



FLORENCE SCHOOL OF REGULATION

SMART METERING: SUMMARY AND CONCLUSIONS

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SUMMARY AND CONCLUSIONS

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The FSR Workshop on “Smart Metering” organized by the Florence School of Regulation gathered 45 participants from 15 countries. The Workshop was devoted to: (1) reviewing European progress to date in terms of smart metering technologies and deployment and (2) identifying research needs related to smart metering within the context of domestic and EU energy policies. Participants to the workshop were mostly experts from EU Institutions, National Regulatory Authorities, Energy Companies and Academic Institutions.

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I. Smart metering as an enabler of smart grids

Smart metering is view as a crucial factor for an efficient functioning of the internal electricity market and a successful implementation of the EU policies related to the energy efficiency, renewable energy and security of supply. Smart metering is not only about remote meter reading; smart metering is the visible face of a new way to understand the energy system (smart metering is the “bridge” between smart buildings and smart grids). Given ambitious EU objectives, promoting smart energy systems (grids, metering, and buildings) should be a cornerstone of policies from now to 2050.

BOX 1: Definitions

<i>Smart meter and smart metering (SM)</i>	A smart meter is an advanced meter that identifies consumption in more detail than a conventional meter; and optionally, but generally, communicates that information via some network system back to the local distribution company for monitoring and billing purposes. Smart meter generally allows distribution company to interact with the meter for controlling (e.g. connection/disconnection) functionalities. Depending of the range of functionalities, there are two kinds of smart meters: Automatic Meter Reading (AMR) and Automated Meter Management (AMM).
<i>Automatic Meter Reading (AMR) and Automated Meter management (AMM)</i>	Automatic Meter Reading (AMR) is the technology of automatically collecting data from metering devices and transferring that data to a central database for billing and/or analyzing. Automated Meter Management (AMM) broadens the scope of AMR beyond just meter readings with additional features enabled by two-way real-time data communication which allows command-control functionalities.
<i>Smart grids</i>	A smart grid integrates new innovative tools and technologies from generation, transmission and distribution all the way to consumer appliances and equipment. A smart grid would create an energy system that: i) Responds to local and system-wide inputs and has much more information about broader system problems and iii) Incorporates extensive measurements, rapid communications, centralized advanced diagnostics, and feedback control to optimize the use of the grid.
<i>Communication system</i>	Smart meters are often combined with modern communication technologies thus enabling cost-effective remote meter reading. Several communication technologies have been used to transmit data from individual consumers' meters to a centralized data base: electricity lines (so-called power line carrier or PLC technology), fixed line and mobile telephone, internet, radio waves, etc. Communication protocols and standards are needed to ensure interoperability between different metering and communication technologies
<i>Minimum functional requirements</i>	The specification of minimum functional requirements is necessary to ensure interoperability and to ensure the pursuance of the same objectives of the smart metering policy and the core benefits realized.

The benefits of smart metering can accrue to different stakeholders of the energy sector:

- **Benefits for consumers** come from different factors: from the enhanced customer awareness, from energy saving possibilities, as well as from more accurate meter reading and billing and, finally, by making it easier to switch of energy provider.
- **Benefits for suppliers** come from the possibility of more flexible pricing options and more energy management services, facilitating the switching process and the billing management.
- **Benefits for network operators** are coming from: operating cost savings (reduce losses and theft, information for building efficient infrastructure, etc.) and gains of service quality (identification of fault, faster restoration).
- **Benefits for metering companies** come from efficient meter reading and remote activation/deactivation/maintenance.
- **Benefits from a system-wide perspective** come from increase in security of the system (reducing the level of redundant capacity for the same level of security), improving efficiency of markets (reducing market power, facilitating retail competition, increasing transparency), enable efficient penetration of renewable (e.g. micro generation), environmental benefits, improving the regulation (more information available for the regulator), etc.

In spite of all these benefits, two main concerns prevent the massive (voluntary) penetration of smart meters:

- still high relative cost of smart meter devices and
- the benefits of smart metering are distributed amongst all stakeholders and therefore incentives to install them are dispersed. This dispersion creates a coordination problem between stakeholders.

Socially efficient integration of smart devices in the actual systems needs comprehensive regulatory and legislative tools to introduce a clear sharing of costs and benefits between the stakeholders.

II. Views and Experiences of Regulators and the Industry

In Europe, different models are used to promote smart metering. Each smart metering policy model has different properties concerning the specific allocation of costs and sharing benefits between the stakeholders.

The set of specific goals that policy makers have in different member states is the main factor for the selection of a smart metering policy. Indeed, smart metering policies can have different goals depending of which type of benefits policy makers are looking reap from the installation of smart meters. Efficient billing and pricing, saving metering (and losses) costs, demand response, are some example of aforementioned goals. Policies are normally adapted to the specific goal and this defines the type of technological solution that is taken (e.g. minimum requirements).

Smart metering policy also depends on the general regulatory framework of metering. Two main types of metering regulatory regimes exist in the EU: the regulated regime and the market-based regime.

In the regulated regime the metering service is a monopoly business carried out by distribution network operators (DNO) and therefore paid by the final customer either by regulated metering tariff or as part of grid tariffs. In this case, ownership of the customer meter lies with the distribution network operator. Almost all countries in EU have applied the regulated model.

In the market-based regime the metering service is open to competition. Metering services are carried out by an unregulated third party. The consumer or the supplier decides on the type of meter to be installed. It is therefore necessary to provide a certain level of standardization and interoperability of the meters installed in order to avoid technical barriers to customer switching. The market-based regimes have been applied in UK, Germany and the Netherlands. Main policy options to promote smart metering actions may be divided into three categories (not all policies are applicable to both regulatory regimes and market-based regime):

- Enabling or mandatory decisions directly related to smart metering (e.g. financial incentives, roll out obligations)
- Metering related regulation (e.g. metering obligations and minimum requirements)
- Other form of regulation with and impact of smart metering (removing any legal or regulatory barrier, etc.)

Regulators, DNO and suppliers from regulatory regime (Italy, Sweden, and Norway) and from market based regime (Germany) have presented their experiences in smart metering policy and implementation.

From the regulatory regime point of view

In **Italy**, following a voluntary meter replacement program launched by the incumbent utility ENEL in 1990, the regulatory authority (AEEG) has mandated full introduction of smart meters in 2006 for electricity. By now, Italy is a pioneer in terms of smart meter installation in electricity with more than 90% of low voltage customers already equipped with smart meters.

Functions available today for around 30 million of customers are: supply activation/deactivation, monthly reading, change of contractual power, reduction of the contractual power and switching. In 2008, after a complete public consultation, AEEG has mandated smart meters replacement timetable for gas.

Metering activities are regulated (distribution network operator) and the metering tariff is separated from network tariff. Applied smart metering policy consists on roll-out obligations deadlines (with penalties) for installation /commissioning with minimum functional requirement. Roll-out obligations are different for electricity and gas: replacement shall be completed by 2011 for electricity and by 2016 for gas.

The extra charge for each household customer due to electricity smart meters, from 2004 to 2007, has been less than 2 Euros year. From 2008 to 2013 the metering tariff is adjusted yearly following an X performance factor of 5% ($> 1.9\%$ X performance factor of distribution activity).

Exploiting new smart metering functionalities, as quality of supply and demand-response in coordination with smart grids, will be the next step in Italy.

In **Sweden**, a law was passed in 2003 requiring mandatory hourly metering (from July 2006) for final customers with a fuse subscription of 63 A. From July 2009 all metering points should be read monthly and final customers should be invoiced based on their real consumption. The goals of the roll-out were to support billing based on actual consumptions and to promote energy efficiency through enhanced energy consumption visualization.

Metering obligations have promoted (indirectly) the installation of smart metering. Although the law does not prescribe how this should be done, in practice all households in Sweden will have smart meters as of 1 July 2009.

Metering activities are regulated and the distribution network operators, who are responsible for meter reading, bear the cost of meter replacement. For some distribution network operators the costs/benefits balance is unbalanced because of the high cost of manual meter reads in low populated areas.

Massive roll-out by Vattenfall started up in August 2006 in three regions and was completed in June 2008 (near 1 Million of meters by now). Different meter models and technologies with different functionalities are being deployed until now (AMR1, AMR2 and AMR3).

In **Norway**, since January 2005, there is mandatory hourly metering requirement for final customers with consumptions over 100MWh per year. About 10 distribution network operators have installed Automatic Meter Reading (AMR) on a voluntary basis. Currently there is political discussion (but no formal decision yet) about mandatory installation of AMR. In June 2007 the

regulator (NVE) indicated a possible rollout to all customers by 2013, but this is still being assessed (the regulator is analyzing the initial reactions from public hearings).

From 2004 to 2007 the regulator has undertaken cost/benefit analysis of AMR in Norway. Cost/benefit analysis concludes that cost benefit is only positive if uncertain benefits are included and it is not profitable for the distribution company alone.

Metering activities are regulated in Norway. Investments in smart metering by distribution network operators should be financed within their existing income regimes. AMR financing is done as an ordinary investment within the income cap regulation. Under this framework, full recovery of normal cost is ensured for the companies as a whole. For each individual company, the difference between actual cost and normal cost is shared in a 40/60% basis. This should give incentives to improve the performance in installation and smart meter cost.

The regulator, in cooperation with industry and stakeholders, is working on the definition of the minimal functional requirements for smart meters. The different tasks and functional requirements are divided in two categories: obligatory tasks and optional tasks. The obligatory tasks (paid by distribution companies) concern the registration and saving of metering values (hourly), the collection of meter data according to type of contract, and the instantaneous metering in connection with switching, registration of interruptions. The optional tasks (paid by the customer) concern the information given to customers on display or other, the hourly metering in connection with hourly contracts, and the measuring of local production.

From market based oriented regulation

In **Germany**, installation, operation and maintenance of electricity meters are open to competition. Legislation for full metering liberalization came into force at the end of 2008. By now, customers can choose metering operator and meter type. Metering is done by an independent metering operator. Customers sign a metering contract and pay a contracted price for metering services. At the time, there is no legal compulsion for smart meters only load variable tariffs need to be offered by suppliers by 2010.

Federal network agency is cooperating with market participants to provide binding standards and legal certainty and is fostering the integration of smart metering concepts in order to achieve energy efficiency goals.

Although there is no policy on smart metering, some suppliers have started to install smart meters. Some examples are: Yellow strom, a gas and electricity retail supplier with about 1.4 million customers launched web-based smart meters nation-wide to the German market in the summer 2008. Yellow reports that customers have saved 5-20% of energy by the use of yellow smart meters and web tools. The key success factor is giving to customers useful and

easy-to-read real-time energy consumption information. RWE is installing smart electricity meter to 100,000 household in Mülheim and der ruhr. Rheinergie is preparing a full roll-out of intelligent meters across Cologne until 2012.

BOX 2: Other regulators' views and comments

Austria	Metering activities are regulated and metering tariffs are separated from grid tariff. Smart metering installation will be evaluated first for electricity and then for gas. The regulator has to be sure that smart metering installation will bring benefits to costumers. In order to evaluate how metering tariffs will evolve after smart metering installation, several synergies have to be examined. Very large investments have to be made in relation to smart metering and they have to be compensated by savings in future operating expenditures (Opex).
Czech Republic	To date there is limited experience with smart metering. Given the high cost of smart meters in gas, nothing will be done in this area for the next few years. In electricity, smart meters will be installed despite their high cost. However, there are some concerns related to the management of private information, particularly for whom information will be available and how it should be protected.
Finland	Some progress is being made with respect to smart metering in electricity provision. Following a recent decree, customers with a subscribed power of more than 63A and customers with less than 63A will have to be metered hourly by 2010 and 2013 respectively. This decree establishes some requirements for the distribution network operators on meter replacement and organization. For instance, consumers will be able to ask on day t+1 detailed consumption information of day t.
France	The distribution system operator (DSO) is responsible for meters. The French regulatory authority (CRE) has just finished a consultation about smart metering. The result shows high diversity of preferred smart meters functionalities for different stakeholders: some want smarter meter more than others. The selected policy has been to introduce a mandatory obligation for one standard meter box with minimal functional characteristics and enough flexibility for customer to plug a second box able to provide more commercial special services. Minimal functional service will be ensured by the DSO while extra services, not included in the mission of DSO, will be provided by the suppliers. At this moment a decree that established a roll-out for 96% of customer by 2016 has to be signed by the Minister. There is not progress in the installation of smart meters in gas.
Greece	There is some experience with smart meters among medium voltage (MV) costumers. For households, nothing has been done yet. The lack of proper cost-benefit analysis and the high cost of meters are the main barriers to the smart metering deployment.
Spain	The government has made a statement to replace all the meters in electricity. By now, some discussions are taking place about the minimum functional requirements of meters. As customers are not aware about the different meters possibilities (the only information that they have is Time of Use tariffs), the regulator is considering launching an information campaign. Smart meter is a useful tool necessary to exploit all the benefits of smart consumption. However, if costumers are not involved enough, there will be no effect.

III. Smart meter technologies: A fast moving frontier

Although, smart meter systems could be considered as a relatively mature technology, four main issues should be solved in order to move to wide-spread and efficient deployment of smart meters:

- How to coordinate smart transmission grid, smart distribution grid and smart meters/houses/ and buildings?
- How to choose meters features and minimum functional requirements?
- How to determine the communication features requirements?
- How and who should set the standards?

Smart grids coordination

Smart meters are the link between transmission & distribution grids and houses and building appliances. Smart meters have many functionalities that need to be exploited in coordination of the system (grid) to produce real benefits (e.g. demand response, network planning). Innovative coordination tools and appropriated regulatory framework should be developed in order to exploit the maximum benefits from smart devices.

Minimum functional requirements

Smart meter minimum functional requirements are necessary to guarantee the pursuance of the metering policy objectives, to ensure the interoperability between different technologies and to ensure that all the customers have the same options.

Minimum functional requirements have to be set in order to avoid technology lock-in situations. Meters have a lifetime of about 20 years and therefore their characteristics should consider: i) the possibility to evolve to integrate in 10 or 15 years new information technologies, new dynamic customer behavior, and new market rules and ii) to be modular to allow remote upgrade, host technologies that will be invented in 10 years.

Given the fast development of new information and communication technologies, specification of minimum requirements and harmonization should be carried out at high levels of functional abstraction and not at low levels of technical detail. Therefore, minimum requirements should fulfill the following criteria: i) be system oriented, ii) avoid raising barriers or limits to technical/techno innovation and iii) prevent the rejection of new solutions/architectures. Particularly, the ability to integrate distributed generation through bi-directionality or the potential to upgrade to bi-directionality should be considered at the time of defining minimum requirements. Performance requirements (as annual percentage of successful remote

transactions or annual number of meters that at least once register a failure) could help to improve the selection of efficient smart metering technologies.

Minimum functional requirements are linked to type of regime used for metering policy. On the one hand, a market-based metering regime requires appropriate regulation of minimum functional requirements in order to avoid new technical barriers to customer switching (ensuring interoperability between different data bases) and in order to enable system-wide benefits to be achieved. In a regulated regime, this should be granted by design. On the other hand, current situation of information and communication markets is indeed a strong argument in favor of a market-based metering regime: as the customer has to bear the cost of the meter, he should choose more suitable solutions in terms of performances and service. In the regulated regime, the customer choice in terms of the smart metering device is very limited because the technical solution is determined by the distribution network company or the regulatory authority.

Communication system characteristics

Although usually forgotten, communication framework is a very important component of smart metering. The needed capabilities of a communication system depends on the kind of functions a smart meter is supposed to undertake; said differently, communication constraints can limit strongly the benefits that a smart meter can bring into the system. Therefore, communication technology options and associated costs must be considered carefully in every cost/benefit analysis.

Two main types of communication support are competing or complementing each other at this moment: i) dedicated communication infrastructure (PLC – Power Line Carrier and Wireless technology) and non-dedicated communication infrastructures (e.g. web services). Dedicated infrastructure can be tailor designed and has good reliability while they are more expensive and need the development of new standards. Web service technologies are cheaper and standards are already developed. However, web services are not yet available at each household and its reliability is not robust.

Definition of standards

Efficient innovation process on smart meters should include a large set of different technologies (meters, communications, etc). In this context, interoperability and interchangeability of components need the definition of open standards. Practically, standards should ensure that a meter will be open to integrate new services, host innovations of manufacturers and manageable during its whole lifecycle. Standards and openness should be encouraged. The question is whether it requires European cooperation and a strong European-level standard.

There are a few member states' initiatives to define standards for smart meters: the Netherlands, France and Spain. In the Netherlands, a group of Dutch utilities and manufacturers (Kema, Eneco, Nuon, Essent, delta + L&G, Actaris, Iskra, Sagem) have defined the DLMS companion standard, for electricity and gas smart meters. In France, ERDF Pilot project (about 300.000 points) installed successfully interoperable PLC meters from 3 manufacturers according to open standards. In Spain, Iberdrola developed a new open standard for the next generation of meters (integrating into existing standards).

Some European projects are being done in order to develop and improve standards. PRIME (Power line Intelligent Metering Evolution) project focuses in the interoperability of open standards. OPEN (Open and Public Extended Network) meter project aims to fill the knowledge gaps necessary to enable the relevant industries to agree on the required standards.

IV. A Research Agenda: Regulation and Smart Metering Policies

Concerning regulatory and legislative coordination tools, four main issues should be solved in order to efficiently promote smart metering:

1. Where to put the border between regulated and market activities in order to achieve most of the benefits from smart metering at a minimum cost in the long run (avoiding lock in situations)?

This question should be analyzed considering the different properties of each policy option. On the one hand, the regulated policy options can be easily oriented to provide system-wide benefits. However, they have the risk of lock-in in technologies and suffer from imperfect regulation. On the other hand, market-based policy options have the benefits of promoting innovations and cost reductions. Competition within different meters and technologies will lead

to the most interesting and innovative solutions. However, more market-based policy options have the risk of only resulting in smart meter investments with a positive net private benefit (system-wide and environmental benefits may not be achieved on voluntary basis).

Ideally, balanced approaches should be used somewhere in between the two extremes: fully regulated and fully competitive smart metering policy. Large monopoly of DNOs on smart metering could lead to the wrong technology choices hampering further developments and innovation as it is hard to precisely define all the functionalities of the ultimate smart meter. An alternative solution should be to define two levels of smart metering: i) a basic level of metering being implemented by the DNOs while corresponding to an EU wide open standard (like the GSM standard) and ii) to allow to suppliers to “plug and play” on this basic box with more advanced meters. In this way, DNO keeps the monopoly and public service only on the basic metering standard. This should be completed by a proper regulatory framework for network activities to improve “pricing” and to give signals to consumers or suppliers to coordinate actions in order to reap system wide benefits.

In conclusion, three regulatory questions should be answered here:

- 1.1 Which level of smart metering deployment is optimal?*
- 1.2 How to achieve this level of deployment (regulated vs. market policy options)?*
- 1.3 How to define minimum functional requirement for smart meters?*

2. How to avoid lock-in in technologies and ensure interoperability?

In order to avoid lock-in, the regulatory framework should let room for innovation. But innovation needs some degree of harmonization to ensure interoperability and interchangeability between different technologies applied on smart metering. Given existing diversity of available technologies, standard settings and harmonization should be considered at the functional level, leaving to manufacturers, metering companies, electricity suppliers and consumers the freedom to adopt different (competing) technical solutions, as long as they are compatible with the efficient functioning of the internal electricity market.

3. What is a good level of intervention? Harmonization and smart meter policies should be set at the European or at National level?

Current developments in Europe are characterized by a lack of technical and regulatory harmonization, thus leading to a patchwork of national and sometimes even infra-national solutions. Very often this situation creates unnecessary extra costs, reduce potential

economies of scale that should benefit all stakeholders and introduces new barriers to full integration of the EU electricity markets. Therefore, some degree of harmonization is needed in order to facilitate the quick and cost effective introduction of smart metering in the European electricity market.

4. The problem of smart metering costs/benefits measurement. How to evaluate and isolate the impact of smart metering?

Cost/Benefit analyses are useful for policy makers in the choice of smart metering policies. Although many studies have realized “ex-ante” cost/benefit analyses, “ex-post” cost-benefit analyses have not been undertaken. This kind of studies should help to better understand the effect of policies and in this way, to improve how they are designed.

Cost-benefit analyze methodologies should be designed in order to have a proper idea about different actual cost and benefits of smart metering. Particularly, environmental impacts of smart metering should be further analyzed; the workshop shown that there is some disagreement as to the extent that smart metering result in environmental benefits.

All the papers and presentations of the workshop can be downloaded from:
<http://www.eui.eu/RSCAS/Research/FSR/>