Innovation and Energy Regulation

Including Report on ERRA Survey in 2016

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Introduction

New innovative technologies (e.g. smart metering, smart grids, smart appliances, demand response methods, distributed generation, new energy efficiency methods and electric storage) become an increasingly important topic across the world. The achieving of new energy and climate policy goals regarding reduced CO₂ emission, increased ratio of renewable sources and strong energy efficiency measures accelerate these technology changes. Regulators should be familiar with the potential challenges of deployment and the benefits of using these technologies. Supporting this innovation and assisting consumers to utilize these new possibilities regulators have to provide adequate incentives to the energy industry and to end-users. In order to enable ERRA member regulators to fully understand the possible scope of new innovations and to be able to adapt to the new situation, ERRA has decided to support its members in this field as well.

ERRA organizes - together with the Polish Energy Association (PKEE) – a Forum in Poznan, Poland: the ERRA Regulatory Innovation Day (ERID) on 12-13 May, 2016, which is focuses on the new “smart” technologies, the innovative operation modes and the necessary regulatory support for them. The Forum concentrates to the following issues:
- Creating the culture of innovations in the energy sector
- How to incentivize innovations in the energy sector?
- Acceleration of innovation and the development of the electricity networks of the future (smart grid elements and smart meters)
- Demand Side Response and system operators
- Energy storage
- Integration of e-mobility & its regulation
- New smart appliances and their system effects
- Changing expectation and behavior of customers.

Preparing for the Forum ERRA prepared a status report on the present position of ERRA members regarding innovation, regulatory support of development and implementation of new innovative technologies and solutions.

This Report is aiming to introduce the industrial tendencies, the required new smart technologies and innovative operation models together with their necessary regulatory support. The supportive legal and regulatory framework is necessary to achieve the energy and climate policy goals.

The Report introduces the ERRA internal survey-questionnaire and the evaluation results of the answers. At the end of the Report you can find some recommendation for the regulators.

1. New energy and climate policy goals and industrial tendencies, which require new innovative technologies and their regulatory support

The European Union has ambitious energy and climate policy goals regarding reduced CO₂ (Green House Gas) emission, increased ratio of renewable sources (RES) and strong energy efficiency measures;
- 2020: 20-20-20 % reduction targets (GHG, RES, Energy Efficiency) – national economy wide targets
- 2030: 40 -27-27 % (GHG, RES overall, Energy Efficiency) targets
- 2050: In the range of 85-95% CO₂ reductions in the electricity sector

The global climate framework achieved on the Paris Climate Summit could accelerate these movements World-wide.

Based on the ambitious targets and the introduced incentive schemes the renewable energy sources are spreading, and that will result strategic and behavioural change of electricity system and market participants. Especially the high ratio of intermittent renewable energy (wind and solar) created new challenges and increased the value of flexibility (both supply and demand side + storage technologies).

These climate policy targets which are closely related to energy policy accelerated the restructuring of grid based energy supply, especially for electricity and gas. Some countries made clear steps to shift the electricity supply system from a centralized to a decentralized system, and the transformation of the energy sector is taking shape. The decentralized energy supply system of the future is characterized by a two way flow of information and energy. Significant changes are also taking place on the customer side: passive energy consumers are increasingly becoming “Prosumers”, who are actively assisting to shape the energy supply system. These changes are requiring the advanced measurement and communication technologies as well as the data processing systems. Such changes apart from promises of efficiency gains, poses also some threats from the point of view of data privacy, cybersecurity, safety. Though considering potential benefits, regulators must take into account certain technological and financial risks associated to new and innovative technologies. Dealing with those technologies, in most cases they have to find ultima ratio between innovativeness and ‘traditional’ goals they protect and promote like security of supply, competition and sustainable development. Another important problem is to adjust regulatory policy so as to enable and/or promote innovative approach of regulated entities.

There are new expectations, changing behaviours and real actions at the demand side as well. Some end-user formations (like: Smart Energy Demand Coalition) offer its clients state-of-the-art services for an integrated management of their energy issues along the entire value chain. These services include energy efficiency, portfolio management and green power supply, direct marketing of power from renewable energy resources and flexible management of distributed power plants, consumers and storages technologies. The implemented new technologies enable the customers to manage and monetise flexibilities in real-time and to optimize the energy costs and their consumption comprehensively.

2. Regulator in the Innovation Ecosystem

Energy innovations are not isolated islands that exist in an autarchic self-driving environment. On the contrary, during the whole cycle, from research through research, development, demonstration and deployment (RD3), with various intensity, they are assisted by different institutions, that create innovation ecosystem. Comparing to biological ecosystem, the innovation ecosystem “models the economic rather than the energy dynamics of the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation” (D. J. Jackson¹). Such an ecosystem is created by different institutional actors (universities, business, seed funds, venture capitals, government agencies (incl. funding ones) and policymakers). Regulators may

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play also important role in this institutional setup, considering their specific place hold somewhere between core government and market forces. What has to be taken into account is that energy regulators are agencies endowed with public mission (regulation of energy markets) and their involvement is a result of two main policies towards innovation i.e. regulatory and government policy towards innovations. Ideal situation occurs when those two policies meet i.e. government pro-innovation policy corresponds with regulatory one. Within their roles and functions, energy regulators usually have certain area of discretionary power in fulfilling their task and duties that give them a space for carrying on pro-innovative policy. It might also be that the law ascribes them concrete tasks and duties to carry on such a policy. In particular, energy regulators may use following measures to carry on pro-innovative policy:

- Initializing public consultations and debates,
- Gathering and sharing information amongst various stakeholders of energy innovation ecosystem;
- Building internal capacity in terms of professional staff and/or units dealing with energy innovations;
- Promotion of various types of innovations in the energy sector (incl. starting and participation in public debates);
- Using various forms of cooperation with other actors of innovative ecosystem and promotion of such a cooperation between regulated entities and other stakeholders;
- Financial incentives like extra rewards in tariffs or incentive schemes for innovators or specific funds (e.g. British Low Carbon Network Fund);
- Creation of friendly environment and adopting non-financial measures enabling the deployment of energy innovations.

Deployment of any measure mentioned above, should be preceded by gaining internal excellence in technical and economic aspects of energy innovations and accompanied by extended dialogue with other actors of innovation ecosystem (utilities, universities, NGOs, professional organizations, government agencies etc.).

3. Incentivizing Innovators

New technologies or innovative business models can deeply affect the functioning of existing industries. Innovations can deliver important benefits to competition and consumers, in terms of new and improved services, and can stimulate innovation and price competition from established providers. This is mostly the case of companies active in competitive environment, while energy regulation relates foremost to network industries, which are natural monopolies. In the absence of competition, there is little incentive for innovation and this is why sound regulatory policy is important in the case of network companies. Incentivizing innovations by energy regulators must take into account legitimate public policy concerns (e.g. safety, privacy) while substituting competitive market as a main spur for any business to be more innovative.

Regarding different approaches to incentivizing utilities, referring to a classification made by D. Bauknecht\(^2\) we present the following regulatory approaches of innovations:

- Input-based mechanisms – which target the costs of RD&D (Research, Development & Deployment) and explicitly include them in the regulatory scheme. Such a mechanisms may be well implemented in price-based regulatory environment and may take following forms:
  
  = pass through RD&D to consumers,
  = capitalization of such costs (i.e. such costs are treated as operational)

\(^2\) D. Bauknecht, Incentive regulation and network innovations, EUI Working Papers, RSCAS 2011/02.
Output-based mechanisms – under these approach companies may only benefit from successful innovations. Examples of output based mechanisms are:

- Additional allowances rising the cap imposed by regulator,
- Extending the regulatory period
- Regulatory holidays

Both mechanisms have its advantages and disadvantages and may be deployed after careful assessment of regulatory environment and goals to be achieved.

In practice, regulators deploy various approaches to incentivize utilities, like revenue cap with rate of return, yardstick regulation, price cap based on allowed revenues or hybrid solutions. There are also examples of performance based models, clearly referring to stimulation of innovations like British RIIO.

### INCENTIVE BASED REGULATION IN GREAT BRITAIN – THE RIIO MODEL

**RIIO (Revenue=Incentives+ Innovation + Outputs),** a performance based model for setting the network companies' price controls, which aims to encourage network companies to:

- Put stakeholders at the heart of their decision-making process
- Invest efficiently to ensure continued safe and reliable services
- Innovate to reduce network costs for current and future consumers
- Play a full role in delivering a low carbon economy and wider environmental objectives.

A part of RIIO is the **Network Innovation Stimulus** which includes two annual Network Innovation Competitions one for electricity transmission companies and one for gas network companies. Through the NICs these companies compete for funding for the research, development and demonstration of new technologies, operating and commercial arrangements. Funding is provided for those innovation projects which meet our evaluation criteria – which are available on our website. The review and assessment of the projects by three independent expert panels.


Fostering innovations in terms of regulatory incentives may be a source of various benefits for DSOs, consumers, economy and regulatory system as such (e.g. optimization of network operation, improvement of power quality, decreasing operational costs, active responding to consumers' needs), though deployment of any advanced model of pro-innovative regulation must be preceded by careful studies, regulatory dialogue with stakeholders and clear identification of goals to be achieved. Deployment of any regulatory measure must also take into account all other measures and incentives available for network companies in the ecosystem of innovation.

4. **Regulation and new technologies** (introducing new technologies and their regulatory relevance)

The following sub-chapters are aiming to introduce the industrial tendencies, the foreseen (in some cases already implemented) new smart technologies and innovative operation models together with

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3 Excluding regulated entities from some part of regulatory requirements for some time-period.
their necessary regulatory support. This supportive legal and regulatory framework is necessary to achieve the energy and climate policy goals.

4.1. Distributed Energy Resources

In the last decade, technological innovations and a changing economic and regulatory environment have resulted in a renewed interest for distributed generation. Several major factors have contributed to this evolution, i.e. distributed generation technologies development, increasing difficulties for the construction of new transmission lines, increased demand for highly reliable electricity on demand side, electricity market liberalization and concerns about climate change. Distributed generation was originally a concept largely referring to small schedulable units, mainly gas fired, but the environmental policy development has been now pushing this concept to embrace a broader spectrum of generation units, including mixtures of renewables and thermal generation combined in different percentages and been connected to the grid to lower voltage levels.

Regulation has to cope with many advantages which distributed generation can bring to the power system and its economic efficiency. Distributed generation technologies in many cases provide this flexibility due to their small sizes and the short construction lead times compared to most types of larger central power plants. Smaller generation units have the potential of supporting an increase of power system flexibility in several ways: operation, geographical volume spread and expandability. These resources provide a significant contribution as well to system reliability, providing a hedge from technical and economic point of view against the incentives for cost-effectiveness that come from the introduction of competition in generation. Distributed generation could serve as a substitute for investments in transmission and distribution capacity (demand for distributed generation from T&D companies) or as a bypass for transmission and distribution costs (demand for distributed generation from electricity customers). Furthermore, well-chosen distributed generation locations (i.e. close to the load) can also contribute to reduced grid losses. Finally, distributed generation can also contribute in the provision of ancillary services. These include services necessary to maintain a sustained and stable operation of the grid. So far, too many regulatory schemes have been neglecting the relevance of integrating renewable support schemes with additional premiums for their grid operability. This has allowed much of the renewable capacity to be able to access the grid outside of the TSO control, thus causing a tumultuous growth of congestion and re-dispatch costs, of the outweighing the advantage of large volumes of cheap RES energy.

At present, environmental policies or concerns are the major driving force for the demand for distributed generation in Europe. Environmental regulations force players in the electricity market to look for cleaner energy- and cost-efficient solutions. Here, distributed generation can also play a role, as it allows optimizing the energy consumption of firms that have a large demand for both heat and electricity. More recently, this has also been the case of US, under the spin given by the American Recovery and Reinvestment Act of 2009, while before distributed generation has been seen as a major source of hedging against price volatility and system reliability and security.

However, many countries have been recently experiencing how distributed generation could also have some costs, both economic and environmental, especially if distributed generation (incl. wind and solar) is not supported by incentives foreseeing opportune phase-in and phase-out periods. In the end, the size and the mix of the installed distributed generation capacity will depend on the relative size of the costs and benefits of each technology. The key remaining challenge is then to design a regulatory framework that fully reflects these costs and benefits to the economy and to the environment. The extent to which distributed generation is integrated efficiently in the electricity market relies on the market structure, market operation and related incentives to TSO and DSO to integrate distributed generation capacity and on pricing of energy and capacity.

Concerning the environmental dimension of an increased use of distributed generation, regulation must be in condition to acknowledge that the benefits crucially depend on the market share of the different distributed generation technologies and on the mix of central generation that is replaced.
4.2 Demand Side Response

EU targets for renewable energy and decarbonization will continue to deliver increased generation from renewable energy sources. The traditional means of balancing the system, in which generation is scheduled to match forecast demand, is becoming more expensive. A decarbonized electricity system will include a considerable quantity of installed capacity that is less readily dispatchable than the present fleet, whether due to technical constraints (such as variable or intermittent renewable generation) or commercial attributes (due to low or zero marginal costs, perhaps exacerbated by output-based support mechanisms). As the resource mix across Europe shifts, the responsiveness of the residual fraction of the market will take on greater importance for ensuring security of supply. Under pressure of profit squeeze, retiring thermal capacity reduces generation adequacy, as well as reserve and other ancillary service capabilities required for secure system operation (many of which will not easily be provided by the replacement low carbon technologies). There will continue to be a requirement to maintain adequate available capacity (MW of reliable supply or reliable demand reduction capable of operating during a given period of time and with appropriate response times). This is being addressed in many markets through the introduction of capacity mechanisms or strategic reserve arrangements to deliver capacity, while an easy-to-reach alternative delivering comparable results could emerge from incentives for a more proactive participation of the demand.

Looking further into the future, the level of available low-carbon capacity will create a greater need for a range of capacity with flexibility and reserve capabilities within this residual fraction of system resources. This may change the system security focus away from capacity adequacy towards ‘capability’, which relates to the ability to deliver capacity according to the needs of the system at the time. The extension to a more active and dynamic demand participation is becoming a more and more attractive option to provide flexibility to the TSOs and help ensure system security across Europe. The resurgence of capacity mechanisms do not only focus on generation but also put a strong focus on demand as in the French capacity obligation mechanism where it is expected to play a significant role.

It will be essential that the value of different types of services is correctly recognized in future electricity markets, as well as the different roles and responsibilities of each provider to ensure an efficient development.

The economics of a system with high penetration of variable renewables – notably wind and solar, which have high energy output but low contribution to system peaks – are fundamentally different to the systems from a decade ago. As a result of the changes, it is – arguably – becoming uneconomic to serve all demand peaks with firm generation, and demand side solutions are required.

Apart from peak demand conditions, renewable generation places new needs for system services, including rapid response (upward or downward), ramping capability, etc. in response to forecast error and changes in solar or wind. The demand side has potential to provide many of these services in competition with conventional (and renewable) generation. This presents a challenge – demand inclusion may not be in the short term commercial interests of retail companies which also have generation interests.

Ultimately, the effective inclusion of the demand side is essential to the efficient operation of electricity markets. Demand side inclusion can help to improve market operation, improve competition, and limit the exercise of market power. There are many examples of TSOs successfully incorporating demand response to lower the costs of ancillary services and to contribute to organized capacity markets or mechanisms.

4.3 E-mobility and H-mobility

Electro mobility is alternative transport technology with reduced environmental effects - in terms of noise, air quality and greenhouse gas emission (if the electricity is generated from renewable sources). It can be applied to different transport modes such as buses, light vehicles, passenger cars and e-bikes. There are estimations that by 2040 global sales of electric vehicles (EV) would be 41
million, compared with 462,000 in 2015. In 2040 there are expectations that EVs will displace consumption of 13 million barrels of oil per day (15% of global production) and using 1900 TWh of electricity in the year, equivalent to nearly 8% of global electricity demand in 2015. The large-scale integration of these EVs into electric grids brings unique challenges but also opportunities. If gathered and unmanaged, EV charging could increase stress on already strained power system and raise the risk of grid failures. EV can make it difficult to accurately forecast grid loads and ensure proper assignment of charging costs. However large-scale EV integration brings innovative possibilities such as: i) serving as distributed storage resources (for example compensating fluctuations caused by the intermittent renewable supplies); ii) assisting demand management (EVs will be able to utilize power at off-peak times, it will mean that a significantly greater proportion of electricity can be generated by base-load plant and hence at lower average cost); iii) when integrated with other energy resources (CHP, PV, wind), an integral part of resilient microgrid systems (some battery technologies allow short-duration high-current opportunity charging/discharging).

These challenges and opportunities require smart technologies - known as vehicle to grid (V2G) - to optimally match the power demand for charging and will enable EV owners when not actually charging batteries to sell electricity back to the grid when needed. However considerable infrastructure and IT development is needed to bring this into result. While a number of firms and others have begun to investigate these possibilities, the regulatory incentives and policy supports to encourage large-scale EV participation in power systems are not yet in place.

Another possibility to move forward to a more sustainable transportation is H-mobility. In this case the vehicle use compressed hydrogen gas as fuel to generate electric power with fuel cells which can transform hydrogen directly into electricity. Hydrogen is widely available, can be produced and stored easily. Hence the system requirements for this technology are similar to EV. The main benefit of this transportation is that it produces zero harmful tail pipe emissions with water is the only product of the process.

A coalition of European partners has launched a project named Hydrogen Mobility Europe (H2ME) to deploy a total of 325 fuel cell electric vehicles and 29 new refueling stations. This project rolled out by ambitious initiatives, and the results could be an important part for further commercialization.

### 4.4 Energy storage

The electric power sector in the EU is the largest producer of greenhouse gas emissions - 23% of the EU total. Analyses have shown that in order to achieve the targeted overall 80% greenhouse gas reduction by 2050 in the EU, a nearly complete decarbonisation of electric power production will be required. In the decarbonisation scenarios the share of renewables in electricity generation ranges up to 85%. A majority of these renewable production goals will be covered by solar PV as well as wind, whose intermittent production unfortunately is matter to seasonal, hourly and minute weather variability. Maintaining the electricity system operation security more flexibility is required. Thus the EU recognises energy storage as an important component in its transition to a decarbonised power sector. However energy storage is useful almost in every section of electrical power systems: i) improving power system efficiency; ii) rising self-consumption and self-production of energy; iii) increasing energy access via off-grid electrification; iv) growing emphasis on electricity grid stability, reliability and resilience.

Storage systems include a number of technologies in various stages of development. Generally speaking, PSH, CAES, and some battery technologies are the most mature, while flow batteries, SMES, ultracapacitors and other battery technologies are currently at much earlier stages of development. Based on the types of services, energy storage systems can be grouped into three main time categories. The abbreviation and the maturity of different storage technologies are shown in Figure 1. [IEC]

Figure 1.: Maturity of energy storage technologies

**Short-term (seconds-minutes)**- Ultracapacitors and SMES technologies use static electric or magnetic fields to directly store electricity. Flywheels store and then release electricity from the grid by spinning and then applying torque to its rotor to slow rotation. These technologies generally have high cycle lives and power densities, but much lower energy densities. This makes them best suited for supplying short bursts of electricity into the power system. Modern technologies struggle in today’s energy markets due to high costs relative to their market value.

**Distributed battery storage**- Batteries use chemical reactions (e.g. lithium-based (lithium-ion, lithium-polymer, lithium-air, and lithium-ceramic), NaS, and lead-acid batteries). This storage technology can be used for both short- and long-term applications and benefits from being scalable. Furthermore, it can be installed throughout the energy system and has already achieved limited deployment in power systems for applications at varying scales. Widespread deployment is hampered by challenges in energy and power density, lifetime as well as costs.

**Long-term (hours-seasons) storage applications**- PSH and CAES are currently the most mature methods for long-term electricity storage. These technologies face high investment costs due to typically large project sizes and low projected efficiencies (for non-adiabatic CAES design proposals). In the case of pumped hydro and CAES, geographic requirements can lead to higher capital costs. Hydrogen storage also can be used for long-term energy applications. Electricity is converted into hydrogen, stored, and then re-converted into the desired end-use form (e.g. electricity, heat, synthetic natural gas, pure hydrogen or liquid fuel). These storage technologies have significant potential due to their high energy density and potential for use in large-scale energy storage applications. However struggle with high upfront costs, low overall efficiencies as well as a lack of existing infrastructure for large-scale applications (e.g. hydrogen storage for fuel-cell vehicles). The Figure 2 shows the system application and general module size of different storage technologies.
There are many cases where energy storage deployment is competitive or near-competitive in today’s power system. However at present, most European countries do not have regulatory acknowledgements of storage as a component of the power system, storage is treated as a combination of power consumption and generation and has to conform to relevant rules for both operating modes - national legislation only addresses part of the whole topic. Because of this, energy storage solutions could not be competitive enough in the market today in most of the countries.

There are some promising tendencies in Europe treating storage technologies differently. The current regulation in Germany and the UK enables participation of storage technologies in frequency reserve markets via combined offerings (“pooling”) with other providers. The use of storage technologies for Transmission & Distribution deferral is currently possible in Italy and the UK. The UK enables small generating facilities, including energy storage, to obtain exemption from the obligation to hold a generation licence on a case-by-case basis, which enables TSOs and DSOs to deploy smaller-scale energy storage for T&D deferral. National legislation in Italy also allows TSOs and DSOs to build and operate storage if it is proven to be the most efficient way to address T&D problem.

Worldwide, California has created the Energy Storage Law. This law requires utilities to procure storage technologies equal to 2.25% of peak load by 2015 and 5% by 2020, additionally California’s largest utilities need to invest in and deploy 1,3 GW of energy storage by 2020 into the transmission, distribution and consumption.

4.5 Smart grids and smart metering

Everything is getting ‘smart’ around us nowadays and the electric power grid could not be the exception. The meaning of smart grid is to utilize the wide range of opportunities provided by the digital technology such as multi-way communication between system operators and customers, real-time remote measurement and control with more advanced applications. A key feature of this
automation technology is that it lets the operators to adjust and control each device (or group of devices) from a central location. Visualization and use of extremely high amount of data is associated with smart grids. Sustainability is the key factor planning and operation methods, and the advancement in technology offers useful tools in the energy sector. There are countless opportunities to achieve more efficient transmission/distribution and use of energy. New controlling mechanisms improve the stability and the restoration parameters of the grid; therefore the security of supply improves. Investments in smart grid related development will reduce the operation and maintenance costs of the network. These systems also facilitate the integration of renewable energy systems which are projected to spread even more in the near future. The concept of smart grid includes a more decentralized structure. The utilization of the generation and the network infrastructure is a common problem worldwide, and peak shaving operations would be much easier with more precise controlling and data managements.

The smart grid of the future will consist so much important parts such as controlling actors, computers, newly designed power system elements (lines, cables, switchers etc.). It will take some time for all the technologies to operate perfectly and the system to become fully reliable with online services. However, when this transformation ends, the smart grid will likely be an upgrade for the energy sector as much as the internet was for the information and communication sector.

With smart grids, the traditional passive distribution is going to be replaced by active distribution that will transform customers into an active player. In this new perspective, it is important to understand and involve them in order for them to fully understand the smart grid potential and consciously assume their role as active participants in the future electricity system. Because of that, one of the most important parts of the smart grid concept is smart metering. The bidirectional power flows (self generation) and the willingness of consumers to change their behaviour to reduce their electricity bills need more advanced meters than the already deployed ones. Smart metering is the communication system (hardware, software and associated systems) that creates a network between advanced meters and business systems. This allows collection and distribution of information to customers and other parties such as system operators or retail providers. The deployment of smart metering could reduce the operational and maintenance cost and losses, defer generating capacity and network development investments. Cost savings are also achievable through new tariff schemes (e.g. real-time pricing) with market approach.

Regulation plays a major role in a smart metering roll-out. The regulatory authorities are one of the obvious parties to take up responsibility for the economic assessment and for devising a roll-out strategy, thus ensuring overall efficiency. The regulation of smart metering investment and operation needs to be carefully adjusted to the roll-out plans to mitigate potential barriers to these systems and create sufficient incentives for market parties to invest and use it.

4.6 Home Area Network and the Internet of Things

Arrangement that allows people to manage intentionally home energy resources and to improve their behaviour in order to reduce energy consumption is the Home Area Network (HAN) and the Internet of Things (IoT) – HAN&IoT. This concept, has gained importance due to four factors: i) the fast progress and miniaturization in semiconductor technology; ii) the growth of microcontrollers unit processing power; iii) the integration of advanced signal conditioning in small sensor nodes; iv) the rapid development and progress of wireless technologies. The HAN&IoT concept is based on the interaction between services and features. Since the residence is equipped with technology that observes the inhabitants, HAN&IoT provides proactive services that can deliver: i) energy management; ii) healthcare; iii) entertainment; and iv) security.

**Energy management.** Households use one of the major parts of the world’s energy and more than half of the energy consumption in homes comes from electricity. The central task of energy management is to reduce costs for the provision of energy in households and residential building facilities without compromising the user’s comfort. The functions of the home energy management
are: controlling activation/deactivation of home appliances, collecting real-time energy consumption from smart meter and power consumption data from various household appliances, generating and monitoring a dashboard to provide feedback about power usage, providing control menus to control appliances and providing a universal link to the broadband Internet. The home energy management system allows the elements to work together, with the intention of reaching a common goal: the energy saving of a house. A few key features that apply to energy saving driven homes are: i) smart devices, which are able to offer the opportunity to monitor and to remotely control key features within homes; ii) decision-support tools designed to assist users in making smart decisions. It becomes then necessary that at the same time with the energy management challenge, a proper communication protocol between smart devices would regularly improve the system performance.

**Healthcare.** Advanced technology in homes will lead to various opportunities in the near future - one of the most important is the monitoring of a person’s health, as a consequence of an aging population. Healthcare technologies contain simple devices (blood glucometers and blood pressure monitors, etc.) which deliver outputs for specific physiological conditions, smart applications or software able to analyse and process body signals, sensor integrated smart devices (gaming devices, smartphones and pads), wearable sensors (e.g., wrist straps, T-Shirts) and additional devices entirely manufactured for the purpose of body signal monitoring/processing. Whether at home or work, healthcare IT infrastructures transfer sensitive patient health information and, as such, this issue faces several constraints and information security threats.

**Entertainment.** Media consumption within the home has been growing over the years and new forms of domestic entertainment are very popular, forever changing how we act and relate. Such a category shows the enormous development potential.

**Security.** Real-time multimedia applications like monitoring or surveillance using multiple cameras have recently begun to be proliferated over flexible and low-cost multi-hop wireless networks. In these types of multimedia systems, several sources share the limited network resources and together transmit the captured video streams to a remote central monitor. There are also security systems using both face recognition and sound localization techniques to identify foreign faces through a door phone – if equipped with gateway, the real-time monitoring and control could be achieved through a smart phone.

5. **ERRA regulators and innovation – results of ERRA internal survey**

The following two sub-chapters introduce the aim, the scope and the method of the ERRA internal survey together with the evaluation of the answers.

5.1. **Introduction of the questionnaire and survey method**

Preparing for the ERRA Regulatory Innovation Day (ERID on 12-13 May, 2016 in Poznan, Poland) ERRA aimed to make a status report on the present position of ERRA members regarding innovation, regulatory support of development and implementation of new innovative technologies and solutions.

The prepared survey-questionnaire collected information from ERRA members on the following issues:

- general regulatory approach to innovations,
- implementation of storage technologies supporting system flexibility (solving system imbalances), and the regulatory support of these technologies,
- introduction of incentives supporting Demand Side Response (involving end-users’ contribution to keep the system balanced),
- deployment of smart grid and smart metering system elements and their regulatory support,
- different aspects of e-mobility,
- volume of distributed generation/energy “prosumers” and their regulatory relevance,
changing consumer expectations and behaviour,
future preferences of ERRA members regarding the role and specificities of different innovative technologies and related regulatory measures.

The on-line electronic survey-questionnaire was simple with limited number of mainly multiple-choice questions with the possibility to add explanatory notes describing the national situation.

14 ERRA members participated in the survey: Armenia, Bosnia and Herzegovina, Estonia, Georgia, Hungary, Kyrgyz Republic, Latvia, Macedonia, Mongolia, Pakistan, Poland, Serbia, Turkey, Ukraine, representing the 43% of all ERRA Member countries. The energy markets of these countries are at a different stage of development and their regulatory systems represent a wide range of support regime for smart technologies and new innovative operation modes. Some of the survey participants regulate their energy markets under the common, binding EU regulation, while some others have special and unique market structure and regulatory system with different priorities.

The following subchapter is summarizing the evaluation of the survey results.

5.2. Evaluation of ERRA Survey on Regulators and Innovation

5.2.1. General approach of the Regulator to innovations

ERRA would like to thank all these members for their contribution to the success of the survey!
There are different methods, how the regulatory authorities follow the energy industry trends. In most of the cases (53%) the regulatory staff periodically consults with representatives of the energy industry to be familiar with new technologies and operations, 27% of them consults with academic or research institutions following the tendencies, while 20% has dedicated departments or sections, which are responsible for researching the literature and following the new innovative technologies and operation methods (See Figure 3).

Following the industry trends and the related regulatory challenges, some additional methods were also mentioned, such as: ordering and reading different related periodicals, regularly attending related conferences, organizing and attending stakeholder meetings with energy policy and industry representatives and internet research. In most cases information gathering is part of the daily work of the regulatory staff. The Kyrgyz regulator has formal agreement with academic and/or research institutions following the tendencies and supporting innovation in the energy supply chain.

Half of the regulatory authorities do activities aiming to support innovation and/or implement new technologies into any element of the supply chain. These active regulators have already started to develop support mechanisms promoting innovation, pilot projects and/or the implementation of new technologies.

Regulatory “participation” in pilot projects (e.g: smart metering) doesn’t necessarily mean the introduction of any specific support mechanism related to these pilot projects. The Serbian regulator mentioned that they provide opinion on the implementation plan of economically justifiable forms of advanced metering systems adopted by the TSO or DSO. The Turkish regulator reported that there are some pilot projects introduced and they are at the early stage of its implementation.

5.2.2. Storage - as a technology supporting system flexibility, solving imbalances of the electricity system

More than half of the regulators reported that the electricity transmission or the distribution system is affected by serious imbalances requiring more flexibility. In those systems in which the imbalances are serious, the system operators implemented different solutions.
In nearly half of the cases the imbalances are solved by flexible (load follow and peaking) generation units. In the other half of the cases the TSO or the DSO uses the demand side to solve the imbalances. In Turkey the TSO has already reported to the regulators that they are planning to use storage technology and demand side management approach in the future. See the ratio of these solutions on the Figure 4!

Figure 4.

Regarding the status of the implementation of storage technologies and the related regulatory measures, in five countries there is already an installed storage capacity (pumped storage hydro, electric accumulators, mechanical equipment, etc.) for operation purpose, while in two cases there are already installed Pilot Projects with storage capacity in the electricity system. The Mongolian and the Pakistani regulators reported that there are regulatory measures in place supporting the different storage technologies.

In Turkey the draft regulatory measures have already been prepared, while in Hungary there was an initiative by the TSO (battery storage pilot project) approved by the regulator, but it has not been realized yet. In Estonia some projects are at research level (for example one hydro accumulation power plant) without any supportive legal/regulatory framework.

5.2.3. Demand Side Response

Out of the 14 respondents in four countries (Estonia, Latvia, Pakistan and Poland) the electricity TSO, DSO or the retail supplier have already introduced some incentives supporting end-users to behave in a way, which contributes to keeping the system balanced - called Demand Side Response [DSR] program. All the four introduced cases are focusing on load shifting (shifting the demand from “on peak” hours to “off peak” hours). In Latvia and Serbia the day and night distribution tariffs are different, giving the right incentive for load shifting (in the Serbian case the TSO tariff has the same type of differentiation).

According to the Estonian regulator; “the Estonian TSO has completed a survey on electricity consumption (demand side) management, according to which consumption management helps to decrease investments in production and in the electricity network. In the short term, consumption management can primarily be implemented on the level of distribution networks as an alternative to modernizing substations. Consumption management is the network operators’ tool in controlling network restrictions/congestions. Consumption management helps consumers to make better decisions through price information, and this creates additional opportunities for market participants for business activities. Therefore, every electricity market participant benefits from consumption management. According to the survey, a large part of the potential of consumption management seems to be in the distribution network. Therefore, cooperation between transmission and distribution network operators is very important and there is a necessity to consider creating a
respective communication framework for them. In Estonia, there is significant potential for consumption management in business and household sectors, and as a result, so-called aggregators play an important role in the wider spread of consumption management. To realize the potential of consumption management, regulation and market organizations need to be developed further.”

5.2.4. Smart grids (smart meters)

64% of responses mentioned that there are some concept papers prepared, specifying the role, the scope and the proposed implementation schedule of the elements of smart grids (in TSO and DSO system). The same regulators reported that there is a prepared action plan - on TSO or DSO level - scheduling the implementation of different smart grid elements. The main focus is on smart metering and there is less attention dedicated to the other elements of smart grid.

More than half of the regulators informed ERRA that the DSOs have already implemented or scheduled to implement a Pilot Project for the deployment of smart metering among small and household customers.

In Poland approx. 1 million household customers are involved in the 4 year-long smart metering pilot project between 2014 and 2018. There is a common specification of business agreements, as a binding legal requirement on the conditions of the Pilot Project. There is no special tariff for those customers, who participate in the Pilot Project.

In Hungary 18.000 household customers participated in the 2 year-long smart metering pilot project. The universal service providers (USPs) offered special smart tariffs for all project participants during the project. The USPs and DSOs evaluated the different technical aspects and multi-utility solutions utilized in the pilot projects. In 2016 the Hungarian Parliament introduced a special section to the electricity act, which regulates the conditions and responsibilities of involved players in further smart metering pilot projects.

In Bosnia and Herzegovina approx. 10-15% of households have smart metering equipment. There are countries with scheduled small scale pilot project plans (less than 1000 households). Some of those ERRA member countries, which did not participate in this survey, have results with smart metering pilot projects (e.g. Romania).

Nearly half of the regulators (46%) informed ERRA, that the DSOs have already prepared Cost Benefit Analysis (CBA) regarding the deployment of smart metering among small and household customers. In three cases the outcome of the CBA was reported to the National Regulatory Authority (NRA) and showed positive results (the calculated aggregated cost of implementation and operation of smart meters is lower than the expected benefits).

In two Baltic cases (Latvia and Estonia) the CBA result was positive for up to 100% of deployment of smart meters so DSOs are gradually heading towards this target; thus it was decided to replace all the conventional meters with smart meters. In Mongolia the result of the CBA was positive in one customer segment, namely customers with relatively high demand in “on peak” hours, but the outcome of the CBA was not robust and convincing enough for regulatory position taking. In Serbia the CBA is prepared for the purpose of World Bank loan request. In Hungary the CBA result was negative.

In two countries (Estonia and Turkey) there is existing regulation in the electricity sector supporting the deployment of smart metering. In Estonia the binding Grid Code states that all standard electricity meters must be replaced by remotely reading meters by the end of 2016. According to the
Turkish answer there is a special ex ante price component covering the justified cost related to the deployment of smart metering.

5.2.5. E-mobility

The regulatory authorities are interested in different aspects of e-mobility (electrical cars).

Seven regulators marked their interest in the issue of allocating the related responsibilities (construction and operation of charging system, data management, scheduling of charging/discharging cycle of car batteries for system operation purposes, billing) among potential players (DSO, TSO, supplier, free market player). Five of the NRAs mentioned their interest in the necessary legal/regulatory framework supporting the deployment of electric cars, while four of them are interested in special tariff elements of the e-mobility system. (See the Figure 5!)

In Estonia the Regulatory Authority does not regulate e-mobility. CO2-quota sales income funded the purchase subsidy of electric cars (this purchase subsidy project has already ended).

There is some information regarding the implementation schedule of electrical car charging stations (systems) in ERRA member countries.

Among the responses the Estonian regulator reported the highest number of charging stations in operation at the end of 2015. They put already 176 stations into operation, covering all the main roads with high traffic density. The distance between charging stations is 40-60 km in Estonia. In Ukraine there are approx. 100 stations, while in Hungary and in Mongolia this number is approximately 50. In Poland there are a few charging stations in operation, while in Macedonia there are 2 of them.

In Hungary the association of e-mobility cluster ("Jedlik Ányos Terv") sets a target number for the year 2020: 3000 charging stations in the country.

Today none of the respondents reported on the existence of legal/regulatory framework, which is allocating the e-mobility related responsibilities (construction and operation of charging system, data management, scheduling of charging/discharging cycle of car batteries for system operation purposes, billing) among potential players (DSO, TSO, supplier, free market player).

Estonia has already implemented special tariff elements for the e-mobility system.
5.2.6. Distributed generation/Energy “prosumers”

Nearly all of the countries (86%) have “distributed generation” capacity, which generation units are connected to the medium and/or low Voltage distribution system.

At the end of 2015 in 3 cases the aggregated capacity in all types of distributed generation was less than 1% of the total installed generation capacity of the country, between 1 and 5% in 7 country cases and between 5 and 10% in 2 countries (See the Figure 6).

The small/micro, households-scale renewable generators (mostly roof-top solar) represent substantial ratio of the distributed generation in those countries, where the climate and energy policy measures are supporting these types of renewable producers, which are in most cases “prosumers” (customers with own electricity production selling the surplus to the electricity system). The customers in these countries are ready to invest their own money into self generation. They are motivated mostly by the following circumstances:

- existence of legal/regulatory framework supporting renewable self generation (easy connection rules, simple net metering and billing system, attractive commodity price of surplus energy selling to the electricity system),
- awareness of environmental protection,
- security of supply aspects (less dependence on foreign gas supply).
In the survey ERRA collected specific data on the aggregated capacity of the small/micro generation facilities (for household purposes). These figures are relatively small in most of the ERRA countries, what shows small ratio of household-sized renewable generation units connected to the distribution network: in 2 countries between 1 and 3%, while in 7 countries less than 1% (See the Figure 7).

![Figure 7.](image)

In more than half of the countries there is special legal/regulatory framework in place regulating the network connection, metering and billing of the small/micro generation facilities (for household purposes). 42% of those countries which have distributed generation there is special legal/regulatory framework in place regulating the network tariff and the commodity (kWh) prices of surplus energy sold to the electricity system (generated by the “prosumers”).

In Bosnia and Herzegovina the regulator mentioned that they do not have any special legal/regulatory framework handling (supporting) “prosumers”. They treat the “prosumers” like other producers connected to the distribution network.

5.2.7. Changing consumer expectations/behaviour

The consumer expectation and satisfaction is measured (by the suppliers and/or DSOs and/or regulators) in 43% of the countries filling in this survey. Half of those regulators for whom the results of the consumer expectation and satisfaction measurement is available, could detect changes in the expectation/behaviour of consumers.

The changing interest (higher expectation) of the customers in better supply quality (continuity of supply, commercial supply quality, Voltage quality) was detected in 9 countries! In the following two issues the customers showed high interest in 6 cases:
- better information related to their own consumption (consumption profile, bill structure, metered consumption related billing, etc.),
- energy saving or bill reduction.

In two cases (Estonia and Ukraine) end-users were interested in sustainable (“green”) energy supply possibilities. (See the consumer interest on Figure 8!)
Among those regulators, where changes in the expectation/behaviour of consumers has been detected, in five country cases (Estonia, Kyrgyz Rep., Latvia, Mongolia and Poland) the Regulator and/or the Government and/or the energy companies launched information campaign(s) “educating” customers how to behave as a “smart customer” (consumer empowerment). In Estonia, Georgia and Mongolia the regulators realized that the suppliers/traders are interested in better serving their customers; adapting the supply-offer to the customers’ needs.

5.2.8. Future Preferences

ERRA wanted to inquire about the future preferences of the members in order to be able to better plan its future educational programs and work-plans. Respondents were asked, whether they are interested in the role and specificities of the different new (innovative) technologies and related regulatory measures. The Figure 9. shows the average preference of the 14 ERRA members participating in the survey.
6. Recommendations

The deployment of introduced new smart technologies and operation modes require new, innovative regulatory framework, which is adjusted to the new formulating industry model, assisting the achievement of new policy goals and supporting the fulfilment of changing customer expectation.

The results of the ERRA internal survey shows, there are possibilities for regulatory development in the field of supporting innovation, deployment of new, smart technologies for the benefit of consumers and for the operation safety of the energy systems.

The regulators should discover the possibilities adjusting the existing price-regulation systems and other type of incentives to support resolving different challenges, like:

- consulting with researchers, academic institutions, energy industry experts and customer representatives on the available new technologies, innovative methods, behaviour-changes and the related regulatory challenges,
- building internal capacity of regulatory staff in the area of new and innovative technologies,
- supporting smart grid development (without accusing too much burden on end-users),
- supporting smart meter deployment; empowering consumers and addressing data privacy and cybersecurity concerns,
- preparing special support (and network tariff) system for the different storage technologies allowing these technologies to compete on the ancillary service markets assisting system operators and customers to keep the balance,
developing (or just implementing) such regulatory incentives of the network operators, which give them impetus to support the end-user in energy efficiency measures (e.g. decoupled rates) and in different demand side response activities,
- adjusting the regulation to the special requirements of e-mobility deployment,
- setting requirements and providing incentives for DSOs smoothly connecting the distributed generators,
- creating such pricing regimes, which support the “prosumers” managing the surplus of their self generated power,
- continuously measuring the expectation and satisfaction of customers and adjusting the relevant regulation accordingly.

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