternative microgenerator control strategies and alternative network designs, development of new tools for multi-microgrids management operation and standardisation of technical and commercial protocols.

Research in MICROGRIDS, focused on the operation of a single microgrid, and has successfully investigated appropriate control techniques and demonstrated the feasibility of microgrids operation through laboratory experiments.

The project MORE MICROGRIDS extends the work significantly with the investigation of new micro source, storage and load controllers to provide efficient operation of microgrids, development of alternative control strategies (centralised versus decentralised), and alternative network designs.

Other issues tackled include technical and commercial integration of multi-microgrids, field trials of alternative control and management strategies, standardisation of technical and commercial protocols and hardware. The impact on power system operation and on the development of electricity network infrastructures was also in focus.

The project DISPOWER[16] has significantly contributed to the further development of technology as well as to the European exchange of experience in the field of integrating small and distributed generators into the electricity distribution grid. The central question was how technology has to be developed so that the growing number of decentralised energy resources can be further integrated into the European future electricity grids, without losing reliability, safety and quality.

DISPOWER has developed new methodologies, components and tools for planning, operational control, training, forecast and trading for the reliable and cost-effective integration of distributed generation and renewable energies. Laboratory facilities have been setup for developing, testing and demonstrating new operational control strategies and DER components in an expected system environment of different low voltage and medium voltage distribution grids with high DER penetration levels.

Several DISPOWER developments have already been implemented into existing market products and some other are currently being further developed for an improved integration of distributed generation technologies in different European power supply zones.

Main results include strategies and concepts for grid stability and system control in DG networks, preparation of safety and quality standards, investigations on power quality improvements and requirements as well as development of management systems for local grids with high penetration of DG units.

Furthermore assessment of impact to consumers by ICTs, energy trading and load management, planning tools to insure reliable and cost effective integration of DG components in regional and local grids, Internet based systems for communication, energy management and trading and investigations on contract and tariff issues regarding energy trading and wheeling and ancillary services were realised.

Improvement and adaptation of test facilities, experiments for further development of DG components, control systems and design tools were done during the project's lifetime.

The CRISP project[17] aimed to investigate, develop and test how latest advanced intelligence by ICT technologies could be exploited in a novel way for cost-effective, fine-grained and reliable monitoring, management and control of power networks that have a high degree of Distributed Generation and RES penetration.

15 http://microgrids.power.ece.ntua.gr/micro/default.php

16 http://www.dispower.org

17 http://www.ecn.nl/crisp/index.html

Source: JRC

The opportunities for interactive power networks to create new possible control mechanisms that create flexibility and self-managing networks were investigated. Normal and emergency operations were also investigated covering different time scales. Insight in performance, security and architecture of highly distributed systems were successfully analysed. Technical availability, functionality and economic cost-benefit considerations were integrated in tests under real conditions.

Some of the main results include the design and testing of new operating strategies for distributed power generation enabled by recent advances in ICT technologies for distributed intelligence. Focus was also on practical scenarios for supply-demand matching, intelligent load shedding, fault detection and diagnostics and network security.

The main objective of FENIX[18] project was to conceptualise, design and demonstrate that Virtual Power Plant architectures would enable Distributed Energy Resources (DER) -based systems to become the solution for the future cost efficient, secure and sustainable EU electricity supply system.

Main results include enabling distributed energy resources to make the EU electricity supply system cost-efficient, secure and sustainable through aggregation into Large Scale Virtual Power Plants (LSVPP), development of intelligent interfaces for commercial and grid integration of DER into LSVPP, development of novel network services and new DMS and EMS applications to include LSVPP in system operation, development of new commercial and regulatory solutions to support LSVPP.

Concepts were validated through two large field tests in Spain and UK. Interaction with stakeholders was done through an advisory group.

The subject of the IRED-CLUSTER[19] co-ordination action (CA) was to extend the existing cluster activities in such a way that a real European added value could be obtained by mobilising research as a major contribution to the European research area.

The most important elements of activities include a systematic exchange of information and good practice by improving links to relevant research, to regulatory bodies and to policies and schemes on European, national, regional and international levels, the set-up of strategic actions such as transnational co-operation, the organisation and co-ordination of common initiatives on standards, testing procedures and the establishment of common education and training and the identification of highest priority research topics in the field of integration of RES and DG and formation of appropriate realisation schemes.

18 http://www.fenix-project.org

19 http://www.ired-cluster.org

RECOMMENDATIONS:

To continue the support for RTD project and its coordination. To foster large scale pilot to connect DG and RES to the Grid before 2020.

ICT for network losses (technical and non technical)

Technical losses are an inevitable consequence of the science of distributing electricity and of transforming from one voltage to another.

In an environment where any form of inefficiency in the energy cycle may be seen as highly undesirable (e.g. in terms of 'carbon footprint') it is important to remember that with technical losses typically in the range of 5%, this represents an overall 'machine' efficiency of 95% which compares extremely favourably with most other energy conversion / distribution processes. A single improvement of it will have important economical consequences. If load factor at LV could be improved (i.e. increased) by smoothing the load profile, there would be benefits in terms of reducing variable losses, improving voltage regulation, and also in terms of creating additional capacity headroom.

BENEFITS AND IMPORTANCE OF MINIMISING LOSSES

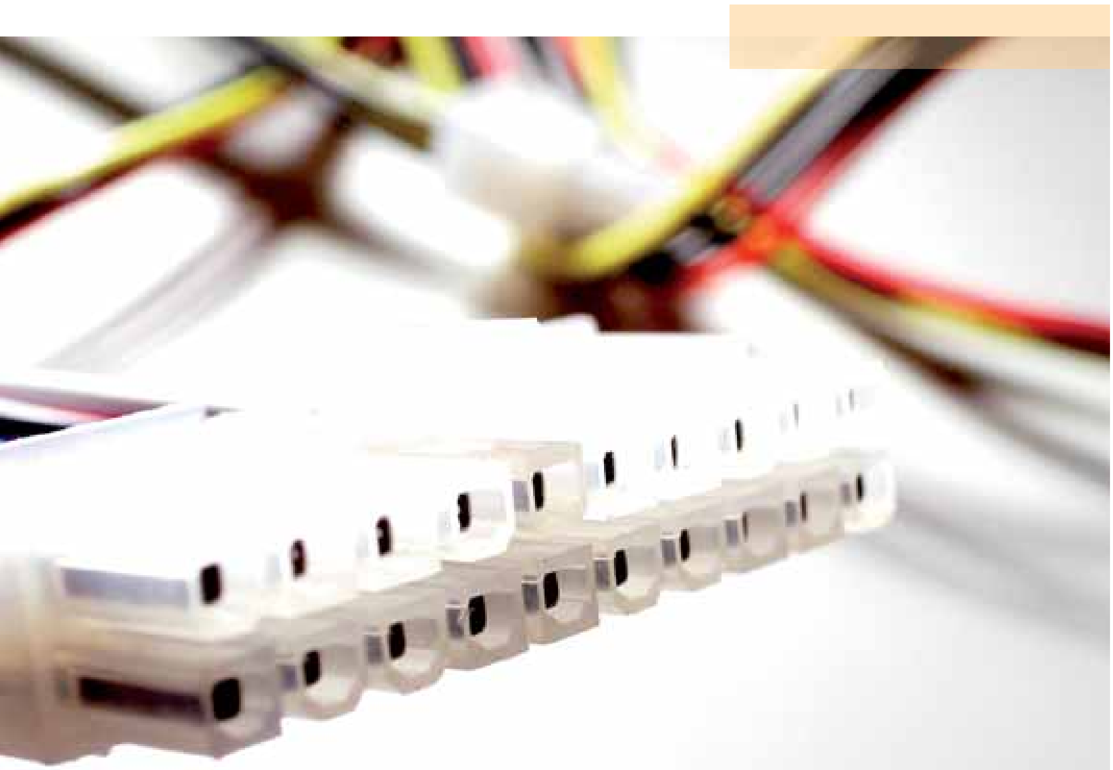
It has long been recognised that minimising distribution network technical losses is integral to good distribution engineering practice. Minimising losses has the following utility and wider societal benefits as e.g. it maximises the available capacity of plant and equipment to deliver useful energy (i.e. rather than supplying losses). By the same token, minimising losses also minimises the amount of generation required purely to supply network losses (technical and non-technical losses). Other benefits include demonstrating to utilities customers and society generally that utilities are managing their carbon footprint and maximising revenue-earning opportunities arising from the regulatory incentive if any.

RECOMMENDATIONS

Network owners and operators are in a position to initiate the transition towards SmartGrid and will be responsible for most of the investments. This requires the support of regulators to provide incentives and security for the investments. Public-private partnerships (PPP) could be the first steps. Coordinated pilot projects at European-scale could facilitate this deployment.

Regarding the coordination needs between the transmission and distribution systems, which have to efficiently and safely work together, both systems need to be further developed, not necessarily only in terms of carrying capacity but also and mostly in terms of ICT infrastructure and communication platforms. In particular, the transmission system strongly needs clear interfaces with the downstream distributed system.

Source: JRC



7 ICT for Breakthrough Industry Transformation

The breakthrough technology considered is related to electric cars and their usage not only for transportation purpose but also to provide significant energy storage and other ancillary services.

Energy Storage in Electric Cars — Plug-in Hybrid Electric Vehicles (PHEV)

Plug-in hybrid electric vehicles (PHEVs) combine today's hybrid automotive technology with large battery systems that can be recharged from the electrical grid. Plug-in hybrid, as well as pure electric vehicles (EV) offer both an opportunity and a challenge to the electric power system, as they could provide a significant energy storage. Currently, electricity cannot be stored, so off-peak periods, for example in night hours, are wasted. PHEVs could be the answer, as batteries are recharged in the evening during off-peak periods. They could power the electrical grid in times of high demand or, more likely, could function as reserve or other ancillary services — a concept commonly referred to as vehicle to grid (V2G). Should PHEVs be deployed on a broad scale for V2G applications, the impact on the electric power system (particularly the distribution system) would be significant.

Transportation accounts approximately for two-third of global oil demand and this section is 95% reliant on oil. PHEV/EV can also be part of an effective strategy to face climate change.

IDC Energy Insights expects that, assuming PHEV/EV sales growth will be similar to the pattern seen so far with hybrid electric vehicles, PHEVs could have about 5% of the market after being commercially available for 10 years. This could reduce emissions by 2% and petroleum usage by 3%[20].

Utilities need to learn how to manage large numbers of distributed energy storage devices and two-way power flows.

ICT PROCESS AND TECHNOLOGY DESCRIPTION

Since PHEVs will connect to the grid to either purchase or sell electricity it will be necessary for electric grids to be updated to become two-way systems, making possible to collect electricity from remote storages, like PHEV car batteries.

To simplify, basic enabling technologies will be car, batteries, charging points, exchange stations, and from an ICT perspective: smart meters, meter data management system (the repository), meter reading/communications software (between meter and systems), meter systems interfaces (between other systems and MDM), web-enabled end-user applications, end-users energy management systems (Figure 13).

Settlement of electricity consumption and sales, and/or compensation for the use of PHEV for reserve or other ancillary services will then need to be managed by utilities billing systems. In fact, even if V2G approach could supply energy to the grid at times of peak demand, V2G is more likely to have a role in providing power services, such as regulation and spinning reserves, for which PHEV owners would get paid. In either case, these possibilities bring with them challenges related to interconnection issues and impact on the electric distribution system.

20 IDC Energy Insights raw estimations

A V2G approach could be beneficial to the utility as it could be used to manage wind power fluctuations and to match ramp rates of gas-fired generators. Interconnecting PHEVs would be very simple if the vehicles were only drawing power from the grid to recharge batteries. In effect, the vehicle would plug in like any other domestic appliance. The PHEV batteries could also relatively simply be used to provide backup power to a home or business during an outage. But if the vehicles were designed to feed power back onto the grid based on a signal from the utility, then protection equipment would be needed. Given that there is no rotating equipment and that the battery system would be producing DC power, a protection system could be as simple as those used in photovoltaic or fuel cell systems utilising inverter-based approaches.

Initially, growing V2G deployment would likely require a review of the capabilities of individual feeders to handle power fed onto the grid. But, concurrently, utilities would also need to re-evaluate and perhaps modify the design approach they take in building and retrofitting the distribution system. Likewise, to gain full advantage, communications and control technologies would have to be modified to dispatch PHEVs when reserves, regulation, or other ancillary services are needed.

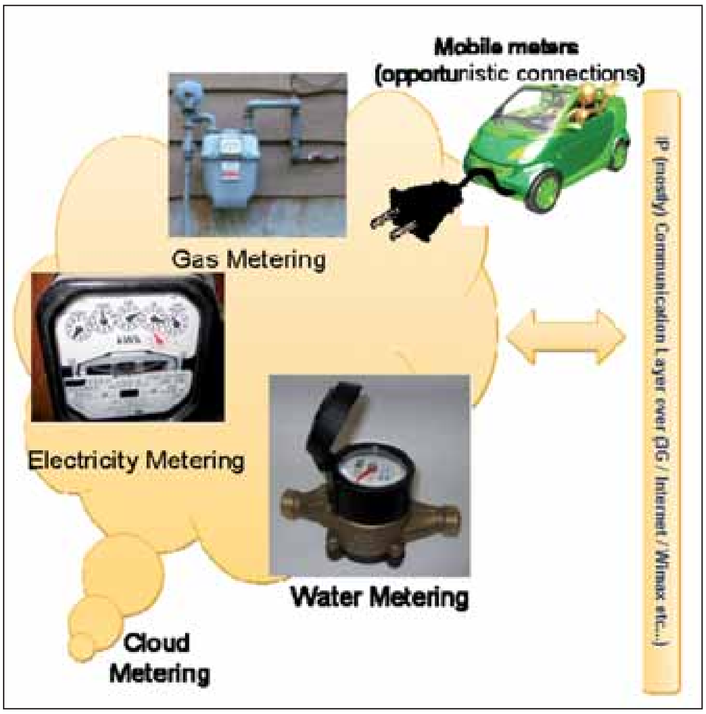


Figure 13:

Cloud metering as an extension of the metering process to Electrical vehicles (Mobile metering)

Source : SAP (2009)

DATA AVAILABLE

There are some pilot projects taking place through Europe. As the projects unfold there will be more and more data to look at to see the performances of PHEVs and their interactions with electricity grids.

Contribution to efficiency and environment could be increased by technology development of batteries allowing PHEV to be used on longer versus shorter average daily distances. The energy mix used to produce electricity to charge vehicles is also a determinant of PHEV contribution to a cleaner environment. The possibility to use renewable energy represents the best option, not only for pollution, but, being PHEV a storage facility, also to increase renewables level of utilisation, decoupling the moment of production from usage (for instance usage of wind energy during the night in country like Denmark or the northern part of Germany).

Projects currently underway, which will unveil huge experiences include: EdF's partnership with Toyota to evaluate PHEVs in Europe; RWE's partnership with Daimler for the "eMobility Germany" project; Daimler's partnership with Enel for "eMobility Italy"; Saab and Volvo's pilot project collaboration with Vattenfall in Sweden; and Dong Energy's testing of an electric vehicle fleet that can plug-in into the grid with project Better Place, also involving Renault-Nissan, and last but certainly not least the Edison Project consortium taking place in Denmark.

In September 2007, EdF formed a technology partnership with Toyota to evaluate PHEVs in Europe. Their objective is to develop practical solutions for the commercialisation of Toyota's prototype vehicle technology, which can further reduce the environmental impact of vehicles especially in urban areas. Under the joint agreement, a small number of PHEVs were integrated into EdF's vehicle fleet to be tested on public roads in France under typical driving conditions. Road trials of the PHEV commenced in France in the fall of 2007 and may be expanded to other European countries.

EdF and Toyota have developed an innovative charging and invoicing system, equipped in each of the test vehicles. This system is compatible with a new generation of public charging stations, which aim to make electric power more accessible on public roads and car parks and to reduce the cost for the customer. EdF penned a second partnership in October 2007 with Elektromotive to install 250 new charging points over the next six months in London and elsewhere in the UK.

Saab and Volvo will collaborate on a pilot project around plug-in hybrid vehicles. The two car manufacturers will test ten Volvo PHEVs on Sweden's public roads next year. Swedish energy company Vattenfall and battery manufacturer ETC Battery and Fuel Cells Sweden are also partners in the new project. The project will continue from 2008 to 2010 and the ten plug-in hybrids are scheduled to be under test by 2009. Data collected during the demonstration project will be used to evaluate batteries, analyse driving patterns, and refine simulation software used for PHEV and HEV development. The expected cost of the project is US$9.6 million, and the partnership has applied for a government grant for half of that.

Following Toyota and Saab's footsteps, Daimler signed partnerships in with German RWE and Italian Enel during the last quarter of 2008. As a part of "eMobility Germany" Daimler will supply 100 cars powered by lithium-ion batteries. The cars will mostly be from its Smart car models and will have a range of about 100 km from a single charge. Since the cars cannot be recharged from an ordinary power socket, RWE is to set up 500 special charging sites (supply points) at owners' homes, workplaces and in car parks and shopping centres. Owners will be automatically billed for recharging, similar to the way they pay mobile phone bills.

As part of "eMobility Italy" Daimler will also supply 100 electric vehicles (mainly Smart cars), while Enel will develop 400 charging stations for testing in Rome, Milan and Pisa by 2010.

Danish utility, DONG Energy is also testing and development of an electric vehicle fleet that can plug-in into the grid. The firm signed a letter of intent with California-based Project Better Place at the end of Q1 2008 aimed at reducing CO_2 emissions from the Danish car fleet. Together with Project Better Place, DONG Energy will work on giving Danish consumers access to buying environmentally friendly electric vehicles (EVs) at attractive prices. Within the next few years, Better Place Denmark is to introduce environmentally friendly, battery driven EVs to the streets of Denmark. DONG's other aspiration is to achieve a new way of storing the unstable electricity output from wind turbines, as EVs are typically charged during the night, when the exploitation of power generation is low and considering DONG's strong developments in the wind energy arena. The vehicles will be developed and provided by the Renault-Nissan Alliance partnership with Project Better Place Denmark. Renault will provide Better Place Denmark with the electric vehicles, thus achieving the objective of zero emissions while at the same time offering driving performances similar to a gasoline engine.

Project Better Place, before Denmark, launched its first V2G pilot in Israel, partnering with Renault-Nissan. Their aim is to integrate all necessary companies and components that already exist to make widespread use of electric cars a reality. Electric cars will get their power through a system called the Electric Recharge Grid (ERG). The parts of the ERG include the car, batteries, charging points, exchange stations (first automated battery switching station was launched in Yokohama, Japan, in May, 2009) software and renewable energy systems — all of which need committed manufacturers and suppliers. Project Better Place calls this a "virtual oil field".

Complementing Better Place's efforts are those of Coulomb Technologies, which plans to install 500 PHEV charging stations along California highways in 2009. The company has also already formed a joint venture with a German company to distribute Charge Point stations throughout Europe, the Middle East, and Africa (EMEA). Reportedly, Coulomb's "ChargePoint" charging station can be installed in twenty minutes and cost only $2,000 dollars (paid for by Coulomb).

Most recently, in February 2009, the EDISON Project was launched. The EDISON consortium aims to design a full-scale system for implementation of electric vehicles in Denmark. The project will be tested in a real-life testbed on the Danish Island of Bornholm. The long-term objective of the project is to support over 200,000 vehicles on the road or over 10% of the total number of vehicles. The research consortium is made up of several key actors such as energy companies, researches and private technology providers and will therefore be able to give a 360-degree view on the feasibility of full-scale electric vehicle solutions.

So far governments throughout Europe have been busy trying to sponsor a more vast adoption of fuel alternative vehicles, including PHEVs. Most countries have adopted some form of tax incentive to keep costs of ownership for these new-technology vehicles competitive.

As an example in Sweden incentives for environmentally friendly vehicles embrace reduced company car tax, free parking in selected cities, reduced vehicle insurance, exemption from congestion charges in Stockholm and lower annual registration taxes. The Swedish Government has also mandated that 85% of Government vehicle purchases (excl police, fire and ambulance vehicles) must be alternative fuel vehicles; all petrol stations with an annual volume of more than $1000m^3$ must have an alternative fuel pump by 31 December, 2009, and all new filling stations must offer alternative fuels.

Similarly in France the government has agreed far-reaching tax incentives for both the fuel and alternative-fuel vehicles e.g. no mineral oil tax on ethanol, no company car tax for the first two years, reduced registration tax, no VAT on fuel for the fleet customer.

In Italy alternative-fuel vehicles sold in are eligible for 30% to 65% government support on the purchase price, if a company purchases the vehicle. As a result, most privately driven alternative-fuel vehicles in Italy, including hybrids and electric vehicles, are leased.

For customers to have confidence in the feasibility of large-scale PHEV deployment, important barriers concerning standardisation at various levels needs to be addressed. In Europe one such committee has been established which brings together all the major utility industry players and the major car manufacturers. This group will present by the end of the year 2009 a first draft of the common standard to be proposed to the ISO, addressing standardisation of outlet plugs and battery characteristics, which will be crucial in defining the correct business cases. The group has established two task forces, one will look at Vehicle-Grid Communication standards, while the other standards for cables and connectors.

RECOMMENDATIONS

Looking more closely at ongoing initiatives and pilot projects for EV focusing not only on technical issues regarding the creation of the infrastructure but also on business case to facilitate investment is needed.

Furthermore, intelligent grid initiatives are constantly releasing new material concerning EVs and relevant companies that are claiming to already have the technology to integrate EVs.

With respect to regulation, promotion of the advances of commercial PHEV/EV, promotion of renewable energy programmes around the concept that cars of the future could be powered with renewable energy rather than gasoline is needed. Furthermore there is a need to push the creation of time-of-use rate plans that provide consumers an incentive to recharge EVs and other rechargeable electronics during off-peak hours, as well as establish programmes for battery recycling and proper disposal.

For research and development, it is recommended to contribute in funding pilot to study and field test projects involving PHEVs/EVs. Vehicle-to-Grid (V2G) demonstrations should be a part of that effort. Particular evidence should be given to infrastructure development and ICT enabling solutions.

Market recommendation include cooperation with the utilities to estimate the number of EVs they could fuel with excess load in the evening and divulgate that information, for example via their own website or others (e.g. Google), launch a marketing campaign to illustrate how using electricity to power EVs is better for the environment and for consumers' budgets than using gasoline, and finally assist in developing energy management capability for end users. It is also urgently needed to create ICT enabled energy efficiency standard indicators and reinforce their collection and monitoring.

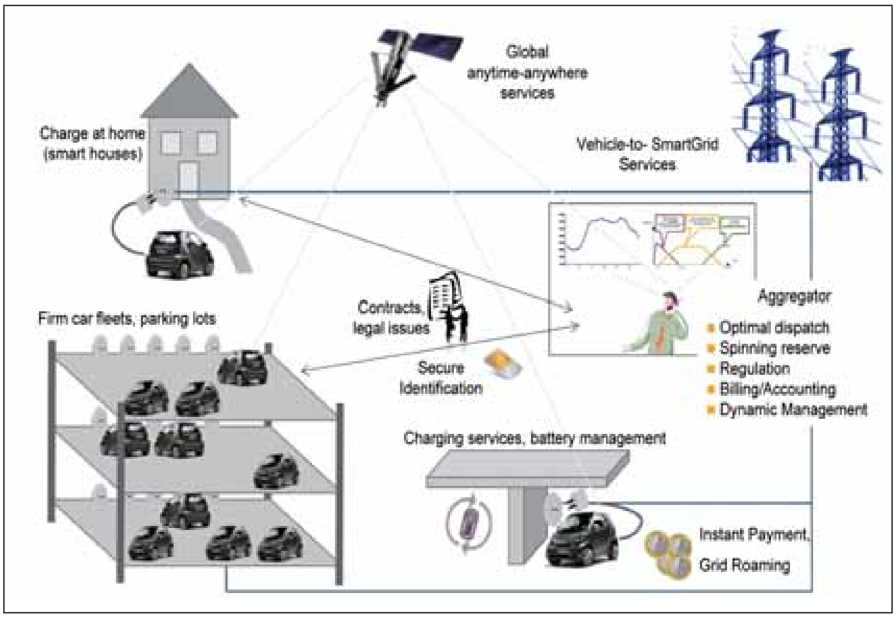


Figure 14:

Software and infrastructure required for new electric mobility concepts

Source: SAP (2009)

EVs towards billing for the future energy infrastructure

In the future energy infrastructure billing will play a major role. As we move towards a service-based society, a variety of services will be offered within a specific time frame, and the providers need to be able to charge for it in a quick, transparent and cross-border way. New forms of billing and payment will arise i.e. instant-payments will be needed. In an extreme future scenario, electric cars will be even able to charge their batteries while waiting at the traffic lights, with energy being wirelessly transmitted from special installations at the road. As this transaction will be in the seconds, respective billing capabilities should be there. The smart meter that is seen as a key entity for the future SmartGrid, will be a distributed one, composed of many real and virtual units e.g. at home, at the car, or even embedded as part of every electrical device and bound to the user.

RECOMMENDATIONS

To that extent we propose to create a real-time, pan-European ubiquitous micro-/mini- billing infrastructure[21]. Existing systems e.g. mobile payments, GeldKarte, etc. could be seen as the first steps. The infrastructure should of course include security, archiving, invoicing, signing and verifying of invoices, real-time payments, cross-channel support etc. A change of the regulatory framework should allow for the whole the SEPA (Single Euro Payments Area) micro-payments. Another action would be to promote electronic money and real-time secure electronic transactions. Finally engage Telcos (experienced in micro/mini payment solution providers) in dialogue with banks (mini/macro billing payment providers).

21 Bibliography:
SAP — Stamatis Karnouskos, Mobile Payment: A journey through existing procedures and standardization initiatives, IEEE Communications Surveys & Tutorials, Vol. 6, No. 4, 4th Quarter 2004. http://www.comsoc.org/livepubs/surveys/public/2004/oct/pdf/KARNOUSKOS.pdf
András Vilmos and Stamatis Karnouskos (SAP), Towards a Global Mobile Payment Service, 3rd International Conference on Mobile Business 2004 (m>Business), 12-13 July 2004, New York City, U.S.A. http://stamatis.karnouskos.googlepages.com/2004_MBUSINESS_GMPS_KARNOUSKOS.PDF

8 Conclusions

Investments are needed in the following technologies, best practices and processes:

1. ICT STUDIES, BUSINESS CASES, SURVEYS, PROJECTS BEST PRACTICES, GO TO MARKET REQUIREMENTS:

A European standard business case for smart metering is to be build comprising best practices from existing projects. A library of case studies across a diversity of business customers (schools, grocery, stores, retail stores, private sector office buildings, warehouses, etc.) to be used by Utilities about Demand-Response would also help.

Assistance in developing energy management capabilities for end users is needed as well as the creation of ICT enabled energy efficiency standard indicators. Finally a comprehensive survey of European Demand-Response pilots (EU survey) is needed.

2. CUSTOMER INFORMATION AND COMMUNICATIONS ENABLEMENT (SMART METERING):

Time of Use Metering and Billing; the real consumption should be mandatory in Europe. Large scale penetration of smart metering should reach 100% penetration in 2015. Incentives for investments and focus on standardisation are key. European harmonisation and standardisation groups should be setup. Interoperability should be tackled via pan-European open standards between metering suppliers and end-to-end from customers to Utilities.

Joint cooperation between Utilities and Telecommunications operators should be set up. A publicly available infrastructure for smart metering (versus PLC and GPRS) should be considered.

3. DEMAND SIDE AND DEMAND RESPONSE MANAGEMENT AND REAL TIME PRICING

Automated demand/response communication standards are needed. Incentives to develop innovative business models to share benefits on Demand-Response across various stakeholders should be realised.

Technical feasibility of distributed, autonomous load control must be investigated.

4. HOME ENERGY MANAGEMENT DEVICE (INTERNET LIKE BOX)

Metering or home equipment manufacturers should bring products that are able to collect real time consumption of household appliances and connect to the smart meters.

5. READINESS OF INFRASTRUCTURE NETWORK TO CONNECT LARGE SCALE DG AND RES

Research on innovative technologies for minimising network losses (technical and non technical) and improving network stability should be investigated. Large scale connection of DG and RES to the Grid by 2020 (considering 20 to 50% renewable capacity connected to the Grid) should be considered.

6. ICT READINESS FOR ELECTRIC POWERED TRANSPORT (E.G. PHEV)

Car manufacturers and European green car programmes that promote the deployment of PHEV should be in place. This should be done in conjunction with the promotion of renewable energy programmes around cars.

Via European regulation it should be pushed the creation of a pan-European secure and real-time electronic payment platform that can be part of a billing infrastructure for electric cars.

By implementing these recommendations, significant energy savings can be achieved. The extent of the savings will depend on the successful combination of smart processes (like demand/response) and smart technologies (like smart meters).

The first expected benefits include peak load shaving (up to 50%), consumer energy saving (up to 25%) and network loss reduction. However more benefits will arise beyond this initial stage.

Annex 1: Methodology and Credits

In the autumn of 2008 the European Commission set up a (high level) advisory group aiming at providing information on potential as well as recommendations in terms of ICT for Energy Efficiency. This high-level advisory group was composed of seven working groups and one of these on Smart Grids.

The mandate of the group was to provide a "preliminary" set of references about potential current data and trend analysis of the impact of ICT in the Energy sector, taking into account good practices applied worldwide. It is difficult to find exhaustive useful references to proven data, but the group was asked to provide with some links and demonstrate that this is an ongoing activity in the community.

Chairmen:

- Maher Chebbo, SAP Utilities and Communication for EMEA
- Miguel A. Sánchez Fornié, Iberdrola, European Utilities Telecom Council (EUTC)

Industry:

- Rolf Adam, BOOZ & Company GmbH
- Roberta Bigliani, IDC Energy Insights
- Stamatis Karnouskos, SAP Research
- François Loubry, Alcatel-Lucent
- Marion Mesnage, Accenture Technology Labs
- Gerhard Miller, Infineon Technologies
- Fritz Schwarlaender, SAP EMEA Industry Business Solutions Utilities
- Willem Strabbing, KEMA
- Michael Weinhold, Siemens
- Jeremy Willsmore, IBM Europe's Energy and Utilities Business

Broader Business Associations:

- Christine Lins, European Renewable Energy Council (EREC)
- Thomas Harder, European Centre for Power Electronics (ECPE)
- Gunnar Lorenz, Eurelectric

Research Centres:

- Hans Akkermans, Enersearch
- Michele de Nigris, Cesi Ricerca SpA

European Commission:

- Manuel Sánchez Jiménez (manuel.sanchez-jimenez@ec.europa.eu)
- Gianluca Fulli (gianluca.fulli@ec.europa.eu)

This booklet is a compendium of the findings of the group complemented by keynote messages delivered by high-level representatives of stakeholders at the ICT for Energy Efficiency event organised by the European Commission and the Czech Presidency in March 2009.

Annex 2: A technical perspective for the implementation of SmartGrid in Europe.

by **Dr. Manuel Sánchez Jiménez**, European Commission

The fundamental method of operating the electric grids in the European Union has not changed significantly during the past hundred years, while the number of customers and their needs have grown exponentially.

The time for half measures and patchwork solutions is over. To tackle this enormous issue, we are moving toward a sustainable internal electricity market with a more diversified generation structure, one in which small units will seek integration into larger electricity grids. In 2006, the European Technology Platform SmartGrids — a stakeholder group sponsored by the European Commission — laid out plans for a network managed by distributed control, in which every node in these smart electricity networks will be awake, responsive, adaptive, price-smart, eco-sensitive, real-time, flexible, humming, and interconnected with everything else.

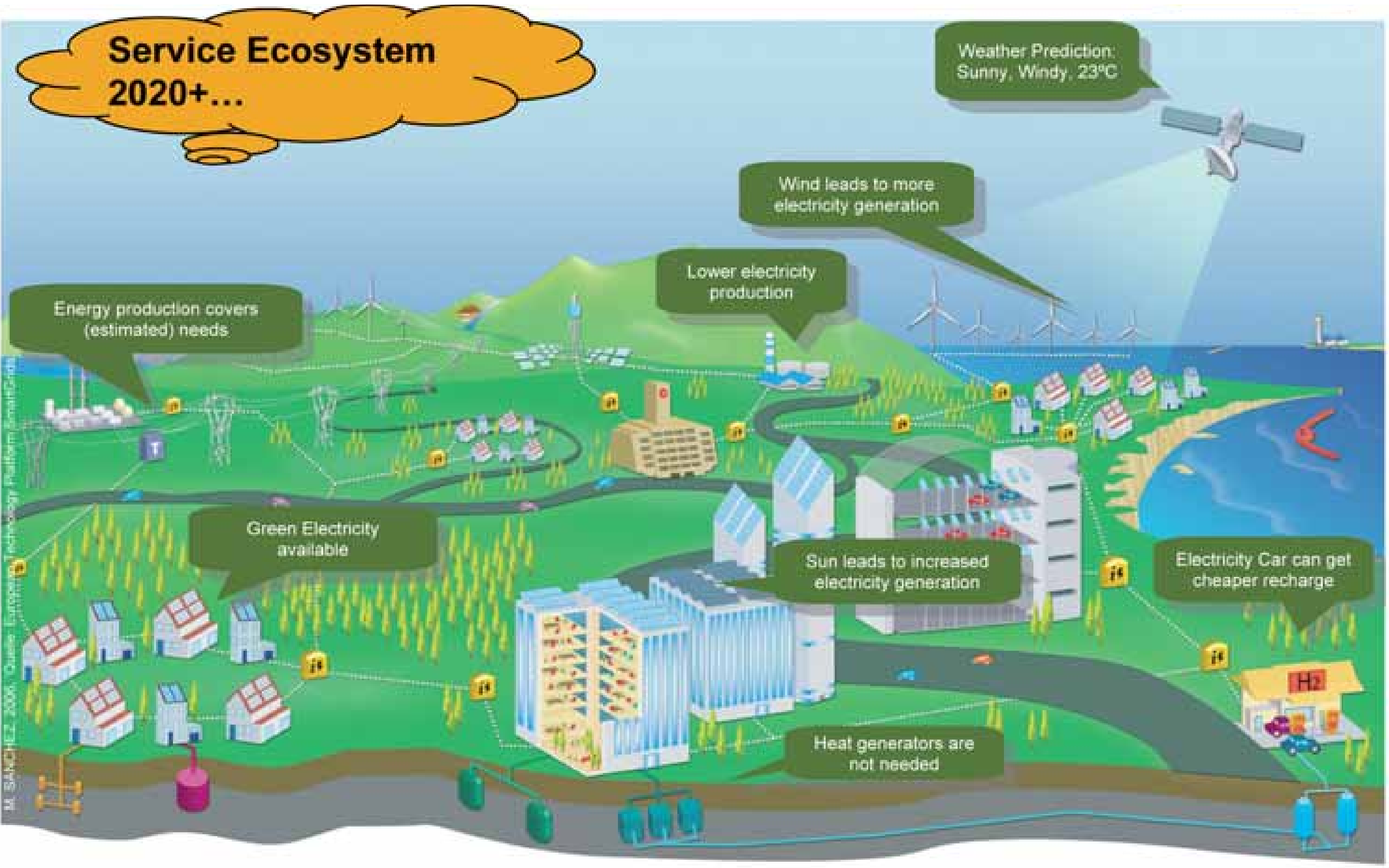
These changes are complex and will not come cheap: massive investments in transmission and distribution networks are being planned across the EU — according with the European Technology Platform SmartGrids, up to €90 billion directly related to investment in smart-grid technology by 2020.

In this transition, new and emerging markets are expected to cover generating capacity, reserve capacity, and ancillary services. Some of these services are already currently handled by informal trading systems; others will be based on the full potential that smart energy devices can provide when they are assembled together in a system.

The most distinguishing feature of future electricity grids in Europe will be users' ability to play an active role in the supply chain. The key to success for utilities adjusting to this change will lie in mitigating losses and investments on the generating side and advocating for new tariff structures, opening new win-win possibilities for the electricity market. Furthermore, electricity tariff structures, such as real-time pricing or critical peak pricing, and load control are expected to lead to further reduction of energy consumption. The one lesson learned so far based on the more than thirty million smartmeters installed in Europe is that much of the success of smart metering as a means of reducing domestic energy consumption depends on how the information is packaged and presented to the user.

This evolution will shift the responsibility of the electricity production to a much larger number of actors who generate on a much smaller scale; it will mean that the responsibility for the control and transmission of electricity is also shifted to a smaller scale.

Another feature of future electricity networks will be the use of more and more intelligent control and less hardware such as lines and generators to provide the required level of reliability for power supply and to improve the overall cost/benefit ratio. Sophisticated control and communications technologies will be required to ensure smooth operation and the establishment of new business models for power distribution, as well as the development of advanced energy-storage technology, power electronics, and specific superconducting devices.



European Technology Platform SmartGrids
Source: Manuel Sánchez Jiménez

How quickly will all this happen? A single leap from the current network to this vision is not credible, but taking the period beyond the lifetime of the current generation of equipment — say, 2015 to 2020 — enables innovative market regulation rules, trial tests of advanced components and development of the concept described above under a few, but well coordinated pilot projects.

Granted, from a technical point of view, the idea of SmartGrid remains rather speculative, and the biggest investment needed to achieve it will be a research and engineering effort to establish what kind of communication technology and control solutions could support this vision at a European-wide level. Key steps have already been initiated across the continent during the last few years under European and national research programmes, but a lot of work remains to be done over the next decade for the design, validation, and implementation of the appropriate architecture and control strategies. The major challenge is the organisation of the designing of the network structure, as the process would have to involve a large number of stakeholders at European level.

The implementation of the energy and climate policy and instruments adopted by the European Union in January 2008 will require efforts, but it will imply huge opportunities too, for all sectors. European business, and the ICT sector in particular, will be key partners in the new environment that will emerge.

THEMATIC NETWORK ICT4SMARTDG

The general objective of this Thematic Network (TN) is to foster and promote the development of ICT solutions which could promote large-scale integration of domestic and distributed micro-generation and therefore improve energy efficiency through the implementation of smart technology into local power grids.

The TN will bring together key relevant players in the telecommunications and energy sector. They will overview and provide insight of existing and new innovative ICT technologies available for smart distributed generation at domestic level, forecast steps forward that can promote large-scale implementation, identify best technical solutions available, non-technical barriers, as well as promote all TN results and conclusions as key elements to boost deployment.

Three main activities signify how the work will be carried out i.e.:

1) Information and experience exchange: Actions in the form of workshops and seminars to present what

members of the network have done and learnt in this field, as well as to take advantage and feedback from other previous initiatives or related projects, how they see the future approach for large-scale deployment (many-users) including business models, and quantification of benefits of those ICT-based solutions for all stakeholders.

2) Awareness actions: Dissemination of actions for the general public (end-users), dissemination of actions addressed to policy makers: European Commission, European Parliament, Committee of Regions, national, regional and local administrations, annual network conference events etc. The aim of these actions will be to support awareness-raising of the benefits that innovative ICT solutions can provide, and motivate policymakers to address non-technical barriers to foster large scale deployment.

3) Investigation of large-scale deployment: Achieve consensus on the following issues: definition of business models with best solutions; identification of non-technical barriers; evaluate social acceptance and ethical issues.

> http://www.ict4smartdg.eutc.org/

THEMATIC NETWORK SEESGEN-ICT

SEESGEN-ICT (Supporting Energy Efficiency in Smart Generation Grids through ICT) is a Thematic Network composed of a large base of core participants (24 from 15 different EU countries), to be increased through the organisation of workshops and meetings. The project is funded under the EU ICT Policy Support Programme. The final aim is to bring together the maximum number of key players in Europe to enhance the role of ICT-based solutions for improving and implementing energy efficiency in smart distributed power generation and grids.

SEESGEN-ICT will report state of the art, best practices and recommendations regarding ICT and related successful business cases from all regions (EMEA, Americas and Asia Pacific), thus creating a basis for improving business models and regulation. It will also promote new research and development initiatives to achieve the required solutions. The TN is designed around five main areas: large-scale integration of distributed energy resources, monitoring of energy efficiency and demand-side management. Business models for deploying expected solutions and associated environmental aspects are also treated. SEESGENICT will finally deliver recommendations for supporting best practices of ICT implementation through test facilities. The activities developed within SEESGEN-ICT are strongly connected to the priorities indicated in the SmartGrids European Technology Platform context.

> http://seesgen-ict.cesiricerca.it

Annex 3:
List of Acronyms

AMI	Advanced Metering Infrastructure
AMM	Automatic Meter Management
CAGR	Compound Annual Growth Rate
CML	Customer Minutes Lost
DG	Distributed Generator
DSM	Demand Side Management
DSO	Distribution System Operator
EDM	Electronic Document Management
DR	Demand-Response
FACTS	(Flexible AC Transmission System
GPS	Global Positioning System
HV	High Voltage
LV	Low Voltage
MBI	Maintenance and Business Intelligence
MDM	Meter Data Management
MDUS	Meter Data Unification and Synchronisation System
MID	Measuring Instruments Directive
MV	Medium Voltage
NDE	Non Delivered Energy
PHEV	Plug-in Hybrid Electrical Vehicles
PLC	Power Line Communication
PMU	Phasor Measurement Unit
R&D	Research & Development
RES	Renewable Energy Sources

RTP	Real Time Pricing
SCADA	Supervisory Control and Data Acquisition
SEESGEN-ICT	Supporting Energy Efficiency in Smart GENeration Grids through ICT
SEPA	Single Euro Payments Area
PLC	Power Line Carrier
TN	Thematic Network
ToU	Time of Use Tarrifs
TRTP	Real Time Pricing 1
TSO	Transmission System Operator
T&D	Transmission and Distribution
US	United States
V2G	Vehicle to Grid
VPP	Virtual Power Plant
WAMS	Wide Area Measurement System
WiFi	Wireless Lan Standard
Wimax	Worldwide Interoperability for Microwave Access

European Commission

ICT for a Low Carbon Economy
Smart Electricity Distribution Networks

Luxembourg: Office for Official Publications of the European Communities

2009 — 46 pp. — 21 x 29.7 cm

ISBN 978-92-79-13347-3

doi:10.2759/19105

KK-31-09-141-EN-C

ICT for a Low Carbon Economy
Smart Electricity Distribution Networks

JULY 2009

For further information:

European Commission
Directorate-General Information Society and Media
ICT for Sustainable Growth Unit
B-1049 Brussels

http://ec.europa.eu/ictforsg
INFSO-ICTforSG@ec.europa.eu

Publications Office

ISBN 978-92-79-13347-3

9 789279 133473

European Commission
Information Society and Media