FROM SMART METERS TOWARDS SMART GRIDS

DE LA CONTOARE INTELIGENTE SPRE REŢELE INTELIGENTE

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Abstract: *According to the UE directives, Smart Metering was going to reach the level of 80% in 2020 and 100% in 2022. The EC study "Benchmarking smart metering deployment in the EU-28" states that, by 2024, it is expected that almost 77% of European consumers will have a smart meter for electricity. So, Smart Metering is a first step to increase the process of implementing digital technologies to achieve a Smart Grid and a new energy market, involving the consumers. The new challenges of the global digital revolution need special attention regarding the implementation of these new solutions into the National Power System. In this context, the paper presents the achievements in the digital technologies deployment and how to accelerate this process.*

Keywords: Smart Grid, Smart Metering, power systems, energy management, energy market

Rezumat: *Conform directivelor Uniunii Europene, contorizarea inteligentă trebuia să atingă un nivel de 80% în 2020 şi 100% în 2022. În studiul realizat de Comisia Europeană "Benchmarking smart metering deployment in the EU-28", se afirmă că, până în 2024, vor avea un contor inteligent de energie electrică cel puţin 77% dintre consumatori. Astfel, contorizarea inteligentă reprezintă un prim pas în cadrul procesului de implementare a tehnologiilor digitale în vederea realizării unei reţele electrice inteligente (Smart Grid) şi a unei pieţe noi de energie care să implice şi consumatorii. Noile provocări ale revoluţiei digitale globale necesită o atenţie deosebită în ce priveşte integrarea acestor noi soluţii în cadrul Sistemului Energetic Naţional. În acest context, lucrarea prezintă realizările în implementarea tehnologiilor digitale şi soluţii de accelerare a acestui proces.*

Cuvinte-cheie: Smart Grid, contoare inteligente, sisteme energetice, managementul energiei, piaţă de energie

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1. Introduction

The European has put in place legislation to reduce its CO_2 emissions by at least 40% by 2030 – as part of the EU's 2030 climate and energy framework and current contribution to the Paris Agreement. The EU also set targets of at least 27% for renewable energy sources (RES) in overall energy consumption and energy efficiency by 2030. By 2050, the plan is to achieve an effectively carbon-neutral power portfolio, in which the share of electricity from RES will amount to more than 50%. These targets mean two main aspects:

- on the one hand, this will include large-scale renewable generation sources such as offshore wind farms, whose development will require substantial investments in the transmission grid;
- on the other hand, distribution networks will need to accommodate an increasing number of small-scale sources.

As a consequence, power will not only flow in one direction, from the power system to the consumer, but increasingly from the customer to the power system as well. The result will be a grid that is largely automated, applying greater intelligence to operate, monitor and even heal itself. This “Smart Grid” will be more flexible, more reliable and better able to serve the needs of a digital economy. But, the Smart Grid is not just about utilities and technologies; it is also about giving to the consumers the information and tools they need to make choices about their energy use. "Smart meters", and other mechanisms, will allow the consumers to see how much electricity they use, when they use it, and its cost. Combined with real-time pricing, this will allow the consumers to save money by using less power when electricity is most expensive. Achieving such a system requires advances in systems science and engineering, that will enable effective design, as well as improvements to communication and networking infrastructure. Multidisciplinary efforts will encompass computer science, mathematics, statistics, engineering, and a full spectrum of physical sciences - even extending into ethics, psychology, and a broad array of human factors. It is a great need for more awareness about what the implementing of a Smart Grid will include, especially to identify the most important steps for policy makers and industry. According to the Third Energy Package, Smart Metering is the first step to achieve such a Smart Grid.

2. Smart Metering in the European Union Legislation

The Third Energy Package provides that implementation of Smart Metering may be subject to an economic assessment of long-term costs and benefits to the market and individual consumers. For electricity, Member States must:

- proceed with the smart metering roll-out to at least 80% of positively assessed cases on their territory by 2020;
- prepare an implementation timetable over a period of up to 10 years.

2.1. Definitions

According to the EC Recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems (2012/148/EU), we can define the concepts of „Smart Grid” and „Smart Metering system” as it follows:

- A „Smart Grid” is an electric grid system where all participants (from electricity generators, to transmission and distribution operators, to electricity consumers) communicate and work with each other to increase the efficiency and reliability of the grid. A key feature of a Smart Grid system is the use of advanced technologies (see Fig.1) that provide participants with relevant, real-time information.

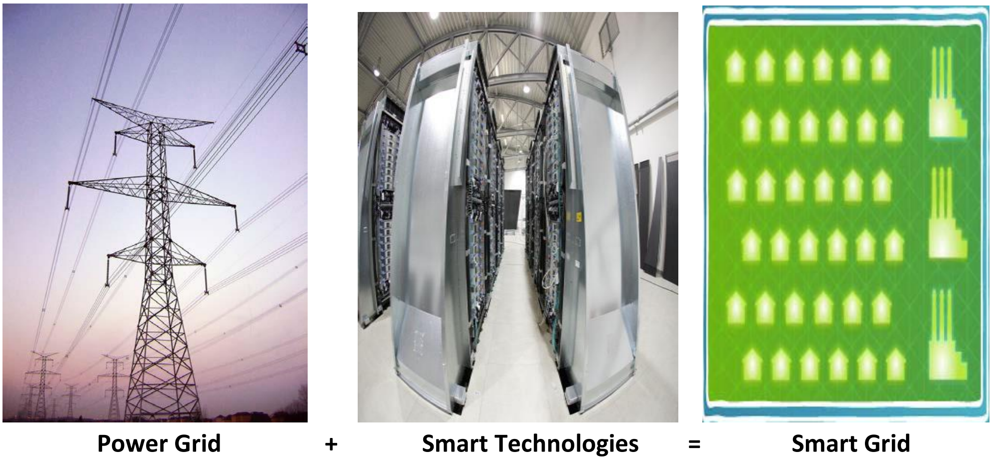

Figure 1. The basis structure of a Smart Grid (source: NATURE, 2013)

These technologies (see Table 1) include a combination of smart devices with a smart communication network which can supply massive amounts of new data to an operator. The addition of load and voltage information, video surveillance, access alarms, trouble calls, and field reports can certainly provide a complete picture of the network. In the mean time, these technologies allow generators, system managers, and customers to receive instantaneous information on electricity needs and prices.

- A „Smart metering system” means an electronic system that can measure energy consumption, adding more information than a conventional meter, and can transmit and receive data using a form of electronic communication.

Table 1. **Smart Grid Technologies**

No.	Smart Technology	Characterization
1.	Smart Communication Networks	Integrated communication networks capable of supporting high-speed and large volumes of data in a bi-directional flow between the operational centers and the electric infrastructure.
2.	Smart Devices	Utilizing the latest sensors and automated devices, these more intelligent devices will supply more data to the operations center. Measurement information will aid operations and software applications in making better decisions (eg. smart meters).
3.	Smart Operator/Console	Improvements in outage and distribution management systems will provide a single user-interface that communicates SCADA, DNA, OMS and mobile workforce management (MWM) data to system operators.

A Smart Meter is one component of a Smart Grid, an approach to managing energy distribution and consumption that uses Internet technologies to create bi-directional communication, coordination and control. So, a Smart Meter is an Internet-capable device that measures energy, water or natural gas consumption of a building or home. Whereas traditional meters only measure total consumption, Smart Meters record when and how much of a resource is consumed. Power companies are deploying Smart Meters to monitor consumer usage and adjust prices according to the time of day and season. The Smart Meter acts as the network termination point, an ingress router between the utility's network and the building it is monitoring. When connected to a building automation system, a Smart Meter will allow the building administrator to control heating, ventilation and air conditioning (HVAC) based on real-time energy costs.

In short, we can say the digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid „smart".

2.2. The main features required for a Smart Metering System

The EC has included, into the Recommendation 2012/148/EU, 10 common minimum functional requirements for electricity Smart Metering systems. These functionalities capture the essential elements that a Smart Metering set-up should have to benefit all stakeholders — the consumer, the metering and system operator — while enabling, in a secured and safe environment, the commercial aspects of supply/demand and the integration of distributed generation. The Recommendation proposes that all electricity Smart Metering systems are at least equipped with the functionalities summarised in Table 2. These functionalities are the outcome of the Commission consultation with Member States who had already advanced, before the publication of the Recommendation, with the deployment of Smart Metering.

*Table 2***. The recommended 10 common minimum functional requirements (2012/148/EU Recommendation**)

No.	**LEVEL**	**FUNCTIONALITIES**
1.	CONSUMER	a) Provide readings directly to the customer and to any 3-rd party designated by the consumer b) Update the readings frequently enough to use energy savings schemes
2.	METERING OPERATOR	c) Allow remote reading of meters by the operator d) Provide two-way communication for maintenance and control e)Allow frequent enough readings for network planning
3.	COMMERCIAL ASPECTS OF ENERGY SUPPLY	f) Support advanced tariff systems g) Remote on/off control supply and/or flow or power limitation
4.	SECURITY DATA PROTECTION	h) Provide secure data communication i) Fraud prevention and detection
5.	DISTRIBUTED GENERATION	j) Provide import/export and reactive metering

The 10 common minimum functionalities recommended are consistent with the European Energy Regulators respective guidelines regarding Smart Metering functionalities, in particular those which benefit consumers. They are based on, and remain consistent with, those tabled under the standardisation mandate M/441. Table 3 illustrates the correspondence of the 10 common minimum functionalities with those proposed by the M/441 working group.

Functionalities (a) and (b) in conjunction with functionality (f) support advanced pricing structures and are **key for both consumer and network operators** to achieve energy efficiencies and save costs by reducing the peaks in energy demand.

It is therefore strongly recommended that the Smart Metering systems to be rolled-out are equipped with such functionalities that allow the automatic transfer of information about consumption data and advanced tariffs' options to the final customers, e.g. via standardised interface. Therefore, it is important to carefully consider the functionalities that smart metering systems should have, and map those into benefits when conducting the Cost-Benefit Analysis, since different functionalities result in significant variation of the final outcome of the assessment, and in the decision for, or against, large-scale deployment.

Table 3. **Smart Metering Functionalities for Electricity**

	M/441 additional functionalities identified in EN-CLC-ETSI TR 50572:2011 *„Functional reference architecture for communications in smart metering systems"*	**2012/148/EU common minimum functionalities identified in EC Recommendation of 9 - 03- 2012 *„on preparation for the roll-aut of smart metering systems"***
F1	Remote reading of metrological register(s) and provision to designated market organisations	**For the customer:** a) Provide readings directly to the customer and to any third party designated by the consumer b) Update the readings referred to in point (a) frequentlyenough to allow the information to be used to achieveenergy savings …The rate has to be adapted to the response time of the energyconsuming or energy-producing products. The general consensus is that an update rate of every 15 minutes is needed at least.
F2	Two-way communication between the metering system and designated market organisation(s)	**For the metering operator:** c) Allow remote reading of meters by the operator d) Provide two-way communication between the smartmetering system and external networks for maintenance and control of the metering system e)Allow readings to be taken frequently enough for the information to be used for network planning
F3	To support advanced tariffing and payment systems	**For commercial aspects of energy supply:** f) Support advanced tariff systems
F4	To allow remote disablement and enablement of supply and flow power limitation	g) Allow remote on/off control of the supply and/or flow or power limitation
F5	To provide secure communication enabling the smart meter to export metrological data for display and potential analysis to the end consumer or a third party	**For security and data protection:** h) Provide secure data communication i) Fraud prevention and detection
F6	To provide information via web portal/gateway to an in-home/building display or auxiliary equipment	**For distributed generation:** j) Provide import/export and reactive metering

3. How to implement a smart grid in the european union

3.1. The main phases of implementing Smart Grids in EU

There are in fact two grids to keep in mind as our future rapidly becomes the present:

- the **first** one – we'll call it "a smarter grid" – offers valuable technologies as the smart metering systems can be deployed within the very near future or are already deployed today;
- the **second** one – the real Smart Grid – represents the longer-term promise of a grid remarkable in its intelligence and impressive in its scope (see Table 4), although it is considered to be a decade or moreto achieve it. We can speak about a tale in two timelines.

Table 4. **Differences between a current grid and a Smart Grid**

No.	Parts of the Power Delivery Infrastructure	Current Grid	Smart Grid
1.	Communications	None or one-way; typically not real-time	Two-way, real-time
2.	Customer interaction	Limited	Extensive
3.	Metering	Electromechanical	Digital (enabling real-time pricing and net metering)
4.	Operation and maintenance	Manual equipment checks, time-based maintenance	Remote monitoring, predictive, condition-based maintenance
5.	Generation	Centralized	Centralized and distributed
6.	Reliability	Prone to failures and cascading outages; essentially reactive	Automated, pro-active protection;prevents outages before they start
7.	Restoration following disturbance	Manual	Self-healing
8.	System topology	Radial; generally one-way power flow	Network; multiple power flow pathways
9.	Power flow control	Limited	Comprehensive, automated

According to Eurelectric, the Smart Grids implementing in the EU can be clustered in three phases (see Table 5):

1. The **facilitation phase** at both national and EU level - includes the development of regulation and market models, standardization and testing promising projects.

2. The **deployment phase -** includes a large-scale introduction of „smart network management” and „smart integrated generation” functionalities in the member states (see Figure 2).

3. The **commercialization phase** – includes new services offered by commercial parties. This will involve a large number of stakeholders and is expected to take longer, most probably beyond 2020.

Table 5. **The Smart Grids implementing phases in EU**

No.	**PHASE**	**ACTIONS**
1.	FACILITATION	1.1. Providing regulatory incentives for innovative grid investments 1.2. Developing market models 1.3. Setting standards and ensuring data protection & privacy 1.4. Testing through demonstration projects & sharing knowledge
2.	DEPLOYMENT	2.1. Rolling out smart metering – Informed customers 2.2. Monitoring and controlling the grid & distributed generation 2.3. Moving to integrated local & central balancing of all generation 2.4. Aggregating distributed energy sources
3.	COMMERCIALIZATION	3.1. Integrating large-scale e-mobility, heating, cooling and storage 3.2. Moving to real customer participation in the power market

SMART NETWORK MANAGEMENT	**SMART INTEGRATED GENERATION**	**SMART MARKETS AND CUSTOMERS**
➢ Conventional grid develop- ment combined with… ➢ Faster fault identification and self-healing capabilities through grid automation ➢ Advanced network operation and control ➢ Smart metering	➢ Balancing the power grid with a large share of variable renewables, including distributed generation ➢ Integrating electric vehicles and heating & cooling systems ➢ Intelligent storage solutions	➢ Developing demand response programmes and load control ➢ Aggregating distributed energy sources including e-mobility

Figure 2. The Functionalities of a Smart Grid

While the facilitation phase will require the EU support, the two following phases - deployment and large-scale commercialisation - will take place ***in those member countries where Smart Grids are considered to be economically viable***, taking into account the energy supply mix, current and future demand, and the status of today's networks.

3.2. Smart Metering Deployment in the European Union

In designing their Smart Metering systems, the authorities in Member States must also anticipate future energy services, operational needs of the energy system and the deployment of smart grids. Accordingly, it is important to focus on screening of any relevant technological developments which would allow Member States to deploy the most advanced Smart Metering systems in order to boost the competitiveness of the devices' producers in line with the cost-benefit analysis. In this context, setting a complete set of functionalities is key for facilitating the roll-out process itself, but also securing benefits for different stakeholders (DSOs, Consumers, Suppliers, etc.), creating the necessary cost-efficiencies and ensuring lasting value.

Figures 3-6 show the advantages of Smart Meters deployment estimated from the EU Member States CBA data.

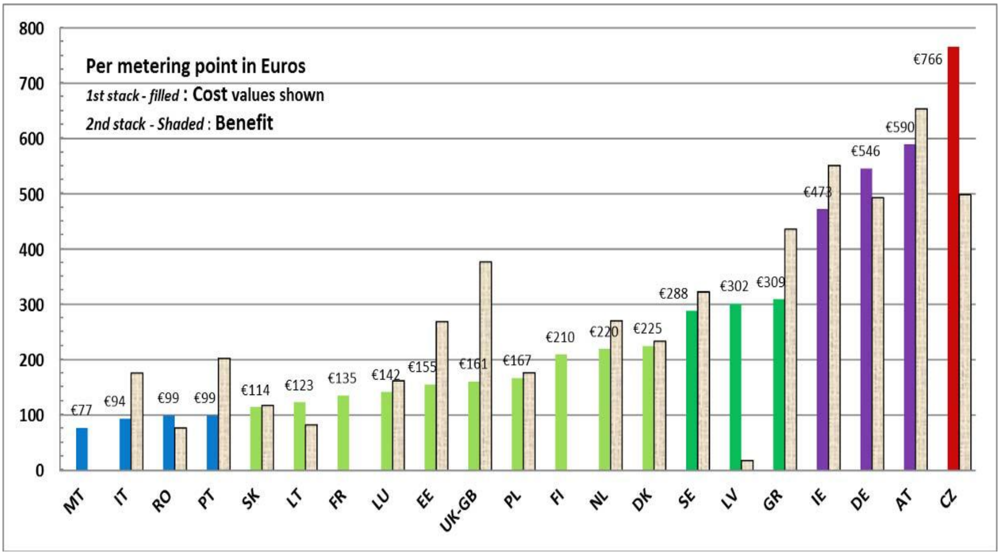

Figure 3. Normalised cost and benefit values per metering point

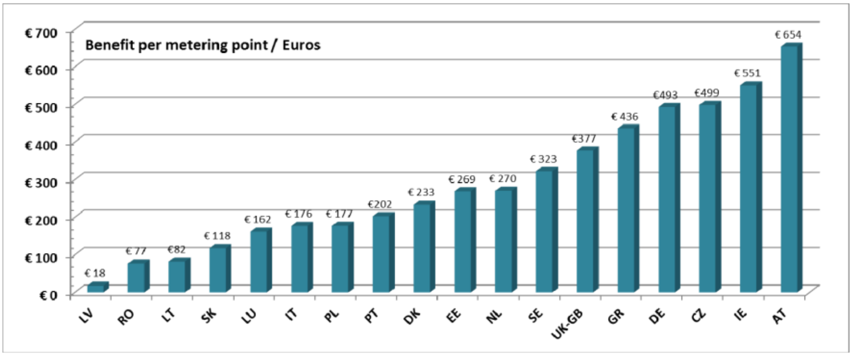

Figure 4. Normalised benefit values per metering point in the EU Member States

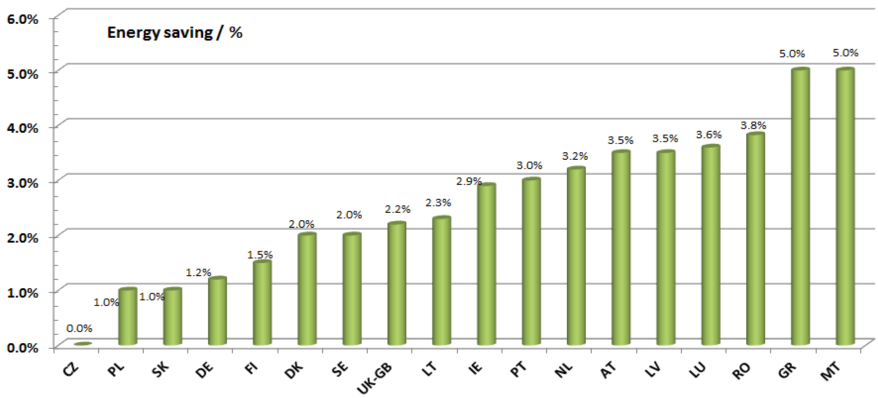

Figure 5. Potential for energy saving over total electricity consumption expected from Smart Metering roll-outs

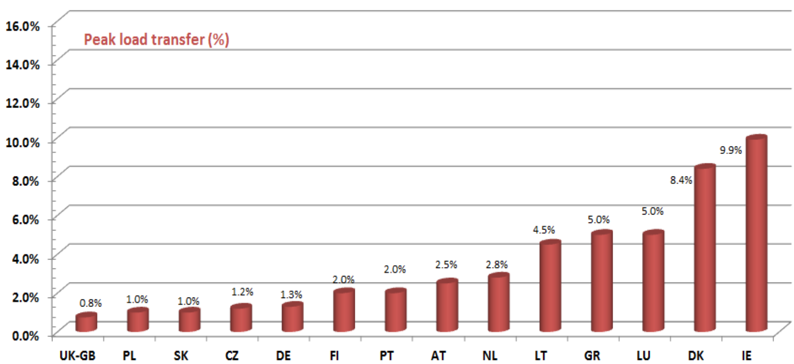

Figure 6. Potential for peak load shifting over total electricity consumption expected from Smart Metering roll-outs

4. Conclusions

The integration of multiple systems is the basis of a Smart Grid. The Smart Grid will evolve rapidly as more devices are introduced and improved. Also, system applications are being enhanced to optimally use all the data to more automatically maintain continuous electrical service and reliability.

The majority of EU Member States decided to carry out a cost-benefit analysis (CBA) before reflecting on the way forward and deciding next steps. As regards electricity, about two thirds of Member States have decided in favour of a largescale roll-out of Smart Metering by 2020 or earlier. Some, such as Italy and Spain, have decided to go ahead without conducting a detailed CBA. But, the main idea is that the deployment and large-scale commercialisation phases will take place in those member countries where Smart Grids are considered to be economically viable, taking into account the energy supply mix, current and future demand, and the status of today's networks.

Under the Smart Metering mandate (M/441), 50 standards have been available for use since end of 2012. Work is currently ongoing to standardise the core interfaces between the meter and the communication network, and between networks, so as to allow true 'any-to-any' connectivity.

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