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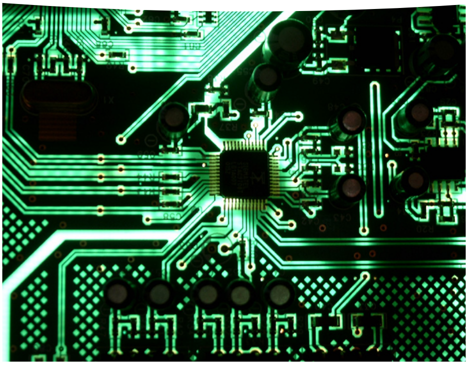

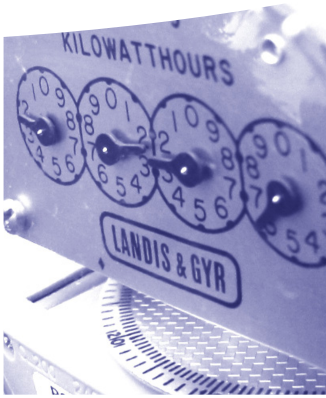

Smart Grid in the Danube Region Countries

An Assessment Report

PREPARED BY

REKK

NEW SZÉCHENYI PLAN

The assessment report was commissioned by the Sustainable Energy Priority Area of the Danube Region Strategy.

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January 2014

MINISTRY OF
FOREIGN AFFAIRS
OF HUNGARY

The assessment report was supported by the VOP-1.1.1-11-2011-0001 project of the Ministry of Foreign Affairs of Hungary.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 ABBREVIATIONS

AIT – average interruption time

AMI – Advanced Metering Infrastructure

AMM – Advanced Metering Management

AMR – Advanced Metering Reading

ARC – Adequacy Reference Margin (ARM)

CAPEX – capital expenditures

CBA – cost-benefit assessment

CEER - Council of European Energy Regulators

CER - Commission for Energy Regulation (Irish energy regulator)

CHP – combined heat and power

CSP – concentrated solar power plant

DG – distributed generation

DLR – dynamic line rating

DR – Danube Region

DSM – demand side management

DSO – distribution system operator

EBRD – European Bank for Reconstruction and Development

EDSO for Smart Grids – European Distribution Operators" Association for Smart Grids

EE – energy efficiency

EEG plant – renewable producers under the German support scheme

EGREG - European Regulators Group for Electricity and Gas

EHV – extra high voltage

ENS – energy not supplied

ENTSO-E - European Network of Transmission System Operators For Electricity

EPRI – Electric Power Research Institute (US)

ETM – Hungarian abbreviation for Distribution System Telemechanics System

EV – electric vehicles

FP7 - Seventh Framework Programme for Research

GDP – gross domestic product

GHG – greenhouse gas

GW – gigawatt

HAN – home area network

HV – high voltage

ICT – info-communication technology

JRC – Joint Research Centre

LV – low voltage

MEDREG – Institution of Mediterranean Energy Regulators

MV – medium voltage

NPV – net present value

NREAP – National Renewable Energy Action Plan

OPEX – operation and maintenance expenditures

ORC – organic rankine cycle

PHEV – plug-in hybrid electric vehicle

PV – photovoltaic panel

R&D – research and development

RC – remaining capacity

RES – renewable energy source

RES-E – renewable electricity

RPF – Reverse power flow

RPT – reserve power flow time

SAIDI – system average interruption duration index

SAIFI – system average interruption frequency index

SEE – South-East Europe

SO&AF – Scenario Outlook & Adequacy Forecast

ToU – time of use

TSO – transmission system operator

V2G – vehicle to grid

VAR – voltage-amper reactive

VPP – virtual power plant

WACC – weighted average cost of capital

2. EXECUTIVE SUMMARY

The Energy Priority Area of the Danube Region Strategy together with the Regional Centre for Energy Policy Research (REKK) engaged in a research project on the status quo of smart grid deployment in the Danube Region countries to introduce the issue of smart grids into the policy agenda and to provide the basis of further cooperation on this highly prioritised topic. The current scoping paper has been prepared on the basis of various information sources:

1. publicly available information from regulators, their associations, DSO associations and other international organisations,
2. survey developed by REKK that has been sent to all DR countries and has been completed either by the regulator, the responsible ministry or – in some cases – the national smart grid association,
3. presentations and discussion at the two workshops organised in the framework of the project:

- Budapest (February 2013) with the participation of Hungarian stakeholders
- Brussels (November 2013) with the participation of DR stakeholders.

Our survey covers 11 countries from the 14 members of the Danube Region Strategy: Germany, Bulgaria and Serbia did not submit the questionnaire.

This paper first discusses the **concept of smart grids and smart meters** in the context of competition, sustainability, system security and the additional services smart metering can offer. The role of smart grids and metering is assessed in reaching the above mentioned goals and a number of performance indicators are identified.

General policy goal	Means	Solutions offered by smart networks	Beneficiary	Performance indicators
Competitive retail electricity markets	Increased retail competition	smart meters	consumers	• supplier switching rate
	innovative end customer tariffs	smart meters	consumers	• existence of ToU tariffs • power quality differentiated tariffs
Sustainability	energy efficiency	smart meters	consumers	• current level of energy intensity
	electric vehicles (EV)	recharging infrastructure	consumers	• share of EVs in the personal vehicle fleet • number of public recharging stations
	DG/RES-E	active distribution network, storage	prosumers	• future share of RES-E
Security	generation adequacy	demand response	network operators	• peak shaving potential • electricity demand forecast • RC-ARM • network loss
		smart electrical appliances		
		DG-load profile harmonisation		
		storage		
	secure grid operation	automatic fault detection and self-healing network		• SAIDI, SAIFI • voltage quality
		voltage control		
Additional services	pre-payment option	smart meters	network operator	• network loss • commercial loss • existence of pay-as-you-go service
	theft detection			
	remote metering			
	remote connection and disconnection			

Table 1: Policy goals, smart grid solutions and performance indicators

The subsequent section is devoted to the **state-of-affairs in smart grids and smart metering** in the Danube Region. The paper looks at smart grid investment levels, the existence and main results of strategic documents regarding smart grids and metering, and current rollout. Smart grid investments, according to the database of the European Commission's Joint Research Center, are concentrated in countries of relatively high RES-E share and GDP levels: in the Danube Region this means Germany, Austria and to a lesser extent the Czech Republic and Slovenia. The adoption of strategic documents is a good proxy for the importance of smart grid and metering deployment on the policy agenda. According to our survey, only Austria, Germany and Slovenia prepared its own smart grid roadmap. An important conclusion from the existing roadmaps is that most often they are not prepared by governmental bodies or the energy regulator but on the initiative of DSO associations and supply manufacturers. The development of smart grid investments is at the early stages, with the exception of Austria. The most important field for future investment is exclusively the distribution network, primarily through smart metering and subsequently by other distribution network related investments.

The following table gives an overview of the rollout plans and the related cost-benefit analyses of smart meters. As far as the completion of the required CBA concerned, the EU member states of the Danube Region have conducted the analysis with the exception of Bulgaria and Croatia. Germany and Slovakia have completed their CBAs recently, while Slovenia prepared its Smart Grid Roadmap in March 2013 which includes smart metering in the context of smart grids but is lacking a separate analysis for smart meters. There are some countries that have conducted the CBA on smart metering but do not yet have a rollout plan; in the Czech Republic it is due to the negative outcome of the CBA and in Hungary legislation is moving slowly.

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
SM rollout plan		✓			✓		✓			✓	
full rollout		2022									
interim target		80%/ 2020			70%/ 2020		95%/ 2019				
CBA prepared	✓	✓					✓	✓		✓	
CBA results	-	+					+	+		+	

Table 2: The rollout plan, target and CBA of smart metering in the Danube region countries

Note: red background: no data or not applicable

Although smart metering and dynamic tariffs are associated with the current and future modernisation of the electricity network, time of use tariffs – usually via radio frequency controlled meters – are quite common in the Central and Eastern European countries. It facilitates the use of electric equipment with heat storage option (boilers, electric stoves) at night when aggregate demand is low.

The next section is structured along the indicators identified in the conceptual framework providing an indication of **potential drivers behind smart grid deployment.** *Growing electricity demand* in general means higher demand for the transportation of electricity and hence higher utilization rate of the transmission and the distribution grid. Smart grids that enable the integration of "prosumers"(households that consume and produce electricity concurrently) at the distribution network can limit the additional demand for electricity transport due to growing consumption. Members of the Energy Community expect much higher growth than the EU member states. The only exception is Serbia (RS) which has published its NREAP in mid-2013 with an annual growth that is much lower than the previous one (0.7% instead of 1.6%).

Smart meters can enhance the *energy saving* of final consumers via continuous and real time feedback on consumption and spending. The energy intensity indicators of the DR countries show that there is a higher potential to increase the efficiency of energy use in countries with lower economic output, notably in Ukraine, Serbia, Moldova, Bosnia and Herzegovina and Bulgaria.

The growing importance of *renewable generation,* both large scale and distributed, is a major challenge for electricity networks. The proxies used for assessing the demand for smart grid solutions are the share of RES-E in gross final electricity consumption and the change in the generation portfolio: the share of intermittent RES-E in the renewable portfolio and net generation capacity. The countries that expect the strongest increase of RES-E in final consumption are Germany, Bulgaria, Romania and Serbia (Table 12). The share of intermittent RES-E (wind and solar) is forecasted to double at least in Austria, Bulgaria, Croatia, Romania, Hungary and Slovenia from the current level to 2020 (Figure 22). It is important to note, however, that the integration of these intermittent resources, from a balancing point of view, is less problematic in countries with large hydro capacities (reservoir and pumped hydro) that can contribute to system balancing.

Electric vehicles constitute new demand for electricity but at the same time are flexible load elements that consume electricity at periods of low load (at nights). In addition, EVs can be used for injecting electricity to the grid when needed (V2G: vehicle-to-grid). The share of EVs and plug-in hybrid electric vehicles (PHEVs) in the total light-duty vehicles (personal cars) is still negligible in the DR countries and the charging infrastructure is sparse.

Once the peaks in the *aggregate load profile* are reduced by shifting consumption to periods of lower electricity demand, the system faces lower balancing needs. We have analysed the potential for peak shaving by identifying the variation of peak to minimum load ratios. According to this measure, the maximum demand in 2012 was roughly double than the minimum in Slovakia, whereas in Montenegro it was almost 3.4 times higher. The countries where the peak-off-peak ratio is the highest are – therefore – Croatia, Bulgaria, Serbia and Montenegro.

Network losses in the power grid can be classified as either technical or non-technical (commercial) losses, where the latter usually refers to electricity theft. While smart grids, and in particular smart metering could be important in reducing theft, future smart networks could result in lower technical losses by improved grid characteristics, e.g. introducing more flexibility to the network. The level of network losses varies considerably in the Danube Region, from as low as 3-5% in Slovakia, Germany and Austria to more than 25% in Moldova. Apart from Moldova, which is a clear outlier, seven other countries have network losses of above 10% of all electricity supplied.

Commercial loss is characterized by two items: theft and inaccurate metering. Both sources of loss can be reduced with the introduction of smart meters. We have not managed to identify a common source for the commercial loss rates of the Danube Region countries, as these rates are DSO specific even within a single country. In Montenegro the level of commercial losses was 13-14% in 2005, which was reduced – after a series of regulatory measures – to 10.8% in 2007 and is currently (from Jan to Sept 2012) 9.5%. DSOs in Moldova, Ukraine and Bosnia and Herzegovina have similarly high commercial losses.

Generation and system adequacy are important because they show to what extent a country is able to cover its electricity demand in different situations with the help of inland generation capacity (generation adequacy) or in the case of spare capacities using import capacities (system adequacy). Ensuring generation adequacy does not mean merely building new generation facilities. Smart grids upgrades can also make important improvements: it can lead to better demand forecasting and, using demand side participation, it can also reduce load in peak hours. By doing so, smart grids enable higher penetration of intermittent generation while also leading to smaller balancing energy and secondary power reserve needs. Although generation adequacy is questionable is some DR countries, when cross-border transmission capacities are considered (system adequacy) even those countries with inadequate generation capacities are able to cover their needs.

One of the most important characteristics of a national electricity grid is the power quality it is able to provide to customers. The most comprehensible aspect of power quality is continuity of service, as the uninterrupted supply of electricity is very important for all kinds of electricity consumers. Smart grids and smart meters can contribute to better *service quality* via automatic error detection based on smart meters with voltage fluctuation detectors and power quality censors, and the automatic substitution of faulted distribution network sections to serve consumers without interruption. Service continuity is not a problem in Germany and Austria, Slovenia and Hungary. At the other extreme, Bosnia and Herzegovina, Serbia, Moldova, Romania and Ukraine are clearly having difficulties with providing a reliable electricity su

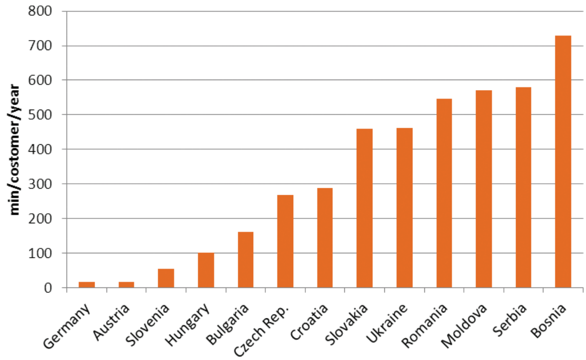

Figure 1: SAIDI value for unplanned interruptions in the Danube Region countries (minutes of interruption/customer/year, 2010/2011/2012)

Source: national data sources

The timely provision on consumption data is expected to facilitate market processes in the retail segment such as *supplier switch,* contract change, or simple movement from one flat to another. In the Danube Region countries, the current rate of supplier switch is quite low, even in countries with fully liberalised electricity retail markets. Austria and Hungary have the highest rates within the full consumer segment. In case of households where smart meters are not common as of today, Germany, Austria and the Czech Republic have higher rates (Figure 30). The instalment of smart meters will not – in itself – motivate consumers to actively choose among alternative suppliers and tariff packages but it can substantially reduce the transaction cost of such action.

The last section is devoted to **regulatory issues,** most notably the incentives provided to DSOs to invest in innovative grid projects that are more risky than conventional network extension. The importance of regulatory issues is reflected in the survey as well: the most important barriers of smart grid deployment are the high associated cost, the inadequate incentives and the lack of regulatory policies. The main roles of the regulator that is almost unanimously shared across the countries is to initiate stakeholder discussion on smart grid and meter deployment and to provide adequate incentives for DSOs to *invest in smart grid projects.* It is important to note that these projects bear higher risk than conventional grid investments as the magnitude and the distribution of the benefits among the market participants is difficult to assess in advance. The majority of the Danube Region countries offer no special incentives to DSOs to invest in smart grid projects. Only the Romanian and the Slovenian regulation have a specific smart grid component. In Romania, for the investment in smart metering systems, DSOs are eligible for an extra 0.5% WACC compared to the WACC of other types of investment. This system is very similar to that of Italy where the extra WACC is 2% for selected smart grid projects. In Slovenia, investors receive a one-time incentive of 2% of the investment value for smart grids investments (in addition to regular income from grid regulation).

From the current report and the workshop the conclusion that can be reached is that different countries face different potential benefits from smart grid deployment, which should be weighted against the cost it requires. In the case of smart meters this attitude is evident from the practices of the countries that, as a rule, base their rollout decision on cost-benefit analysis. However the "smarting of grids" does not happen at once, it is a complex and gradual process. Therefore, it is essential that counties analyse regularly the alternative solutions and their costs and benefits in order to make informed decisions. The national demand for smart grids is not articulated as yet in the majority of the Danube Region countries. Comprehensive assessment is rather an exception than a rule.

It is evident, however, from the preliminary assessment that the drivers behind smart grids in the Danube Region vary across countries; managing the new technologies that have to be integrated into the current network, such as distributed and renewable generation and electric vehicles or the facilitation of retail market competition (via easier supplier switch and innovative tariff packages) are common but other more fundamental services facilitated by smart metering such as the reduction of commercial losses and the improvement of service quality are prioritized as well. The following table provides our findings for the country-specific drivers.

	CZ	RO	SI	CR	BA	MD	AT	HU	ME
RES-E		✓	✓	✓	✓		✓	✓	✓
Electric vehicles									
Energy efficiency					✓	✓			✓
Peak shaving				✓					✓
Network loss		✓			✓	✓			✓
Supply quality		✓			✓	✓			✓
Commerical loss					✓	✓		✓	✓
Retail competition	✓	✓	✓	✓			✓	✓	

Table 3: Preliminary assessment on the demand for smart grid services in the Danube Region countries

Future actions on smart grids in the Danube Region are envisaged on three levels:

1. Regulatory cooperation

The countries of the Danube Region could form a working group on regulation that would provide a supportive environment to the future deployment of smart grids. The initial topics for consideration are:

- the role of DSO in providing ancillary services
- innovation need on future electricity networks: new roles, new actors and new service providers (non-technological issues)
- "best regulatory practices" for the deployment of active distribution network management
- coordinated balancing for the cost efficient integration of RES-E in the DR.

Future work on regulatory cooperation under the PA2 should bear in mind the activities of other international organisations, such as the ENTSO-E activity on network codes. The value added of a DR initiative should be should be taken into account.

2. Research cooperation

The discussion has brought up several issues that can form a basis of joint thinking on the future smart grid research agenda:

- the applicability of demo projects already executed in other countries with similar boundary conditions
- what would be the effect of massive RES-E penetration in DR countries? How would DR countries cope with issues already experienced in Germany?

Potential funding sources are the ERA-net Initiative (for contributing countries) and the Horizon 2020 call that are due later in 2013.

3. Investment cooperation

The third level of possible cooperation – evidently prioritised by the European Commission – is that of joint project proposals between DR countries for transnational investment projects. The scope of PCIs is limited to transmission projects, leaving issues related to the distribution grids ineligible: the role of PA2 in developing such proposals could be discussed. A second option raised was to identify projects eligible for EU regional funds.

These Projects of Regional Interest (PRIs) could focus on both networks and attract financing with the promotion of PA2 or even with the PA2 organising the tendering of PRIs for future funding submission.

3 INTRODUCTION

The future of the European electricity grid is an essential element in achieving the 2020 ambitions of 20% reduction of GHG emissions from the 1990 benchmark, the 20% reduction of energy consumption and reaching the 20% share of energy from renewable sources. To reach these policy goals smart grids are increasingly recognised as a key component. The "smarting of electricity grids" receives high priority on the political agenda of the European Union. The Communication of the Commission on the internal energy market warns that the completion of the internal energy market due by 2014 is behind schedule and requires renewed efforts from the member states.[1] Its Action Plan requires the active participation of consumers (via the measures of the new Energy Efficiency Directive, 2013/2014), the standardisation of smart appliances (2014) and the preparation of national plans for the swift deployment of smart grids (2013). The Energy Community countries frequently update their Energy Efficiency Roadmap which grows in scope with the adoption of new pieces of EE legislation. Consequently, the provisions of the new Energy Efficiency Directive such as the informative billing based on actual consumption and, possibly, time of use energy tariffs coupled with smart meters will appear on the policy agenda of these countries.

Investing into technology does not happen automatically and, in itself, it does not guarantee delivery of expected benefits. Policy makers and regulators need to give the right incentives to network operators, most notably DSOs, to encourage smart grid investment. Similarly, harvesting the full benefits offered by smart meters requires the right incentives for consumers to reduce their overall and peak consumption.

The aim of the paper is to provide a preliminary assessment of the current policies of Danube Region countries regarding smart grids/metering and the identification of possible drivers behind future investment by assessing a collection of indicators that pinpoint potential benefits for future deployment. Some of the issues are discussed in a European context as a benchmark to assess the developmental status of Danube Region countries.

3.1 Methodology

This paper has been prepared on the basis of various information sources:

1. publicly available information from regulators, their associations, DSO associations and other international organisations
2. a survey developed by REKK that has been sent to all DR countries and has been completed either by the regulator, the responsible ministry or – in some cases – the national smart grid association
3. presentations and discussion at the two workshops organised in the framework of the project:
   - Budapest (2013 February) with the participation of Hungarian stakeholders
   - Brussels (2013 November) with the participation of DR stakeholders.

Our survey covers 11 countries from the 14 members of the Danube Region: Germany, Bulgaria and Serbia failed to return the questionnaire.

[1] Communication „Making the internal energy market work" [COM(2012)663]

3.2 The structure of the paper

The paper first discusses the concept of smart grids and smart meters in the context of competition, sustainability, system security and the additional services smart metering can offer. The role of smart grids and metering is assessed in reaching the above mentioned goals and a number of performance indicators are identified. The subsequent section is devoted to the state-of-affairs in smart grids and smart metering in the Danube Region. The paper looks at smart grid investment levels, the existence and main results of strategic documents regarding smart grids and metering, and current rollout levels. The next section is structured according to the indicators identified in the conceptual framework. These indicators are collected and presented for the Danube Region countries based on publicly available resources. The section, thus, provides an indication of potential drivers behind smart grid deployment. The issues addressed include future electricity demand, energy intensity, RES-E plans and current limits on RES-E deployment, electric vehicles, and various aspects of grid security that can be enhanced by smart grid solutions. The last section is devoted to regulatory issues, most notably the incentives provided to DSOs to invest in innovative grid projects that are more risky than conventional network extension, accompanied by a reference case study of the Italian incentive scheme. Finally, conclusions are outlined.

3.3 Similar studies

Assessments similar to the present study, based on surveys, have been made by regional energy regulatory organisations on the status and prospects of smart grid applications. ERGEG has prepared a position paper in 2009 and launched public consultation on the findings. The conclusions were published in June 2010 (ERGEG, 2010). CEER has conducted a survey on the regulatory approaches to smart grids and published its result in 2011 (CEER, 2011). In reference to the MedReg action plan (2011-2012), the Electricity Ad Hoc Group of the Institution of Mediterranean Energy Regulators (MEDREG) has prepared a survey entitled "Smart Grids in MedReg Countries" (MEDREG, 2011). The survey aims to map out the existing status and future plans for Smart Grids in MedReg countries.

4 THE CONCEPT OF SMART GRIDS AND SMART METERS

Technically, smart grids are electricity networks that are equipped with information and communication technologies (ICT) that allow for the interaction of producers, consumers and managers of the network. As the term "smart grid" is borne with reference to the current electricity network, it is best defined by the various functionalities it has to embody to keep pace with the changing demand for grid services. The output based definition developed by the European Technology Platform on Smart Grids[2] is the most widely used, and it has been reaffirmed by the European Commission and ERGEG as well:

"A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to:

- *better facilitate the connection and operation of generators of all sizes and technologies;*
- *allow consumers to play a part in optimizing the operation of the system;*
- *provide consumers with greater information and choice of supply;*
- *significantly reduce the environmental impact of the whole electricity supply system;*
- *deliver enhanced levels of reliability and security of supply."* (European Technology Platform, 2010)

According to CEER, those countries that define smart grids in their strategic documents, adopted very similar definitions (CEER, 2011). The various concepts associated with term "smart grid" are depicted in the following figure.

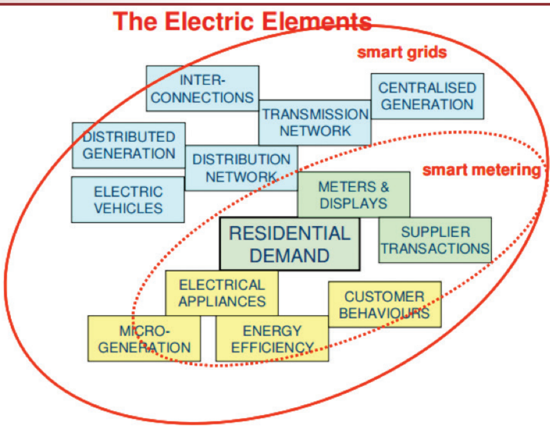

Figure 2: Elements of a smart grid

Source: Nabuurs in ERGEG (2009)

The terms "smart grid" and "smart metering" are often used interchangeably, however smart grid is a wider concept which – in its fully effective form – relies on a smart metering infrastructure. New elements in the

[2] The European Technology Platform for Electricity Networks of the Future, also called ETP SmartGrids has been established with the financial support of DG Research in 2005 to formulate and promote a vision for the development of European electricity networks towards 2020 and beyond. It represents over 100 stakeholders in the European electricity networks sector.

electricity grid are distributed generation units that include households which consume and produce electricity concurrently (prosumers), electric vehicles (EVs) on a significant penetration level, and remote controlled electrical appliances that are turned on in periods of low load and smooth the load profile. Smart meters foster energy efficiency and demand response from the final consumers. The provision of accurate consumption data and the associated energy cost induces a more rational use of energy, whereas the energy tariffs that are differentiated according to the time of use (ToU tariffs) incentivise consumers to shift a part of their consumptions to periods of low electricity demand associated with a lower tariff. Finally, smart metering systems can facilitate supplier-switching and broadly increase innovation in commercial offers to customers.

The distribution grid in this future system will transform from a passive system to an *active network* where the DSOs take on similar management functions as the TSOs with respect to the transmission grid. Distribution network management so far does not include the management of loads, except in the event of emergency situations. Short run security of supply and balancing is now the task of TSOs. And because the transmission network needs to integrate and not just accommodate large scale renewable generation and active distribution networks, the cooperation of DSOs and TSOs is likely to be strengthened.

"Smart meters" are digital devices supplemented with electronic communications enabling the transmission and reception of consumption data and processing software to provide a new set of services for consumers and various benefits to the society as a whole. The term "smart metering" does not only refer to the metering device but also to the whole measurement, collection and allocation system (Figure 3). The metering of several utilities of a household (home area network – HAN) can be served either by multi-utility or several single-utility meters. The data collected by the meters is concentrated and transmitted to the IT infrastructure. There are alternative technical modes for data transmission such as GPRS or fiber optics.

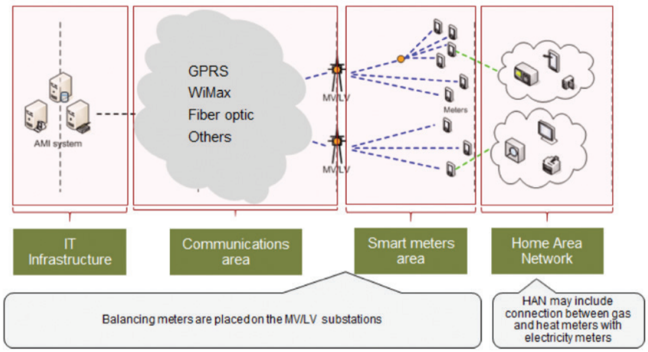

Figure 3: Components of smart metering architecture

Source: A.T. Kearney, 2012, p. 44

Smart meters are usually defined by the function that they are able to fulfil. The EU has adopted a recommendation on the minimum functionalities of smart meters, based on the previous work of ERGEG, on data protection and security issues and on the methodology of carrying out the prescribed cost-benefit analysis of the future rollout.[3] Apart from the minimum functionalities described in Table 4, the EU has collected an additional 33 functionalities to the consideration of Member States.[4]

[3] European Commission Recommendation 2012/148/EU
[4] EC Task Force for Smart Grids

CONSUMER	• Provide readings directly to the consumer and/or any third party designated by the consumer
	• Update the readings frequently enough to use energy saving schemes
METERING OPERATOR	• Allow remote reading by the operator
	• Provide 2-way communication for maintenance and control
	• Allow frequent enough readings to be used for network planning
COMMERCIAL ASPECTS OF SUPPLY	• Support advanced tariff system
	• Allow remote ON/OFF control supply and/or flow or power limitation
SECURITY AND DATA PROTECTION	• Provide secure data communication
	• Fraud prevention and detection
DISTRIBUTED GENERATION	• Provide import/export and reactive metering

Figure 4: Minimum functionalities of smart meters according to Recommendation 2012/148/EU

It is important to note that smart meters do not constitute a smart grid, at the same time it is possible to have a smarter network (both transmission and distribution) without the rollout of smart meters. Smart meters – however - are key elements in the system as they facilitate the active involvement of consumers.

The challenges that future electricity grids have to meet are associated with the policy goals that include the promotion of competitive retail energy markets, sustainability, operation security, and additional services offered by smart meters. The means of reaching these goals, the solutions offered by smart grids/ meters, and the primary beneficiaries are collected in Table 4.

General policy goal	Means	Solutions offered by smart networks	Beneficiary	Performance indicators
Competitive retail electricity markets	Increased retail competition	smart meters	consumers	• supplier switching rate
	innovative end customer tariffs	smart meters	consumers	• existence of ToU tariffs • power quality differentiated tariffs
Sustainability	energy efficiency	smart meters	consumers	• current level of energy intensity
	electric vehicles (EV)	recharging infrastructure	consumers	• share of EVs in the personal vehicle fleet • number of public recharging stations
	DG/RES-E	active distribution network, storage	prosumers	• future share of RES-E
Security	generation adequacy	demand response	network operators	• peak shaving potential • electricity demand forecast • RC-ARM • network loss
		smart electrical appliances		
		DG-load profile harmonisation		
		storage		
	secure grid operation	automatic fault detection and self-healing network		• SAIDI, SAIFI • voltage quality
		voltage control		
Additional services	pre-payment option	smart meters	network operator	• network loss • commercial loss • existence of pay-as-you-go service
	theft detection			
	remote metering			
	remote connection and disconnection			

Table 4: Policy goals, smart grid solutions and performance indicators

The role smart grids can play in reaching the above mentioned goals vary across cases. In some instances smarting of the grid is a prerequisite for meeting the demand that a grid is likely to face in the future. This is the case after a certain penetration level of distributed generation. The distribution networks designed for unidirectional power flow are not able to guarantee safe and secure operation due to voltage level problems. In other cases it can be viewed as an alternative to traditional solutions. Demand side management options, the integration of local storage facilities and automatic RES-E production profiling facilitated by an active distribution grid are alternatives to the capacity extension of balancing power plants and – concurrently - the transmission network. In other instances, smart grids (including smart meters) serve as additional instruments for reaching a certain policy objective. A good example is the electricity savings facilitated by real time consumption data provided by smart meters. Here the smart grid solution is an additional instrument to enhance energy efficiency, next to other potential avenues such as financial support or professional assistance for building refurbishment (Meeus et al, 2012).

The last column of Table 1 lists potential performance indicators that are a) indicators of the current situation and, as such, b) proxies for future demand for smart grid solutions. They will serve the backbone of the chapter devoted to the future demand for smart grids.

4.1 Competitive retail electricity market

Smart meters can promote electricity market competition at the retail level. On the one hand, smart meters can effectively facilitate supplier switch as the consumption balance of the incumbent supplier can be easily and automatically drawn so that the transaction cost of switching for the consumer decreases. On the other hand, once the technology enables tariff differentiation based on the fluctuation of wholesale electricity price, the suppliers can offer innovative tariff packages for customers to choose from based on his/her unique needs, not only in terms of load profile but also power quality and willingness to accept service interruption in case of system emergencies or peaking wholesale prices.

4.2 Sustainability

Smart grid solutions can meet the demand generated by the promotion of sustainable energy systems in two major areas:

- environmentally conscious energy consumption, including increased energy efficiency and the massive penetration of electric vehicles, and
- environmentally sustainable electricity generation, including massive renewable electricity generation (RES-E) and small scale distributed generation.

4.2.1 Sustainable consumption

On the consumption side, sustainability requires increased efficiency in the energy use of final consumers. Consumers can play a more active role in energy saving if they are fully informed about their consumption in real time. The informational effect can be enhanced if their consumption is benchmarked against other households, against consumption in the past or if kWh is translated into USD or EUR.

The reduction of electricity consumption is a benefit in the form of lower bills, but also to the society as a whole by reducing GHG emissions and potentially decreasing dependency on energy imports. Pilot smart metering projects show that the extent of consumption reduction is in the range of 2-3%. The British business case for smart meters showed a 2.8% reduction in electricity consumption, while the pilot program of the Irish regulator (CER) resulted in a 2.5% reduction for residential consumers (A.T. Kearney, 2012). In the latter case, the use of smart meters providing real time consumption data coupled with time of use tariffs and other information sources (bill and statement benchmarking consumption) resulted in 1.1% to 2.9% electricity consumption reduction in the different consumer groups (Table 5).

Usage	All Tariff Groups and DSM Stimuli	Tariff Groups A-D bz DSM Stimulus			
		Bi-monthly Bill and energy use statement (Stimulus 1) %	Monthly Bill and energy use statement (Stimulus 2) %	Bi-monthly Bill, energy use statement and electricity monitor (Stimulus 3) %	Bi-monthly Bill, energy use statement and OLR incentive (Stimulus 4) %
Overall	-2.5*	-1.1	-2.7*	-3.2*	-2.9*
Peak	-8.8*	-6.9*	-8.4*	-11.3*	-8.3*
*denotes results statistically significantly different control group using a 90% confidence level					

Table 5: The achieved overall and peak electricity consumption reduction in the Irish smart metering pilot project

Source: CER (2011)

Other sources quote 4-14% reduction in electricity consumption across various smart metering programmes (MIT, 2011).

Smart meters are additional instruments that can foster energy saving at end users, in addition to more traditional approaches such as financial support (non-refundable grant or preferential credit) or professional advice on building refurbishment. The current level of energy efficiency at the national level or at the household level, especially relative to other countries, is a good indication of the potential that can be harnessed in the future.

Sustainable transportation policies aim at reducing mobile source air pollutant emissions, and one way to advance this objective is with the increased use of electric vehicles. Although at the moment the deployment rate of electric vehicles is difficult to predict, the appearance of mobile electricity consumers raises a number of issues. On the one hand EVs create additional demand for electricity. Although expectations suggest that the majority of recharging will take place at home, the integration of public recharging facilities requires new investment and potentially the cooperation of DSOs with third party service providers. EVs are potential electricity storage units and can shift consumption to periods of low demand (recharging at night), while on the other hand they can increase evening peaks as well (plug-in when returning home from work). EVs can act as storages in virtual power plants (VPPs). A VPP aggregates distributed energy resources, including generators, loads and storage units. These units are controlled by the VPP Control Center in order to create a desired output, to balance generation and consumption within the power system and participate with its units in the energy market. The VPP Control Center aims at the minimization of the imbalance between electricity generation and consumption as well as the maximization of the VPP owner's financial benefit (MERGE, 2012). The impact of EV deployment on the grid is very much dependent on the behaviour of consumers affected by the pricing regime. The following figure is a modelled illustration of the effect of EVs on the load. The higher the penetration level (different % of EVs are connected to the different tariff regimes), the higher the extra load generated by EVs. However, the tariff choice has a profound impact on the profile. "Dumb charging" means that EV owners plug-in their EV when they return home from their commute. Multiple tariffs allow for the shifting of peak consumption to valley periods, but the sharp increase of EV demand at the beginning of the low energy price period might affect the network operation. The smart charging model assumes that EV demand is managed in a way that reduces the system load variation between off-peak hours and peak load hours via advanced management models (automated control).

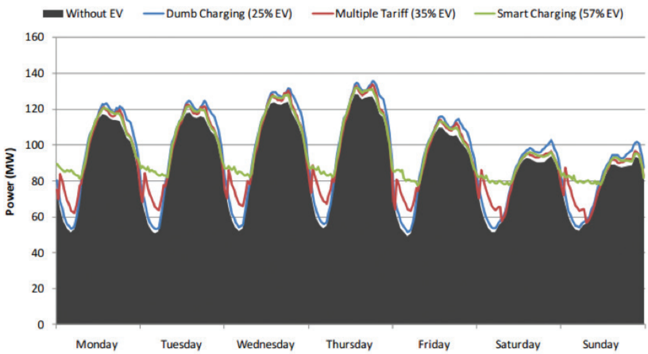

Figure 5: Load profiles with and without EVs, under different tariff regimes

Source: MERGE, 2012, p.17

4.2.2 Sustainable production

On the production side, an increasing amount of renewable based production is the prime contributor to the sustainability objective. The increasing share of RES-E is an important element in supply security as it substitutes imported fossil fuels. Renewable generation units can be of large-scale connected to EHV or HV such as large offshore wind parks, thermal plants co-firing fossils and biomass, electricity producing geothermal plants and concentrated solar power plants (CSPs). Small scale electricity generating units connecting to the distribution network (distributed generation – DG) are already on a massive deployment scale in some countries. In Germany, for example, the DG output of the distribution network already exceeds local load (Eurelectric, 2013). These units might be from renewable sources such as PV units and small wind parks but can also be from biomass or gas as well such as micro-CHPs (Figure 6). Significant cost reduction of these technologies can make them competitive with conventional sources and large scale renewables that will result in even higher penetration levels. DG increases system imbalances, congestion and the need for new network extensions (Figure 7). However, this network capacity extension can be, to some extent, offset by the smarting of the grid that enables the approximation of the utilisation rate of the existing infrastructure to its true limits (DLR). An increase in the quantity of distributed generation also means that new types of actors called ”prosumers” appear among the network users. These actors consume and produce electricity at the same time.

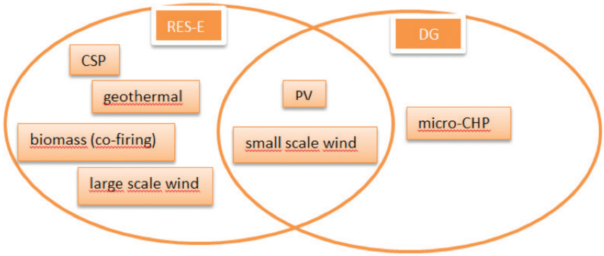

Figure 6: Categorization of RES-E and distributed generation (DG) technologies

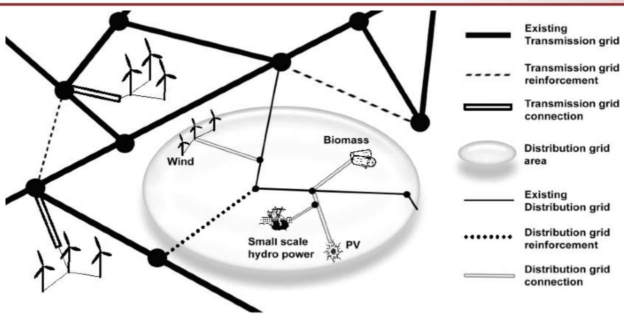

Figure 7: Grid connections and grid reinforcements caused by large-scale DG/RES integration

Source: IMPROGRES, 2010

Weather-dependent renewable energy generation technologies, such as wind and solar power, are inherently uncontrollable and their production levels cannot be predicted with certainty, even a few hours ahead of time. This, coupled with the lack of low-cost large-scale storage options, aggravates the task of continuous real-time balancing of production and consumption.

As wind and PV production is less certain than the load forecast, systems with high share of weather dependent production capacities must commit more reserve generation for balancing than others. "Ramp events" (the ramping up and down of significant renewable capacity) occurring concurrently due to weather events or the lack of RES-E production for a longer period can result in operation challenges. Any method that reduces reserve capacity saves cost to the system as a whole. There are several ways to reduce the balancing needs stemming from intermittent renewable electricity production. Improving the accuracy of intermittent production forecast is straightforward way to do this, as reduction in the forecast error would translate to a lower commitment of regulating capacities. Another way is to shorten gate closure period (the time before the operating period and when generation schedules become final and binding) which would allow for more predictability as the forecast error diminishes closer to the operation time.

Another consequence of large scale penetration of intermittent generation is that balancing might require the forced shedding of RES-E units, which implies that units with zero marginal cost are excluded from the dispatch.

Distributed generation can improve system reliability under certain conditions as DG units can maintain supply to local loads in the event of a broader system outage by disconnecting part of the system from the faulted area ("islanding"). Successful islanded operation, however, requires sufficient generation to serve local loads and also the necessary distributed system control capabilities (MIT, 2011).

Historically the low penetration of distributed RES-E was simply regarded as a reduction in load. However massive RES-E deployment at the distribution grid, that has been characterised by a number of large and schedule following suppliers and many consumers at the end of the distribution network, create new grid operation challenges. While the wires and the transformers can handle power flows in both directions, the existence of DG beyond a certain penetration level can have adverse impacts on system reliability, power quality and safety (MIT, 2011). Another problem caused by distributed generation connected to the grid via power electronic inverters (e.g., solar PV, fuel cells, and most wind turbines) is the distortion of voltage waveform. There are inverters available at the market that are able to cancel these distortions and thus contribute to voltage regulation, however they are more expensive and if grid access regulation does not explicitly require their application, DG owners have little incentive to pay for this extra function.

A further problem associated with large DG penetration is their impact on the protective schemes comprised of multiple layers of coordinated protection devices (circuit breakers and fuses) to interrupt current and short-circuit faults. Today the settings for protection equipment are static but the existence of DG in the network changes the current differently at different points of the grid, which complicates the coordination among protection devices. "Changing fault currents with the introduction of DG could lead to unreliable operation of protective equipment and result in faults propagating beyond the first level of protection (MIT, 2011, p. 115)." Active distribution grid management based on real time information of the grid and its users would mean that the DSOs could dynamically change protective relay settings.

Storage is a potentially important element of future grids as these units – once their cost reduces – can match the divergent load and production patterns. Traditionally, electricity storage refers to pumped hydro facilities that can store energy for a long period of time: 99% of global storage capacity is pumped hydro (Vasconcelos et al., 2012). Storage connected to the distribution system is a means to facilitate the local consumption of locally produced electricity that reduces technical network loss due to lower transport demand. Storage can complement conventional flexible generation and demand side management in order to maintain the balance of the electrical system (Figure 8). The fundamental differences among these options are technological in nature and expressed in such operating parameters as response time, power rating, and energy rating. The major storage technologies are a) mechanical storage (pumped hydro, compressed air energy storage and flywheel), b) electrochemical storage (batteries) and c) electromagnetic storage (superconductors and supercapacitors) (Vasconcelos et al., 2012).

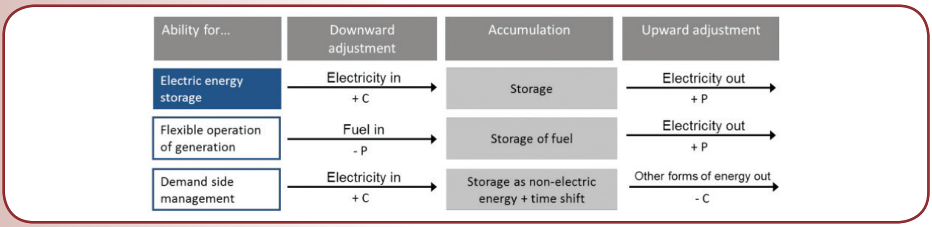

Figure 8: Alternative means of flexibility

Source: Vasconcelos et al. 2012, p. 4

Notes: +C/-C means an increase/decrease in consumption; +P/-P means an increase/decrease in production

4.3 Security

Smart grid solutions can enhance electricity system wide supply security. The security aspect can be divided into the areas of generation adequacy and the security of grid operation.

4.3.1 Generation adequacy

Generation adequacy refers to whether the volume and flexibility of the future generation portfolio – together with the import capacities – is able to supply future load. The variability of intermittent renewable generation – as discussed earlier – requires more balancing effort than a system with negligible or no renewable capacities. We have highlighted several options that can reduce this effect of RES-E on the electricity system, such as better forecasting or shorter gate closure period, and the balancing requirement can be also reduced via smart grid solutions. The maintenance of balance between power injection and load can be secured not only at the production but also the consumption side. On the one hand, the data provided by smart meters on consumption profiles facilitates better load scheduling and hence potentially cheaper balancing. On the other, the flexibility of load can be achieved via smart meters. Smart meters together with the time-of-use (ToU) pricing can motivate consumers to actively participate in grid management by 1) reducing overall consumption due to the information provided on consumed amount (see above under energy efficiency) and 2) shifting demand away from peak periods. Apart from shaving peak consumption, active grid management can facilitate the harmonisation of DG and load profiles. It means that directly controlled appliances are turned on and off according to the production level of local distributed generation (Figure 9). This requires smart meters and a move away from simple time-varying rates (Dynamic Pricing 1.0) to real time pricing of electricity (Dynamic Pricing 2.0).

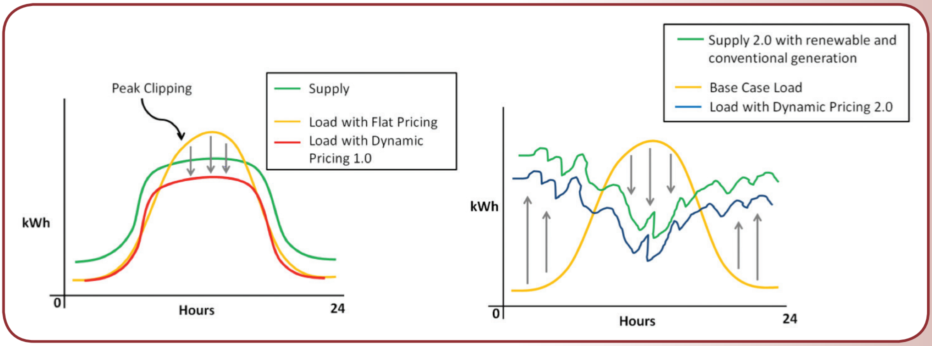

Figure 9: Peak shaving and the load following RES-E production profiles

Source: Faruqui and Davis, 2013

A further option for aligning power with load is the integration of storage units to the distribution network as discussed earlier.

As far as international evidence is concerned, a survey covering a combined 163 studies examined the impact of peak to off-peak price ratio under various tariff structures (ToU and dynamic pricing) and the technology conditions on peak consumption. The following figure plots the reduction in peak usage against the peak to off-peak price ratio in case of time-of-use tariffs (ToU) on the basis of 65 studies.

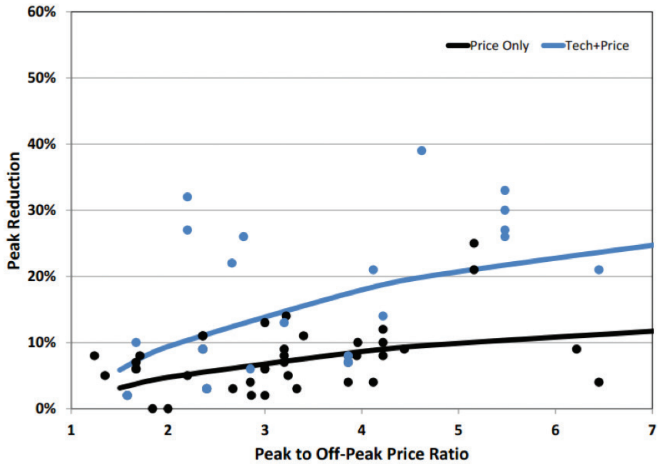

Figure 10: Price responsiveness to ToU pricing based on 65 studies

Source: Faruqui et al., 2013

The conclusions from the data are that if the Peak to Off-Peak Price Ratio is 5, a 9.9% peak reduction can be achieved by pricing only. This percentage can be expanded with the use of enabling technologies to approximately 20.7%. Information-enhancing technologies such as in-home displays help visualize consumption and price information, and can even provide a carbon footprint or a pre-set electricity budget. This information can be conveyed via website or smartphone. The same figures for a 10 Peak to Off-Peak Price Ratio are 13.8% and 29.3% peak reduction. The above mentioned Irish pilot resulted in an 8.8% peak consumption reduction on the average (Table 5).

4.3.2 Secure grid operation

The other aspect of grid security is the reliability of grid operation that translates into the continuity of supply and voltage quality. Continuity of supply relates to the potential interruption of electricity provision which can be measured according to various indicators. Most frequently used indices measure the number of interruption events and the length of these interruptions. These indices are quite important from a regulatory point of view as they complement incentive regulation that essentially encourages firms to increase cost efficiency. Incentive regulation, however, carries the risk that DSOs could fail to invest into grid maintenance and upgrading that compromises service quality. Regulators in most countries introduced service quality indices as direct revenue drivers, i.e. the DSOs are rewarded or penalised according to their achievement against the benchmark value of these indicators. There is a wide range of indicators monitored in European countries for short and long term interruptions, at various voltage levels.[5]

The second aspect of a reliable grid is the quality of voltage. Voltage quality refers to deviation of voltage magnitude and waveform from the optimal level (CEER, 2011). Voltage quality is increasingly important electronic appliances are more susceptible to damage and – at the same time – cause more disturbances themselves. Voltage quality maintenance is not entirely in the capacity of the DSOs as it is affected by the consumers themselves. DSOs – in order to enhance their operational capacity – often set current/ voltage parameters for large consumers in the network code or in the connection agreement. The voltage

[5] For a comprehensive list of these indicators on a country level see: 5TH CEER Benchmarking Report on the Quality of Electricity Supply, 2011

problems are likely to increase with the large scale penetration of distributed generation. Thus managing voltage quality is expected to be more costly in the future, and this will translate into higher network tariffs. Whereas interruptions affect all users, the impact of voltage quality deviations varies across consumers. In some countries, the customer can agree with the distributor to get a higher level of quality (both in terms of voltage quality and interruptions). This "power quality contract" element is generally incorporated in the connection contracts. Smart meters can to some extent monitor certain voltage quality indicators, and several counties plan to use them to this end as well (CEER, 2011). As such they facilitate the market segmentation of consumers based on their optimal level of service that can consequently ease the pressure on network tariff increase.

Distribution automation via integrating communications, IT infrastructure, and sensors within a distribution management system offers new distribution system operation applications for DSOs such as automated fault detection and optimization of power flows and voltages. Automated fault detection means that the software, based on information received from the grid, can locate the site of the fault, estimate the extent of the damage, and provide a secondary path for service to affected consumers. As such it can reduce the time of outages and the number of consumers affected. Oklahoma Gas and Electric Company reported to reduce outage time by 54-70% after installing hardware for automated fault detection (MIT, 2012).

Sensors (volt/VAR control) that measure voltage levels at the end of the lines reduce power consumption and hence reduce network loss. As consumers draw power along the distribution line, the voltage level drops. In order to keep voltage level within the pre-set range at the end consumers (+/- 5% of 120 Volt) DSOs employ adjustable transformers controlled from the substation. To make sure that the voltage does not drop at the end of the line below the lower threshold, these voltage regulators increase voltage level to the upper end, as there is no measurement further along the line from the substation (Figure 11). To approximate this conservative to the truly required voltage value would reduce power consumption.

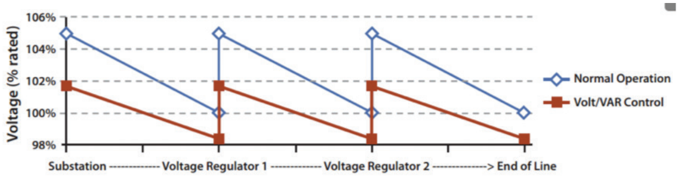

Figure 11: Voltage profiles with and without VAR control

Source: MIT, 2012, p.132

4.4 Additional services

A fundamental opportunity that smart meters offer is the remote metering of individual consumers on a frequent basis and without using manpower. The Italian DSO, ENEL has rolled out 900 thousand meters of electricity without any regulatory push and it resulted in considerable operational cost reduction (from 80 to 48 EUR/customer/year) and in reduced average interruption time from 128 to 46 minutes (A.T. Kearney, 2012). Earlier rollouts used smart meters that offer only one-way communication so that it can be read remotely (AMR – Advanced Metering Reading). For communicating information to the consumers via the meter (e.g. tariffs in real time) more advanced equipment is required. The so called AMI (Advanced Metering Infrastructure) includes meters able to provide bidirectional communication between consumers and operators. Recent national smart meter rollout regulations push for the rollout of AMIs so that can offer a much wider range of services in the future.

Smart meters offer further services for consumers and DSOs. The issues of *commercial loss and non-payment* are considerable in some countries and less important in others. The impact of smart meters on electricity theft is expected to be considerable. The cost-benefit analysis conducted about the future rollout of smart meters in Romania assumes 60% commercial loss reduction in its realistic scenario (and 80% in the optimistic scenario) based on the project experience of the consultant in other markets (A.T. Kearney, 2012).

In addition, smart meters enable quick service order (to stop and start service), pay-as-you-go service (only the prepaid amount is supplied) and minimal supply regulation which ensures that a minimum amount of electricity is supplied even in case of non-payment.

5 STATE-OF-AFFAIRS IN SMART GRIDS AND SMART METERING IN THE DANUBE REGION

This section provides an overview of the current policy and investment situation on smart grids and smart metering in the DR countries, within a European context when applicable. First, it deals with smart grid investments in Europe and the DR, based on the database of the Joint Research Centre (JRC) of the European Commission. Then it looks at the availability of smart grid roadmaps which is a good indication of the national ambitions on smart grid deployment. The last section gives a more detailed view on the smart metering rollout plans and the current policy situation in each Danube Region country.

5.1 European smart grid investment review

According to data published by the JRC, by 2012 a total of EUR 1.8 billion was invested in 281 European smart grid projects.[6] By far the largest number of projects has been carried out in Denmark, while 70% of the projects were carried out between only seven countries (Denmark, Germany, Italy, Austria, the UK, France and Spain) (Figure 12). In 2012 around half of the projects were in the research and development (R&D) phase and the other half in the demonstration phase, which is a visible shift from the previous year of measurement when only 40% of projects were demonstration programs (Figure 13).[7] Demonstration projects on average need larger investments than R&D projects and, as a result, in 2012 around 70% of all European smart grid investment went to demonstration projects. It is interesting that Denmark has so far mainly invested in research, and therefore while it has had more projects than any other European country its per-project cost was significantly lower.

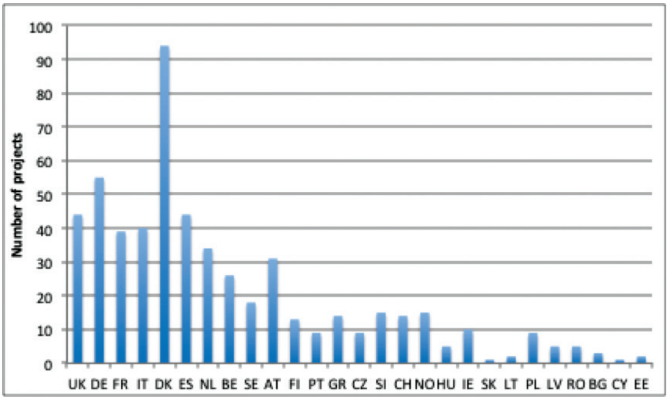

Figure 12: Cumulated number of smart grid projects until 2012, all European countries where data is available

Source: JRC

[6] The JRC's smart grid project inventory (portal.smartgridsprojects.eu) was launched in 2011 and is updated annually by an online questionnaire filled out voluntarily by smart grid project participants. The last update was in September 2012.

[7] The distinction between R&D and a demonstration project is that while the former is mainly intended to create knowledge for future smart grid applications, the latter is regarded as a "preview" phase before the marketing of smart grid solutions – i.e. before the deployment or roll-out of these application. For a more detailed description about these categories, see the JRC report "Smart Grid projects in Europe: Lessons learned and current developments, 2012 update", pp. 15-16.

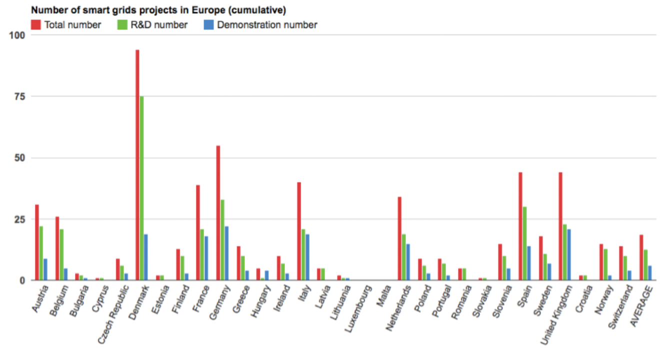

Figure 13: Cumulated number of smart grid projects until 2012 broken down to R&D and demonstration type projects, all European countries where data is available

Source: JRC

At the same time, until 2012 93% of investments were carried out in the EU15 countries with more than EUR 200 million invested in the UK, France and Germany, and close to that amount in Italy, Denmark and Spain (Figure 15). The total budget share of DSO or utility led projects is close to 60%, and these projects are, not surprisingly, mostly in the demonstration phase (Figure 14). Projects led by universities, research centers and consultancies (grouped by JRC into a single category) account for 23% of total investment, two third of which is going to R&D projects. TSO-led projects have a share of close to 10%, while all other categories (manufacturers, IT and telecommunication companies, etc.) are each less than 5% of the total financing. In sum, DSOs and utilities have a prominent role in smart grid promotion. The projects they lead account for over EUR 1 billion of investment throughout Europe.

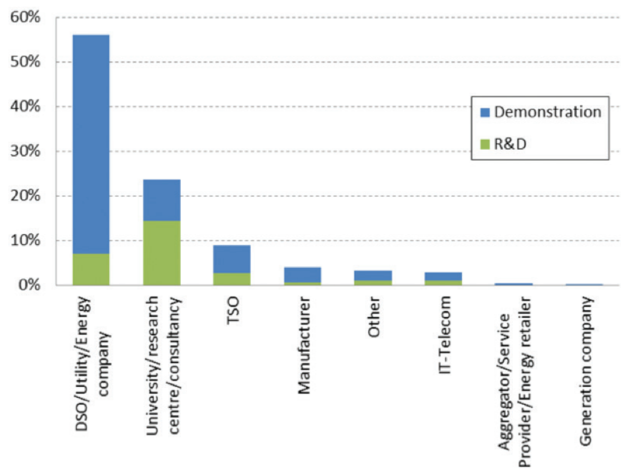

Figure 14: Budget share of projects in Europe by type of project leading organisations, cumulative until 2012

Source: JRC

We should note that according to the JRC, only 45% of funding comes from private capital, and 80% of the projects have received some public funding, highlighting the important role of the state in providing financial support in the early phases of smart grid development.

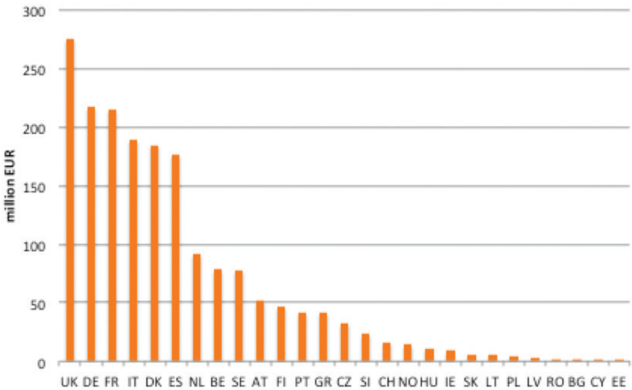

Figure 15: Total cumulated investments in smart grid projects until 2012, all European countries where data is available, million euros

Source: JRC

Taking into account only the 15 countries with total cumulated investments of more than 20 million euros per country until 2012[8], smart network management[9] programs (21.4% of investments in these countries), "smart customer" and smart home projects (20.0%) and the integration of distributed generation (18.9%) are prominent, with "aggregation" – an umbrella term for all kind of demand response and virtual power plant (VPP) projects - follows with a 14.5% share. The composition of projects according to their application type, however, shows sizeable differences in Europe, which is illustrated in Figure 16. Information provision for customers and smart home applications, for example, play a big role in the UK and Belgium, while the integration of distributed generation has been the most important target of investments in France and Italy. In the larger European countries the project portfolio is generally balanced with no real dominance by a single issue. Meanwhile in the Czech Republic the overwhelming majority of investments are directed toward the "smarting" of network management, while in Slovenia aggregation-type projects have been the most important target. Large scale renewable integration is a focus of smart grid investments in Spain and Denmark due to the already high penetration of wind facilities. The low share of a specific type of investment does not necessary mean that the application is a low priority; in Italy smart meters are rolled out fully, hence the low spending on smart metering pilots.

[8] Disregarding countries with only a small amount of investments does not significantly bias our analysis as countries with more than 20 million euros of cumulated investments account for more than 1.7 billion euros of the total 1.8 billion counting all European countries.

[9] The JRC defines smart network management projects as "implementations focusing on increasing the operational flexibility of the electricity grid, like substation automation, grid monitoring and control, etc." For the definitions of other project types see the JRC report "Smart Grid projects in Europe: Lessons learned and current developments, 2012 update", pp. 43-50.

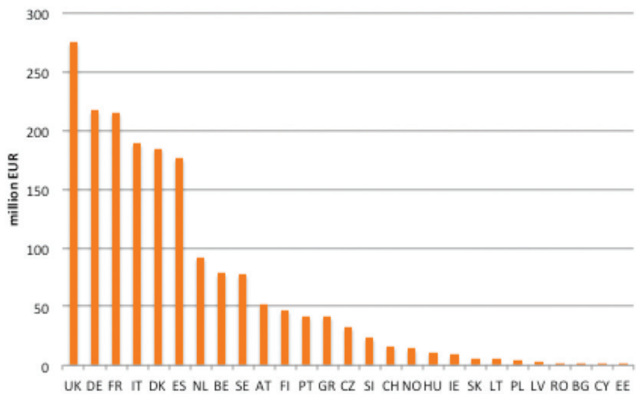

Figure 16 Cumulated smart grid investments by application type until 2012 (in European countries with more than 20 million EUR of total cumulated smart grid investments), million EUR

Source: JRC

5.2 Smart grid projects in the Danube Region countries

Looking at Danube Region countries, we find that the JRC has information about total investments for eight countries (Germany, Austria, the Czech Republic, Slovenia, Hungary, Slovakia, Romania and Croatia). At the same time, a breakdown for application type level is not available for Croatia, and for Slovakia all investments are indicated as "other".

	integration of distributed generation	smart network management	smart customer and smart home	aggregation (demand response and VPP)	e-mobility	integration of large-scale RES	smart metering pilots	other	sum
DE	29,15	17,57	48,66	60,79	36,1	5,11	15,85	3,67	**216,9**
AT	5,25	6,03	2,68	1,57	33,3	0,87	0	1,32	**51,02**
CZ	1,85	23,9	0	1,85	2,25	1	1,52	0	**32,37**
SI	1,42	4,39	0	13,03	0	0	0	3,03	**21,87**
HU	0	4,8	0	0,86	4,65	0	0,53	0	**10,84**
SK	0	0	0	0	0	0	0	5,99	**5,99**
RO	0	0	0	1,02	0	0,3	0	0	**1,32**
HR*	0	0	0	0	0	0	0	0	**0**

Table 6: Cumulated smart grid investments in Danube Region countries by application type until 2012, million EUR

Source: JRC

* Though Croatia appears in the JRC database under application type breakdown, no data for the country is available.

Table 6 shows that there are four Danube Region countries that have been investing over 20 million EURs: Germany more than 200 million EURs, Austria over 50 million EURs, the Czech Republic 32 million EURs and Slovenia exceeding 20 million EURs. Slovenia also stands out regarding per capita smart grid investments (more than EUR 10 per inhabitant), coming only second after Denmark in a European comparison. A reason for the relatively large investments in Slovenia is the availability of European Union funds: around 70% of projects have been co-financed by either the 6th or 7th Framework Programme of the European Commission (FP6 and FP7) or regional development funds. In the JRC database, there are only five DR countries that have finished or currently carrying out domestic smart grid projects: Austria, Germany, the Czech Republic, Slovenia and Hungary

In Austria, there are a number of projects with various objectives. The emphasis is on the issue of integrating decentralized production and flexible loads, as well as on accommodating widespread e-mobility. Information provision for customers with the aim of affecting energy use is also a key objective. An important project of this type is called the Smart Grid Model Region Salzburg, an urban pilot project carried out by Salzburg AG, a distribution system operator. DSOs like the aforementioned Salzburg AG, VKW-Netz AG, and Kelag AG participate in some of the projects. Some projects are primarily focused on distribution grid monitoring (Kelag's ProAktivNetz project, which has been carried out between 2011 and 2013).

Smart Grid Model Region Salzburg is a flagship smart grid demonstration program in Austria in the city of Salzburg. The most interesting feature of this approach is that it bundles different smart grid applications together and – at the end of the projects – will assess their combined effect. The project is jointly supported by a utility (Salzburg AG), a property developer (Salzburg Wohnbau), a technology company (Siemens) and four research institutions (Austrian Institute of Technology, Vienna Institute of Technology, CURE and Fichtner), and is being funded by the Austrian Climate and Energy Fund under the project "New Energies 2020". The aim is to develop an integrated smart grid approach, and includes 12 separate projects:

- B2G (Building to Grid): the role of buildings in peak load reduction and better energy efficiency
- C2G (Consumer to Grid): feedback to consumers to reduce energy consumption
- PEEM (Persuasive End user Energy Management): encouraging consumers to shift their energy consumption to more favourable daytimes
- SmartHeatNet: enabling peak load reduction in district heating
- SmartSynergy: ICT infrastructure to smart grids and e-mobility
- Vehicle to Grid (V2G) – Interfaces: business models and interfaces for enabling e-mobility
- Vehicle to Grid (V2G) – Strategies: technological, economic and ecological consequences of large-scale e-mobility
- ZUQDE (Central voltage and reactive power control for distributed generation): technical solutions affecting the power grid to be able to accommodate more distributed power generation
- DG DemoNet Validation: using innovative voltage control concept in the medium voltage grid
- HIT (Buildings as interactive smart grid participants): combination of all of the above mentioned project elements in an innovative housing area
- Smart Web Grid: designing data exchange between smart grid actors and linking smart grid services
- DG DemoNet – Smart Low Voltage Grid: integrating PV and e-mobility into the low-voltage grid.

Further information on these projects can be found at www.smartgridssalzburg.at.

In Germany, while utilities like RWE, EnBW and Vattenfall are involved in some projects, most programs are led by either universities or research institutions.

In the Czech Republic, there are only two projects in the JRC's database led by DSOs. One of these, called Smart Region, is carried out by the DSO CEZ Distribuce and is dedicated to creating a fully automated LV and MV grid which is able to switch between island and normal operation. The other project, Smart Grid Prague, is led by the DSO PREdistribuce, which aims to replace the earlier SCADA with a new grid control system.

Slovenia's smart grid projects are either led by the TSO (ELES) or technology companies, with projects aimed at grid automation, smart metering deployment, and the accommodation of decentralized power production. The programs carried out by ELES have different objectives, among them better network analysis, the upgrade of the existing wide area measurement system and the installation of a data communication network for TSO operations. Another project plans to integrate demand side management and renewable producers as sources of additional tertiary reserves.

Hungary's two projects are carried out by ELMŰ-ÉMÁSZ, an RWE-owned DSO. One is an e-mobility project, while the other (called ETM) is meant to provide distribution network automation.

The **ETM** project (Hungarian abbreviation for Distribution System Telemechanics System) of Hungarian utility ELMŰ-ÉMÁSZ is a network automation project aimed at quicker response to power interruption at the consumer level by means of faster error localization and a more rapid reconfiguration of the network. The first phase of the project was concluded by installing "telemechanics" (network control) systems at 800 of the 10/0.4 kV stations of ELMŰ-ÉMÁSZ between 2009 and 2012. The project also covers reconstruction of several substations. A related project is called TMOK targeted the integration and testing of SCADA solution to the distribution grid, which has been concluded by 2010. Another step of the project was the installation of a number of remotely controllable switches at about 1000 locations so far. The project first started in the service area of the Budapest-based ELMŰ, and continued from 2012 in the network of EMÁSZ in Northern Hungary.

Beyond domestic projects, there are a multitude of those that are carried out in international cooperation and involve at least one DR country, mainly Germany, Austria, or the Czech Republic. These projects aim at development and research supporting smart grid and metering technologies. Some of the most important multinational projects are financed by the FP7. Grid4EU, for instance, is led by the DSOs of Germany and the Czech Republic, and will enhance dynamic demand and supply management. Green eMotion, involving Germany and Hungary, is a project led by Siemens AG with the objective of connecting national e-mobility initiatives. Another important project, Meter-ON, is also supported by the FP7 and is led by EDSO for Smart Grids, an association of European DSOs. This project involves organizations from Austria, Italy and Spain and aims to steer the implementation of smart metering solutions in Europe.

5.3 National smart grid roadmaps

It is not a straightforward exercise to judge the commitment of a country towards the deployment of smart grids, however the existence of a roadmap or strategy paper in this respect is a good proxy for evaluation. On the other hand, the lack of an official roadmap does not necessarily imply that an area is being neglected. Again, Italy is well advanced in smart grid deployment and regulation but without such an official timetable.

The Communication of the Commission warns that the completion of the internal energy market due by 2014 is behind schedule and will require renewed efforts from the member states.[10] Its Action Plan requires the active participation of consumers (via the measures of the new Energy Efficiency Directive, 2013/2014), the standardisation of smart appliances (2014), and the preparation of national plans for the swift deployment of smart grids (2013). The Energy Community countries frequently update their Energy Efficiency Roadmap with the adoption of new pieces of EE legislation. Consequently, the provisions of the new Energy Efficiency Directive, such as the informative billing based on actual consumption and possibly time of use energy tariffs coupled with smart meters, will appear on the policy agenda of these countries. Lack of individual meters together with the high level of non-payment is listed among the most important barriers to energy efficiency improvements in the West Balkans (World Bank, 2010).

The European Commission has prepared guidance on how to conduct cost-benefit analysis on smart grid investment project (JRC, 2012). It is a step-by-step assessment framework based on the previous work of EPRI (Electric Power Research Institute, US) with several additions and modifications to fit it to the European context.

[10] Communication „Making the internal energy market work" [COM(2012)663]

Although several countries refer to the importance of such network development mode, the group of countries planning explicitly and concrete steps is limited. The following table provides an overview on some European national roadmaps.

Country	Year	Responsible	Publication	Stakeholders involved
Austria	2010	National Technology Platform Smart Grids Austria	http://www.smartgrids.at/termine-downloads/#downloads	NTP is a consortium of actors involved in electricity supply. Currently it consists of approx. 50 members including DSOs, energy suppliers and other members from the industry.
France	2009	French Environment and Energy Management Agency (ADEME)	http://www2.ademe.fr/servlet/getBin?name=-E5CD06235AC8FB098D2F-C88B22F6E1F4_tomcatlocal1306936086761.pdf	The French TSO (RTE), the main DSO (ERDF, 95% of distribution networks), the association of distribution network owners (FNCCR), several French energy companies (manufacturers, producers, etc.) and various experts (from universities and ministries).
UK	2009	Electricity Networks Strategy Group	http://webarchive.nationalarchives.gov.uk/20100919181607/http://www.ensg.gov.uk/assets/ensg_routemap_final.pdf	The Electricity Networks Strategy Group (ENSG) provides a high-level forum which brings together key stakeholders in electricity networks to support the Government and Ofgem in meeting the long-term energy challenges of tackling climate change and ensuring secure, clean and affordable energy. It has been tasked by DECC and Ofgem to produce a high level smart grid vision and routemap.
Ireland	2011	Sustainable Energy Authority of Ireland	http://www.seai.ie/Publications/Energy_Modelling_Group_/SEAI_2050_Energy_Roadmaps/Smartgrid_Roadmap.pdf	The Sustainable Energy Authority of Ireland; electricity regulator; electricity transmission system operator; electricity distribution system operator; Department of Energy, Communications and Natural Resources; Science Foundation of Ireland; Smart Grid Ireland (a group representing consumers)
Denmark	2010	Energynet.dk and Danish Energy Association	http://energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/Forskning/Smart%20Grid%20in%20Denmark.pdf	member companies of the Danish Energy Association
Slovenia	2012	consortium	http://www.eimv.si/pdf/pametna-omrezja-2012-pop7-web.pdf	The Roadmap has been prepared by DSOs, The University of Ljubljana and Electroinstitute Milna Vidmar, it has no official status.
Germany	2012	German Association of Energy and Water Industries (BDEW);German Electric and Electronic Manufacturers' Association (ZVEI)	http://www.bdew.de/internet.nsf/id/96CFAB914FE5D18C-C1257BBB002A79CB/$file/Smart%20Grids%20in%20Germany.pdf	In cooperation with distribution network experts, the BDEW has analysed technical components that may offer a particularly great potential and that today are already considered to be relatively close to the market. This analysis was reviewed together with experts from the manufacturing industry organised within the ZVEI.

Table 7: Smart grid implementation roadmaps in Europe (not comprehensive list)

According to the survey, from within the Danube Region only Austria, Germany and Slovenia prepared their own smart grid roadmap. Additional countries might be in the process of developing such document but we did not inquire about planned or ongoing strategy development in the survey. An important conclusion from the existing roadmaps is that most often they are not prepared by governmental bodies or the energy regulator, but on the initiative of industrial associations covering DSOs and supply manufacturers.

According to the survey respondents smart grid investments are still in the early stages, with the exception of Austria (survey questions are in grey background throughout the whole paper). The most important field for future investment is exclusively the distribution network; mainly smart metering, and other distribution network related investments.

How would you characterise the current development phase regarding smart grid investments in your country?

	CZ	RO	SI	CR	BA	MD	AT	HU	ME	UA	SR
Leading role							✓				
Advanced role											
Average role											
At the beginning		✓	✓	✓	✓				✓		✓
Not started yet	✓					✓		✓		✓	

In which field – do you expect – the biggest SG investment need?

	CZ	RO	SI	CR	BA	MD	AT	HU	ME	UA	SR
distribution network (excluding SMs)		✓				✓	✓			✓	
SMs	✓		✓	✓	✓			✓	✓		✓
transmission network											

According to the survey, for the Czech Republic ITC infrastructure development for smart metering is a priority. The focus in Slovenia is distribution automation, demand side management technologies and virtual power plant technologies. In Bosnia and Herzegovina the whole electricity network requires a considerable upgrade, including the HV network and substations (110/x kV), MV network (up to 35kV), and LV network. Slovakia has recently prepared its CBA on smart metering and considers it to be the main component of future smart grids.

5.4 Smart metering landscape in the Danube Region

Directive 2009/72/EC of the 3rd Energy Package and the Energy Services Directive (2006/32/EC) require Member States to implement intelligent metering systems that assist the active participation of consumers in the energy supply market.[11] The implementation of metering systems is conditional on a positive cost-benefit assessment (CBA) that was due in September 2012 for all Member States. Furthermore Member States are required to prepare a timetable with a target of up to 10 years for the implementation of intelligent metering systems. Once the roll-out of smart meters is assessed positively in the CBA, at least 80% of consumers in the respective country must be equipped with intelligent metering systems by 2020.

The advancement of smart meters in the European Union member states is assessed along two dimensions in the European Smart Metering Landscape Report (2013). The first dimension is the legal and regulatory status of smart meters (CBA, timeline for rollout, legislative barriers and legal minimum requirements), the

[11] Article 13(1) of the Energy Services Directive (ESD) demands that end customers are provided with competitively priced individual meters that accurately reflect consumption and provide information on the actual time of use.

other is the progress in implementation (rollout status, available services) (Figure 17).

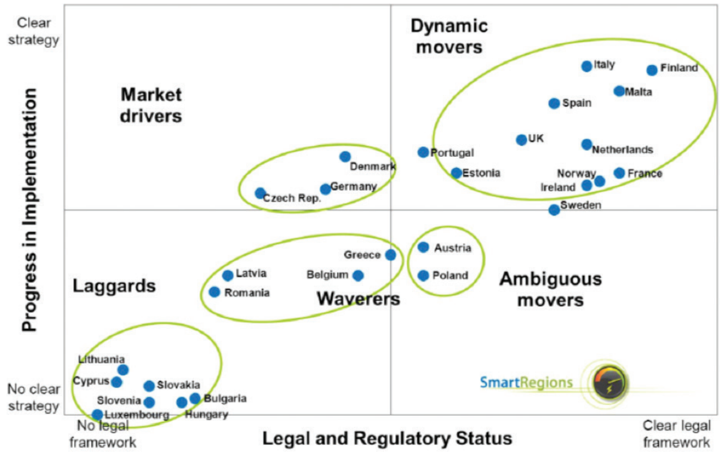

Figure 17: Assessment of smart metering advancement of EU member states

Source: European Smart Metering Landscape Report 2012 – update May 2013

As far as the completion of the required CBA concerned for electricity, the EU member states of the Danube Region have conducted the analysis with the exception of Bulgaria and Croatia. Since the publication of the CEER report in 2013, Germany and Slovakia have finished their respective CBAs. Slovenia prepared its Smart Grid Roadmap in March 2013, which includes smart metering in the context of smart grids.

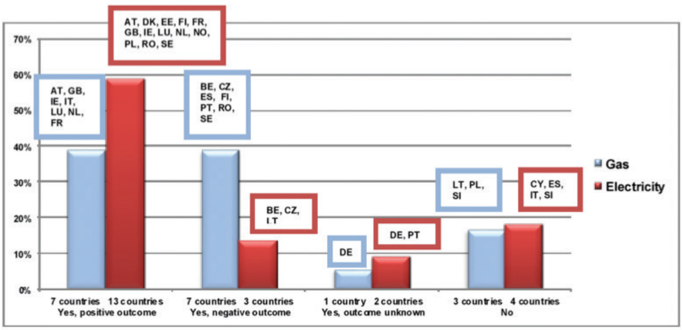

Figure 18: The status of smart metering CBA in January 2013

Source: CEER, 2013

Notes: Hungary, Slovakia and Bulgaria failed to respond to this survey

The following table gives an overview of the rollout plans and the CBAs in the Danube Region countries. These are some countries that have conducted the CBA on smart metering but do not yet have a completed rollout plan: As mentioned before, neither the Czech Republic nor Hungary have completed a rollout plan following their CBA due to the negative outcome of the CBA for the former and the slow pace of legislation for the latter. The forthcoming section discusses the current smart metering situation in the individual countries based on the questionnaires, the Landscape Report, and various national sources.

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
SM rollout plan		✓			✓		✓			✓	
full rollout		2022									
interim target		80%/ 2020			70%/ 2020		95%/ 2019				
CBA prepared	✓	✓					✓	✓		✓	
CBA results	-	+					+	+		+	

Table 8: The rollout plan, target and CBA of smart metering in the Danube region countries

Note: red background: no data or not applicable

Austria

The new national Electricity Act (2010) authorises the Ministry of Economy to introduce smart metering in Austria following its CBA, with the aim of improving customer information, billing, and energy efficiency. The CBA was carried out in 2010 and concluded that the implementation of smart metering will benefit the economy. In 2011 the regulator (E-Control) set the minimum requirement for smart meters, and the following year and the Ministry of Economy issued a decree on the rollout plan. According to this plan network operators have to install smart meters at least:

- 10% of all metering points by 2015,
- 70% of all metering points by 2017, and
- 95% of all metering points by 2019.

Bulgaria

Smart metering is in a pilot phase in Bulgaria, and since 2009 CEZ has installed 18,000 meters. The level of non-technical losses was reported to be 25%, and this spurred the instalment of electric meters with remote reading (Landscape Report, 2013).

Czech Republic

The CBA required by Directive 2009/72/EC had a negative result and consequently the Czech Republic decided not to roll-out smart metering systems until 2018.[12] The main argument against smart metering deployment is that the additional benefits of AMM (advanced metering management) over the already existing double-tariff system (called HDO) are not enough to justify the costs of the rollout. The current system is available for all customers who use electricity for space and water heating. It includes two tariffs, allowing for DSOs to remotely control those appliances based on actual network load and to send tariff signals to customers. The strong negative outcome is also explained by the following factors:

[12] Ministry of Industry and Trade: Economic assessment of the long-term costs and benefits for the market and individual consumers through the application of smart metering systems in the Czech Republic power sector, available at: http://www.mpo.cz/dokument106758.html

- The high investment costs of AMM technology: even a 50% decrease of its price would not result in a positive net present value (NPV) of its implementation;
- The high costs related to installation of meters and necessary technology adaptation;
- The high costs of ICT infrastructure update;
- The low interest of customers for additional data on their consumption and their reluctance to change their consumption patterns – a result indicated by the AMM pilot projects.

The Czech Republic instead suggests preserving its existing system until at least 2020 and complementing it with a new tariff, while also continuing AMM pilot projects and evaluating them by the end of 2016, after which the country could establish an action plan for AMM by 2018 as a part of longer-term smart grid implementation.

The CBA compared two scenarios: the "Basic" scenario that preserves the current HDO system and yearly meter reading, with the "Blanket" scenario which is an AMM installation at 100% of the consumer delivery points that are technically feasible with yearly meter reading. The CBA calculated that 7 years would be necessary for the preparatory phase of the rollout, and another 7 years for the realization phase.[13]

The discounted cash-flow analysis assumed 7 years of preparation, 7 years of realization, and a subsequent 12 years of operation of smart metering.

On the expenditures side, the different elements of the AMM rollout included the following: CAPEX and OPEX for the installation and procurement of AMM equipment and meters; OPEX for data acquisition, data processing and communication; CAPEX and OPEX for IT infrastructure updates at DSOs, the market operator and electricity trade; and other expenditures.

The assumed benefits are the following: savings on electricity due to lower absolute level of electricity consumption, savings on the alternative HDO system, savings in direct relation to smart metering (fewer disconnections, cheaper supplier switching, reduced expenditure related to the consumer's point of delivery), reduced expenditure as new tariffs induce a shift in consumption, savings resulting from a decrease in non-technical losses, and finally, savings on manual meter reading.

The expected next step in relation to smart metering systems is to re-assess the situation on the basis of technological development, ongoing pilot projects and evaluation of the benefits arising from the effective implementation of intelligent metering systems in the framework of implementation of smart grids under the prospective action plan for smart grids. The preparation of such a smart grid action plan was already initiated in 2013, in line with the requirement of the Communication in November 2012.[14]

Germany

Germany has no smart metering roll-out plan. The implementation of smart metering is traditionally market-driven. DSOs are however not very keen on investing in such projects beyond pilots without more regulatory certainty and a much clearer understanding of the business model for such investments. The "Energiewende" requires an even higher penetration level for renewable energy sources and the corresponding improvement of the electricity grids, making a massive smart meter rollout essential. The formal rollout target is 15% (CEER, 2013). The Ministry commissioned Ernst & Young to prepare the CBA which was published in 2013.[15] The report concludes that

[13] The preparatory phase includes „administrative issues, project management, planning and strategic decision making of the implementation manner, testing in laboratory conditions, as well as service and control activities including realization of necessary technical adjustments of distribution system and consumer's point of delivery". The realization phase includes "a change of metering devices and accessories, implementation of IT systems, which will form the AMM infrastructure. In some cases, it will be necessary to perform specific building adjustments (consumer's point of delivery) due to an exchange of relevant equipment."
[14] COM (2012) 663 final „Making the internal energy market work"
[15] http://www.bmwi.de/EN/Service/publications,did=588534.html

- the EU rollout scenario (80% by 2020) results in negative NPV and it is not economically reasonable for the majority of consumer groups,
- the current legislation requires smart meter installation only for those with a high potential for load shifting and energy efficiency - namely small businesses, new buildings, renewable plans and CHPs installed after 2011 - but the scope of mandatory installation should be extended to all CHPs and EEG plants above 250 kW, plus controllable energy applications (heat pumps and EVs),
- the NPV becomes positive if active feed-in management is introduced: the opportunity to limit each RES-E up to 5% of annual capacity in times of grid congestion and voltage fluctuation would mean 50% deferred network extension investment compared to the baseline scenario.

The conclusion of the study, hence, is that developing an extensive smart metering infrastructure only economical if it is coupled with smart distribution grids.

Hungary

There is no binding regulation regarding the implementation of smart metering in Hungary. The regulator commissioned a study in 2010 that examined the different models and timeframes of implementation and a preliminary CBA (A.T. Kearney and Force Motrice, 2010). The study recommends the finalisation of the pilot project evaluations in 2013 and a rollout commencing in 2014, which is not realistic because there has not yet been a comprehensive assessment. The perceived benefits include the reduction of theft, network loss and bad debt (Table 9). The only instance of a positive NPV during the 2011-2020 period is associated with a faster rollout, but the industry NPV is consistently negative (Figure 19). If the residual value of the equipment is included in the analysis, then the aggregate NPV is always positive but the industry NPV depends on the pace of rollout.

reduction of theft	70%
reduction of network loss	20%
reduction of bad debt over 30 days	90%

Table 9: The assumptions regarding the benefits of smart metering in the electricity sector in Hungary

Source: A.T. Kearney and Force Motrice, 2010

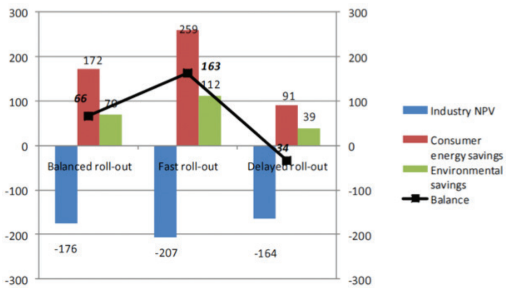

Figure 19: The NPV of smart metering in the 2011-2020 period, mUSD

Source: A.T. Kearney and Force Motrice, 2010

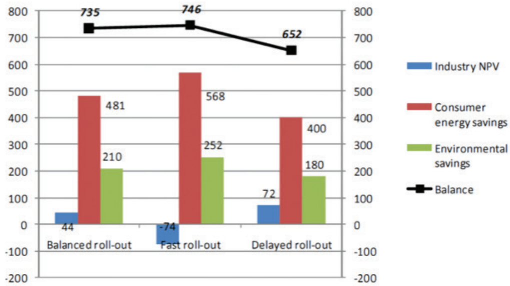

Figure 20: The NPV of smart metering for the lifetime of the equipment, mUSD (explicit period + residual value)

Source: A.T. Kearney and Force Motrice, 2010

Romania

The Romanian government decided to proceed with the rollout of intelligent metering (Art. 66 of Electricity and natural gas Law no. 123 /2012, published in the Official Gazette No. 485 of 16.07.2012.) following the publication of the CBA (A.T Kearney, 2012). The study concludes that the implementation of smart metering has the potential to be a profitable investment thanks to the reduction of grid loss and the reduction in operational cost for utilities (meter reading cost). The study indicated a return on investment of about 44% in the 2013-2032 time period. The result is, however, sensitive to the actual reduction of grid losses; if the assumed level of 60% is halved, the NPV remains only slightly positive. Additional social benefits that are not included in this figure in the form of consumption reduction and demand response opportunities can be achieved through the development of smart grids.

At the moment, ANRE is preparing an order to be approved by the Regulatory Committee which will establish the conditions, obligations, and other rules to be taken into account in the implementations of a smart metering system in Romania. The planned year for full rollout is 2022, but this target is subject to the availability of structural funds that may be required to reduce the tariff price pressure.

Slovenia

The Slovenian DSO (SODO d.o.o.) has commissioned a study on the cost and benefit of smart grid deployment. The Slovenian smart grid roadmap, although it has no official status, provides a comprehensive analysis of two scenarios: the baseline scenario that is essentially the business-as-usual case and the development scenario that aims at fulfilling the EU environmental targets of Slovenia. There is no separate CBA for a smart meter rollout.

Slovakia

Slovakia prepared its smart metering CBA in 2013 and decided to execute a selective smart metering deployment based on the outcome. The project includes supply points with annual consumption of over 4 MWh accounting for approximately 23% of the forecast Low Voltage supply points in 2020. The target number of supply points installed with smart meters in 2020 is 603,750 accounting for the supply of approximately 53% of the total annual Low Voltage electricity consumption.

	DSOs	electricity suppliers	consumers
Share	16.77%	13.56%	70.16%

Table 10: The distribution of benefits of the installation of 600 000 smart meter among the market participants

Source: Ministry of Economy of the Slovak Republic, 2013

Bosnia and Herzegovina
In Bosnia and Herzegovina there is no plan on the country level but there are plans on the entity level and in Brcko District (SERC jurisdiction) about smart metering. According to the Energy Strategy of Republic of Srpska for 2030, 70% of all metering devices should be converted to smart meters by 2020. It can be assumed that the Federation of BiH shares a similar outlook.

Croatia, Ukraine, Moldova and Montenegro
None of the above countries have a rollout plan, nor have they conducted a CBA on smart metering.

5.4.1 The current deployment of smart meters

At LV level the share of consumers equipped with smart meters is negligible, except from Slovenia where the quoted share is 30% and Slovakia (23% at LV). In Austria, the current share is 3.4% (Smart Meter Landscape Report, 2013). The share of electricity outfitted with smart meters out of the total electricity supply (across all voltage levels) demonstrates that larger consumers at HV and MV already possess advanced metering infrastructure.

What is the level of smart meter rollout as a % of all meters?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
0-10%	✓	✓		✓	✓	✓	✓	✓	✓		
10-50%			✓							✓	✓
50-90%											
90-100%											

In Slovenia 80% of total electricity consumption is metered with smart devices mostly because industrial customers have installed these devices for a number of years. As far as households are concerned, the ratio is approximately 30%.

As we have discussed earlier, the smart meters differ according their functionalities, with AMR primarily facilitating remote metering and AMI allowing for two-way communication. It seems that the countries pay attention to the prioritisation of AMI that can be the backbone of demand side management programs. In Romania, Slovakia,[16] and Austria[17] the two way communication will be a mandatory functionality of the smart meter systems installed by the DSO's. The 2013 CEER review concluded that bidirectional communication, remote reading, and interval metering are all functions that are required by the national regulations in each of the 21 surveyed EU countries (CEER, 2013). However, some countries has already forced large consumers to install AMR devices to measure daily load profiles and hence enable better forecast. In Slovenia, for example, consumers with a contracted power of more than 41kW were required to install AMRs in 2008 (Landscape Report, 2013). In Slovakia approximately 50% of electricity is metered by AMR devices.

[16] Ministerial Decree 358/2013
[17] E-Control Ordinance Determining the Requirements for Smart Meters 2011, available at: http://www.e-control.at/portal/page/portal/medienbibliothek/gas/dokumente/pdfs/IMA-VO_en.pd

Although smart metering and dynamic tariffs are associated with the current and future modernisation of the electricity network, time of use tariffs – usually via radio frequency controlled meters – are quite common in the Central and Eastern European countries. They facilitate the use of electric equipment with a heat storage option (boilers, electric stoves) at night when aggregate demand is low. In Hungary, 35-40% of households use such metering.

Do DSOs in your country employ electricity metering that allows for time of use tariff setting? (e.g. day and night tariff with separate meters or with radiofrequency operation)

CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
✓		✓	✓	✓			✓	✓		✓

System flexibility required for the integration of intermittent RES-E capacities can be provided by consumers as well as producers. The questionnaire tried to map the role of load in such services. It is important to note, that many of the DR countries (e.g. Croatia, Moldova, Montenegro, Bosnia and Herzegovina or Ukraine) have no ancillary services market that could integrate the load in electricity system balancing. Even in countries with an operating balancing market, only Hungary reported that it was open to consumers as well. In practice, however, load service is offered jointly with supply under joint ownership. The only aggregator operating in the Hungarian market (Virtual Power Plant) consists of producers only. In Romania, the regulation allows for the operation of aggregators, but in practice there is no such activity. In sum, the integration of load in system balancing is effectively non-existent the region.

6 FUTURE DEMAND FOR SMART GRIDS

The potential demand for smart grid deployment is approximated with the help of performance indicators listed in Table 4. They are a) indicators of the current situation and as such b) proxies for future demand for smart grid solutions. The expected benefits/services from smart grids vary widely among the Danube Region countries, but based on the responses there is an overriding preference for grid operation related services. This entails the more efficient utilisation of the existing infrastructure via monitoring, automation (asset management) and self-healing, in which the network can detect, analyse and restore grid operation based on a continuous grid assessment. The primary beneficiaries of these services are the DSOs. In countries of more developed electricity markets such as the Czech Republic, Austria, Slovenia (and to an extent Hungary), the focus is on consumer participation, whereby direct consumer involvement in their energy management and in support of retail competition reduces costs. Commercial loss reduction is a somewhat divisive issue, either considered completely irrelevant (Slovenia, Croatia, Austria, Czech Republic) or very much emphasised (Romania, Bosnia and Herzegovina, Hungary and Ukraine). Interestingly, the integration of all network users (referring mainly to distributed/renewable generation and storage units) did not prove to be a common driver in the region. The product differentiation based on power quality offered at different prices is only important in Ukraine.

Please rank the key benefits/services you associate with smart grid development in your country!

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
Active customers	✓		✓				✓	✓			✓
Integration of all network users	✓					✓	✓			✓	
Enables markets	✓		✓				✓				
Power quality based market segmentation									✓		
Optimizes asset management	✓	✓	✓	✓	✓		✓			✓	✓
Self healing network	✓	✓		✓	✓			✓	✓	✓	
Commerical loss reduction		✓			✓			✓	✓		

Note: (✓ means relatively high priority)

6.1 Electricity demand

Growing electricity demand generally means higher demand for electricity transport and hence higher utilization rate of the transmission and the distribution grid. The rate of transport need, however, depends on the share of distributed generation. Once it becomes considerable and the distribution grid can handle the associated voltage problems, the locally produced electricity can serve local load to a much greater extent than in a hierarchical grid structure. Smart grids that enable the integration of all network users into the distribution network can also limit the additional demand for electricity transport caused by growing consumption.

Observing the forecasted annual increase in electricity consumption, it can be gathered that that the members of the Energy Community expect much higher growth than the EU member states. The only exception is Serbia (RS) which has published its NREAP in mid-2013 with an annual growth that is much lower than the previous one (0.7% instead of 1.6%).

	2012/2020	rate of annual increase	source
AT	15%	1,9%	NREAP
BG	12%	1,5%	NREAP
CZ	17%	2,1%	NREAP
DE	1%	0,1%	NREAP
HU	15%	1,9%	NREAP
RO	27%	3,4%	NREAP
SR	15%	1,9%	NREAP
SI	9%	1,1%	NREAP
BA	34%	4,2%	Energy Community
CR	20%	2,5%	Energy Community
MD	39%	4,9%	Energy Community
ME	20%	2,6%	Energy Community
RS	6%	0,7%	NREAP, 2013
UA	38%	4,7%	Ministry of Energy and Coal Industry

Table 11: The expected annual change of gross final electricity consumption growth in the Danube Region countries

6.2 Energy efficiency

The overall energy efficiency of a country is characterized by its energy intensity. Reduction of energy intensity is often experienced concurrently with economic development, and thereby GDP growth can occur simultaneously with the reduction of energy use. The two main indicators for measuring a country's energy efficiency are primary and final energy intensity. Both energy intensity ratios compare the energy used in a given economy to GDP, thereby indicating what amount of energy is required for producing a unit of GDP (usually measured in USD and on purchasing power parity in cross-country analyses). The crucial difference between the two is that primary intensities relate primary energy consumption to GDP, while final intensities use final consumption data. Primary energy intensity is sufficient for comparing overall energy requirements against GDP, and final energy intensity is more suitable to compare the actual energy use pattern against GDP. The discrepancy between primary and final energy intensity is due to the extent of network and conversion losses. Consequently if a country uses mainly electricity for heating purposes (that is the case in many SEE countries) than it suffers more conversion losses (higher primary intensity) than in case of using unconverted energy sources such as natural gas. Apart from these factors, the share of secondary (converted) energy carriers in foreign trade (e.g. exports or imports of petroleum products) may also lead to sizeable differences of primary and final energy consumption. For example, if a large share of petroleum products is exported from a country after conversion, this would more negatively affect the primary energy intensity of the country than its final energy intensity.

The energy intensity indicators of the DR countries show that there is a higher potential to increase the efficiency of energy use in countries with lower economic output, notably in Ukraine, Serbia, Moldova, Bosnia and Herzegovina and Bulgaria.

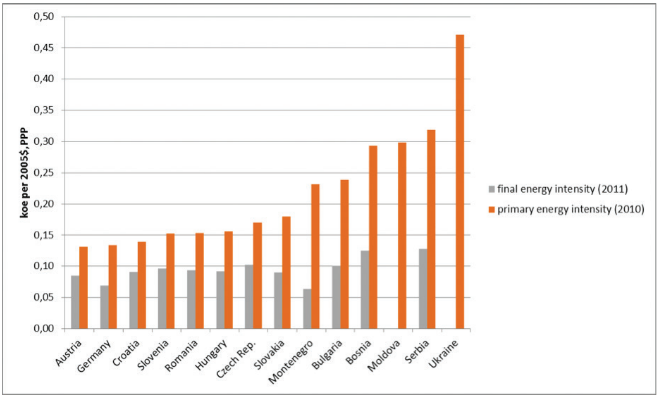

Figure 21: Energy intensity indicators for the Danube Region countries

Source: Enerdata, EIA

6.3 RES-E production trajectories

The growing importance of renewable generation, both large scale and distributed, is a major challenge for electricity networks. The proxies used for assessing this demand for smart grid solutions are the share of RES-E in gross final electricity consumption (as collected in the NREAPs for EU member states) and the change in the generation portfolio, measured by the share of intermittent sources in the renewable portfolio and net generation capacity. The countries that expect the strongest increase of RES-E in final consumption are Germany, Bulgaria, Romania and Serbia (Table 12). It is important to note that negative value do not mean decreasing RES-E generation, but more likely lower expected final consumption. Croatia's RES-E target is from 2009 and will likely to be changed to a more challenging figure in the forthcoming NREAP due this year.

	change from the reference year to 2020	Reference year	Source
AT	-2,60	2010	NREAP table 3
BG	10,16	2010	NREAP table 3
CZ	6,90	2010	NREAP table 3
DE	21,20	2010	NREAP table 3
HU	4,20	2010	NREAP table 3
RO	15,14	2010	NREAP table 3
SR	4,90	2010	NREAP table 3
SI	6,90	2010	NREAP table 3
BA	–	–	
CR	-4,85	average of 2011 and 2012	Energy Act of 2009
MD	–	–	REKK RES-E survey
ME	-0,13	average of 2011 and 2012	REKK RES-E survey
RS	9,10	average of 2010 and 2011	NREAP, 2013
UA	4,50	average of 2011 and 2012	CISSTAT 2013

Table 12: The predicted increase of RES-E in gross final electricity consumption (%)

The share of intermittent RES-E (wind and solar) in Austria, Bulgaria, Croatia and Romania (Figure 22) is forecasted to increase considerably by 2020. These are the "best estimate" forecasts submitted by the respective TSOs to ENTSO-E. The share of intermittent RES-E in net generating capacity is expected to at least double in Austria, Bulgaria, Croatia, Romania, Hungary and Slovenia (Figure 22). It is important to note, however, that the integration of these intermittent resources, from a balancing point of view, is less problematic in countries with large hydro capacities (reservoir and pumped hydro) that can contribute to system balancing.

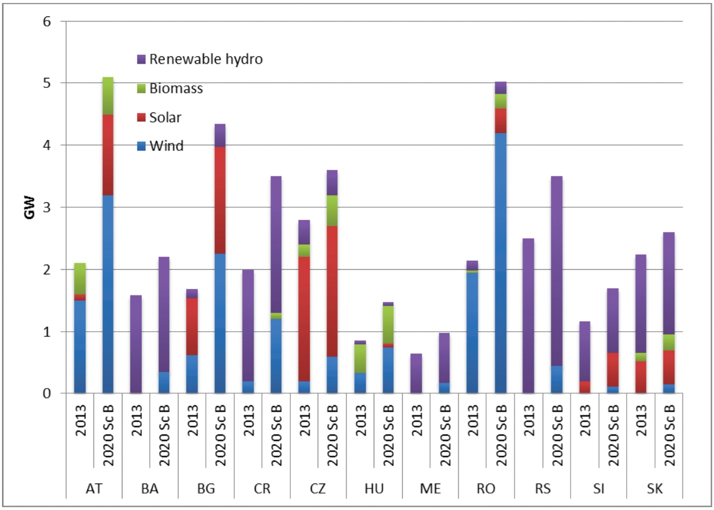

Figure 22: The RES-E generation portfolio of DR countries in 2013 and 2020 (best case scenario)

Source: ENTSO-E, SOAF

Note: Moldova and Ukraine are not members of ENTSO-E

The following figure illustrates the current and future share of intermittent capacity in net generating capacities. Germany is already operating its network with a very high share of intermittent capacities, whereas some countries have no experience so far with the system integration of such capacities.

[18] Nodal hosting capacity has been tested by a simulation of the connection of a generator at the MV bus and examined the limit of power injection taking into consideration the thermal, current and voltage limits with the existing network structure without compromising quality of service. The research has shown that 85% of the buses involved can accommodate at least 3 MW DG generation capacity.

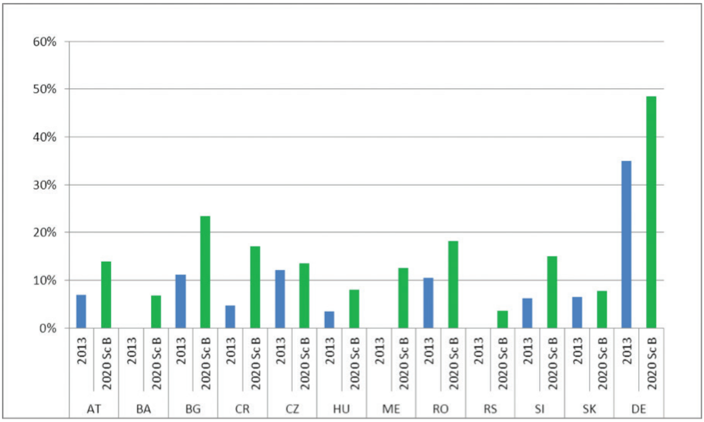

Figure 23: The share of intermittent RES-E capacity (wind and PV) in net generational capacity, %

Source: ENTSO-E, SOAF

Note: Moldova and Ukraine are not members of ENTSO-E

6.4 Current grid capacity limits on RES-E capacity deployment

This section discusses how much the grid is effectively a limiting factor for RES-E capacity deployment.

6.4.1 Reverse power flow

Reverse power-flow time (RPT) is an important measure that indicates the time period when the electricity injected by distributed generators outweighs the load of the concerned grid area in that period of time and hence reverses the default power flow, i.e. from high to medium and low voltage levels. The frequent occurrence of RPF signals the high penetration of distributed generation. It is important to note that the bidirectional flows in the grid (measured by RPT) is not a common knowledge for regulators. Italy carried out a research in 2007-2008 focusing on the nodal hosting capacity covering approx. 10% of the Italian MV network.[18] This can be an important indicator for the regulator as well because it signals geographic areas where the smarting of the distribution grid has higher value added than in other sections. In Italy, the regulatory incentives for DSOs to invest in these types of solutions is partly based on this criterion; the geographic area of development had to be one that is experiencing reverse power-flow more that 1% of time in a year (Lo Sciavo et al., 2012).

Measuring reverse flow is not yet a common practice in the DR countries. Only Slovenia and Ukraine indicated that power flows are measured, and reverse power flows often occur on different points of distribution network. However, aggregated data is not available.

[18] Nodal hosting capacity has been tested by a simulation of the connection of a generator at the MV bus and examined the limit of power injection taking into consideration the thermal, current and voltage limits with the existing network structure without compromising quality of service. The research has shown that 85% of the buses involved can accommodate at least 3 MW DG generation capacity.

6.4.2 RES-E curtailment and capacity limitations

In many countries renewable electricity is granted priority dispatch meaning that they enjoy priority in the merit order over other generation plants in case of a similar price offering. In case of grid security concerns, production might need to be curtailed. Some countries explicitly forbid the curtailment of RES-E, others allow only after the curtailment of non-RES-E producers, and some (e.g. Italy) allow for the curtailment of RES-E (usually in areas of weaker grid and concentrated wind production). In Italy RES-E producers receive monthly compensation for the loss incurred based on actual wind data (provided by GME) due to the electricity not sold.[19] The problem with RES-E curtailment is that once production units with zero marginal cost are idle, the electricity supply on the average is not cost efficient.

RES-E curtailment is not a common practice in the Danube Region, and it is important to note that the remote control of these units is only possible once they are technically capable of receiving such control information. This is likely to be an important technical requirement for future capacities in countries where this is not yet regulated. The second wind capacity tender in Hungary in 2009/2010 (that was abandoned) already required that only production facilities equipped with this technology can apply for capacity quota. On the other hand, most countries have set limits for new intermittent production capacities, most notably with respect to wind. This capacity limitation reduces the need for intermittent RES-E curtailment, as there is a trade-off between these two restrictions.

Does your country employs network capacity quota of any sort for intermittent RES-E generation?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
capacity quota		✓		✓	✓			✓		✓	
MW (wind)		2500-3000		400	350			740		500	

Note: red background: no data or not applicable

Croatia examined 29 locations for possible wind units and has concluded that 400 MW of new capacity is possible with around 800 GWh/year of production. Due to the amount of secondary reserves, probably 400 MW remains an effective technical limit. Bosnia and Herzegovina has set a 350 MW capacity limit for wind power. Although the Romanian response to the survey states that there is no capacity cap in the country, according to Transelectrica (TSO) the grid can integrate 2.5-3 GW of wind capacity in its current state. In contrast, by September 2013 8.8 GW of technical connection permits have been signed in addition to 14 GW of connection contracts (EWEA, 2013). Connection opportunities are allocated on a "first come, first served" basis in the case of scarce grid capacity, and RES-E plants do not enjoy positive discrimination against conventional producers in the connection process. Access may be denied in case of insufficient capacity. In Hungary, the second wind tender assumed an overall 740 MW limit on wind capacities. Slovakia has only 3 MW wind capacity currently because of a ban on wind capacities since 2009, and therefore does not need a capacity limit. However, the wind industry estimates that 500-600 MW can be integrated to the current grid (EWEA, 2013).

As far as the transmission system is concerned, the TYNDP 2012 concludes that 80% of the identified 100 bottlenecks in Europe are related to the direct or indirect integration of renewable energy sources such as wind and solar power. Several Danube Region countries cited renewable production growth as the main reason for future network extensions. This especially concerns Romania, Bulgaria, Serbia, Montenegro and Croatia (Figure 24). The impact of new network investments on RES-E development is considerable; 35% of the projects directly contribute to the integration of RES-E and another 40% do so indirectly through the accommodation of inter-area flows triggered by RES-E (Figure 25).

[19] ARG/elt 5/10 "Condizioni per il dispacciamento dell'energia elettrica prodotta da fonti rinnovabili nonprogrammabili"

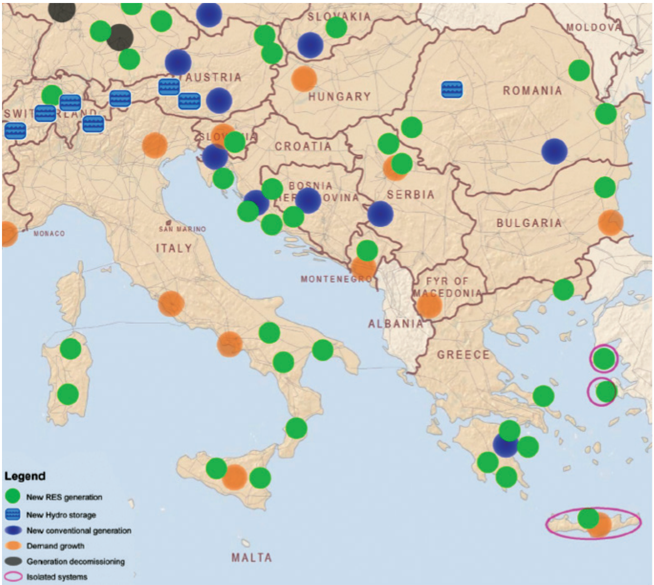

Figure 24: Drivers of network development, Continental South-East Region

Source: ENTSO-E TYNDP 2012, p. 48

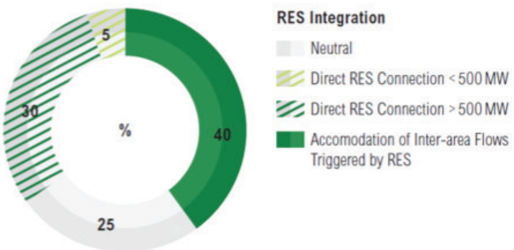

Figure 25: Share of planned network projects contributing to RES integration in the Continental South-East Region

Source: ENTSO-E TYNDP 2012, p. 82

6.4.3 Electric vehicles

Electric vehicles are considered to be important future actors at the distribution network. They constitute new demand for electricity but at the same time are flexible load elements that consume electricity at periods of low load (at nights). In addition, EVs can be used for injecting electricity into the grid when needed (V2G: vehicle-to-grid). Incentivizing this type of load profile is a crucial regulatory issue, in addition to the organisation of charging points (private versus public). The share of EVs and plug-in hybrid electric vehicles (PHEVs) in the total light-duty vehicles (personal cars) is still negligible in the DR countries and the charging infrastructure is sparse.

How many public charging points are in operation?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
No of public charging points		–	50	4	–	–	3295	10	10	18	–

Note: red background: no data

6.5 The need for better generation adequacy

When considering potential demand for smart grid solutions, a country's generation adequacy is an important factor. It is important to know the extent to which a country is able to meet its electricity demand in all hours of the day, and the more difficult this is the more important it is to reduce loads during peak hours. The quick spread of intermittent renewable electricity production may exacerbate this problem by introducing power generation variability that is difficult to forecast, and hence potentially lead to a timeframe when not only demand is high but electricity generation is less than expected. Smarter grids can be an important tool in improving generation adequacy in these situations - they can lead to better demand forecasting and enable peak-shaving, e.g. through DSM solutions. By doing so, smart grid solutions could improve the ability of generation capacity to meet swings in demand and reduce the need for secondary power reserves, leading to a more efficient and cheap power grid. To investigate the question of generation adequacy, first we analyse the demand patterns of Danube Region countries based on ENTSO-E data, and then turn to the supply side focusing on differences in the generation mix of these countries.

6.5.1 Potential for peak shaving

Once the peaks in the aggregate load profile is reduced by shifting consumption to periods of lower electricity demand, the system faces lower balancing needs. To analyse demand variations of national electricity markets we collected information on the minimum and maximum electricity loads in each Danube Region country: the data are from ENTSO-E and for 2012 only. By looking at the difference of minimum and maximum values we can assess the potential for smoothing the load pattern and the need for flexible power generation and/or flexible load. Figure 26 illustrates two different ratios for all DR countries: a) the ratio of the absolute maximum hourly load[20] to the absolute minimum hourly load and b) the ratio of the peak hour average load[21] to the off-peak hour average load.

[20] The single highest hourly load in each country in 2012

[21] It is the single hour when the average yearly load was the highest in 2012 in each country.

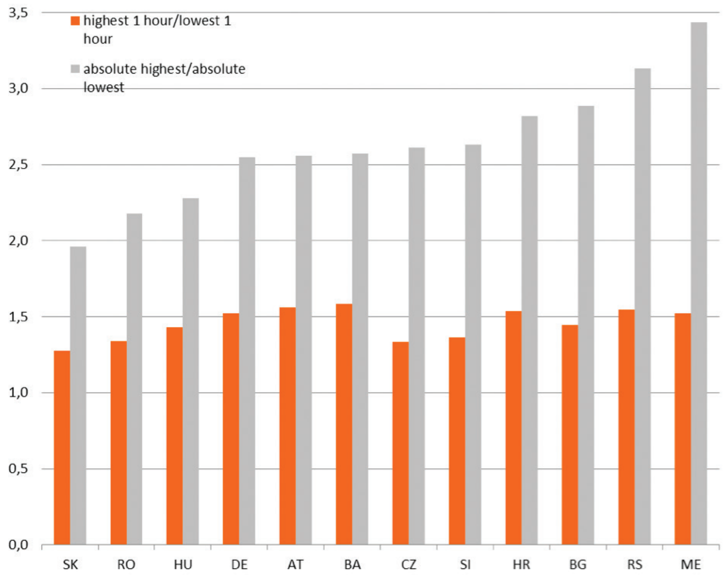

Figure 26: Peak-to-off-peak load values in Danube Region countries, 2012

Source: REKK calculation based on ENTSO-E data

Note: No ENTSO-E data or alternative data source was available for Ukraine and Moldova.

The spread among the countries is only considerable in case of the absolute values. According to this measure, the maximum demand in 2012 was roughly double than the minimum in Slovakia, whereas in Montenegro it was almost 3.4 times higher. The countries where the peak-valley ratio is the highest are Croatia, Bulgaria, Serbia and Montenegro.

Figure 27 illustrates the hourly loads for Bulgaria in 2012. We can conclude that even in Bulgaria the extremely high maximum load was only a single occurrence in 2012, and higher loads, e.g. above 6000 MW, were not common.

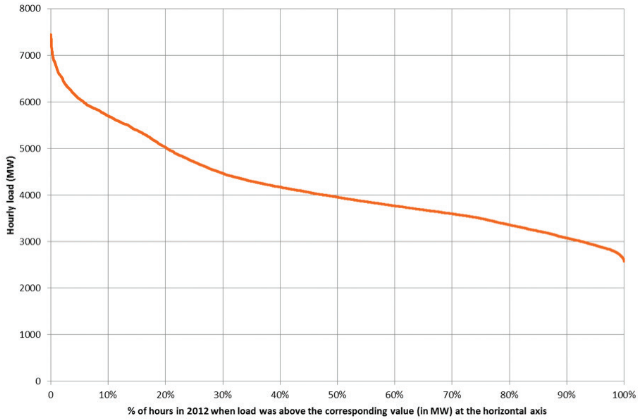

Figure 27: Bulgaria's hourly load diagram for 2012

Source: REKK calculation based on ENTSO-E data

The differences in the minimum/maximum load ratios suggest that peak shaving has higher potential in the above mentioned countries.

6.5.2 Network losses

Network losses in the power grid can be classified as either technical or non-technical (commercial) losses, where the latter usually refers to electricity theft. While smart grids, and particularly smart metering solutions, could be important in reducing theft, including smart grid solutions as part of future network developments could also lead to lower technical losses by improving grid characteristics, e.g. introducing more flexibility to the network.

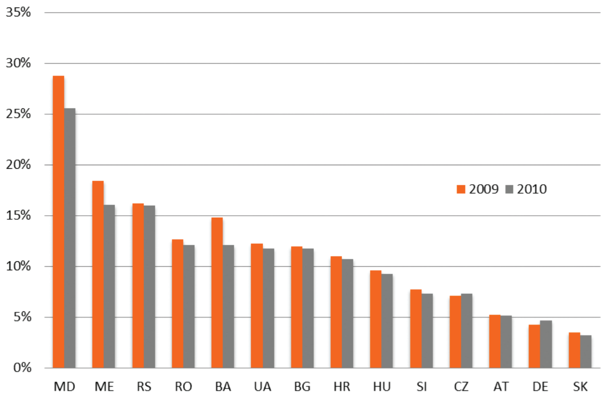

Figure 28: Electricity losses (both at transmission and distribution levels) as a % of domestic electricity supplied

Sources: calculations by REKK based on IEA Energy Statistics of Non-OECD countries 2012 and IEA Electricity Information 2012

In this chapter we only deal with overall network losses. From Figure 28 we can see that the level of network losses varies considerably across the Danube Region, from as low as 3-5% in Slovakia, Germany and Austria to more than 25% in Moldova. Apart from Moldova, which is a clear outlier, seven other countries have network losses of above 10% of total electricity supplied.

6.5.3 Commercial loss

Commercial loss includes theft and inaccurate metering, and both types of loss can be reduced with the introduction of smart metering. We have not managed to identify a common source for the commercial loss rates of the Danube Region countries, and these rates are DSO specific even within a single country.

What is the magnitude of commercial losses in your country? Do DSOs consider it a major problem?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
Is it a problem?					✓	✓		✓	✓		✓
% of total distributed amount		7	2		7-14	11		5-8	11.8	2	13

Note: red background: no data or not applicable

In Montenegro, the level of commercial losses was 13-14% in 2005 that has been reduced – after a series of regulatory measures – to 10.8% by 2007.[22] The current level (from Jan to Sept 2012) is 9.5%. DSOs in Moldova, Ukraine and Bosnia and Herzegovina have similarly high commercial losses.

Another potential solution for reducing electricity theft is to offer pay-as-you-go purchase to consumers with limited resources, where consumers can use electricity via pre-purchase cards. This option is only used in Croatia and Hungary currently.

6.5.4 Generation adequacy

In the followings we focus on a system adequacy analysis of the power systems in the Danube Region countries through an overview of generation adequacy.

Generation and system adequacy are important because they show to what extent a country is able to cover its electricity demand in different situations with the help of inland generation capacity (generation adequacy) or in the case of spare capacities using import capacities (system adequacy).

Ensuring generation adequacy does not mean merely building new generation facilities. Smarting of the grids could also play an important role by improving demand forecasting and by demand side participation. By doing so, smart grid solutions could enable higher penetration of intermittent generation while also leading to smaller balancing energy and secondary power reserve needs.

Our analysis is based on the ENTSO-E Scenario Outlook & Adequacy Forecast (SO&AF) 2013, which carries out detailed adequacy analysis over three contrasting Scenarios for 2020, covering different evolutions for generating capacity and load, using the same criteria for the assessment. The three scenarios are the following:

- Scenario A ("Conservative Scenario"): takes into account the commissioning of new secure power plants, and load forecast in this scenario is the best national estimate avail¬able to the TSOs
- Scenario B ("Best Estimate Scenario"): takes into account the generation capacity considered in Scenario A, as well as capacities considered as reason¬ably credible according to the TSOs, while load forecast is the same as in Scenario A.
- Scenario EU 2020: generation capacity taken into account is derived from the National Renewable

[22] Presentation of Novak Medenica (Energy Regulatory Agency of Montenegro) at the ERRA Tariff/Pricing Committee, Skopje, 15-16 September 2008

Action Plans (NREAPs) in compliance with the European 3×20 objectives.[23]

Generation Adequacy Assessment is based on the comparison between the load and the generation capacities in the reference points, while System Adequacy Assessment also takes into account the available export and import capacities.[24]

Generation Adequacy analysis is based on the comparison between the available generation capacity and the load, thus under normal conditions it can be measured with the help of remaining capacity:

- When Remaining Capacity is positive (RC>0), some spare generating capacity is likely to be available on the power system under normal conditions.
- When Remaining Capacity is negative (RC<0), the power system is likely to be short of generating capacity under normal conditions.

Seasonal generation adequacy forecast is assessed through a seasonal extension of the generation adequacy forecast on a power system, by comparison of the related Remaining Capacity (RC) and Adequacy Reference Margin (ARM):

- When Remaining Capacity is over or equal to Reference Adequacy Margin (RC-ARM≥0), some generating capacity is likely to be available for export on the power system.
- When Remaining Capacity is lower than Reference Adequacy Margin (RC-ARM<0), it means that there is a scarcity in power system and it is likely to have to rely on import flows when facing extreme conditions.

The following table shows these generation adequacy measures (in GW) in the case of Danube Region countries in the different scenarios based on the ENTSO-E data (values with red background indicate a problem with generation adequacy).

	2013		2020 Sc A		2020 Sc B		2020 Sc EU 2020	
	RC	RC-ARM	RC	RC-ARM	RC	RC-ARM	RC	RC-ARM
AT	7.5	5.6	6.6	4.6	12.5	10.1	12.8	10.6
BA	0.71	0.41	1.8	1.3	1.8	1.3	1.5	1
BG	4.57	3.26	4.81	3.29	6.15	4.63	5.81	4.29
CR	0.3	-0.1	0.2	-0.4	1.1	0.5	0.6	0
CZ	1.55	0.45	0.8	-0.4	1.4	0.2	0.8	-0.4
DE	1.02	-3.79	-2.21	-6.74	-0.82	-5.41	-0.9	-5.49
HU	-0.52	-1.27	-0.41	-1.14	1.21	0.54	1.65	0.91
ME	0.04	-0.15	0.09	-0.14	0.33	0.09	0.04	-0.15
RO	3.16	1.74	-0.34	-1.96	4.6	2.71	5.12	3.19
RS	0.84	-0.18	3.62	2.34	3.62	2.34	1.4	0.28
SI	0.44	0.22	-0.3	-0.51	0.35	0.08	1.14	0.81
SK	0.35	-0.05	0.65	0.22	1.1	0.65	0.8	0.35

Table 13: Generation adequacy in the Danube Region countries in different scenarios under normal and extreme conditions (GW, January 7 p.m.), GW

Source: ENTSO-E

[23] ENTSO-E carried out the analysis at two given reference points during the year (the third Wednesday in Janu-ary at 7 p.m. and the third Wednesday in July at 11 a.m.), but here we only show the results of the first point.
[24] For the definitions used in the analysis see ENTSO-E Scenario Outlook & Adequacy Forecast (SO&AF) 2013.

In the case of Austria, Bosnia and Herzegovina and Bulgaria generation adequacy situation is positive for all scenarios. Currently there are generation adequacy problems in several counties when facing extreme conditions. Under normal conditions remaining capacity is negative only in the case of Hungary. The 2020 generation adequacy outlook remains negative in most of the Danube Region when countries are facing extreme conditions under the conservative scenario (2020 Sc A), but it becomes positive in the case of best estimate scenario (2020 Sc B). The only exception is Germany whose generation adequacy measures are negative in the case of all 2020 scenarios.

System Adequacy represents the ability of the electricity system to supply the load taking into account the commercial possibilities with neighbouring countries. To assess System Adequacy, Adequacy Reference Margin should be compared to Export and Import Capacity. This comparison determines the ability of the power system to cover ARM through import flows from neighbouring power systems or the ability of a power system to export its positive remaining capacity (RC) to its neighbouring power systems, if necessary.

Under normal conditions:

- When Remaining Capacity is positive and lower than Export Capacity, it means that the spare generating capacity likely to be available on the power system can be exported under normal conditions at the reference point.
- When Remaining Capacity is negative and its absolute value is lower than Import Capacity, it means that all the necessary import flows to meet load can be imported under normal conditions at reference point.

Under extreme conditions:

- When Remaining Capacity minus Adequacy Reference Margin is positive (RC-ARM>0) and lower than Export Capacity, it means that all the spare generating capacity likely to be available on the power system can be exported in most of the situations.
- When Remaining Capacity minus Adequacy Reference Margin is negative (RC-ARM<0) and its absolute value is lower than Import Capacity, it means that all the necessary import flows to meet load can be imported in most of the situations

The following table shows these system adequacy measures (in GW) in the case of Danube Region countries in the different scenarios based on the ENTSO-E data. The first (second) column of each scenario shows Export-RC (Export-(RC-ARM)) in the case if RC (RC-ARM) is positive and Import-Abs(RC) (Import-Abs(RC-ARM)) in the case if RC (RC-ARM) is negative.[25]

[25] Abs means absolute values

	2013		2020 Sc A		2020 Sc B		2020 Sc EU 2020	
	exp/imp-RC	exp/imp-(RC-ARM)	exp/imp-RC	exp/imp-(RC-ARM)	exp/imp-RC	exp/imp-(RC-ARM)	exp/imp-RC	exp/imp-(RC-ARM)
BA	0.79	1.59	0.2	0.7	0.2	0.7	0.5	1
BG	-2.52	-1.01	-2.56	-1.04	-3.9	-2.38	-3.56	-2.44
CR	2.2	4.5	3.8	4.2	2.9	3.5	3.4	4
CZ	2.25	3.75	3.4	2.9	2.8	4	3.4	4.6
DE	13.28	26.71	28.29	23.76	29.68	25.09	29.6	34.49
HU	1.88	2.23	3.09	2.36	3.29	3.96	2.85	3.59
ME	1.16	2.65	2.71	2.66	2.47	2.71	2.76	2.95
RO	-1.06	1.61	3.06	1.44	-1.25	0.64	-1.77	0.21
RS	2.22	2.98	-0.56	0.72	-0.56	0.72	1.66	2.78
SI	2.34	4.33	3.5	3.29	4.2	4.47	3.41	3.74
SK	2.22	3.65	3.49	3.92	3.04	3.49	3.34	3.79

Table 14: System adequacy in the Danube Region countries in different scenarios under normal and extreme conditions (GW, January 7 p.m.), GW

Source: ENTSO-E

Notes: missing export/import capacity data for Austria

Serious system adequacy problems would arise if in the case of negative RC (RC-ARM in extreme conditions) values there was not sufficient transmission capacity to import the needed electricity. It can be seen that in all cases when generation adequacy measures were negative (light red cells), import capacities can ensure missing capacity from neighbouring countries, thus the system adequacy is positive in all analysed countries. Negative values in the table (dark red cells) indicate situations when RC is positive but there is not enough export capacities to sell the extra capacities to the neighbouring countries. This situation arises in Bulgaria in the case of all scenarios and in Romania and Serbia in some scenarios. In these situations the net export position of these countries could be improved by expansion of export capacities.

In conclusion, although generation adequacy is questionable in some DR countries, when trade capacities are considered (system adequacy) even those countries with inadequate generation capacities are able to cover their needs.

6.5.5 Quality of supply: continuity and voltage quality

One of the most important characteristics of a national electricity grid is the power quality it is able to provide to customers. The most noticeable aspect of power quality is continuity of service, as the uninterrupted supply of electricity is very important for all classes of electricity consumers. Power outages of various lengths are easily observed and can cause discomfort for households and financial loss for industrial customers. Apart from service quality, voltage variations are also important. Thus, national energy regulators and transmission system operators (TSOs) throughout the world collect data on electricity supply characteristics and use a number of measures to assess the quality of electricity.

It is important to note that low supply quality is mostly caused by the low technical quality of the transmission and distribution systems. Along with their relative economic development, the status of the grid can vary substantially across the Danube Region countries, and grids at various levels of technical development raise different kind of problems which require unique smart grid solutions.

Smart grids and smart meters can contribute to better service quality via automatic error detection from smart meters with voltage fluctuation detectors and power quality censors that automatically substitute faulty distribution network sections to serve consumers without interruption.

Here we focus only on the state of continuity of service in different countries, and only make comparisons by analysing SAIDI (system average interruption duration index) and SAIFI (system average interruption frequency index) values, the two most commonly used measures for the yearly average duration and frequency of power outages. The reason for limiting our analysis to these two indices is that these are the most readily available indicators in most of the countries under our scrutiny, while other measures are either available only for a limited subset of the countries or published for the purposes of the transmission grid, as in the case of the AIT (average interruption time) and ENS (energy not supplied) indices.

In this paper we use the generally accepted definitions for both indices:

SAIDI = yearly duration of interruptions in minutes per customer served

SAIFI = yearly frequency of interruptions in occurrences per customer served

It should be noted that SAIDI and SAIFI values are collected from various sources, among them the reports of national regulators, TSOs and the 5th CEER Benchmarking Report on the Quality of Electricity Supply, and they are sometimes calculated using different methodologies, e.g. whether vis maior events are accounted for, or which voltage levels are included). While this introduces some inconsistency in the data, slight measurement variations are often of no consequence as the differences between the countries are apparent.

	SAIDI	SAIFI	Year (SAIDI)	Year (SAIFI)	Source
Germany	15		2011		Bundesnetzagentur press release, 2012
Austria	16		2011		E-Control Market Report 2012
Hungary	102	1.45	2010	2010	National Report of the Hungarian Energy Office, 2012
Czech Rep.	268	2.36	2011	2011	National Report of Czech Republic Energy Regulatory Office, 2012
Slovakia	460	3.59	2011	2006	E-Control Market Report 2012
Bulgaria	162	3.36	2011	2011	National Report of SEWRC, 2012
Romania	547	5.6	2011	2011	National Report of the Romanian Energy Regulatory Authority, 2011
Slovenia	55	1.33	2011	2011	Report of the Energy Sector of Slovenia by the Slovenian energy agency, 2011
Croatia	288	2.79	2010	2010	HERA Annual Report, 2009
Serbia	580	7.5	2011	2011	AERS Annual Report, 2011
Bosnia and Herzegovina	729	8.53	2012	2012	Annual Report of BiH State Electricity Regulatory Commission, 2012
Montenegro	no data	no data			
Ukraine	461	4.27	2011	2010	Monitoring and Regulation of the Quality of Electrical Power Services in Ukraine, presentation by Mikhail Verbitsky, 2012
Moldova	570	5.32	2010	2010	CEER 5th Benchmarking Report on the Quality of Electricity Supply

Table 15: Unplanned SAIDI and SAIFI values for the Danube region countries

Table 15 contains the latest publicly available "unplanned" SAIDI and SAIFI values for the Danube Region countries. SAIDI values represent the duration of interruptions in minutes per year for the average customer. While unplanned interruptions can be as low as 15 minutes per year on average in Germany and Austria, at the other extreme we find Bosnia and Herzegovina, Romania, Ukraine, Serbia, Moldova and even Slovakia that represent values of 400-600 minutes per year. Although SAIFI values are only available for a smaller set of countries, they correspond with SAIDI figures. Therefore, SAIDI and SAIFI values indicate that there are only a few countries in the Danube Region where service continuity is not a significant problem. Behind the more developed networks of Germany and Austria, values around 50-100 minutes of unplanned interruptions are observed in Slovenia and Hungary. In the Czech Republic and Bulgaria the values significantly exceed 100 minutes.

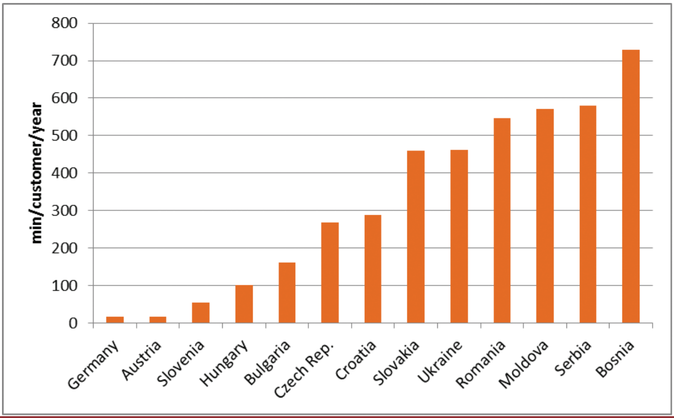

Figure 29: SAIDI value for unplanned interruptions in the Danube Region countries (min/customer/year; 2010/2011/2012)

Note: no data for Montenegro

In countries where electricity supply is less reliable it is easy to assume that some of the smart grid solutions could not be effectively and efficiently introduced without first investing in the aging network. However, we believe that some solutions like better monitoring systems for the sources of interruptions may be able to cost-effectively reduce the duration of outages in these countries as well. We also believe that from the viewpoint of electricity supply stability, smart grid solutions could benefit the average performance countries like Hungary, Slovenia, the Czech Republic or Bulgaria where interruptions are mostly contained but their duration and frequency could still be improved to Western European levels by better monitoring and a more flexible power grid.

As we have discussed before, voltage quality is increasingly important where electronic appliances are more susceptible to damage and also cause more disturbances. The voltage problems are likely to increase with the large scale penetration of distributed generation. Distribution automation via integrating communications, IT infrastructure, and sensors within a distribution management system offer solution to the optimisation of power flows and voltages. The importance of voltage problems differs greatly across the Danube Region countries where only Slovenia and Ukraine indicate that it is a major problem.

Does voltage quality – in your opinion - possess a problem in your country? Please rate its importance!

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
major problem			✓						✓		
exists but at torelable levels		✓				✓				✓	✓
negligible level				✓	✓						
no problem at all	✓						✓	✓			

Consumers can potentially contract power based on their willingness-to-pay for quality. Only in the Czech Republic can consumers contract different power quality at different prices, but these are not standardized products, rather they are agreed to bilaterally. Romania plans to introduce this concept in the medium-term.

6.5.6 Consumer switch

The timely provision on consumption data is expected to facilitate market processes in the retail segment such as supplier switch, contract change, or simply moving from one flat to another. Countries benefit from these processes where smart meter rollout is in an advanced stage (CEER, 2013). In the Danube Region the current rate of supplier switch is quite low, even in countries with fully liberalised electricity retail markets. Austria and Hungary have the highest rates within the full consumer segment. In households, where the smart meters are not yet commonplace, Germany, Austria and the Czech Republic record higher rates (Figure 30). Naturally, the instalment of smart meters will not in itself motivate consumers to actively choose among alternative suppliers and tariff packages, but it can substantially reduce the transaction cost of such action. Slovakia could not provide the figure on the total consumer segment, however among households the rate of supplier switch was 2.7% (57,307 households).

What % of consumers switched supplier in 2011 or 2012 within the total consumer segment?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
%		1%	5%	1%	0%	0%	14%	13%			0%

Note: red background: no data or not applicable

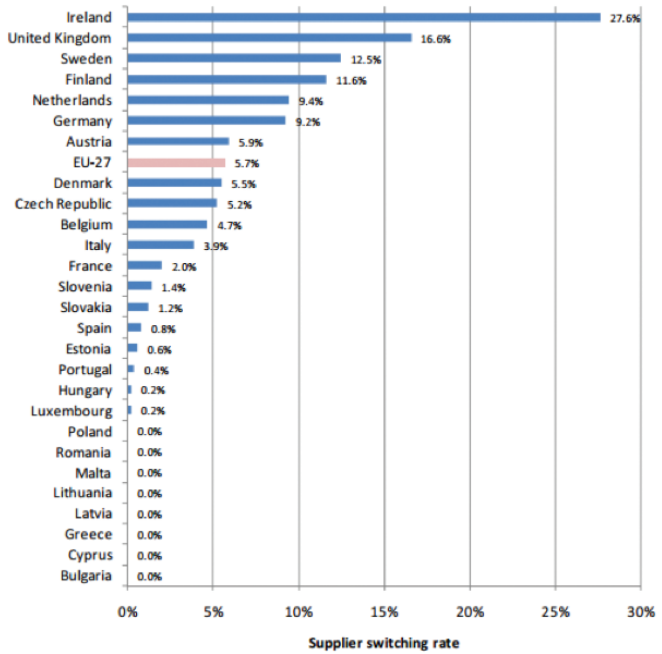

Figure 30: Supplier switching rates of households in 2 years prior to mid-2010 (excluding movers)

Source: ECME, 2010

7 Regulatory issues

Electricity network challenges are not only of technical nature but require the consideration of economic regulation that applies to the affected DSOs, TSOs, producers and consumers. Investment in smart grid infrastructure can only provide fair returns if coupled with adequate regulation that provides strong incentives for market participants to invest in necessary projects and for the users to actively use the services smart grids provide. The following section summarises the views of DR countries on the barriers to smart grid deployment and the role of the regulator. Then it discusses the need to rethink current DSO remuneration schemes and offers the Italian case study as an example of regulatory development that facilitates innovative investments.

7.1 Current regulatory policies on smart grids and smart metering in the Danube Region

Based on the survey, the most significant barriers to smart grid deployment are the high associated cost, the inadequate incentives, and the lack of regulatory policies or "regulatory push". As far as technology concerned, it is not the availability but the lack of standardisation and the data security that are considered to be limiting factors. It is interesting to note that the novelty of such technological solutions to both consumers and utilities is something that needs to be addressed. This is an area that can be improved with very limited resources, but it requires the proactive attitude of the regulator, the respective ministry, and industrial associations. In Hungary, for example, companies that are interested or already involved in the business opportunities associated with smart grid deployment recently formed a "Smart Grid Cluster" aimed at information exchange, knowledge building, and cooperation.[26] Many of the smart grid roadmaps have been prepared by similar industrial clusters in Austria, Slovenia, and Germany. The need for information sharing is expressed by the respondents of the questionnaire as well. Most DR countries agree that the critical role of the regulator is to facilitate stakeholder discussions on smart grid and meter deployment.

What – do you think – are the barriers of smart grid deployment?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
High costs for SG infrastructure – questionable ROI		✓		✓	✓			✓	✓	✓	✓
Inadequate incentives	✓		✓		✓		✓	✓			
IT security		✓		✓							
Lack of regulatory polices	✓		✓			✓			✓	✓	
Lack of public education and awareness	✓						✓				✓
Fear of change (Utilities/Customers)	✓	✓					✓			✓	
Increase of workers lay off											
Immature technology											
Lack of technology standards	✓						✓		✓		

[26] www.okosjovo.hu

What – do you think - the main role of the regulator is in your country regarding smart grid deployment?

	CZ	RO	SI	CR	BA	MD	AT	HU	UA	SR	ME
provide incentives for network operators to invest in innovative SG technologies		✓				✓	✓				✓
changing balancing market rules for the better integration of intermittent RES-E production		✓		✓			✓				
initiate stakeholder discussion to ignite national policy development		✓	✓		✓			✓	✓	✓	
provide regulator push for smart meter roll-out		✓					✓				

Note: red background: no data or not applicable

Several countries highlighted the additional roles they would like to assign to the energy regulator. Slovakia stressed the need for methodological guidance on smart grid development and the initiation of stakeholder discussions on advanced tariffs schemes. Ukraine would like the regulator to initiate financial incentive mechanisms for smart grid integration, but only after state policy is set on grid policy. The concern in Romania is to find a way to finance the investments in smart metering systems so that customers are not bearing the initial costs early on in the process. Similarly, in Austria the main concern is to bring down the cost of the grid to protect consumer interest so that only innovations with positive CBA are deployed.

An important issue identified by the respondents is the *lack of incentives to invest in smart grid projects.* It is important to note that these projects bear higher risk than conventional grid investments as the magnitude and distribution of the benefits among the market participants is difficult to assess in advance. This is due to the complexity of effects, their sensitivity to actual grid conditions (locality), and the limited experience with these technologies. The applicability of results from completed projects mostly depends on the similarity of boundary conditions. The majority of the DR countries do not offer special incentives to DSOs for investment in smart grid projects. Only the Romanian and Slovenian regulation have a specific smart grid provision. In Romania, for the investment in smart metering systems, DSOs are eligible for an extra 0.5% WACC compared to the WACC of other types of investment. This system is very similar to that of Italy where the extra WACC is 2% for selected smart grid projects (see later). In Slovenia, investors receive a one-time payment of 2% of the investment value for smart grid investments (in addition to regular income from grid regulation).

7.2 Adequate distribution utility remuneration

The integration of new grid users, especially the massive distributed generation, requires large investments into the network infrastructure. DSOs have to upgrade the network so that it can deliver electricity securely even when all intermittent producers are operating at their peak power ("fit and forget approach"). The International Energy Agency estimates that the investment needs in the European distribution network - including the replacement and the modernisation/smartening of existing assets in order to serve growing electricity demand and new specifications (smart grids) – amounts to 480 bn EUR up to 2035 (IEA, 2010).

An alternative solution to simple network capacity extension is the "smarting" of the distribution system to enable it to operate similarly to the transmission grid. Smart grids can provide the same service but with lower network capacity extension through the use of higher asset utilisation and the integration of electricity storage options (Figure 31). In this case less capacity expansion is needed due to higher levels of grid utilisation (as a result of real time data) and the active management of DG units and consumers (DSM). However, the addition of the ICT (info-communication technology) element to the network involves considerable investment.

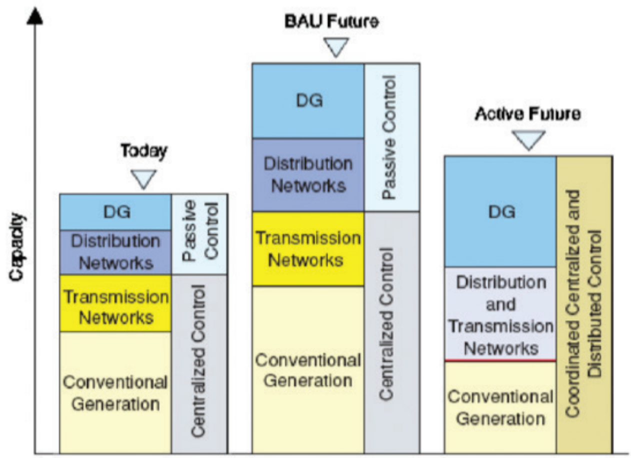

Figure 31: Active vs passive management of distribution networks

Source: Djapic, 2007

Despite the reduction of the additional network capacity requirement, the transformation of the distribution grid still translates to considerable upfront costs. Moreover, the widespread use of distributed generation might increase certain operation cost elements as well. Distribution losses are often quoted as the a major cost saving factor, however, it might just as well increase OPEX, depending on the penetration level of DG and the grid topology (Fries et al, 2009 and Joode, 2007).

DSO revenues are reduced due to the mass appearance of "prosumers," i.e. households and commercial entities that install and operate grid connected DG units. Their electricity need is partly covered from their own resources when available, with the remaining coming from the public grid. When the production is in excess of their own consumption their electricity is injected into the grid. Even during the periods when the majority of distributed generation units (PV and wind) are off-line, the network must be able to cover peak demand in order to maintain the continuity of supply. Electric vehicles might even add to this peak demand, if their consumption is not adequately shifted towards periods of low load by dynamic electricity tariffs. With high DG penetration the network usage time (ratio of energy consumption and peak power – kWh/kW) for consumption from the public network is likely to decrease (depending on the volume of new demand sources associated with low carbon energy systems such as electric vehicles and heat pumps).[27] This leads to a decoupling of revenues and costs within the regulatory period as network tariffs are held constant through the period.

[27] EU Low Carbon Roadmap 2050

The current European network regulation is characterized by the predominance of a flat rate volumetric network tariffs (€/kWh) for households, and the mixture of power demand charge (€/kW), reactive energy charge (€/kVArh) and fixed charge (e.g. €/month) for industrial consumers (Figure 32). In half of the 17 countries covered by the EURELECTRIC survey the energy charge is coupled with a fixed charge component for households but capacity charge is not used in this segment.

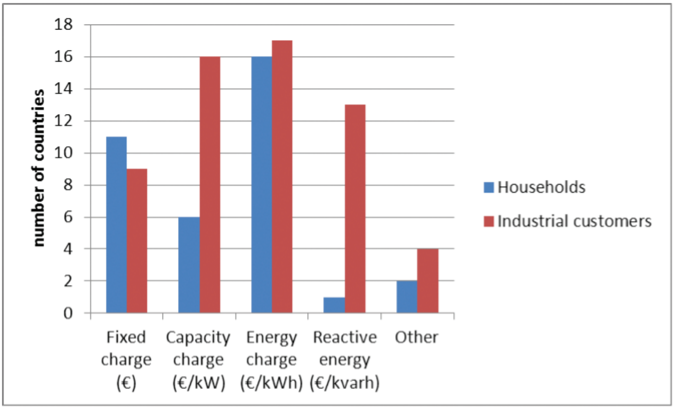

Figure 32: Network tariff components in selected European countries for households and industrial customers

Source: EURELECTRIC, 2013

For network cost created by prosumers is primarily driven by power demand while revenues from these customers are mostly based on the amount of energy consumed (volumetric).[28] Due to the volumetric structure of tariffs, tariff revenue decreases with lower consumption (due to prosumers) at the same time the integration of the very same actors requires network investments and higher operational costs (ancillary services, voltage control etc.). This deters DSOs from connecting renewable units to their network, and a regulatory scheme is needed to overcome this deployment barrier.

There are several solutions to ensure the provision of adequate revenues for DSOs. The first is reforming the network tariff structure by introducing a capacity element to the network tariff. This substitution, however, is likely to reduce the incentive of the customer to save on overall consumption; the customer is induced to stay within the capacity limit (not using all equipment at the same time) but without a constraint once under this upper limit.

Another option is to include incentive payments directly related to smart grid investments. Germany, for example, introduced the so called "enlargement factor" and the "investment budget". The former covers changes in the DSO requirement to supply consumers (e.g. demand changes), while the latter compensates for network restructuring (WIK Consult, 2011). Since 2010, the enlargement factor encompasses the number of connection points for distributed generation (e.g. wind and PV) and it is meant to cover the costs of network extensions at the DSO-level in order to connect an increasing amount of RES-E.

[28] Prosumers are customers that consume electricity from the public network but also produce electricity on the network. The actual consumption status (consumption minus production) changes every second.

In 2005 OFGEM in the UK reformed the price cap regulation for the grid to trigger extra investments to facilitate RES-E integration. This was especially important as, also contained in this regulatory package, the deep connection charge was substituted with a shallow charge regime.[29] DSOs were able to recover their grid related connection and integration costs of RES-E generation upfront through the network tariffs – by an incentive payment per $kW_{DG/RES}$ connected (2.16 €/$kW_{DG/RES}$ (singular) and 1.44€/ $kW_{DG/RES}$/yr (annually)). This payment was even higher (4.3 €/$kW_{DG/RES}$) in the case of innovative network solutions for the first 5 years of operation in the framework of Registered Power Zones (pilot power zones housing innovative network solutions).

7.3 Italian regulatory case study

As Italy is at the forefront of providing innovative regulatory incentives for grid modernisation, it might serve as an interesting example for other countries.[30] The need for network investments is caused by the high deployment rate of intermittent RES-E capacity (mainly PV) in the last few years. Apart from R&D support, the Italian regulation provides an opportunity for DSOs that endeavour to make smart grid investments to compete for an extra remuneration provided for 12 years.

Dedicated R&D support is available to both research centers and universities, as well as the network operators, while the costs are financed by the tariff payer. As an example, the biggest distributor, ENEL is about to finish its 4 pilot programme (Interregional Operational Program – POI) in the 4 Southern regions (Campania, Calabria, Puglia, and Sicily) that will be able to integrate the massive wind and PV development underway in these regions. The program consisted of "traditional" grid reinforcement but involved a substantial smart grid elements as well. The project is expected to result in a MV network that is able to integrate PV plans between 100kW and 1 MW (Nigris, 2011).

Apart from the targeted R&D budget, the Italian regulator (AEEG) *employs an input-based incentive regime* for DSOs to start smart grid demonstration projects.[31] Eight projects have been selected from the proposal submitted by DSOs by an expert panel. The projects had to meet several requirements in order to receive the additional 2% WACC – alongside the default return of the incentive payment – that is guaranteed for 12 years (Lo Sciavo, 2012). First, the geographic area of development had to be one that is experiencing reverse power-flow of more than 1% of time within a year. Reverse power-flow time (RPT) is an important measure that indicates the time period when the electricity injected by distributed generators outweighs the load of the concerned grid area in a given period of time, and hence reverses the default power flow (i.e. from high to medium and low voltage levels). It is important to note that such grid activity (measured by RPT) is not common knowledge for regulators. Secondly, the project had to test all possible solutions on real MV networks with active and passive end-users so as to focus on innovative solutions. Thirdly, the infrastructure developed in the project must use open, non-proprietary communication protocols so as to allow for the integration of all potential users. The selection process was based on some technical scores (feasibility, potential to replicate, degree of innovation, size of the area and the number of active users involved) but mostly depend on a quantitative indicator that measures the maximum amount of electricity that can be injected by distributed generators without the need for network expansion but respecting voltage and current limits both the concerned MV grid but for the electric system as a whole as well (Table 16). The final score of each proposed project is calculated as follows:

[29] Prior to 2005 producers were required to make deep payments, while consumers paid shallow connection charge.
[30] See also Kaderják (2012): Non-tariff issues of RES-E deployment – concept paper on business-regulatory models for enabling renewable energy based power producers to have improved access to networks
[31] Resolution ARG/elt 39/10

$$PI = \frac{Psmart \sum_{n=1}^{4} An}{C}$$

where

PI: key Performance Indicator
Psmart: maximum increase of DG power under safe conditions (voltage, current, frequency) due to the smart grid investment
A: 4 technical scores
C: cost of the project.

"Psmart" is calculated as the difference between the capacity that can be integrated into the grid before and after the investment:

$$P_{smart} = \frac{EI_{post} - EI_{pre}}{8760}$$

where

El-post: DG-produced electricity that can be injected in the network after the project under safe conditions [GWh]
El-pre: DG-produced electricity that can be injected in the network before the project without reverse flow [GWh]

A1	SIZE	b1	N. generation plants/storage	6
		b2	Increase of electricity production injected into the grid	12
		b3	Increase of ratio "electricity production / electricity consumption"	8
		b4	N. primary substations involved in the project	4
			Max A1	**30**
A2	INNOVATION	b5	Participation of disperse generation to voltage regulation	6
		b6	Presence of control system (SCADA)	6
		b7	Bidirectional communication and demand response	6
		b8	Presence of storage systems and active power modulation	12
		b9	Partecipation of DSO to ancillary service market	10
			Max A2	**40**
A3	FEASIBILITY	b10	Project scheulde	4
		b11	Quality improvements	6
			Max A3	**10**
A4	REPLICABILITY	b12	% of costs on not regulated subjects (DG and storage)	2
		b13	Standard protocols	8
		b14	Consistency between investment costs and objectives / excepted benefits of the project	10
			Max A1	**20**
			Max Project	**100**

Table 16: The technical scores related to smart grid projects in Italy
Source: Lo Sciavo, presentation, 2013

The outcome of the first round of project selection shows that the ranking is based on all three elements (subsequent DG increase, qualitative benefits, and cost). Projects 4 and 6 are expensive but allow for a high DG capacity and have substantial additional benefits reflected in the technical score.

Position rank	Distribution company rimary Substation (PS)	Psmart [MW]	Project Benefit (A_j)	Cost [k€]	Priority Index
1	P1. A2A PS Lambrate	53.171	65	733	4715
2	P2. ASM Terni PS Terni	16.176	68	800	1375
3	P3. A2A PS Gavardo	7701	65	755	663
4	P4. ACEA D. PS Roma Malagrotta	44.934	73	4.970	660
5	P5. ASSM Tolentino PS Tolentino	6211	66	689	595
6	P6. ENEL D. PS Carpinone (IS)	36.996	96	6.242	569
7	P7. DEVAL PS Villeneuve	12.951	68	1.616	545
8	P8. A.S.SE.M. PS Severino	3.661	64	642	365

Table 17: The project selected for incentive payment by the Italian regulator

Source: Lo Sciavo, 2013

In 2011 the Italian regulator launched a consultation for a new, output-based incentive regime for smart grids whereby the DSO remuneration would be in part dependent on the two indicators already discussed (RPT and Psmart), plus the extent of RES-E curtailment.[32]

In sum, the key characteristic of the Italian regulation is that it motivates DSOs to invest in network sections where the grid is already operating under strained conditions (RPF time). This is the basis for efficiently financing investments (in the form of extra WACC) from network tariffs paid y end consumers. The calculation of eligibility for incentive payments is based on project ranking that reflects the policy preferences of the regulator. It marks the beginning of a learning process from the evaluation and selection methodology to the monitoring of performance and the future dissemination of results. The planned output-based regulation will build on the experience of the current scheme.

[32] AEEG: Criteri per la definizione delle tariffe per l'erogazione dei servizi di trasmissione, distribuzione e misura dell'energia elettrica per il periodo 2012 -2015 (DCO 45 / 11)

8 CONCLUSIONS

The aim of the current paper was to provide an overview on the current situation in the Danube Region countries regarding smart grid and smart metering deployment and policies, and to identify a rationale for investment in such technologies. The main conclusion from this analysis is that the Danube Region countries differ widely in both respects. Smart grid investment in Europe is led by those countries that have a high renewable share in their electricity production: UK, Denmark, Germany, Spain and Italy. Among the Danube Region countries, Austria and Germany share this similarity.

As far as current policies are concerned, only Slovenia, Germany and Austria have put forward a relevant strategic document. A common characteristic of these documents is that they are initiated and prepared by industrial associations involved in technology deployment. Smart metering policy is often driven by EU requirements, namely the preparation of a cost-benefit analysis for the future rollout and the target of 80% rollout by 2020. Romania, Bosnia and Herzegovina, Austria, Germany and Slovakia have established a rollout target for 2020 based on their positive CBA results. The Czech Republic concluded that the current time-of-use service (night tariff for water heaters and space heating) already takes advantage of most peak shaving benefits which diminishes the value of an AMI rollout that be reassessed in 2018. An important methodological issue regarding the costs and benefits of smart meters is whether they are assessed in isolation of smart grids. The smart metering CBA in Germany concluded that smart metering is only beneficial in case of adjacent smart grid components. On the other hand, many countries excluded it from the analysis, e.g. Romania or Hungary, and still found positive CBA results.

The paper identifies several sources of demand for smart grid services and describes a number of quantitative indicators that highlight efficiencies that can be seized by smart grid deployment in the countries concerned. It is important to note that these proxies provide only a preliminary, cross-country assessment of the demands in the Danube Region. The scope and applicability should be confirmed at the individual country level before any policy is advanced. This was also a requirement of the European Commission when requesting member states to prepare their national smart grid roadmap in 2013 (a deadline that will not be met by the majority of countries). Similarly to the policy assessment, in the demand assessment we have found a rather diverse pattern across the Danube Region. Some countries possess huge efficiency potential in grid operation through network loss reduction, supply quality improvement, and commercial loss reduction (Bosnia and Herzegovina, Moldova, Montenegro and Romania). This means that the most often cited reason for smart grid deployment, coping with the increasing share of renewable and distributed generation, is an important but not an overarching driver in the Danube Region.

	CZ	RO	SI	CR	BA	MD	AT	HU	ME
RES-E		✓	✓	✓	✓		✓	✓	✓
Electric vehicles									
Energy efficiency					✓	✓			✓
Peak shaving				✓					✓
Network loss		✓			✓	✓			✓
Supply quality		✓			✓	✓			✓
Commerical loss					✓	✓		✓	✓
Retail competition	✓	✓	✓	✓			✓	✓	

Table 18: Preliminary assessment on the demand for smart grid services in the Danube Region countries

Bosnia and Herzegovina, Moldova and Montenegro have the highest energy efficiency potential. The positive impact of smart metering on retail competition is quite straightforward, but in many countries consumers do not have the option to choose among electricity suppliers. Electric vehicles are potential new actors in all of the countries, however currently it does not represent a crucial demand source. The widespread use of EVs is likely to happen in the more affluent countries and only later spread more widely across Europe.

One of the main reasons for lagging smart grid deployment is the lack of regulation, especially the inadequacy of current DSO remuneration schemes to incentivise smart grid investment. Some countries are already experimenting with regulations to address this issue. The Italian incentive scheme for smart grid investment is already well into the implementation phase and the DSOs are responding with project tendering. The extra WACC awarded for 12 years can prove to be an effective regulatory solution. Other European countries have adopted similar approaches and inserted a direct revenue drive in the price regulation scheme. Possible future cooperation among the Danube Region countries could concentrate on the regulatory aspects; the identification of good practices, their applicability, and joint development of new regulatory modes suitable for more countries in the region.

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The project is supported by the European Union.