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DIFFUSION OF SMART METERS IN CENTRAL EAST EUROPE

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ABSTRACT

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The present study deals with innovation diffusion as the central component of innovation process and takes smart meters as a concrete example from the electric power industry. Smart meters are seen as key enablers of the industry-wide shift towards smart grids and are recognized by the European Union as means of reaching its environmental and energy goals. However, the spread of smart meters through the market, especially in Central East Europe (CEE), is not corresponding to the expectations and identified benefits. The current work synthesizes available data for the under-researched geographical region of CEE and clarifies the process of smart meter diffusion and drivers behind it. In addition to innovation theories the methods applied are rate of adoption and thematic analysis. The results prove the large gap between optimal and actual diffusion as well as the lagging position of CEE in comparison to the EU's market leaders. The smart metering market is driven from bottom-up and the majority of CEE countries have already carried out or started the initial activities. Therefore, in coming years more intensive smart meters deployment will be seen.

АННОТАЦИЯ

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Исследование имеет дело с распространением инновации как центрального компонента в процессе инноваций и берет смарт метры как конкретный пример из области электроэнергетики. Смарт метры рассматриваются как ключевые помощники всеотраслевого изменения по направлению к концепции смарт грид и признаются Европейским Союзом как способы достижения экологических и энергетических целей. Однако, распространение смарт метров через рынок, особенно в Центральной Восточной Европе не соответствует ожидаемым результатам и установленной выгоде. Данная работа синтезирует доступные данные исследуемого географического региона Центральной Восточной Европы и осветляет процесс распространения смарт метров и мотивационных факторов следующих за ними. В дополнение к теории инновации, применяемыми методами являются скоростьп рименение и тематический анализ. Полученные результаты доказывают значительный пробел между оптимальным и действительным распространением, а так отстающую позицию Центральной Восточной Европы по сравнению с лидерами рынка Европейского Союза. Рынок смарт метров управляется снизу-вверх, и большинство стран Центральной Восточной Европы уже осуществляют или начинают осуществлять инициативную деятельность. в следствии этого в ближайшие годы станет возможным более интенсивное применение технологии смарт метров.

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AMI	Advanced Metering Infrastructure
AMM	Automated Meter Management
AMR	Automated Meter Reading
CEE	Central East Europe
DR	Demand Response
DSO	Distribution System Operator
EP	The European Parliament
ERGEG	European Regulators' Group for Electricity and Gas
ERO	Energy Regulatory Office
EU	The European Union
MDM	Meter Data Management
SG	Smart Grid
SM	Smart Meter
TOU	Time-of-Use
TSO	Transmission System Operator

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"Our society is changing more broadly and more rapidly than at any time since Edison's day. The current power infrastructure is as incompatible with the future as horse trails were to automobiles." Kurt E. Yeager, 2001

1 INTRODUCTION

Electric power system is an omnipresent technology facilitating society's growth, well-being and advancement. Electricity is a transformed source of energy powering not only physical appliances, machines and processes but also industry and economy as such. The importance of electricity is ever increasing with constant growth in demand and shifting trends, such as having plugged in over 1 billion computers or commercializing electric vehicles (Fox-Penner, 2010). The grid which enables electricity to be transmitted and distributed has been named by the National Academy of Engineers the world's largest machine and part of the greatest engineering achievement of the 20th century (Constable & Somerville, 2003).

However, since the days of J. J. Thomson, Thomas Edison, Nikola Tesla, and other electric inventors the industry structure, technology and needs have changed. Traditionally, electric power industry has followed a vertically integrated business structure. Power generation, distribution, and supply were run under state monopolies that pursued the common goal of electrification. Current demand for high energy efficiency, low CO_2 emissions, and sustainable solutions are shifting the industry towards new market structures.

For the last twenty years, we have seen in the Western world electricity markets being restructured and liberalized for the common goal of enhanced competition. The major incentives are efficient allocation of resources, lower prices for end customer and new services resulting from increased competition (Berg Insight, 2010). The directive for common electricity markets (European Commission, 1996) stressed price deregulation, privatization and liberalization as the means to achieve this goal. However, the current major obstacle to achieve the efficient electricity market is a lack of competition on local and national level in both wholesale and retail electricity markets. The reasons are low numbers of competitors, high incentives to collude and high entry barriers (Sioshansi & Pfaffenberger, 2006, p. 265).

Emerging technology solutions bundled in a term “smart grid” are facilitating the efficiency, sustainability, and security goals prioritized by electric power industry, policy makers, and academia. Smart meters and their diffusion are the steppingstone towards an intelligent power grid; delivering new products and services which meet the expectations of 21st century power grid stakeholders.

1.1 Rational behind the work

Below, we discuss the major reasons why the present work deals with the issues of technology diffusion, smart meters, and finally the Central East Europe markets.

a) Studying innovation diffusion

Innovation is currently perceived as a major driver of sustainability, competition, and growth. Innovation and its effects on competitiveness have been studied since Joseph Schumpeter’s works on entrepreneurship and creative destruction[1]. In his theory, innovation and entrepreneurship are seen as the central drivers of economic change and growth. Innovation is also the driver of sustainable growth in the electricity power markets and that is why firms, industries and entire national policies are changing.

[1] Reference to works Theory of Economic Development (1919), and Capitalism, Socialism and Democracy (1943) by Joseph Schumpeter

Innovation is a very complex process passing through multiple stages and being affected by exogenous as well as endogenous factors. Among other stages, the diffusion of technology and knowledge is the central component of the innovation process. The reason is that without diffusion the innovation does not have any economic or social impact or value (OECD, 2005). That is the reason why this work attempts to find out how the sampled innovation diffuses in the electricity markets in a specific geographic region.

b) Studying smart meter technology

The present work concentrates on technological innovation in electricity markets and takes smart meter as a concrete example. Smart meters are part of a larger phenomenon called smart grid. The concept of smart grid has been termed a disruptive technology because it is changing the whole industry's operating paradigm (Fox-Penner, 2010, pp. 20-36). Smart grid is an intelligent electrical network which allows, among others, integration of renewable energy sources, customer response to prices in real time, and optimization of generation on the supply side (Kaplan & Sissine, 2009, pp. 142-144). Smart meters are seen as a milestone of this phenomenon which drives competitiveness and efficiency in electricity markets (Smart Grid Insights: AMI, 2010).

c) Studying Central East European markets

The final dimension is the geographic scope. Various geographical segmentation of energy markets of Europe exist, depending on the compiler. According to Sioshansi and Pfaffenberger (2006, p. 266) there are seven European sub-markets[1]. By the same token, European Energy Regulators agency (ERGEG, 2005) has launched an Electricity Regional Initiative (ERI)

[1] Western Europe, Eastern Europe, South Eastern Europe, Nordic, Iberian peninsula, Italy, UK & Ireland

which also distinguishes seven different European electricity markets[1] varying only in terminology. Currently available studies which deal with electricity retailing and smart metering often focus on traditionally advanced European markets, such as France, Great Britain, Italy or Nordic countries (Haney, A., Joskow, P., Pollitt, M., Defeuilley, C., Glachant, J.M., et al.). The major reason is because the innovation and adoption rates of new technologies have generally been higher. These countries provided enough data, for example from pilot tests, which are crucial for academic research. However, Central East European countries are an inherent part of Europe. These countries play a substantial role in the creation of single European electricity market according to EU's strategy (The European Parliament and the Council of the European Union, 2009). That is why it is important to fill the knowledge gap and study closer the current development in electricity retailing and innovations within the Central East European countries.

1.2 Research problem, objectives, and goals

Smart meters are recognized as one of the keystone enablers of the industry shift towards the smart grid. However, the diffusion process of this innovation remains intact. To successfully map the diffusion process of smart meters, the current work embraces two general approaches. First, the macro-perspective explains broader environmental factors surrounding smart meters, such as economic, legal, technological, or industry specific. Second, the micro-perspective observes firm specific factors, such as size, ownership structure, projects deployed, expenditures or competitors.

To illustrate the complexity of the problem and its multidimensional character let us observe the supply chain processes of the electricity power market. The supply chain consists of electricity generation, electric power transmission,

[1] Baltic, Central-East, Central-South, Central-West, Northern, South-West, France & UK

electricity distribution, and electricity retailing (see Figure 1 and section 1.4). On the one hand, if one company does all the mentioned processes it is vertically integrated and represents a natural monopoly. On the other hand, if the market is open and liberalized, the competition is introduced in electricity generation and retailing, whereas the distribution and transmission remain natural monopolies. Different levels of vertical integration, public ownerships and market structures exist (OECD, 2007) and the differences are encompassed and addressed by the macro-perspective dimension of this work.

Moreover, the focus is put on individual firms from the micro-perspective across the supply chain. The unit of interest are firms who adopt and diffuse the smart meters. The goal of this work is to identify the firms, their distribution across supply chain, and roles in the diffusion process.

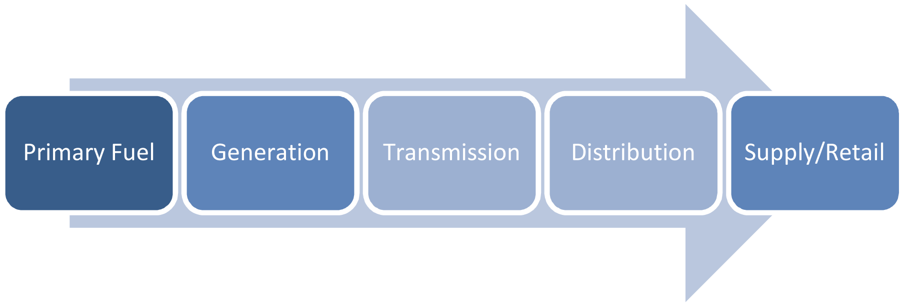

Figure 1 Key Functional Stages of Electricity Supply Chain

The study further focuses geographically on Central East Europe as a distinguished European electricity sub-market which has been lacking major research interest. The region includes the following EU countries: the Czech Republic, Slovakia, Hungary, Poland, Estonia, Latvia, Lithuania, Romania, Bulgaria, and Slovenia.

Summarized objectives of this work as well as research questions and methods are summarized in Table 1 below.

Table 1 Summary of research questions, goals, and methods

#	Research Question	Research Goal	Research Method
1.	What type of innovation is smart meter?	Categorize smart meter according to innovation frameworks	Innovation theories (Teece; Henderson & Clark; Abernathy; Christensen; Porter)
2.	How are smart meters diffused in CEE?	Discover how are smart meters diffused in CEE	Rate of diffusion (Rogers, 2003)
3	What are the major drivers of smart meter diffusion in CCE?	Find out drivers of diffusion of smart meters	Thematic analysis (Boyatzis, 1998; Bryman & Bell, 2007)
4.	What are the managerial implications of smart meter diffusion in CEE?	Reveal managerial implications from findings	Synthesis and analysis of findings

1.3 Theoretical framework

Three major marks constitute the theoretical framework. First, innovation theories are the keystone of the work. The innovation framework is built on typologies of innovations (Teece; Henderson & Clark; Abernathy; Christensen; Porter), innovation models (Rothwell; von Hippel; Chesbrough), innovation process (Greenhalgh & Rogers), and innovation diffusion theories and models (Moore; Rogers; Hall; Evans; Mansfield; Stoneman; Geroski). Second, market theories are discussed in the context of industry structures, competition and their effect on innovation diffusion. Theories of Schumpeter, Stoneman, Joskow, or Hannan and McDowell are discussed. Third, firm specific theories in the context of innovation diffusion are explored and cover such issues as firm size, ownership type, opportunity costs or role of suppliers (Davies; Metcalfe; Rose and Joskow; Bass).

The visually summarized theoretical framework can be seen in the figure below. The interaction and inter-relation of the concepts is illustrated by the circles fading one into another.

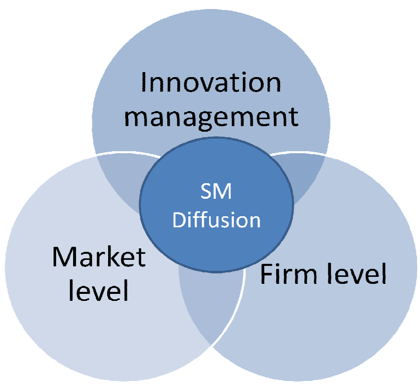

Figure 2 Interrelation of major theoretical concepts

1.4 Definitions of key concepts

The following section defines key concepts used throughout the work. We start with definitions of innovation and diffusion according to the Community Innovation Survey (Eurostat, 2010) and the Oslo Manual (OECD, 2005) respectively.

Innovation: is a new or significantly improved product (good or service) introduced to the market or the introduction within an enterprise of a new or significantly improved process.

Diffusion: is the way in which innovations spread, through market or non-market channels, from their very first implementation to different consumers, countries, regions, sectors, markets and firms.

To clarify the terms related specifically to electricity and gas sector OECD (2007, p. 32) presents in the research of regulation in energy, communications and transportation industries the following explanations.

Generation: operation of electricity generation or gas production facilities.

Transmission: operation of the high-capacity transmission systems that convey electricity or gas from the generation/production facilities to the distribution system.

Import: import of electricity or gas from abroad.

Distribution: operation of distribution systems that convey electricity or gas received from the generation/production facility or the transmission system to the final consumer.

Supply: sale of electricity or gas to the user.

1.5 Research methodology

The current study uses secondary data as the major source of information. Data collected through both, quantitative and qualitative methodologies are utilized. These take form of, for example the following:

- Governmental reports (EU, OECD, UN, WB)
- Industry reports (IERN, IEA, ESMA, ERGEG, SmartRegions)
- Academic papers (Rose & Joskow; Haney, Jamasb, & Pollitt)
- Organizational reports (Berg Insight, Carbon Trust, Capgemini, Frontier Economics)
- Scientific databases (Amadeus, Datamonitor)

This approach accommodates access to reliable data on variables of interest, such as regulation, market structures, competition, costs and benefits of projects, and so forth. The major reasons for utilizing secondary data are the large scope and scale of the study, its cross-national nature, and access to precise and historical data.

It may seem that this study is mostly descriptive trying to identify only patterns and trends. However, information obtained on different countries are critically analyzed and systematically compared, which brings causal approach to this research. As a good example of such study servers the work of Haney, Jamasb and Pollitt (2009) who focused firstly on electricity metering in terms of policy, market structures, and their potential to increase demand-side participation. In addition to technical side they focused on economic side by analyzing cost and benefits of smart metering across countries. They also observe the different approaches of SM diffusion and their impact on policy making. The present thesis utilizes similar approach, synthesizes and compares results of various studies in the CEE context.

1.6 Delimitations

The current study observes smart meters as a single innovation, acknowledging its role in the larger innovation system called smart grid. However, it must be stressed that smart meters are not independent from other innovations and are part of what Rogers (2003, p. 15) calls technology clusters. Therefore, simplified focus on smart meters as an independent innovation may distort the findings.

The term Central East Europe may cause a minor confusion but this work concentrates only on current member states of the EU located in the central and eastern parts of the European Union. Due to various criteria, different terms for similar geographical region exist, such as East-Central Europe or Central and Eastern Europe.

Other restrains reside in the empirical part of the work. The study relies on secondary data and their comparability must be maintained. Further, the data collection and methods of analysis have to be carefully described in order to present comprehensive explanations of how the results were reached. Finally, the recognition and classification of themes which deal with drivers of diffusion derive from raw data and follow inductive methodology. Additional reliability of theme classification could be reached by application of established models or computer software.

2 THEORETICAL PART

Innovation is currently an omnipresent imperative addressed in company statements, product promotions or political agendas. From a private sector perspective innovation is seen as a mean to company growth, profit maximization, sustainability, knowledgeable human capital or simple survival. From a public sector perspective, innovation is a tool to reach country's competitiveness, improved productivity, economic growth, or higher employment.

Innovation can be measured by various means, such as innovation surveys (CIS), intellectual property rights (patents, trademarks, copyrights), or R&D (Greenhalgh & Rogers, 2010, pp. 57-81). Let us illustrate the importance of innovation on the last variable - R&D. On the one hand, public sector innovativeness can be measured by governmental R&D *budget provisions*. International indicator GBAORD[1] offers comparability across countries and is adjusted for differences in economic sizes. In 2006 GBAORD investments were led by the United States with over 1% of GDP, followed by EU's 0.76% and Japan's 0.70% of GDP (Eurostat, 2009).

On the other hand, private sector innovativeness can be measured by R&D *expenditures.* This is the EU's common methodology to measure its ambitions goal, which is the devotion of 3% of GDP to R&D by 2010. The available data for year 2006 showed 1.86% of EU's GDP devoted to R&D. The business enterprise sector was the largest R&D investor with share of almost two thirds (1.17%). Comparably, the public sector's R&D expenditures accounted for the remaining third (0.65%), with a small remaining share (0.02%) of R&D investments financed by private non-profit sector (Eurostat, 2009).

[1] GBAORD - Government budget appropriations or outlays for research and development are a way of measuring government support for research and development activities (Eurostat Glossary, 2010).

2.1 Innovation framework

In order to establish a theoretical framework for innovation diffusion of this work, it is necessary to start with systematic description of innovation. First, typology of innovation is presented from scope and nature *(2.1.1)* perspectives. Next, we present different models (2.1.2) of innovation from evolutionary perspective. Finally, innovation process (2.1.3) is described before turning the attention to innovation diffusion (2.1.4).

2.1.1 Innovation by scope and nature

To begin, let us present general definition of innovation adopted by the Oslo Manual:

"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations" (OECD, 2005, p. 46).

The Oslo Manual (OECD, Eurostat) attempts to bring clarity into the complex field of innovation studies and draw guidelines for innovation measurements. Its three editions (1992, 1997, and 2005) mark the evolution of understanding innovation, during which different concepts and frameworks have been prioritized. The first edition (1992) highlighted technological product and process (TPP) innovations in manufacturing, neglecting the service field. The issue of service innovations has been addressed in the second edition of the Oslo Manual (1997), however organizational and marketing innovations were seen as subjective and difficult to measure (p.8), addressed only in annex (organizational) or not at all (marketing). Finally, the third edition (2005, p.47) officially recognizes the following innovations: product innovations, process innovations, organisational innovations and marketing innovation (see Table 1 in Appendix I for definitions).

It is noteworthy to mention the Manual's strong influence by Schumpeterian theorems so that innovations are studied on the firm level, which is seen as the major source of technical change and creative destruction (1997, p.16).

There are three major measures that underwent change during the evolution of innovation framework: industry type, scope, and linkages (OECD, 2005, p. 11). The following table illustrates these changes on three different editions of the Oslo Manual. On the whole, we may observe a shift from tangible oriented innovations towards innovations encompassing more non-tangible characteristics.

Table 2 Evolution of innovation framework

	Oslo Manual 1st ed. (1992)	Oslo Manual 2nd ed. (1997)	Oslo Manual 3rd ed. (2005)
Industry Type[1]			
Technological	x	x	x
Non-technological			x
Scope			
Product	x	x	x
Process	x	x	x
(Service)[2]		x	x
Organizational			x
Marketing			x
Linkages[3]			
Intra-firm	x	x	x
Inter-firm		x	x
Other actors			x

With regard to the above stated, smart meter technology can be categorized according to the innovation scope. Despite the fact that smart meters introduce new technology as well as new services to the market they are classified as *product* innovation. The reason is that the product innovation covers both goods and services. As a product innovation the smart meters embed in themselves considerable shifts: a) in technology (from electromechanical to digital), b) in functions (two-way communication), and c) in services (real time pricing). Furthermore, the product innovation is

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[1] Technological and non-technological may be substituted by manufacturing and non-manufacturing.
[2] Service innovation is not a separate innovation type however is marked to highlight the difference among editions of the Manual.
[3] Linkages indicate the knowledge flow inside and outside of a firm. “Other actors” stands for links between firm and other actors of innovation system, such as governments, regulators, libraries, suppliers etc.

partitioned into two sub-categories: 1. introduction of new products and services, and 2. significant improvements of existing product and services (OECD, 2005, p. 48). Because the smart meter significantly differs from the characteristics of traditional meter, it is classified as a *new* product innovation. Therefore, according to the scope of innovation we classify smart meters as a new product innovation (see Figure 3 below).

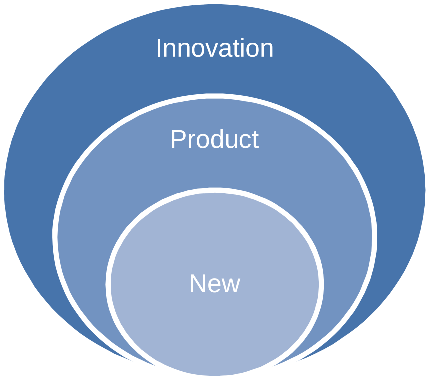

Figure 3 Innovation scope of smart meters

Innovation by nature

Instead of describing every concept in detail separately we present influential authors behind the concepts and discuss the most relevant ones in context of this work.

Table 3 Innovation by nature

Class	Innovation by nature			Author/s
1. Scale of change	Incremental Continuous Sustaining	Vs.	Radical Discontinuous Disruptive	Abernathy, 1978; Porter, 1986; Tushman & Anderson, 1986; Clark; Christensen & Bower, 1995
2. Scope of change	Autonomous Modular		Systemic Architectural	Teece, 1994; Lundvall, 1985; Freeman, 1995; Henderson & Clark, 1990
3. Nature of Interaction	Closed		Open	Chesbrough, 2003

Firstly, as mentioned above, smart grid of which smart meters are essential part has been termed a disruptive innovation (Fox-Penner, 2010). Definition of disruptive innovation by Christensen goes as follows:

"…a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves 'up market', eventually displacing established competitors" (Christensen, 2009).

The smart grid includes several components that disrupt the whole electricity industry's paradigm. Smart meters as one of the components disrupt traditional consumer behaviour by time-based pricing. Business logic and models are therefore also shifted allowing for a completely new range of products and services. Except the smart meters, this includes large scale electricity storages which enable to buffer the supply and demand, i.e. to charge home batteries when electricity demand is low and to draw from the batteries when demand is high and electricity expensive (Fox-Penner, p. 36).

Secondly, the electricity industry has been traditionally advancing by continuous innovations, such as new fuel sources, more efficient power transmission, and improved metering. However the industry's paradigm of inefficient balancing of supply and demand by constant on and off switching of power plants has stayed unchanged. Smart grid, in the context of smart metering, is challenging the conventional system and offers two-way communication where both parties, end consumer and suppliers, posses and exchange information and act accordingly. By this logic changing rational and based on Porter's (1998, p. 197) technological evolution we classify smart meters as discontinuous innovation. Porter sees the major source of discontinuous innovations coming from outside the industry. In the case of smart metering and smart grids these sources are especially information technology and telecommunication industries.

Thirdly, in his study Teece (1994) describes systemic innovation as one which requires readjustment and redesign of parts of the system. For comparison, he describes autonomous innovation as stand-alone innovation which does not require any modification of equipment components. The complexity of smart grid as innovation, its large span across industries (ICT, energy, electronics, consulting, etc.), and multiple stakeholders (legislators, households, electricity utilities, etc.) all signify that smart meters, as part of smart grid, represent a systemic innovation.

Finally, the former point above indicates the boundary-crossing and systemic nature of smart grid. Chesbrough (2006, p. 242) further states that processes of systemic innovations often involve interactions between value networks which leads companies to implement open innovation models. Under these circumstances we consider smart grid as innovation which facilitates open innovation models.

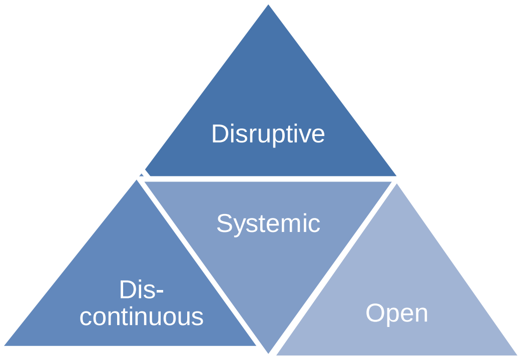

Figure 4 Innovation nature of smart meters

2.1.2 Models of innovation

In order to see the developing and changing nature of innovation over time, we present an overview of major innovation models. Bellow, Rothwell's five-generation innovation model (1994) is discussed in parallel with other innovation models set in time context.

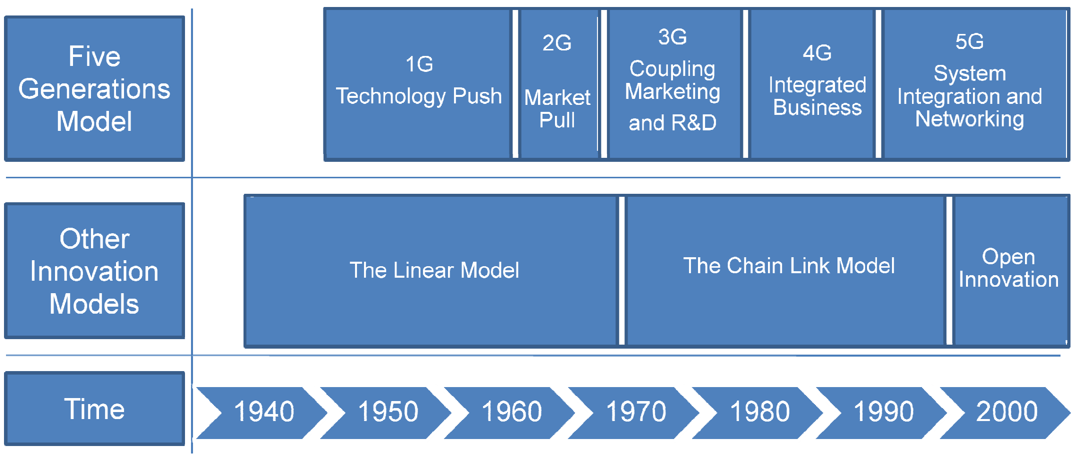

Figure 5 Models of Innovation

Rothwell observes innovation process on manufacturing companies from an evolutionary perspective and identifies five different generations. The first and second generation models had been understood as unidirectional following a linear pattern of innovation (Bush, 1945) overemphasizing either R&D or marketing. The third and fourth generation models recognized the multidirectional nature of innovation facilitating interaction between technology development and market needs. Feedback loops, free information and knowledge flows, strategic alliances, and user-cantered innovations (Kline & Rosenberg, 1986; Rothwell, 1994; von Hippel, 2005) were central themes for these models. The fifth generation is focused around two variables - market time and product development cost. Despite the strong focus on technology and management improvements to reach faster time to market and lower costs, there are obvious indications of "opening-up" of company borders and innovation process as such. These indicators include horizontal management style, cross-functional teams, supplier/manufacturer partnerships, external knowhow and licensing technology, external alliances, and close ties with suppliers and users who are involved in developing processes (Rothwell, 1994). We may observe that factors from the fifth generation model overlap with concepts of open innovation developed by Chesbrough (2003). In open innovation model, company boundaries are opened and knowledge is shared and obtained from external as well as internal sources.

In conclusion, innovation has been described as a constantly changing phenomenon where different processes and perspectives have been prioritized during the stages of its development.

2.1.3 Innovation process

Despite its complexity, authors attempt to portray innovation as a process with a basic research and inventions on one side, and introduction of an innovation to the market on the other. Stage-gate process, new product development (NPD), or fuzzy front end (FFE) are some of the attempts. The current work embraces the description of innovation process by Greenhalgh and Rogers (2010, pp. 6-8), which supports feedback loops among different stages, especially from diffusion to other innovation processes (see figure below).

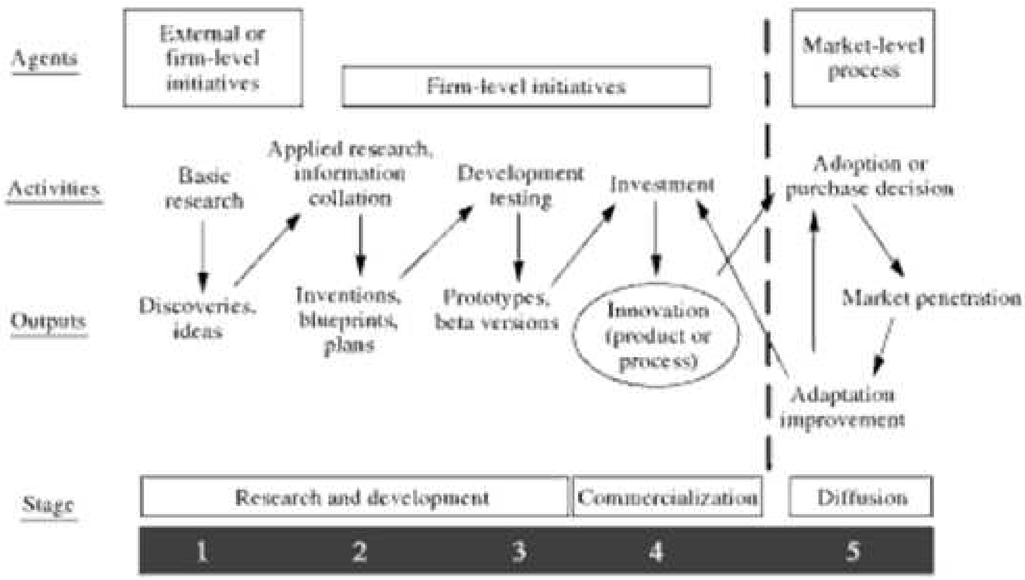

Figure 6 Stages of the innovation process (Greenhalgh & Rogers, 2010)

Each stage requires input in the form of knowledge and time, and if successful produces output in the form of new knowledge, products or processes. The first three stages of innovation process are seen in the sense of traditional R&D which includes various actors and systems, such as research institutes, independent scientists, companies, universities, or national and international policies. The innovation is born in the fourth stage with a commercial product or process. Diffusion is the fifth and final stage of innovation process and is of major interest of the present work. Innovation diffusion stands for adoption of a new product or process by the market and is discussed in detail below.

2.1.4 Innovation diffusion

The innovation process may not be complete and have an economic or social impact unless the new product or process is applied to and used on the market. Diffusion is recognized as a central part of innovation process not only because of mere adoption of new product or process but because of learning, new knowledge creation, imitation, and feedbacks effects (OECD, 2005, p. 32; Hall, 2006, p. 460) during the process. Diffusion of innovations has been influenced by various disciplines but the following two had a paramount influence.

1. Sociological and organizational sciences

The major figure behind the first perspective is Everett M. Rogers who describes the innovation diffusion as both, planned and spontaneous two way communication process about a new idea (2003, p. 6). There are various viewpoints on the minimum criteria of newness needed in order to qualify as innovation, such as being new to the individual/firm, new to the market, or new to the world. Due to the influence of sociological and behavioural sciences in his work he adopts the definition of innovation as anything new to the individual (p.12). In the core of his theory is a communication process among individuals which changes the structure of a social system throughout time. The summary of the main elements, stages, adopter groups, and perceived attributes of innovations in the diffusion process according to Rogers (2003) can be found in the table below.

Table 4 Summary of Rogers's diffusion theory

Elements	Stages[1]	Adopters (%)	Perceived Attributes
Innovation	Knowledge	Innovators (2,5%)	Relative advantage
Communication channel	Persuasion	Early adopters (13,5%)	Compatibility
Time	Decision	Early majority (34%)	Complexity
Social system	Implementation	Later majority (34%)	Trialability
	Confirmation	Laggards (16%)	Observability

Certainly, Rogers is well known for generalizing the technology adoption life cycle (TALC), which is a model describing the adoption rate of new technology products by specified sociographic groups throughout the time. However, the current work turns to its revised version pioneered by Geoffrey A. Moore in 1991. The reason is that Moore's perspective is solely based on new discontinuous technology innovations, which is the case of smart meters as discussed above. The major differences between the traditional and revised representation of adoption distribution are the gaps between the adopter groups on the traditionally smooth-shaped bell curve. Moore (1999) describes the major gap between the early adopters (visionaries) and early majority (pragmatists) as the chasm. Other authors[2], such as Evans (2003, p. 9), address the need to modify the TALC model as well; however he sees the major chasm between the late majority and laggards. The key here is to point

[1] Authors Greenhalgh et al. (2010, p. 177) simplify stages of diffusion process but in essence they resemble these of Rogers: 1. Transfer of information, 2. Decisions to adopt, 3. Eventual saturation
[2] Geroski (2000, p. 609) stresses that the diffusion at the later stages occurs much slower than predicted by the symmetric S-curve.

out the changing nature of the adoption life cycle and its non-smooth character caused mainly by changes in technology/innovation nature and shifts in communications. For illustration, see Moore's model of revised technology adoption life cycle below (Moore, 1999, p. 17).

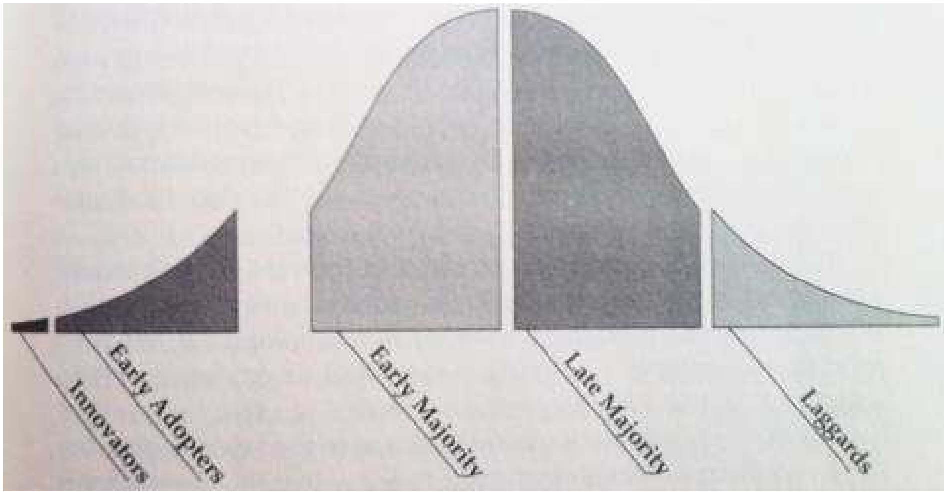

Figure 7 Revised technology adoption life cycle

2. Economic sciences

To be successfully diffused innovation must be economically feasible. That is why economists such as Mansfield (1989), Stoneman (2002), or Hall (2006) step in to the diffusion process and offer economic justifications. Below we briefly present major economic models of technology diffusion. The first two are the most widely used, followed by two additional models discussed by Geroski (2000). The fifth and final model is a practical tool used by firms and governments to evaluate risks and benefits of diffusion. For an overview of diffusion models and influential authors see Appendix I (Table 2, p.107).

a) Epidemic (contagion) model

The first and most widely used diffusion model is the so called epidemic model. As the name implies, this model compares the manner of innovation diffusion to spread of infectious disease in a population. The model is based on a random encounter and information sharing between adopters (infected) and non-adopters (exposed) which may lead to innovation adoption by the non-adopter. In other words, information diffusion drives the innovation diffusion (Geroski, 2000, p. 609).

b) Probit (economic) model

The Probit model of diffusion allows space for variations in the characteristics of potential adopters and stresses the individual nature of the decision making (adoption) process. The appetite for adoption may vary between individuals and firms, based on their qualities, structure, size, or resources. The model takes further considerations of economic factors, such as price of innovation or cost of adjustment (Greenhalgh & Rogers, 2010, pp. 180-184). The rational here resides in firms or individuals who may adjust their characteristics in order to, for example, speed up the diffusion process or increase competition.

c) Density dependent population growth model

The model of density dependency studies the growth and decline rates of organizations (see Geroski, 2000). *Legitimation* and *competition* are two major factors affecting the mentioned rates over time and additionally explaining the S-curve shape of technology diffusion. Legitimation stands for process of acceptance of a new company by the market as well as acceptance of a new technology by the company. As evolution of new technology becomes clearer, stronger standards appear or customer support becomes established, the organization becomes legitimized. This explains the initial influx of company births rates on the S-curve. The competition factor stands behind the later slowdown in adoption rate on the S-curve. The reason is that after more competitors start using the new technology the initial benefits of early adoption decrease. There are two additional factors that affect the diffusion rates: *rent displacement* and *pre-emption*. Rent displacement stands for cannibalization of firm's own activities by adopting new innovation. Finally, pre-emption effect is a distinction between firms for which some innovation is more suitable than for others.

d) Models relying on Information cascades

The diffusion model based on information cascades assumes that consumers approach the innovation adoption by relying on earlier adopters' opinion and simply adopt it without own learning experience. Behind this bandwagon effect, as mentioned by Geroski (2000, p. 618) or Utterback (1994), is the large number of variants of a new innovation which compete for consumer's attention and adoption. Network externalities further strengthen the "herd" effect which causes faster growth of new adopters by the growth in the size of the already-adopted group.

e) Cost and benefit analysis (CBA)

The last "model" is the cost and benefit analysis which is actually a practical instrument rather than a model serving individual firms as well as the whole countries. We mention this instrument among the traditional models listed above because it is widely used, often guiding the decision making process and serving as a bottom line measure in the diffusion process. The European Parliament (2009, p. 91), for example, recommends long-term cost and benefit analysis of smart meter projects in all Member States in order to assess their economic feasibility. Such analysis then serves as a gate-keeper for further deployment and national rollout of smart meters. A good example of an in-depth nationwide cost and benefit analysis of smart meters is the study by NERA Economic Consulting carried out for Australian Government (NERA, 2008).

It is important to note that all the mentioned major disciplines are tightly interlinked, constantly sharing and exchanging knowledge. Furthermore, other disciplines have traditionally influenced the diffusion process, such as anthropology, agricultural economics, population ecology, marketing, psychology, statistics, and many more[1]. In addition, Rogers (2003, pp. 94-100) presents his own detailed overview of typology of diffusion research with eight identified types differing in units of analysis and variables studied.

Finally, based on the major diffusion models discussed above authors Meade and Islam (2006) further identify three main modifications which brought higher flexibility to the forecasting of innovation diffusion (see table below).

[1] For overview of diffusion traditions see Rogers, 2003, p.478

Table 5 Innovation diffusion models modified (Meade & Islam, 2006)

Modification	Author & Year	Title
The introduction of marketing variables in the parameterisation of the models	Robinson and Lakhani (1975)	Dynamic pricing models for new product planning
Generalising the models to consider innovations at different stages of diffusions in different countries	Gatignon, Eliashaberg, and Robertson (1989)	Modelling multinational diffusion patterns: An efficient methodology
Generalising the models to consider the diffusion of successive generations of technology	Norton and Bass (1987)	A diffusion theory model of adoption and substitution for successive generations of high-technology products

A brief conclusion derived from the above presented influential perspectives, models, and sciences can be reached. Many of the models study the diffusion from the adopter's perspective taking into account corresponding factors, such as firm size or resources. Other models focus on environmental factors, such as competition or industry structure. As Hall (2006, p. 463) concludes on the example of diffusion of hybrid corn (Rogers), both economic and non-economic factors matter. Because this study relies on secondary data we embrace an approach which considers both adopters' perspectives (firm level) and environmental factors (market level), and which enables us to answer the research questions asked (see Empirical Part for details).

2.1.4.1 Competition and diffusion

Before turning to industry specific discussion we would like to ask one question: “What effects does competition have on innovation diffusion?” In general it may be believed that competition has positive effects on diffusion, since more organizations start using or selling the innovation which consequently leads to faster diffusion. However, empirical evidence does not reveal such unequivocal findings. Supporting the Schumpeterian marks[1], Hannan and McDowell (1984) found positive effects of firm size and market concentration on adoption, i.e. larger banks in more concentrated market adopt innovation faster. The contrary has been discussed by Levin et al. (1987) who found a negative relationship illustrated on diffusion of optical scanners. More complex perspective[2] present Karshenas and Stoneman (1993) who distinguish among four different effects which influence innovation diffusion: rank, order, stock, and epidemic. Last example is by Rose and Joskow (1990) who provide evidence from electric utility industry that large firms tend to lead the innovation adoption process and are most likely to be among the early adopters. With this discussion we want to point out the ambiguous nature of relationship between innovation diffusion and market completion.

2.2 Evolution of market for smart meters

The following section presents an industry specific discussion on smart meters and major factors influencing their development. First, electricity market, including retail and deregulation is described. Second, we present the legal framework surrounding the electricity retailing and metering. Third, technology framework is described in order to understand the functionality, structure, and the full potential of smart meters.

[1] For detailed discussion on Schumpeterian hypotheses, see Symeonidis (1996)
[2] An inverted U relationship between competition and innovation is discussed by Aghion et al. (2005)

2.2.1 Electric power as a service

In contrast to other energy commodities, electricity has two unique features. First, electricity is consumed at the same moment as it is produced and distributed. Second, electricity cannot be stored in large quantities. Both characteristics are intertwined and derived from the current industry structure and technology setting.

The two core features of electric power mentioned above directly resemble characterizations of a service (Kotler & Armstrong, 2010, pp. 268-270). Electricity, similar to service, cannot be tasted, touched, heard or seen before it is bought. Electricity is *intangible* until we pay the electricity bill which enables us to switch on the lights or electric stove. Furthermore, derived from the first feature, we cannot separate the production and consumption of electricity because they happen in the same *inseparable* moment. Kotler et al. (2010, p. 269) mentions a further dimension of inseparability of service and its provider. For example, the quality of electricity supplied or number of power outages determine the consumer's satisfaction. Both, electricity provider and consumer determine the outcome of electricity service. Next, service quality differs depending on time, place, mood or mean of delivery. If we speak about electricity services in unbundled markets, consumers have the right to switch electricity providers usually based on offered products and services, customer care, or problem solving capabilities. Therefore, the offers of electricity services will be highly *variable* among the providers. Finally, derived from the second feature mentioned in the beginning, it is obvious that electricity cannot be stored for later use or sale and that is why its character is *perishable*. For comparison of characteristics of electricity and services, see the Table 6 below.

Table 6 Shared characteristics of electricity and services

Characteristic	Service	Electricity
Intangibility	x	x
Inseparability	x	x
Variability	x	x
Perishability	x	x

The perishable nature of electricity represents the largest challenge since the creation of electricity distribution network. Major operational, ecological, and distributional loses occur during the peak times of electricity consumption when generators have to meet sudden increases in population's electricity demand. Smart meters and smart grid are to restructure this traditional logic and among others curb the peak times of consumption delivering from this resulting benefits. From the discussion above it may be concluded that electricity as a commodity and services have many similar characteristics which determine their nature, and indicate potential similarities in managerial requirements.

2.2.2 Unbundling, deregulation and competition

Electric power market as a whole has been traditionally represented by state-led and vertically integrated monopolistic companies which benefited from economies of scale but lacked agility. The vertical integration was applied to electricity supply chain, which consists of five key functional stages: primary fuel source, generation, transmission, distribution and supply (Cox, 2002, pp. 124-133). Such traditional model started to be disrupted in the early 1990s when a premise of more efficient allocation of resources by open competition started to prevail. The competition started to be introduced to electricity generation and supply whereas transmission and distribution remained a natural monopoly requiring state regulation. The EU facilitates creation of the electricity market by the many times amended Directive on Internal Market in Electricity[1] which requires full market opening from July 1st 2007. For the revised functional stages of electricity supply chain, see the figure below.

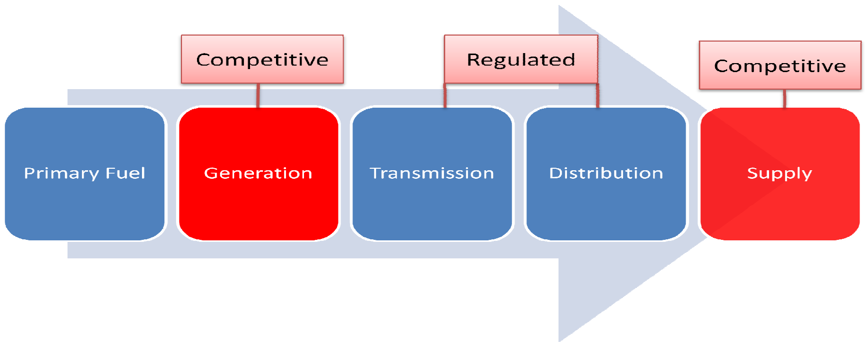

Figure 8 Revised Key Functional Stages of Electricity Supply Chain

Both statistical and case study evidence (Tidd, 2006, p. 8) confirms that competition stimulates firms to invest in innovation and change. By the same token, Tidd argues against traditional Schumpeterian notion that large concentrated firms and lack of rivalry among them make the firms actually less innovative and less competitive on the global markets. Yet, a group of leading economists (Aghion P. , Bloom, Blundell, Griffith, & Howitt, 2005) discovered a robust inverted-U relationship between product market competition and innovation. In less competitive sectors, firms may increase its profits from innovating because it enables them to escape the competition. On the contrary, in competitive sectors where innovation is carried out by laggard firms with low profits the product competition will only further reduce

[1] Directives 96/92/EC, 98/30/EC, 2003/54/EC, 2009/72/EC

profits from innovation. Electric power industry has only recently introduced competitive forces in two of its functional stages (generation and retail) and we believe with increasing competition product innovation will grow because of the potentially higher profits[1]. Smart meters are an example of new product systemic innovation and that is why we understand it as a window to changing market structures.

2.2.3 Legal framework

Institutional factors such as legislation, regulation, taxation or standards, are seen as hampering factors to all except organisational innovations (OECD, 2005, p. 113). That is why the European Union plays a crucial role in designing policies which promote more competitive, environmentally friendly, secure and sustainable Europe.

The 3rd Package of legislation adopted by the European Commission (September 19th 2007) is the corner stone for achieving the above mentioned in internal electricity and gas markets. Relevant to smart metering, the following are the major legislative concepts promoted in 3rd Energy Package (European Commission, 2010; ERGEG, 2010, p. 11; European Parliament, 2009):

- Separate production and supply from transmission networks.
- Promote development of smart grids.
- Equip at least 80 % of consumers with intelligent metering systems by 2020, where rollout of smart meters assessed positively.
- Promote energy efficiency and demand-side management.
- Increase renewable energy sources.

[1] Profits not only in financial sense but also in the sense of multiple benefits for stakeholders

- Ensure active participation of customers.
- Make available consumption data to customers.
- Inform customers on actual electricity/gas consumption and costs.
- Subject implementation of smart meters to cost-benefit analysis.
- Ensure interoperability and appropriate standards of metering systems.
- Prepare a timetable for implementation of intelligent metering systems.

Other regulations address the issues of smart meters, such as Directive on Energy End-use Efficiency and Energy Services (European Parliament, 2006), Directive on the Energy Performance of Buildings (European Parliament, 2002), and Directive on Measuring Instruments (European Parliament, 2004). In addition to the above mentioned, they discuss the following:

- 9 % energy saving target by 2016[1].
- Always provide competitively priced meters when a new connection is made in a new building or a building undergoes major renovations.
- Provide confidence in results, meteorological protection, and security of the meters.

Finally, Mandate M/441 (European Commission, 2009) describes six additional functionalities which promote consumer benefits, interoperability and standardization of smart meters:

1. Remote reading of metrological register(s) and provision to designated market organisation(s).
2. Two-way communication between the metering system and designated

[1] Directive on Energy End-use Efficiency and Energy Services (European Parliament, 2006)

market organisation(s).

3. Support advanced tariffing and payment systems.
4. Allow remote disablement and enablement of supply and flow/power limitation.
5. Communicating with (and where appropriate directly controlling) individual devices within the house/building.
6. Provide information via web portal/gateway to an in-home/building display or auxiliary equipment.

2.2.4 Technology framework

Smart grid is the electricity network of the near future. The ageing electricity power grid contrasts with the available modern digital technologies which have the potential to deliver the awaited benefits of intelligent grid. Among such benefits belong the reduction of CO_2 by efficient distribution and usage, creation of entirely new products and services, reduction of utility operational costs and prices for the end-users. To come to the technological aspects, smart grid is a complex system comprising of several technological sub-systems. The major technological components are the following (NETL, 2010, p. 3):

- Advanced Metering Infrastructure (AMI)
- Customer Side Systems (CS)
- Demand Response (DR)
- Distribution Management System/Distribution Automation (DMS)
- Transmission Enhancement Applications (TA)
- Asset/System Optimization (AO)
- Distributed Energy Resources (DER)
- Information and Communications Integration (ICT)

The scope of this work is narrowed down to smart meters, and as the name suggests, advanced metering infrastructure (AMI) deals exactly with this issue. For the purpose of broader understanding the discussion continues with a brief explanation of metering infrastructure.

2.2.4.1 Advanced Metering Infrastructure

AMI are systems comprising of digital/electronic hardware and software which combine interval data measurement with continuously available remote communications (EPRI, 2007). Its goal is to measure, collect and analyze energy time-based consumption data. AMI can be decomposed into three major building blocks:

1. Meters – electricity, gas, water at customer's site
2. Communications network – network between customer and supplier
3. Meter Data Management (MDM) – information to service provider

A. B. C.

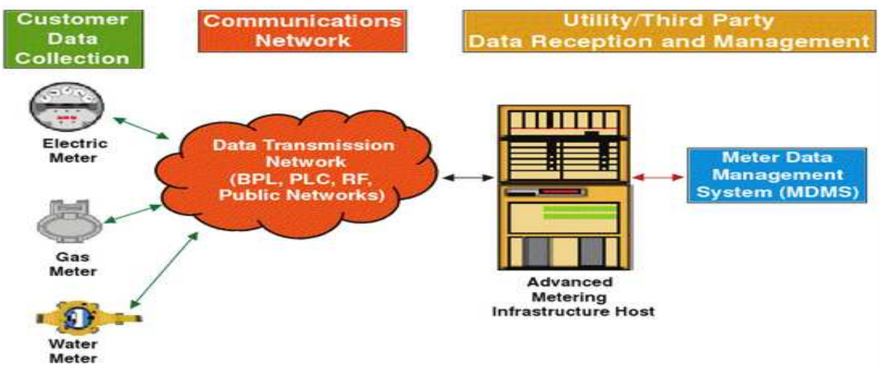

Figure 9 AMI building blocks (EPRI)

Before describing each block separately, it is noteworthy to mention the OPEN meter project (Open Public Extended Network, 2010) financed by the European Commission which tackles the issue of standardisation. Open and public standards endorse the diffusion of smart meters providing security in a turbulent environment.

A. Smart meters

The electricity meter is an important facilitator of the electricity market because it enables both buyer and seller monitor consumption. It is not only a technological device but an actual window to consumption and business logic. Therefore different types and technological shifts in metering devices also change the logic and behaviour on demand and supply sides. Electricity meters can be classified into the following classes (Haney, Jamasb, & Pollitt, pp. 16-18):

a. Electromechanical – the most common type which displays cumulative consumption in kWh and is typically read once a month by meter reader or customer. Monthly bills are based on estimates which can be retrospectively adjusted. Typically, the tariff rate is flat and not dependent on time of use. Some electromechanical meters allow retailers for simple tariff variability, such as day or night time pricing. This is achievable by mechanical or remote (radio teleswitch) adjustments of meters. However, the demand response and power to control and adjust resides mostly on the side of supplier.

b. Retrofitted electromechanical meters – traditional meters are modified by various external attachments. These may be for example prepayment attachments which allow flexibility of tariffs; or a real-time display attachment, which allows consumer to monitor actual consumption in real time. Here holds an assumption that precise real-time data makes consumers more aware and possibly leads to consumption and carbon reductions. This requires direct and active participation of consumers based on one-way signals from supplier.

c. Electronic Electronic – includes a variety of forms and functionalities. Interval electronic meter is the probable metering standard of smart grid system. Interval electronic meters have the capability to record electricity consumption over a short period of time, usually in 15, 30 or 60 minutes intervals. The major benefits are time-varying price system which consequently stimulates the demand response. The meters allow for manual or remote reading and also support credit or prepayment methods.

Additional technology for interval electronic meters is optional - most importantly two-way communication system which substantially enlarges functionality for customers and suppliers. This enables for example remotely connect and disconnect, detect outage or loss of supply, and interface with load control technology. Another optional function is monitoring and recording electricity which is generated by the user (micro-generator) and supplied back to the grid. Possibility to record electricity produced in small scale from solar panels or wind-turbines opens up a new micro-generating market which leads to greater CO_2 reductions. Last but not least optional function is a possibility to communicate with home appliances and adjust their functionality based on demand response, allowing them to run only when electricity demand is low hence the price of electricity is low (demand response).The summary of the major types of electricity meters can be found in the table below.

Table 7 Electricity meter typology (Haney, Jamasb, & Pollitt, 2009)

Meter Type	Standard Functionality	Optional Technology
Electromechanical	Record cumulative consumption	Multiple mechanical registers, radio teleswitch
Retrofitting Electromechanical	External attachments	Real time display, prepayment attachment
Electric Electric	Record consumption in short intervals	Two-way communication; measurement of micro-generation output; communication with appliances

B. Smart communication systems

How does public utility retrieve the data from smart meters? Four methods of network transmission can be used (Asplund, 2008, pp. 206-214):

1) Public wireless – public wireless frequencies used for communication with meters.
2) Radio frequency (RF) – special frequencies, typically more reliable than public wireless.
3) Broadband over power line (BOL) – use of the Internet over electricity power lines.
4) Power line carrier (PLC) – communication transmitted via power line; slower operation, includes special modem on receiver's and sender's side.

C. Meter data management

Data is the essential substance, the fuel of the intelligent metering infrastructure and in general its handling, security, dissemination and proper management must be ensured. The data is collected and analysed by utility or third party service provider and traditionally comprises of the two following properties:

1) Automated meter reading (AMR)

AMR is an established metering practice which enables remote collection of electricity (gas, water) consumption data. The collection of data is done via one or multiple transmission networks described above. However, the communication takes place only in one-way direction; meaning only the meter is sending the information and utility cannot apply other actions, such as remote connection/disconnection, etc.

2) Automated meter management (AMM)

AMM is an enhanced metering practice hinged on time-based data collection. In addition to remote data collection AMM facilitates two-way communication between the customer and utility. This feature enables a wide range of new services, such as time-based pricing, remote connection/disconnection, outage and fraud detection, etc.

2.2.5 Induced innovation diffusion

How does the European Union ensure the fulfilment of its ambitious 20/20/20 plan? In the case of energy sector in general, and smart meters in particular, the EU applies several regulatory levers that help safeguarding its strategic goals. Works by Ebnet et al. (2009) or ECBR (Energy Community Regulatory Board, 2009) highlight the following four major regulatory tools which facilitate smart meter rollouts. In addition, three major drivers[1] of smart meters are listed (Ebnet & Santer, 2009) in the following table.

Table 8 Major regulatory tools and drivers of smart meter diffusion

	Major Regulatory Tools	Major Drivers
1.	Legal obligation	Energy efficiency
2.	Minimum functional requirements	More frequent meter readings
3.	Financial incentives	Peak load management
4.	Standardization	

The above mentioned regulatory tools and major drivers merge into one and illustrate themselves in the form of strategic plans, organizations, initiatives, directives, or unions, to mention some. One example for all, an influential initiative named Strategic Energy Technology Plan (SET-Plan) has been adopted by the Commission in 2007. SET-Plan aims to accelerate the development and deployment (diffusion) of energy efficient and CO_2^{-}lowering technologies. The goal is to be achieved jointly by public and private sector via increased investments, improved marketing, adjustments in legal and administrative environment, and research, development and demonstration (RD&D) of competitive new energy technologies, which facilitate energy efficiency, renewable energy, or pan-European energy network (Commission of the European Communities, 2007; European Electricity Grid Initiative, 2010).

[1] Additional drivers are mentioned by different actors. For example, Arnewid (2009) in addition mentions improving billing accuracy (main driver in Sweden), reducing losses due to fraud (main driver in Italy), enabling micro-generation or e-mobility.

Other organizations, unions or associations pursuing the common EU energy goals by applying the identified regulatory tools are for example ETSO-E, ERGEG, EDSO-SG, EEGI, and Eurelectric. The mentioned unions are shaping the common European market and regulatory energy environment from different sides, such as cross-border electricity exchanges by ETSO-E[1], or uniting the voice of national electricity industry organizations by Eurelectric[2].

2.2.6 Stakeholders of smart metering

The recently completed five year-long study named EU-DEEP[3] which involved 16 European countries may serve as a suitable guideline for mapping the involved stakeholders in a new technology innovation deployment. The study has focused on energy technology DER (distributed energy resources) which is in fact a direct component of the smart grid network. This technology deals with micro-generation of electricity and its subsequent distribution, i.e. customers produce own electricity from e.g. solar panels on the rooftops, store it in batteries or resell it further into the grid. The research has also been asking similar question as the present study, such as: What is the regulatory framework? How will the technology change the current business logic? What are the impacts on consumers and adopters? The following is the list of major identified stakeholders[4] (EU-DEEP, 2009).

[1] European Network for Transmission System Operators
[2] The Union of the Electricity Industry-EURELECTRIC
[3] European Distributed Energy Partnership, a project part of the Sixth Framework Programme for Research and Technological Development (see www.eu-deep.com).
[4] Certainly, other institutions or authors present additional or more detailed stakeholders, such as telecommunication companies, Internet companies, or data companies (Frontier Economics, Ylios, Stratorg, Quintel, 2010).

Table 9 Main stakeholders of smart metering

1	Policy makers	6	Consumers and Energy Facility Managers
2	Regulators	7	Manufacturers
3	Transmission System Operators	8	Investors
4	Distribution System Operators	9	Research Community and Research Promoters
5	Energy Producers, Retailers, and Service Providers		

2.2.7 Benefits of smart metering

The current work has so far implied the multiple benefits derived from smart metering. There are dozens of academic, business, and industry studies focusing on smart metering benefits, as well as challenges and opportunities (Sandoy, 2009; ERGEG, 2009; Mozsolics, 2011; Deasley, Riechmann, & Bothe, 2009). Most importantly, the benefits of smart metering span across the whole electricity value chain. We synthesize the above mentioned studies to present the major benefits according to stakeholders of the value chain.

1. Customers – energy consumption awareness; potential energy savings; accurate billing; innovative tariffs and pricing; simpler change of supplier; improved services and easier comparison of these

2. Distributors – reduction of expenses by automation (lower meter reading costs); identification of outages; improved network monitoring and control; lower theft; integration of distributed generation;

3. Suppliers – facilitation of new entries; improved information on usage; reduction of balancing energy by improved forecasting; optimization of expenses by peak shifting

As implied by the benefits discussed above and as outlined by EU's 20-20-20 strategy, smart metering delivers benefits for society as a whole. Carbon dioxide reductions resulting from lower energy consumption are two major benefits for society derived from smart metering. We have collected data on smart metering benefits identified by each CEE and validation country sample and present the results in section 3.3.

2.2.8 Barriers to smart meter adoption

Based on the empirical results of over 500 SMEs from the UK which underwent advanced metering trial, the research institute Carbon Trust (2007) identified three main areas that impede the adoption of smart meters on the company level. For the summary see Table 10 below.

Table 10 Summary of major barriers to smart meter adoption (Carbon Trust, 2007)

1. Reasons for lack of implementation	2. Technical and practical barriers	3. Established market problems
Unconvincing case	Installation issues	Stranded assets
Lack of time/low priority	Commercial interoperability	Balancing and settlement issues
Lack of resources	Communications	
Other		

First, companies expressed major reasons why they did not implement the identified energy saving actions. Three quarters of reasons were explained by lack of resources and lack of time combined with low priority. In addition, cases were recorded where companies expressed lack of willingness to comply with using the meter efficiently. See the summary in the figure below.

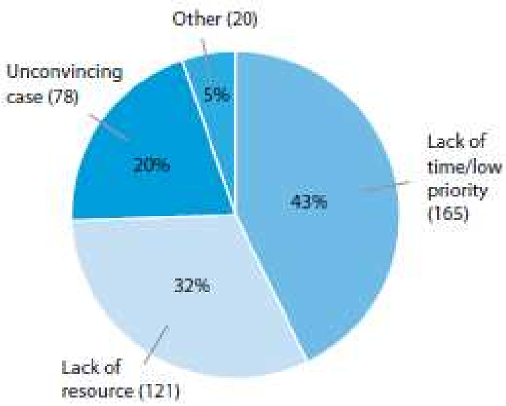

Figure 10 Reasons for not implementing identified energy savings (Carbon Trust, 2007, p. 40)

The second group deals with technical and practical issues and identifies three problem areas: installation, commercial interoperability, and communications. The companies have expressed difficulties coordinating the meter replacement which resulted in subsequent delays in installations. Next, there was a constraint in communication between the meter data collectors and electricity suppliers. Traditionally the electricity suppliers have own or preferred data collectors who supply them with standardized easy to process data. However, smart meters may require new specialized meter data collectors which may in addition aggregate the data in different formats. For these reasons the electricity suppliers are reluctant to change their practice. Concerns about lack of transparency concerning the charges for smart meter services were also expressed. Issues with the communication technology were stressed more than with smart meters themselves, which further underlines the current battle for standards and protocols (see Mandate M/441, 2009; OPEN meter project, 2010).

Third, market environment is a very important facilitator as well as inhibitor of smart meter diffusion. The companies in the pilot projects expressed concerns about lost value when they replace yet functional meters with smart ones or if they adopt meter whose functionality becomes obsolete by legislation shift. A country specific case is UK where owners of the electricity meters are not distributors but electricity suppliers. Therefore, if the customer decides to change supplier, the initial investment may be lost or value transferred. Such lost values due to legal or regulatory shifts are defined as stranded assets (see Pedell, 2006, p. 88). We come again to the discussion of minimum required industry-wide standards, such as type of communication or metering interval, which stimulate diffusion and remove several above mentioned barriers (see ERGEG, The Drive Towards Smart Grids, 2010). Balancing and settlemenet refers to issues between generators and suppliers during the time of concurrent operation of both regular and smart meters.

3 EMPIRICAL PART

Empirical part of the work begins with defining the methodology which enables us to reach the study's objectives. Rate of adoption (Rogers, 2003) and thematic analysis (Boyatzis, 1998) are two main methods embraced by the study, and coding manual further clarifies boundaries of the work. The discussion follows with presentation of identified smart meter diffusion results for each CEE country separately. Next, the results and methodology are validated by an additional sample of three countries after which the results are comparatively examined. In the same section, smart metering benefits identified for each sample country are presented. Subsequently, final results on total diffusion rates in CEE and drivers of smart meter diffusion are discussed. Prior to the conclusions of the study managerial and policy implications derived from the results are suggested.

3.1 Methodology

To begin the practical section of this work let us restate the research questions asked in the introduction:

1. What type of innovation is smart meter?
2. How are smart meters diffused in CEE?
3. What are the major drivers of smart meter diffusion in CEE?
4. What are the managerial implications of results?

The initial question has been answered in the theoretical part by the discussion on innovation nature, typology, and scope of smart meters (see section 2.1.1). Nevertheless, the managerial implications of smart meters as disruptive discontinuous systemic innovation which facilitates open innovations can be discussed only after we answer the second and third research question. That is why the major focus is now devoted to research questions number two and three.

The second and third questions seek answers of different nature and that is why two different analytical methods are applied. The second question is mainly concerned with the *rate of adoption* which is build on the innovation diffusion concepts of Rogers (2003, p. 23). We seek the number of smart meters diffused in the sampled region throughout a period of time. The data is collected and plotted on cumulative frequency charts which enable us observation of speed of diffusion in each country and the whole region. The findings are subsequently benchmarked against the EU market leaders in smart metering.

The third question is attempting to uncover the hidden drivers and patterns behind the smart meter diffusion process. An analytical method enabling to reach the objective is *thematic analysis*. Described by many disciplines and authors such as Boyatzis (1998) or Ezzy (2002), thematic analysis hinges on encoding qualitative information according to specific code. The code is actually a list of themes or a complex model which is represented by underlying patterns found in the information. Furthermore, there are two ways how to construct the themes: a) deductively, based on established theoretical concepts and models, or b) inductively, from the raw information (Boyatzis, 1998, pp. vi-vii; Marks & Yardley, 2004, p. 57). In our case, the themes were drawn from the actual data therefore followed the inductive coding[1]. Lastly, thematic analysis distinguishes between latent and manifest themes of analysis. The manifest themes are those based on apparent and observable content where words or topics are measured by, for example frequency of occurrence in a text. On the other hand, latent themes are those linked with

[1] Existing research and theories were considered, such as PESTLE analysis, to frame the thematic analysis by deductive coding. However this did not provide satisfying outcomes.

hidden and context based meanings (Boyatzis, 1998, p. 16; Bryman & Bell, 2007, p. 637). The current study focused on the manifest themes which were identified mainly in the following data sources:

- SmartRegions – European Smart Metering Landscape Report, 2011
- ESMA – Annual Report on the Progress in Smart Metering, 2010
- ERGEG - Status Review on Regulatory Aspects of Smart Metering (Electricity and Gas) as of May 2009

Information from the following sources served as supplementary material:

- National energy regulators
- Governments and state agencies
- Energy companies (production, supply, sale, and distribution)
- Amadeus database

The process of data collection and data analysis was highly interrelated. The data collection shaped and de facto created the categories and themes into which data was coded (initiative, regulation, cost benefit analysis, pilot project, and rollout). The data collection thus has an influential role on data interpretation and analysis. This phenomenon is rather a rule than exception in qualitative research as discussed by Ezzy (2002, p. 60). The stages of thematic analysis in this work followed the steps described by Boyatzis (1998, pp. 3-4):

1. Pattern recognition

The most relevant data related to the objective of the study had to be systematically extracted from various source of information[1].

[1] See Dey (2005, p. 100) for discussion on categorizing, interpreting and analyzing qualitative

2. Pattern classification and coding

The data have been coded according to their content and thus clustered into the related thematic blocks (initiative, regulation, pilot project, etc.). A unit has been attached to each activity within each theme discovered[1].

3. Pattern interpretation

3.1.1 Coding Manual

There has been a very complex evolution in classifying and coding the recognized pattern. This is a critical task which was given a thorough consideration because the data interpretation directly relies on the assigned code. To answer the research question on drivers of SM diffusion in CEE, three dimensions were considered: 1. *Activities* based on thematic analysis, 2. *Ownership structure* of actors who carry out the activity, and 3. *Percentage of smart meters* out of total electricity meters in a country. The final result is represented by a proportional bubble chart encompassing all the three variables mentioned above. We follow with a detailed discussion on construction and coding of each dimension.

The first dimension was constructed by applying *thematic analysis* on the secondary data described above. Five themes[2] were recognized and a value was attached to each based in ascending order from one to five. The values linked to the themes follow ascending logic to resemble the progress of smart meter diffusion and implementation within the market. This logic was later

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data.

[1] See Marks et.al (2004, p. 59) for discussion on data coding.

[2] The words theme and activity are used interchangeably because themes are constructed based on the activities in the industry and market.

confirmed by a positive correlation coefficient[1] between activity code number and percentage of smart meters diffused. This confirms the linear logic of the code – the higher the activity the more smart meters diffused. For summary, see the Table 11 and subsequent explanations below.

Table 11 Summary of activity coding

Activity	Code	Detail
Initiative	1	Public and private consortiums, declarations, official plans, studies, and researches
Regulation	2	National laws and regulations in context of smart metering
Cost benefit analysis	3	Long term economic assessment of costs and benefits of nation-wide rollout of smart meters
Pilot project	4	Small scale deployment of smart meters
Rollout	5	Company-wide or nation-wide deployment of smart meters

1. *Initiative* is understood as a first-step activity towards smart meter diffusion. Carried out by public and private organizations, initiative includes consortiums, declarations, official plans, information platforms, studies, or researches.

[1] A significant positive value of 0,527 was a result of correlation coefficient between activity number and percentage of smart meters diffused.

2. *Regulation* denotes each country's political intentions and obligations to move towards efficient and competitive energy market in the context of smart metering. Laws and regulations with EU-wide legal force, as discussed in chapter 2.2.3, were not considered for each country, since these are valid for all EU countries equally. However, we have included National Energy Efficiency Action Plan (NEEAP) as a regulation adopted by each country, which was an actual requirement of the European Parliament[1]. The reason is that this document represents a national long-term strategy and sets obligations for reaching energy efficiency by multiple means of which smart meters and smart grids are important part.

3. *Cost benefit analysis (CBA)* represents a first concrete action by each state to assess long term costs and benefits of a wide-scale national deployment of smart meters. Cost benefit analysis is an economic assessment tool recommended and embedded in the Directive 2009/72/EC. Positively assessed results shall lead to equipping 80% of customers with smart meters by 2020 (European Parliament, 2009, p. 91). CBA shall be carried out by each member state by 3 September 2012.

4. *Pilot project* stand for concrete implementation and small scale deployment of smart meters in proportion to the actor's (DSO's) customer base.

5. *Rollout* denotes a large scale deployment of smart meters on a national or company level.

[1] Based on Directive 2006/32/EC of the European Parliament and the Council on energy end-use efficiency and energy services.

A second dimension is added by analyzing *ownership structure* of the initiator of the above discussed activities. We differentiate between public and private actors based on the ownership structure in percentage shares. For example, the percentage controlled in a company by private investors equals to 70 percent and by the state to 30 percent. By considering the ownership variable we link the activities with their actors can therefore reach better understanding of the market drivers. Careful investigation of ownership structure was carried out and in several cases proportioning of ownerships between home company and its subsidiary was necessary. For example, a state owns 80 percent of home company which holds only 85 percent stake in its subsidiary. Correspondingly, proportion of state ownership in the subsidiary equals to 68 percent[1].

The final dimension is the *smart meter percentage of total electricity meters*. This variable allows us to proportionally compare the progress of SM deployment among the CEE countries in a specific time. The percentage is represented by the size of bubble on the final chart which allows us to visually illustrate the different levels of progress in SM diffusion.

3.1.2 Data validation

Currently, the data derives from geographically, and in many cases culturally and historically affiliated countries of Central East Europe. That is why comparison of significantly different countries can highlight or on the contrary undermine the validity of applied analysis. To validate the data, we have decided to apply the same methods[2] to three additional countries from the segment of “dynamic movers”, as described by Renner et al. (2011, p.1). The

[1] 85% of 80% equals to 68%.
[2] Thematic analysis, ownership structure, and SM percentage out of total electricity meters

segment is characterized by clearly defined policies and legal frameworks leading the countries towards full implementation of smart metering. The three countries chosen are: Finland, France, and Italy. In addition, the analysis of market leaders represents a benchmark against which the CEE countries are measured and differences comparatively observed.

3.2 Smart metering in Central East Europe

The present section discusses diffusion process of smart meters in each country of our CEE sample. The goal is to shed light on each country individually which enables us to see similarities and differences which we utilize in the final discussion on smart metering in Central East Europe (section 3.4). We point out major national SM activities especially these related to economic, legal, political and scientific development. Companies that adopt smart meters are identified, their actual or planned SM diffusion rates presented, and if unclear ownership structures clarified. The results are synthesized in diffusion charts for each country that depict diffusion rates of smart meters throughout the time.

3.2.1 Bulgaria

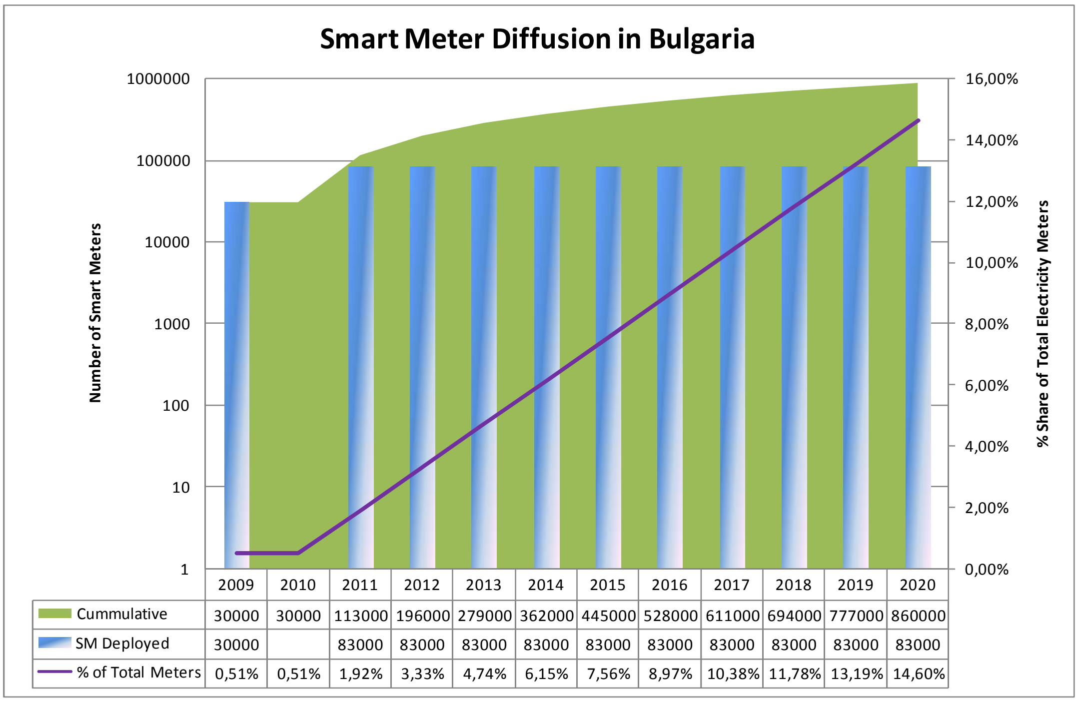
In general, smart metering activities in Bulgaria are rather limited, especially due to the lack of official and comprehensive strategy regarding SM. One of the three major utilities in Bulgaria, E.ON Bulgaria[1] (2010, p. 10) outlines smart metering pilot project as their innovation activity for 2009, however fails to present any details on investments or number of SM deployed. A recently published interview with E.ON Bulgaria (2011) sheds more light on the company's plans. Interviewer Georgi Georgiev finds out about E.ON Bulgaria's EUR 65,5 million investment plan to deploy 850 thousand smart

[1] E.ON Bulgaria has 1,1 million customers, approximately 19% of Bulgarian market.

meters until 2020[1]. This information is the only long term SM deployment plan identified in Bulgaria. Neither national cost and benefit analysis has been carried out nor legislation or policy frameworks have been defined. The same situation prevails in the main reports on smart metering (ESMA, SmartRegions) which do not mention any specific activity in the form of pilot projects, regulations or policies.

Two other major activities are worth noting. Firstly, CEZ Distribution Bulgaria[2] (2010) presents its investment activity in a form of replacement of over 336 thousand electricity meters in West Bulgaria in 2006-2007. Details on technology used are lacking therefore the data is not considered. However, a concrete smart metering project has been carried out by CEZ Bulgaria in cooperation with ADD Bulgaria (ADD Bulgaria, 2009). An advanced meter management system for 30 thousand SMs was deployed throughout the year 2009. Secondly, Bulgarian telecom company Mobiltel (2010) has entered a major deal with a global smart grid solution provider Sensus and their Bulgarian representative Akwaror. The deal started with a pilot project in 2010 whose results are anticipated by Bulgarian utilities. The deployed system is called FlexNet and delivers the following benefits of AMI in Bulgaria: power outage detection, fraud detection, remote measurement, monthly billing, consumption and price monitoring via web portal, efficient network management, consumption analysis, and overall network control for customers of electricity, gas water, and thermal heat meters (Simonetta, 2010). Furthermore, FlexNet is not only a smart metering system but an actual infrastructure for the whole smart grid. If successfully implemented across utilities, Bulgaria may become a European leader in smart grid utilization. For visualized diffusion rates of SMs in Bulgaria, refer to the figure below.

[1] In order to visualize diffusion rates and because E.ON's detailed deployment plan is not available, the total of 850 000 SMs was equally divided into the 10 year period (2011-2020).
[2] CEZ Distribution Bulgaria has close to 2 million customers, over 33% of Bulgarian market.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cummulative	30000	30000	113000	196000	279000	362000	445000	528000	611000	694000	777000	860000
SM Deployed	30000		83000	83000	83000	83000	83000	83000	83000	83000	83000	83000
% of Total Meters	0,51%	0,51%	1,92%	3,33%	4,74%	6,15%	7,56%	8,97%	10,38%	11,78%	13,19%	14,60%

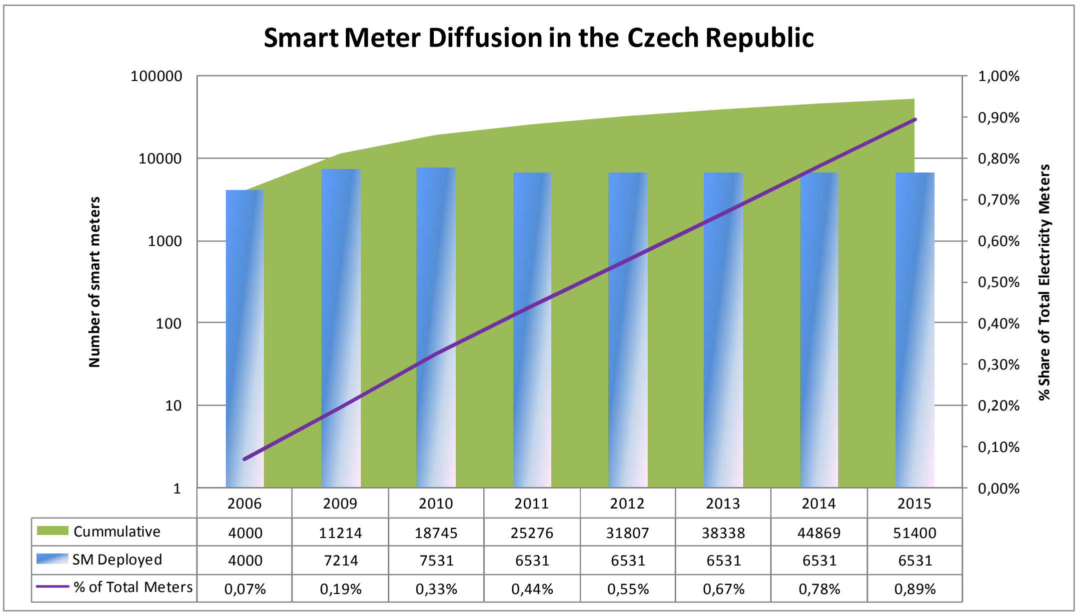
Figure 11 Smart meter diffusion in Bulgaria

3.2.2 The Czech Republic

The Czech Republic represents a country which has been carefully monitoring and evaluating the smart metering technology from the early stages but which has been hesitating to make any radical decisions. In 2006 the first SM cost benefit analysis was carried out in cooperation between energy utility CEZ a.s. and Ministry of Industry and Trade of the Czech Republic leading to a negative result (ERGEG, 2009, p. 25). More positive results were expected from the second cost benefit analysis which was carried out in 2009. The Czech Republic has not adopted any specific regulation or legislation which would require smart meter rollout even though these are under consideration (Renner, et al., 2011, p. 3).

Three main utilities show smart metering activities: CEZ, PRE, and E.ON. The early mover was E.ON, which experimented with 4 thousand SMs in the region of South Moravia already in 2006 (ESMA, 2009, p.46; Shargal, 2009, p. 4). The pilot test's goal was to investigate technical issues and evaluate various technology manafacturers. CEZ followed with its "Smart Region" initiation to which belongs a pilot project in Vrchlabi city with 4,9 thousand SM planned to be deployed between 2010-2015. The Vrchlabi project evaluates not only smart meters but the whole smart grid solution. Except new metering, communication or feedback systems the project includes installations of charging stations for electronic vehicles, possibilities to micro-generate and redistribute renewable energy, and monitor and plan consumption of electricity, water, and gas via home displays (CEZ, 2010). CEZ plans to equip additional 40 thousand[1] households with SMs in the same period and depending on the result prepare for the potential mass rollout of smart grid solutions for over 1 million inhabitants (ESMA, 2009, p.47). The last utility carrying out smart metering projects is PRE, main utility for Prague region. Its daughter companies, PREdistribuce and PREmereni, installed 2 thousand and 500 SMs between the years 2009-2010 respectively (PREmereni, 2010, str. 6; PREdistribuce, 2010, str. 17). The figure below summarizes available data[2] on smart metering in the Czech Republic.

[1] Approximately 1 percent of CEZ's customers
[2] The total number of SMs planned to be deployed in a specific time interval was equally divided into corresponding years in order to visualize the diffusion rate.



	2006	2009	2010	2011	2012	2013	2014	2015
Cummulative	4000	11214	18745	25276	31807	38338	44869	51400
SM Deployed	4000	7214	7531	6531	6531	6531	6531	6531
% of Total Meters	0,07%	0,19%	0,33%	0,44%	0,55%	0,67%	0,78%	0,89%

Figure 12 Smart meter diffusion in the Czech Republic

3.2.3 Estonia

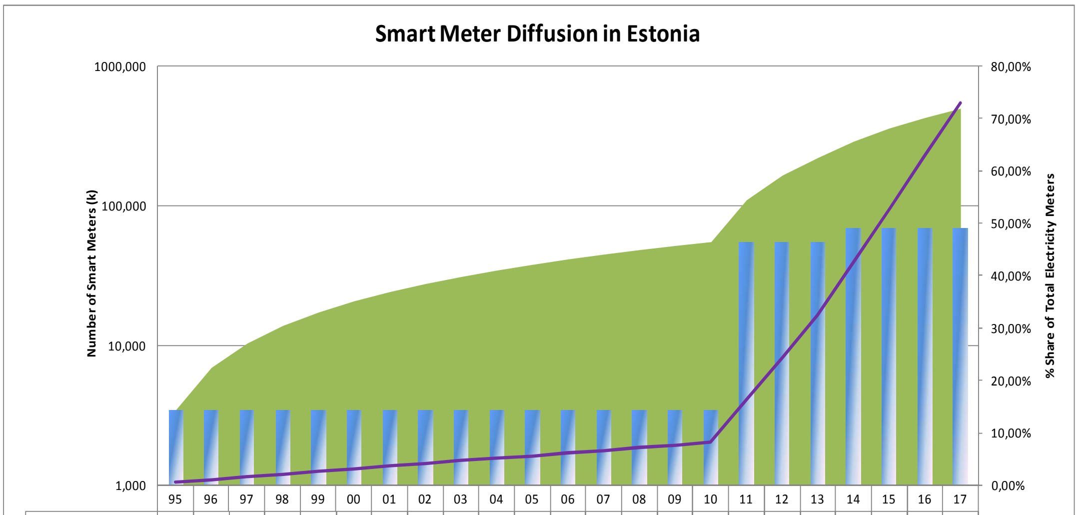
The diffusion of smart meters in Estonia is characterized by independent actions of energy utilities acting without any regulatory or legal guidelines. An official cost benefit analysis has not been carried out however large scale rollout is being considered by DSOs with a planned schedule 2011-2017 (Renner, et al., 2011, p. 29). Estonian market seemingly exhibits company-led diffusion however the largest utility Eesti Energia with close to 90 percent market share is completely owned by Estonian state (Eesti Energia, 2011). Therefore we may observe a unique blend where the state exercises its policy objectives via a stock company without the need of codifying the legal environment.

In order to map the diffusion process in Estonia several assumptions had to be made. The reports of ESMA (European Smart Metering Alliance, 2010, p. 11) and SmartRegions (Renner, et al., 2011, p. 30) both mention a planned rollout of smart meters in Estonia for the period 2011-2013/2017[1]. The largest and at the same time state owned utility Jaotusvõrk OÜ, a subsidy of Eesti Energia, is a significant driver which desires to accomplish 220 thousand AMR meters by 2013 and full rollout by 2017. As mentioned by Eesti Energia (2010), their total number of customers equals to 496 thousand, which assumedly corresponds to the number of company's total meters. Furthermore, in relation to a national rollout SmartRegions (2011, p. 30) report mentions a smart metering procurement for 680 thousand meters which is understood as a total number of meters in Estonia. Next, information on SMs deployed in Estonia was found only for time intervals 1995-2010, 2011-2013, and 2014-2017. Eesti Energia (Renner, et al., 2011, pp. 29-30) deployed or plans to deploy 55, 165, and 276 thousand SMs respectively. However, exact information on how many SMs were deployed in each year is missing. That is why we have evenly divided the total number of SMs deployed in each period by a single year unit.

Diffusion activity was also identified in a privately held VKG Elektrivõrgud OÜ with a market share of 4 percent. Unfortunately, the information available proved to be untrustworthy, unclear, and contradictory. VKG Elektrivõrgud did not present any information about SM deployed. On the one hand, data was found on information portal Smart Grid Information Clearing House[2] which states a 35 thousand SM deployed by VKG Elektrivõrgud which actually equals to the total number of VKG's customers/meters. On the other hand, the supplier of this solution ADD Group[3] official admits only approximately 18 thousand SM implemented in Estonia, which is contradictory to the first source. For these reasons we do not include VKG Elektrivõrgud smart meter activity in the diffusion curve however we acknowledge this activity.

[1] ESMA mentions year 2013 and SmartRegions mentions year 2017 as the year of rollout accomplishment.
[2] http://www.sgiclearinghouse.org/Europe?voc_28=All&submit=Apply
[3] http://www.addgrup.com/implementations-en/

All in all, in our study Estonia exhibits the highest percentage share of smart meters out of total electricity meters implemented in CEE until 2010. Based on the current plans and predictions Estonia will reach close to 73 percent coverage diffusion rate in 2017 which makes it realistic to reach the EU's objective of 80 percent coverage until 2020. For detailed results[1] see the Figure 13.



	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Cummulative (k)	3,438	6,875	10,31	13,75	17,18	20,62	24,06	27,50	30,93	34,37	37,81	41,25	44,68	48,12	51,56	55,00	110	165	220	289	358	427	496
SM Deployed (k)	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	55	55	55	69	69	69	69
% of Total Meters	0,51%	1,01%	1,52%	2,02%	2,53%	3,03%	3,54%	4,04%	4,55%	5,06%	5,56%	6,07%	6,57%	7,08%	7,58%	8,09%	16,18	24,26	32,35	42,50	52,65	62,79	72,94

Figure 13 Smart meter diffusion in Estonia

3.2.4 Hungary

From a regulatory perspective, Hungarian Energy Office (HEO) and the government are two institutions actively dealing with smart metering in Hungary. HEO (2010) is the leading regulatory body responsible for preparing SM regulation. With the financial support of the World Bank, HEO has initiated a consortium with two private consulting firms Force Motrice and A.T.

[1] The units are in thousands (k).

Kearney in 2009. The goal was to deliver a study which analysis the possibilities of introduction of smart metering in Hungary (CBA[1]) and the results were published in June 2010 (Force Motrice; A.T. Kearney). Initiated by the World Bank, an additional requirement was to delivery generally applicable results so the findings may be shared and utilized internationally. We would like to use the Hungarian in-depth study to illustrate structural, organizational and managerial complexity resulting from the discussed industry shift towards intelligent electricity grid.

The consulting firms considered environmental factors by STEEP analysis; quantified costs and benefits of smart metering by CBA analysis; presented four different SM operation models, three different rollout scenarios; and prepared time schedule until the benchmark year 2020. Before presenting the final recommendations, let us observe several crucial details which enable us to understand managerial issues relevant not only to the Hungarian case.

Depending on the speed of smart meter rollout three rollout schedules were considered: fast, balanced, and delayed rollout. Next, four models of how smart metering can be operationally organized within the new and restructured value chain were considered. Major findings, benefits and hindrances of each model are discussed below based on quantitative analysis and international benchmarks (Force Motrice; A.T. Kearney, 2010, pp. 64-74).

1. DSO Basic Model

This model resembles the current situation in majority of countries where DSOs handle electricity and gas metering systems separately and

[1] Understood in the sense of Directive 2009/72/EC as the official cost benefit analysis.

independently. Rollout scenario of SMs under this market model resulted in the following: high initial costs due to sunk costs and duplication of SM systems; increasing benefit gains alongside the growing SM coverage; and payback time of SM rollout during the 10 year-plan on national level. However, the payback time for cluster “industry players” does not occur even in the 10th and last year of the SM rollout plan.

2. DSO Cooperation Model

Under this model, DSOs cooperate together on SM deployment which leads to better utilization of resources and lower costs. The DSOs would achieve this by developing joined operation and communication solutions, which are assumed to limit the number of duplicated systems, and facilitate information, cost and risk sharing.

3. Central SM Operator Model

The pattern behind the SM operator model resides in establishing one central company responsible for the whole country which performs all data acquisition and service activities related to smart metering. Despite the substantial cost and operational benefits a strong caution was raised against this model. High concentration of power would create a monopolistic institution which would require a considerable regulatory supervision by the state and would hence impose further substantial costs.

4. Area SM Operator Model

The final model recommends establishing several SM operators operating across the country thus avoiding the problem of centralization of power in one institution. The model calculated with three different SM data centres therefore the investment requirements and operational costs increased, however total benefits also increased.

In summary, the study presents the following three main recommendations which result in the highest returns and benefits (Force Motrice; A.T. Kearney, 2010):

1. Implementation of area smart metering data acquisition and service company model (abbr. Area SM Operator Model)
2. Implementation of quick rollout scenario at national level
   - Coverage of target groups with SMs within five years of the time of decision, however not exceeding 70% total coverage to reach positive benefits and returns (p.76).
3. SMs are owned, installed, operated, maintained, and inspected by DSOs.
4. Assessment of “smart metering fee” paid by the end customers to the industry stakeholders (DSOs, SM operators) for financing additional SM costs during the rollout period (p.80).

The discussion above on various SM market models illustrates through how large evaluation process each country has to go before taking a resolute stance towards mass deployment of smart meters. Various market models discussed above also confirm our earlier argument that smart meters are a *systemic innovation*. As proved on the Hungarian CBA there is a need for considerable systemic reorganization in order to reach maximum benefits for most of the SM stakeholders.

Finally, we come to present the actual diffusion rates of smart meters in Hungary. The only identified utility to carry out pilot projects was E.ON

Hungaria[1] with approximately 40 percent share of all electricity metering points in Hungary (Force Motrice; A.T. Kearney, 2010, p. 58). Landis & Gyr provided AMM solution for E.ON's first SM deployment of 19 thousand meters between the years 2006-2008 (Landis+Gyr, 2008). Information about E.ON's second SM deployment plan on 9 thousand meters between the years 2010-2012 was obtained directly from E.ON Hugaria representative in an email interview (László, 2011). No activity was recognized for the years 2009-2010. See the final diffusion chart in the figure below.

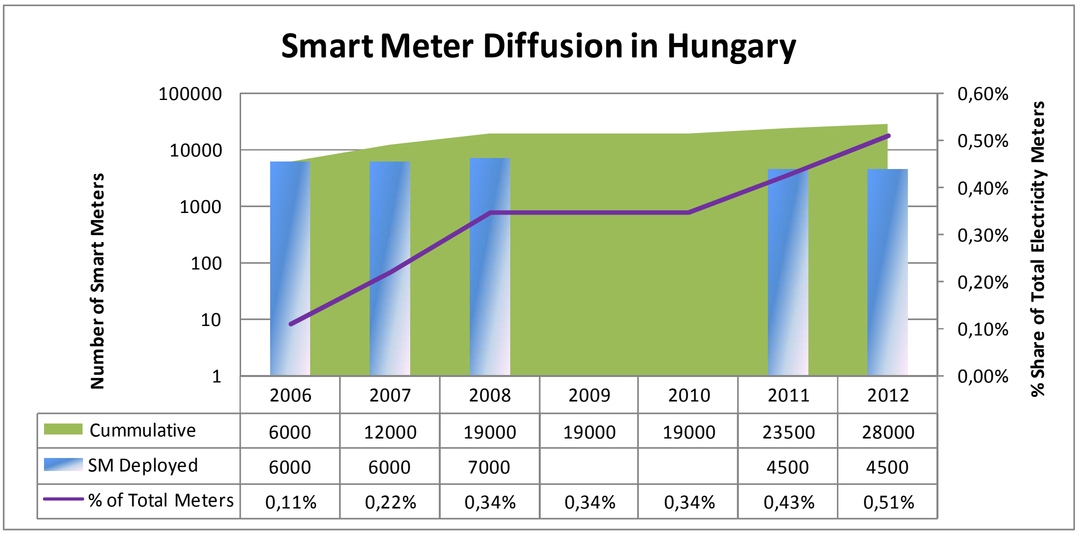


Figure 14 Smart meter diffusion in Hungary

3.2.5 Latvia

Latvia can be characterized by relatively high penetration of advanced meter reading (AMR) technology (Renner, et al., 2011, p. 56). However, majority of the AMR users are industrial customers with connected load of 100 kW and

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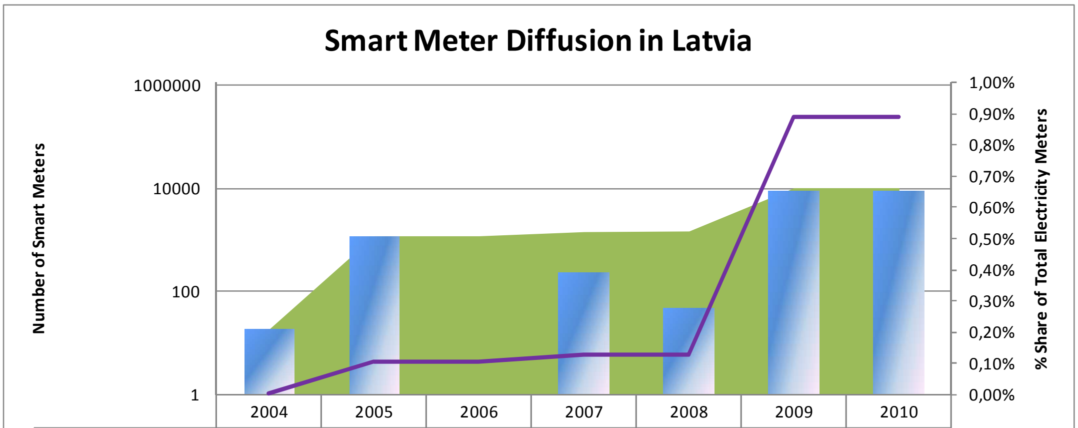
[1] E.ON Hungaria currently handles approx. 2,2 million metering points under its three DSO companies: E.ON Dél-dunántúli Áramszolgáltató, E.ON Tiszántúli Áramszolgáltató, E.ON Észak-magyarországi Áramszolgáltató

more. The ratio between industrial users and household users of AMR is 7:3, respectively. The data available about deployed AMR meters are characterized as pilot projects carried out by the dominant distribution system operator AS Sadales Tikls (2011) which covers 99 percent of Latvian territory. Interestingly, residential customers read their electricity meters and pay for the bills on monthly basis (European Smart Metering Alliance, 2010, p. 21) therefore are required to monitor their consumption cautiously. Prior to the SM rollout in this segment, such practice is a good prerequisite for realizing the expected SM benefits for end consumers, such as active participation, demand shifting, and cost savings.

DSO company AS Sadales Tikls is a direct subsidy of Latvenergo, which is 100 percent owned by Latvian state (Energy in Central and Eastern Europe, 2011). The Latvian energy market is very concentrated with over 90 percent of total energy generated by Latvenergo. Official SM cost benefit analysis has not been carried out, and neither policy nor legal requirements have been adopted (ERGEG, ESMA, SmartRegions). The following figure represents the identified smart metering diffusion in Latvia.



	2004	2005	2006	2007	2008	2009	2010
Cummulative	18	1168	1168	1392	1437	10000	10000
SM Deployed	18	1150		224	45	8563	8563
% of Total Meters	0,0016%	0,1036%	0,1036%	0,1235%	0,1274%	0,8869%	0,8869%

Figure 15 Smart meter diffusion in Latvia

3.2.6 Lithuania

Lithuania is currently characterized as a “laggard” country (Renner, et al., 2011, p. 13) with a very limited preparation or implementation of smart metering. We may seek the reasons of this situation in the objectives drafted in Lithuania’s National Energy Strategy plan (2010). The Government of the Republic of Lithuania has set three energy-related priorities in the mentioned document: (1) independence, (2) competitiveness, and (3) sustainability, which are planned to be achieved during the years 2020, 2030 and 2050 respectively.

As implied in the objectives, the major energy priority of Lithuania is integration of its national power system to the pan-European electricity network. This includes, for example, power links to Poland and Sweden which diversifies Lithuania’s power supply and ensures stable prices and secure supply (Government of the Republic of Lithuania, 2010, p. 6). The second priority focuses on reforming the monopolistic structures of power markets in Lithuania. Market competition is recognized as a mean to achieve lower energy prices and modernize gaining energy infrastructure. Finally, the last priority is associated with energy efficiency and sustainability. Lithuania expects “breakthrough technologies” to be established by the year 2050, and until then it plans to monitor their development and support the ones economically viable (p.6). The last objective underlines Lithuania’s “laggard” position, their waiting stance, and major focus on other issues. However, smart grid technologies and their utilization are seen as means to achieve energy efficiency goals (p.18) and systemic balancing of power generation (p.41) *already* from the year 2020 onward.

Regarding the smart metering activities in Lithuania, only one pilot project was identified. Lietuvos Energija[1], Lithuanian TSO in cooperation with Enica, UK based metering and energy consulting provider, plans to deploy 5 thousand SMs over a 4-year period (Enica, 2010). This plan is visualized in proportion to the total electricity meters in Lithuania in the figure below.

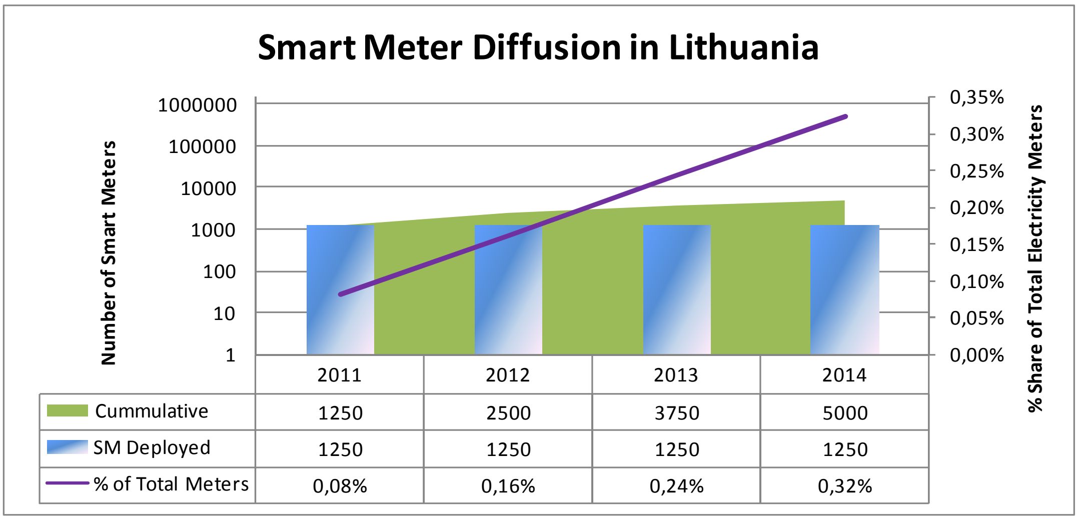


Figure 16 Smart meter diffusion in Lithuania

3.2.7 Poland

Activities related to smart metering in Poland may be characterized by a triple helix strategy. Three major institutional bodies are seen as the main drivers of implementing the nationwide smart grid project: 1. Science, 2. Governmental administration, and 3. Energy industry. This innovation strategy was clearly demonstrated by international conference on smart grids and the improvement of energy efficiency held in Wroclaw last year (Energy Regulatory Office, 2010).

[1] Owned by Government of Lithuania from 96,5 percent (Energy in Central & Eastern Europe, 2011)

Poland demonstrates strong ambitions to modernize its energy sector by multiple initiatives. To start with, Polish Energy Regulatory Office (2008) has initiated a feasibility study which assesses technical, cost, legal and socio-economic issues of smart metering in Poland. Next, declaration concerning introduction of smart metering in Poland was signed by multiple bodies, specifically Energy Regulator, Consumer's Federation, The Polish National Energy Conservation Agency, and others representing the three helices – academia, business, and government (Woszczyk, 2009). Another declaration[1] signed by ERO[2]'s (2010) president outlines four strategic areas, among others advanced automation of power systems, energy partnerships, and civil popularization of innovative energy solutions. Additionally, "Consortium Smart Grids Poland" was signed by scientific and economic institutions to declare establishment of an organization devoted to smart grid development in Poland (Energy Regulatory Office, 2010). Next, a study on implementation of electricity smart metering in Poland was carried out and led by Energy Institute Gdansk [3] during 2010 (Instytut Energetyki Oddział Gdańsk, 2010). The last two initiatives were prepared by Polish TSO, PSE-Operator S.A. The first included the creation of smart metering information platform piio.pl (2010), and the second studied the demand side response (DSR) of smart metering (Platforma Informacyjna Inteligentnego Opomiarowania, 2009). High intensity of smart metering activities in Poland has been confirmed by the Council of Ministers who adopted Energy Policy of Poland until 2030 which outlines strategy for smart metering on national level (Ministry of Economy, 2009).

Before presenting diffusion rates of SMs in Poland, ownership structure of the identified adopters (DSOs) have to be clarified. Specifically, multi-oriented

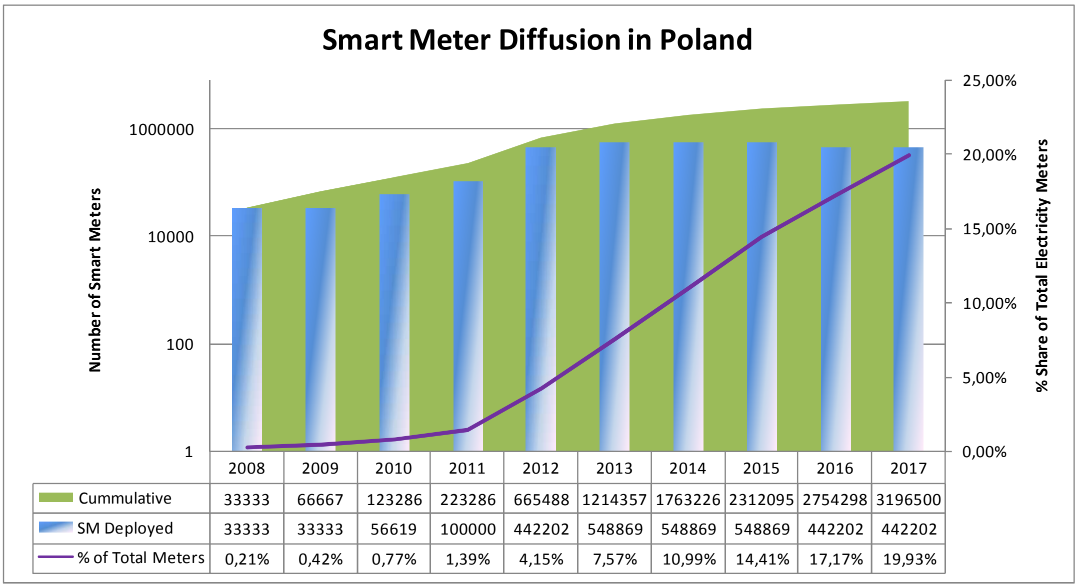
[1] "Declaration of Creating the National Technological Energy Platform for Energy"
[2] Energy Regulatory Office
[3] Other institutions involved were Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej , and Ernst&Young Business Advisory. The study included also a managerial report however published only in Polish language.

Tauron Group[1] (2011), in which the State Treasury holds 30,06 percent, has among others two distribution companies, EnergiaPro and Enion. In both of them Tauron Group holds 85 percent of the shares and additional 0,8 percent is held directly by the State Treasury in Enion (Enion - Grupa Tauron, 2008). Therefore, the percentage controlled by state equals to 26,01 percent in EnergaPro and 26,81 percent in Enion. By the same token, the State Treasury controls 84,19 percent of Energa SA[2] (Energa SA, 2010). Energa SA owns 85,06 percent of a distribution company Energa Operator (2010) and in addition State Treasury holds an additional 14,55 percent directly. As a result, the state directly controls 87 percent of Energa Operator. The last DSO in our focus is RWE Stoen Operator, which is a direct subsidy of RWE Aktienengesellschaft, and responsible for energy distribution in Warsaw and its surroundings. The ownership structure of RWE Aktienengesellschaft (Bureau van Dijk, 2011) revels ownership stakes held by governments of Norway, Sweden, and France totalling to 1,57 percent, the rest being privately owned.

The four companies discussed above are active adopters of smart meters in Poland. First, Energa Operator presents its advanced metering infrastructure (AMI) project which started in 2010 with deployment of 16786 SMs for industrial recipients (Czyzewski, 2010). The project is divided into nine stages with the expected completion in 2017. In the first stage 100 thousand SMs are planned to be deployed in the cities of Hel, Kalisz and Drawsko Pomorskie region until 2011. From then on, Energa moves to a full rollout of smart meters for the rest of its 2 653 214[3] customers until 2017. Second, Enea Operator has deployed 5,5 thousand SMs for industrial clients and 1 thousand for individual clients during 2010 (Zaleski, 2011). Third, EnergiaPro

[1] Energy supplier in the southern region
[2] Energy supplier in the central north region
[3] Total number of Energa's customers is 2,77 millions (Energa Operator, 2011). We excluded the customers already equipped with SM to reach the remaining customer base.

first experiments with trial pilot project with 20 thousand SMs for individuals between the years 2010-2012. During the subsequent years of 2013-2015 EnergiaPro plans to equip 20 percent[1] of its 1,6 million customers by smart meters (Renner, et al., 2011, p. 70). Last, until 2010[2] RWE Stoen Operator equipped 100 thousand of its 870 thousand customers in Warsaw with SMs which enables them to monitor electricity consumption in real time via the Internet (RWE, 2008, p. 9). The figure below summarizes the diffusion activity in Poland.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cummulative	33333	66667	123286	223286	665488	1214357	1763226	2312095	2754298	3196500
SM Deployed	33333	33333	56619	100000	442202	548869	548869	548869	442202	442202
% of Total Meters	0,21%	0,42%	0,77%	1,39%	4,15%	7,57%	10,99%	14,41%	17,17%	19,93%

Figure 17 Smart meter diffusion in Poland

3.2.8 Romania

Currently, there is no official smart metering policy, legal obligation or strategy adopted in Romania. Cost benefit analysis has not been carried out however

[1] 320 thousand customers
[2] Announced in RWE's Annual Report 2008, therefore we consider 2008 as starting and 2010 as finishing year of the SM deployment. The total of 100 thousand SMs was equally divided into the three-year period.

an important decision on nationwide SM rollout is expected in 2012. Furthermore, Romanian Energy Regulatory Authority (ANRE) carried out several initiatives facilitating smart metering in Romania. Some of the initiatives included defining electricity tariffs for domestic customers based on time-of-use (TOU), drafting out metering code, or defining the minimal set of facilities for each metering category (Renner, et al., 2011, p. 73).

The largest utility in Romania is Electrica S.A., which is a fully state-owned company with approximately 38 percent[1] of total electricity customers in the country. Among other major energy utilities active in Romania belong Enel, CEZ and E.ON however these did not embody or disclose any smart metering activity in the region. Renner et al. (2011, p. 74) present detailed data analysis[2] on smart metering evolution in Electrica S.A. Their data cover the time interval 2003-2008 in which 12 thousand SMs[3] were cumulatively deployed by the company. Electrica S.A. itself confirms 59 thousands smart meters deployed until 2011 (Electrica S.A., 2010; Renner, et al., p. 74). To reach the confirmed amount of SMs and due to the missing exact deployment values we distributed the missing 47 thousand SMs[4] equally between 2009 and 2010. The final figure of smart meter diffusion solely based on one utility in Romania can be found below.

[1] Electrica S.A. serves approximately 3million customers out of 8 million (ESMA, 2009, p.23)
[2] Renner et al. cross-reference the following conference paper which we were unable to directly obtain: Apetrei, Albu, Silvas, & Federenciuc. *From AMR to AMI – Romanian Case*, Conference on Electricity Distribution of Serbia and Montenegro, September 26 - October 1, 2010.
[3] Advanced smart meters that support AMI and AMR technology were included.
[4] The difference between known values for 2008 and 2011 is

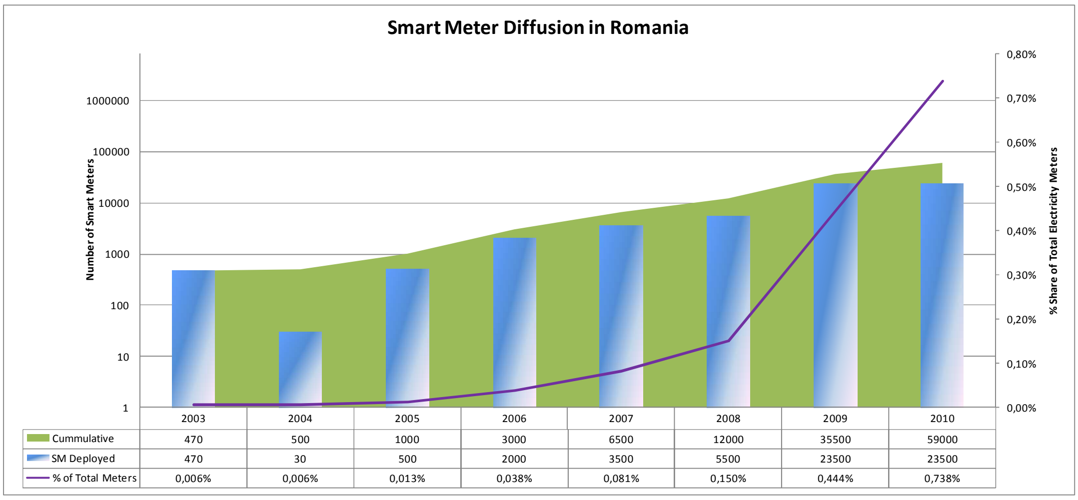


Figure 18 Smart meter diffusion in Romania

3.2.9 Slovak Republic

In Slovakia, two economic analyses[1] were identified evaluating costs and benefits of smart metering rollout for residential and small business customers. The first was carried out by distribution company Vychodoslovenska Distribucna a.s. (VSDS)[2], which is a strategic partner of RWE Group. The company's spokesperson (Danihelova, 2010) commented the initial results of the study as highly uneconomical and counterproductive for customers due to high initial cost of meters and communication systems which strongly outweighed the benefits. The spokesperson has pointed out that a mass rollout of SMs residential customers could lead to an increase in electricity price. However, Danihelova (2010) adds VSDS operates SMs[3] for large industrial customers and businesses up to 150 kilovolts for several years. The second study was carried out by DSO for western region[4] Zapadoslovenska Energetika a.s. (ZSE), a daughter company of E.ON AG.

[1] Not understood as the official cost benefit analysis according to Directive 2009/72/EC
[2] Operates in Kosice, Presov, and part of Banska Bystrica
[3] Older types of advanced meters are not necessarily "smart", lacking two-way communication, etc.
4 Operates in Bratislava, Nitra, and Trnava

While the results were still unknown the head of communications (Kimijan, 2010) universally commented that if positively assessed at least 80 percent of households should be equipped with smart meters until 2020. This is however a general requirement imbedded in Directive 2009/72/EC (European Parliament, 2009) and the company did not embody their initiative in any physical SM deployment. As the previous DSO, ZSE only states it implements smart meters for industrial customers which it has been doing since 2003.

In contrast, the last major DSO which did not carry out publicly any economic study of SM deployment for residential and small business customers proved to be the most active. Stredoslovenska Energetika a.s. (SSE)[1], a member of EdF Group, started to yearly buy and deploy 40 thousand SMs from 2009. As the communication director pointed out (Žatková, 2010), the SM installations are implemented especially for newly connected users as well as in cases of old meter replacements.

Official plans, policies, legislation or strategic decisions or initiatives regarding smart metering implementation in Slovakia were not identified. However, since the Slovak Republic controls tight majority[2] in all the major DSOs discussed above the state has the potential to influence further directions of smart metering in Slovakia.

1 Operates in Banska Bystrica, Trencin, and Zilina

[2] 51 percent of VSDS, ZSE, and SSE is controlled by Governmental Fund of the Slovak Republic

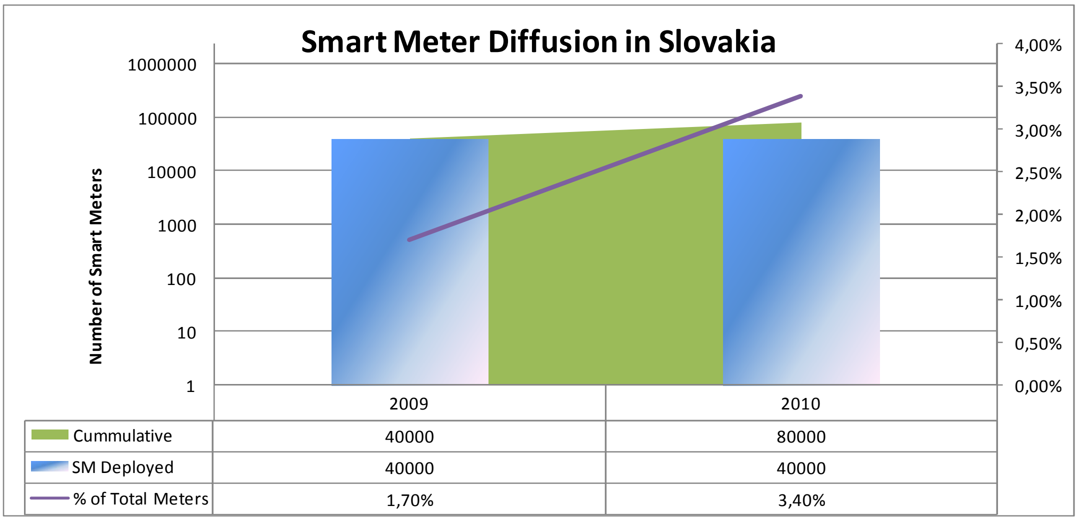


Figure 19 Smart meter diffusion in Slovakia

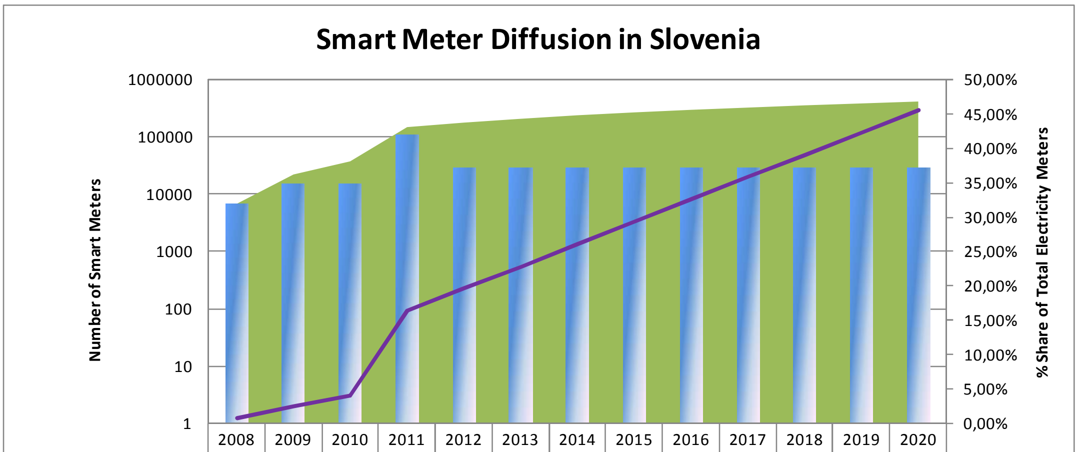
3.2.10 Slovenia

Two large scale assessments of smart metering rollout for residential and small business customers in Slovenia were carried out by the Milan Vidmar Electric Power Research Institute (EIMV). The first analysis worked with a nationwide AMI rollout scenario which assumed a harmonization of systems controlled by country's five DSOs[1]. As a result, multiple benefits, such as detection of power outages, accurate monthly billing or accurate consumption planning were identified and the payback time was calculated to be 11 years. The second analysis was carried out by EIMV for central Electricity Distribution System Operator (SODO) with positive macroeconomic implications of mass SM rollout in 2010 (Renner, et al., 2011, p. 79).

The first identified smart metering project was carried out by the largest Slovenian DSO Elektro Ljubljana. In 2008, the company had introduced a SM solution introducing new services and dynamic pricing for first 6,6 thousand

[1] Elektro Gorenjska, Elektro Celje, Elektro Ljubljana, Elektro Maribor, Elektro Primorska

customers. Due to the success of the pilot project, additional 30 thousand customers were equipped with smart meter by mid 2010 (Landis+Gyr, 2010). The company further states it will comply with EU's smart metering directive and cover all its 325 thousand[1] customers by 2020. The second major smart metering project was announced by Elektro Gorenjska which covers all of its 80 thousand customers by smart meters in 2011 (Renner, et al., 2011, p. 79). The actual and planned SM deployment in Slovenia is visualized in the Figure 20 Diffusion of smart meters in SloveniaFigure 20 below.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cummulative	6600	21600	36600	145440	174280	203120	231960	260800	289640	318480	347320	376160	405000
SM Deployed	6600	15000	15000	108840	28840	28840	28840	28840	28840	28840	28840	28840	28840
% of Total Meters	0,74%	2,43%	4,11%	16,34%	19,58%	22,82%	26,06%	29,30%	32,54%	35,78%	39,02%	42,27%	45,51%

Figure 20 Diffusion of smart meters in Slovenia

3.3 Data validation and benchmarking

The current section presents findings on smart metering in three significantly different European regions and countries in order to validate and test the methodology applied. Italy, France, and Finland are three countries drawn from the segment of dynamic movers, according to the SmartRegions study

[1] To comply with its plan Elektro Ljubljana has to equip its remaining 288 400 customers with smart meters by 2020. Therefore, the remaining amount of SMs to be deployed was equally divided into the remaining 10-year period.

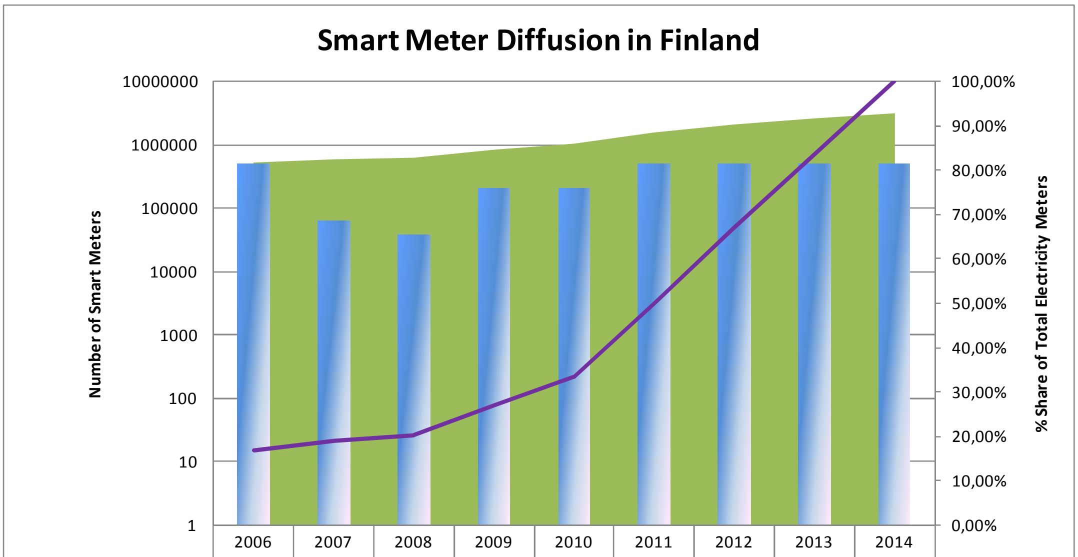
(Renner, et al., 2011, p. 1). Furthermore, the three different countries represent three different electricity regions according to the Electricity Regional Initiative (ERI), as discussed in introductory part of the work. Italy represents Central-South region, Finland represents Nordic region, and France belongs France-UK-Ireland region.

3.3.1 Finland

Representing the Nordic region, Finland has been taking the leadership role in smart meter implementation. From legal perspective, Finland has anchored SM diffusion in recently amended Electricity Market Act (66/2009[1]) which requires almost full smart meter penetration by January 2014 (ESMA, pp. 11-12).

Data for the aggregated chart on SM diffusion in Finland was constructed according to four identified benchmarks. First, the ECEEE[2] conference proceeding paper on comparative analysis of smart metering in Europe states there are over 500 thousand AMR meters in Finland in 2006 (Morch, Parsons, & Kester, 2007, p. 196). Second, according to industry specific information platform (smartmeters.com, 2009) out of approximately 3 million households 20 percent[3] were equipped with smart meter in 2008. Third mark is mentioned by Renner et al. (2011, p. 32) in SmartRegions report which states diffusion rate of over 1 million by the year 2010. Final diffusion benchmark is set by the above mentioned regulatory act (Electricity Market Act, 66/2009) which mandates full scale implementation until January 2014. For graphical illustration, refer to the Figure 21 below.

[1] Valtioneuvoston asetus sähköntoimitusten selvityksestä ja mittauksesta
[2] European Council for Energy Efficient Economy
[3] Approximately 600 000 households were equipped with SM in 2008.



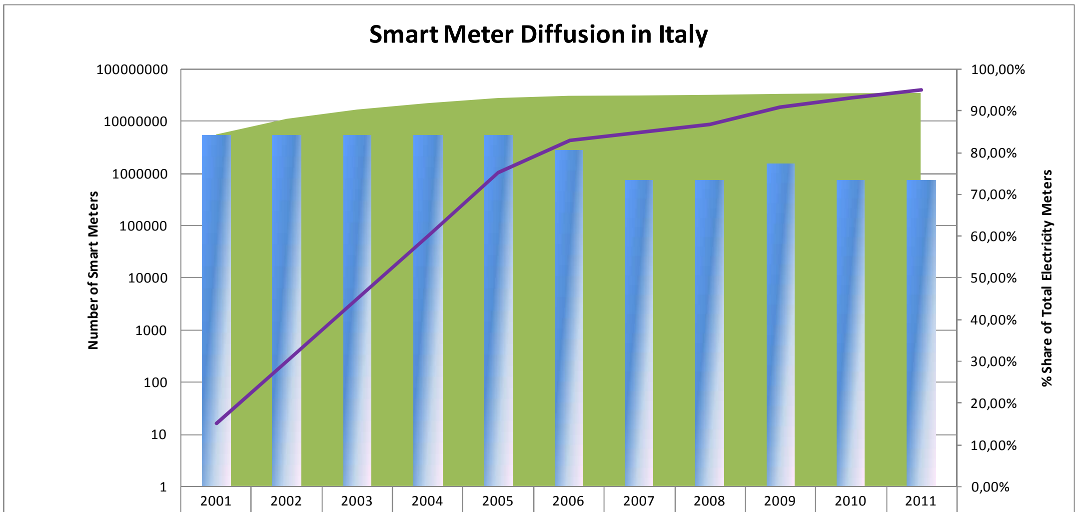
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cummulative	500000	563000	600000	800000	1000000	1500000	2000000	2500000	3000000
SM Deployed	500000	63000	37000	200000	200000	500000	500000	500000	500000
% of Total Meters	16,67%	18,77%	20%	27%	33%	50%	67%	83%	100%

Figure 21 Smart meter diffusion in Finland

3.3.2 Italy

Italy is one of the first movers who has adopted smart meters in very rapid pace. Enel SpA is Italy's largest power utility with close to 90 percent market share and 32 million customers (Enel, 2011). With its Telegestore project Enel debuted as the world's first utility deploying smart meters in 2001 (Van Gerwen, Saskia, & Wilhite, 2006, p. 6). Between the years 2001-2006 Enel had managed to equip over 80 percent of its customer base with smart meters (Rogai, 2006). Currently, all of Enel's 32 million customers belong to their smart metering system (Enel, 2011). The company has implemented hourly based tariff system which enables one of the core benefits of SM – development of new services matching customer needs (Enel, 2011). Other benefits resulting from the deployment mentioned by Enel are demand side management, operating cost savings, peak shaving, savings in billing, and invoices on real consumption (Rogai, 2006, p. 20).

In 2009, Italian third largest electricity distributor Acea Distribuzione significantly contributed to SM diffusion by rolling out 1,5 million smart meters in 2009 (ESMA, 2010, p.84). Renner et al. (2011, p. 5) predict 95 percent penetration of smart meters by the end of 2011. Due to the lack of exact data for each year, we estimated the diffusion rates for the years 2007, 2008, 2010 and 2011 in order to meet the 95 percent diffusion prediction[1]. For the final chart depicting SM diffusion in Italy, refer to the figure below.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cummulative	5400000	10800000	16200000	21600000	27000000	29800000	30525000	31250000	32750000	33475000	34200000
SM Deployed	5400000	5400000	5400000	5400000	5400000	2800000	725000	725000	1500000	725000	725000
% of Total Meters	15,00%	30,00%	45,00%	60,00%	75,00%	82,78%	84,79%	86,81%	90,97%	92,99%	95,00%

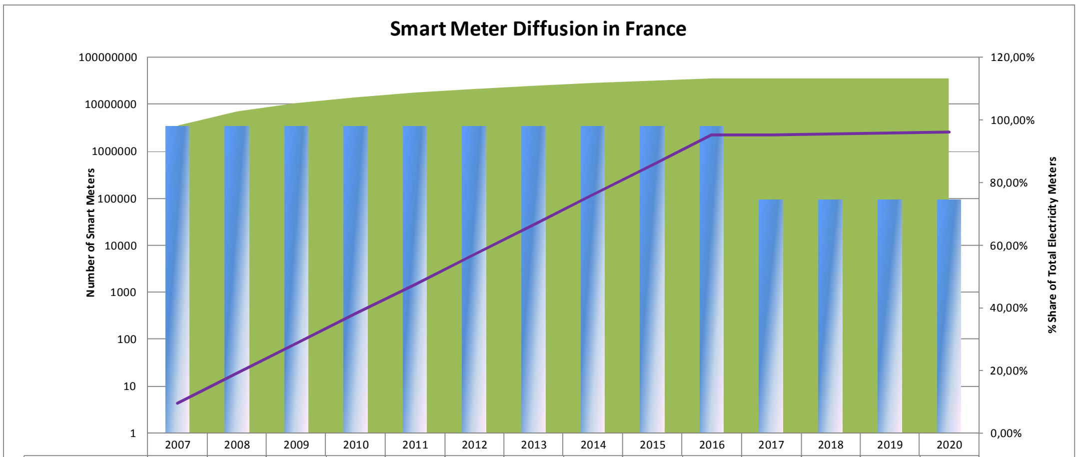
Figure 22 Smart meter diffusion in Italy

3.3.3 France

The market leader of electricity distribution in France is ERDF with a market share of 95 percent and 34 million customers. Based on the survey and recommendation of French Energy Regulation Commission (2009, p. 73),

[1] Data was available until the year 2006 (29,8 million SM cumulatively deployed by Enel). In 2009 Acea Distribuzione rolled out 1,5 million SM. The prediction for 2011 is 95 percent which equals to 34,2 million SM. The difference between sum of known values (2006, 2009) and the final predicted value (2011) equaled to 2,9 million SM. This value was equally divided into the missing years (2007, 2008, 2010, and 2011) to match the prediction.

ERDF started to install smart meters from 2007 and plans to cover its entire customer base until 2016. Due to lack of exact rollout numbers of SM for each year, the 34 million SM to be installed were equally divided into the stated 10 year period (2007-2016). Furthermore, ESMA (p.12) states France aims for an overall SM coverage of 96 percent by 2020. These values are visually presented in the figure below.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cummulative	3400000	6800000	10200000	13600000	17000000	20400000	23800000	27200000	30600000	34000000	34089474	34178947	34268421	34357895
SM Deployed	3400000	3400000	3400000	3400000	3400000	3400000	3400000	3400000	3400000	3400000	89474	89474	89474	89474
% of Total Meters	9,50%	19,00%	28,50%	38,00%	47,50%	57,00%	66,50%	76,00%	85,50%	95,00%	95,25%	95,50%	95,75%	96,00%

Figure 23 Diffusion of smart meters in France

3.3.4 Smart metering benefits in CEE, France, Italy and Finland

In the theoretical section (2.2.7) we discussed general benefits of smart meter implementation. The current section presents country specific benefits identified for each country sample. Exceptions are Latvia and Slovakia for which no coherent expressed SM benefits were identified. In addition, for comparability reasons we present benefits stated by the dynamic movers segment. The following official sources were utilized to identify nationwide smart metering benefits: national energy strategy plans, smart grid/smart metering reports (ESMA, ERGEG, SmartRegions); energy regulators' annual reports; state information platforms.

Table 12 Smart metering benefits in Central East Europe, France, Italy and Finland

Benefit/Driver	BG	CZ	EE	HU	LV	LT	PL	RO	SK	SL	IT	FR	FI
Lower costs for meter readings				x			x			x			
Possibility for Demand Side Management (DSM)							x			x		x	x
Combined automated meter reading for electricity, gas, water and heat	x									x			
Possibility for better information of customers about their consumption	x			x						x	x	x	x
Possibility of accurate monthly billing	x			x						x		x	x
Accurate data enables more cost efficient distribution system planning	x			x		x	x			x		x	x
Faster detection of power outages	x									x		x	
Easier integration of distributed generation										x			
Lower administrative costs and efficient supplier switching		x		x			x			x			
More accurate consumption planning										x			
Promotion of energy efficiency and energy savings	x	x	x	x		x	x	x			x	x	
Political, Comply with EU regulation		x		x			x				x		
Sales-related potentials to promote competition				x			x				x		x
Energy security							x				x	x	x
Theft and debt management	x										x	x	

From the table above it is notable that the main benefit recognized by majority of countries is the energy efficiency and energy savings which is both an environmental and economic driven benefit. Energy efficiency contributes to, for example lower CO_2 emissions, and energy savings contributes to consumers' economic well-being. The second most referred to benefit relates to cost savings on distributors' side derived from accurate data handling. The third most recognized benefit is improving the customers' knowledge on energy consumption. On the opposite end, the least referred to benefits are integration of distributed energy, more accurate consumption planning, and combining automated meter reading for electricity, gas, water and heat. Although important, the less referred to benefits are not as critical as, for example empowering consumers or increasing efficiency of energy distribution.

3.4 The diffusion of smart meters in CEE

After the detailed discussion on smart metering diffusion process in each country sample we are able to synthesize the information and attempt to answer the second research question: "How are smart meters diffused in Central East Europe?"

First of all, let us present descriptive statistics to enhance data analysis and interpretation. The total population of the CEE sample equals to approximately 20,43 percent[1] of total population of the European Union. Representing one fifth of EU-27 population denotes underlying importance of this geographical region. Furthermore, total number of electricity meters in CEE equals to approximately 47,8 million and according to the EU's 2020 strategy, 80 percent of these should be smart. Again, approximately 38,3 million electricity meters is a significant market size for potential smart meter manufacturers, related service providers, electricity retailers or any other relevant actors. For specific data see the table below.

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[1] By 1 January, 2009 population of EU-27 reached 499,8 million (Marcu, 2009)

Table 13 Population and electricity meters in Central East Europe

Total Electricity Meters in CEE	47 812 537
Total CEE Population	102126104
Share of Meters	0,468171556
Approx. % of Total	46,82%

All diffusion rates combined together constitute our final diffusion chart present in Figure 25. The timeline spans across twenty five years (1995-2020) for which smart meter diffusion rates were identified and reaches 11,04 percent[1] adoption rate by 2020. On a first sight we observe very low activity in terms of SM percentage share of total electricity meters during the first thirteen years (1995-2007). Most of the diffusion activity was done by Estonia which actually carried out the entire diffusion during 1995-2003 alone. Later on, Romania (2003), Latvia (2004), and the Czech Republic (2006) carried out the first adoptions of smart meters. The year 2008 sees the first recognisable uplift of the percentage share curve when Hungary, Slovenia and mainly Poland began with smart meter adoption. Finally, year 2010 sees a major uplift shift from which all except Lithuania (2011) diffuse smart meters. The rapid uplift sees a slowdown in 2017 however this is mainly due to a limited long term planning and not yet revealed diffusion data by the adopters. From 2018-2020 only Slovenia and Bulgaria reveal their smart meter diffusion plans.

In addition to the total diffusion curve observable from cumulative percentage[2] in the Figure 25 we have added each country's cumulative percentages of smart meters diffused out of total electricity meters in Central East Europe. This comparison enables us to see each country's contribution to currently

[1] See Appendix II for detailed information
[2] In the Figure 25 labeled as % of Total Electricity Meters in CEE

revealed total diffusion rate. Yet, a clear limitation of using such comparison arises due to lack of diffusion data equally revealed for all countries and years. However, several indications emerge, especially these related to each country's market size. Out of the 11,04 percent of total diffusion identified until 2020 Poland takes 6,7 percent share. Compared to the rest of the sample Poland stands out as an outlier and we acknowledge two reasons for this. First, Poland has revealed relatively clear and long term plans for SM deployment. Second and most important, it is the largest country by population and number of electricity meters in our CEE sample. In fact, Poland's total number of electricity meters alone represents 33,6 percent of the total CEE electricity meter market. In the **Error! Reference source not found.** we want to point out the large differences in market sizes among the CEE sample which affect the perception of total diffusion in the whole region. The implication of this is that even a relatively high diffusion activity in, for example Estonia has a relatively small impact on the diffusion in the whole CEE region due to its small market size. For comparison of electricity meter market sizes see the figure below.

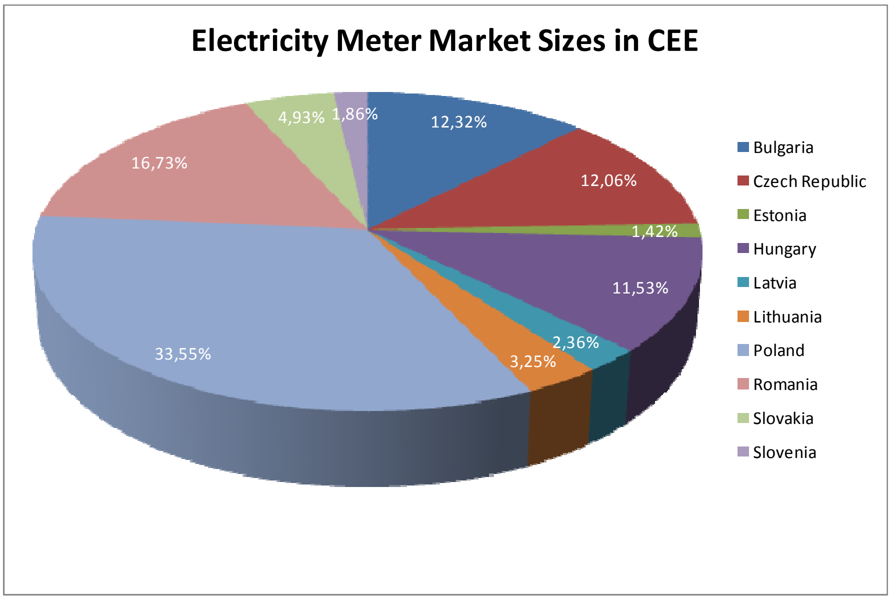

Figure 24 Electricity meter market sizes in Central East Europe

Overall, the total diffusion curve reveals total adoption rate of 11,04 percent by 2020. As discussed above, the EU's 2020 strategy as well as 3rd Energy Package both promote and demand 80 percent of member states' electricity meters to be smart by 2020, where rollout positively assessed. Even though majority of the CEE countries have not carried out the cost benefit analysis yet, the rollout conditions are continuously improving by lower technology costs, established standards, international experience, etc. Therefore, if we assume the region's readiness for SM rollout it should reach 80 percent by 2020. In contrast, the current findings reveal only 11,04 percent of meters to be smart in CEE by 2020.

There are several explicit and implicit reasons behind the difference between optimal and actual smart meter diffusion rates. First, even though all data present in this work originate from reliable and up-to-date sources, they are not primary. Therefore, some adopters' internal plans to rollout smart meters or carry out pilot tests could have remained unidentified, thus were not included in our data sets. Second, the validation and benchmarking against the dynamic movers have proved that CEE is largely behind in smart meter adoption. For example, the CEE's most advanced adopter in 2010 is Estonia with 8,09 percent adoption in contrast to, for example France who diffused close to 40 percent during the same time period. Third, compounded annual growth rate (CAGR) of smart meters identified in CEE equals to 32,6 percent between 1995-2020. Despite the already large growth rate percentage CAGR would have to equal to 43,1 percent to meet the EU's goal. From graphing out the growth rates (see in Appendix II) we observe an actual slowdown of diffusion from 2017 and a greatly widening gap between actual and optimal diffusion. This we explain by lack of revealed diffusion data due to large time horizon. However, with time and increasing number of adopters we believe the gap between optimal and actual diffusion rate will reduce. For overview of smart meter diffusion in Central East Europe refer to the figure below.

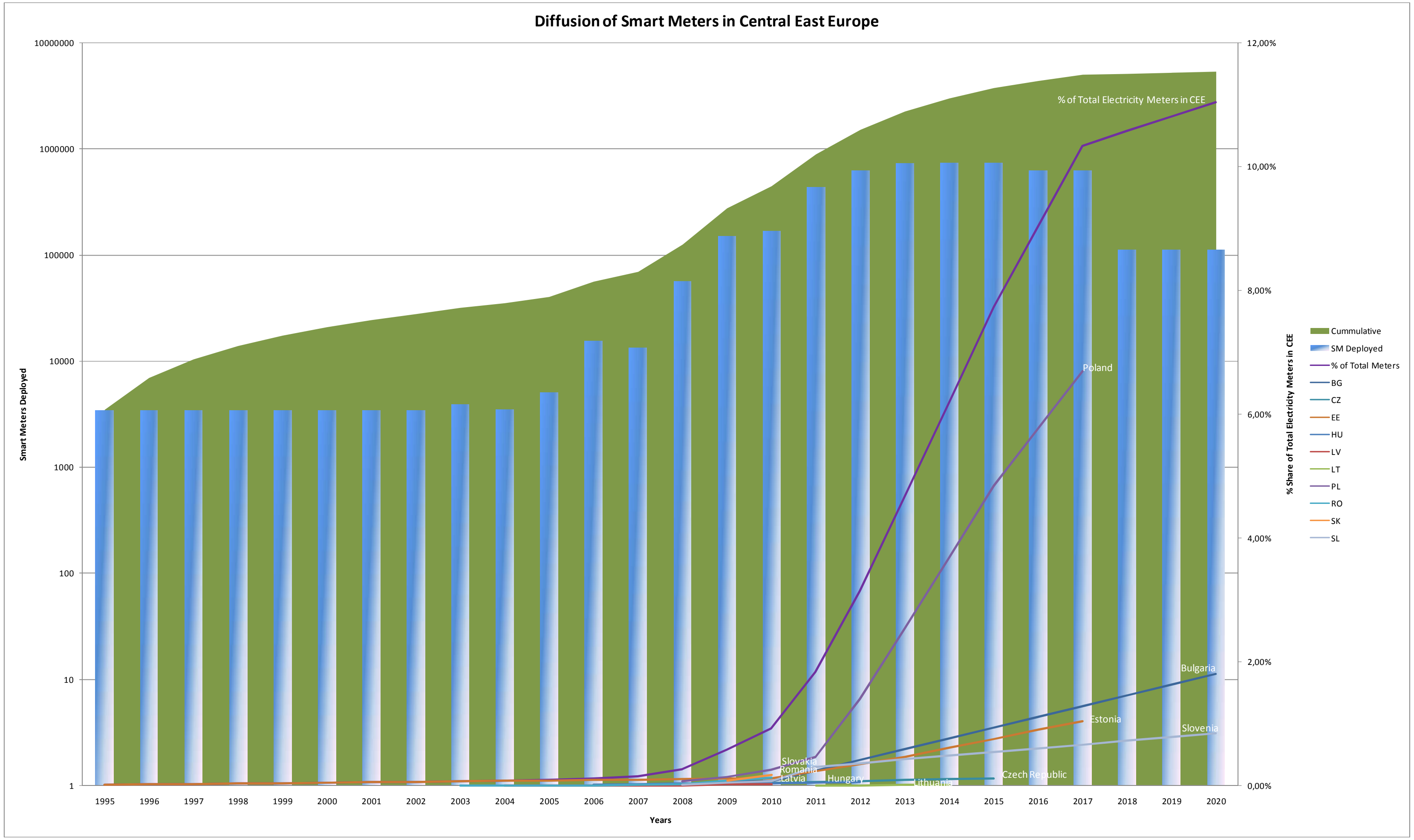

Figure 25 Diffusion of smart meters in Central East Europe

3.5 The drivers of smart meter diffusion in CEE

The current section presents discussion on the results of carried out thematic analysis which shall aid us in answering the third research question: “What are the major drivers of smart meter diffusion in Central East Europe?”

Let us start with summarized data on the three variables of interest: 1. *Activity* based on thematic analysis, 2. *Ownership structure* of actors who carry out activity, and 3. *Percentage of smart meters* out of total electricity meters in a country. The first variable represents an average of all activities identified in each country throughout the time. The second variable stands for average ownership structure of all actors behind each activity in a country. Finally, the third variable represents percentage of smart meters diffused in each country in 2010 (see the table below).

Table 14 Drivers of smart meter diffusion in CEE, France, Italy and Finland

Country	Country Code	Activity	State Control %	SM % of Total in 2010
Bulgaria	BG	3,8	52,40%	0,51%
Czech Republic	CZ	3,5	59,32%	0,33%
Estonia	EE	4	80,00%	8,09%
Hungary	HU	3,00	65,33%	0,34%
Latvia	LV	3,29	100,00%	0,89%
Lithuania	LT	2,33	98,83%	0,08%[1]
Poland	PL	2,65	78,43%	0,77%
Romania	RO	2,71	100,00%	0,74%
Slovakia	SK	3,67	59,17%	3,40%
Slovenia	SL	3,50	96,58%	4,11%
France	FR	2,17	89,17%	38,00%
Italy	IT	3,5	81,52%	92,99%
Finland	FI	3,4375	78,75%	33,33%

[1] Lithuania revealed its first smart meter diffusion rates only from 2011 therefore is omitted from comparative analysis when the measure SM % of Total is required.

The summarized data enable us to test several assumptions the study has worked with. First, the themes or activities were developed to reflect the gradual progress of smart meter diffusion in a market therefore the code 1-5 represents an ordinal number sequence. The five themes graded in ascending order were: initiative (1), regulation (2), cost benefit analysis (3), pilot project (4), and rollout (5). To test this logic we measured correlation coefficient between activities and percentage of smart meters diffused in 2010. Without measuring the significance, the result equalled to 0,628996[1] which denotes considerably positive linear relationship between the two. The implications are that CEE follows bottom-up gradual diffusion process from initiatives to rollouts to reach smart meter diffusion. Conversely, when the same correlation also included the validation country sample (France, Finland, Italy) the result lead to inconsequential 0,032812. The reason is that the validation countries have multiple times higher percentage of smart meters diffused which disrupts the linearity. When only the validation countries compared, the activity and percentage of smart meters diffused depict again positive relationship (0,474814). The implications resulting from this difference are that even though both of the segments (CEE and validation countries) follow bottom-up market diffusion logic, the validation countries diffuse much higher numbers of smart meters expressed as percentage shares of total electricity meters in each country.

Second, with the same correlation coefficient methodology we were able to uncover a negative linear relationship between state control and activities which equalled to -0,505606. The negative relationship denotes that activities in the bottom of the market are mostly lead by the state while the actual adoption of smart meters is carried out by less state controlled actors. However obvious this finding is, it signifies that electricity markets are opening up where state focuses on shaping the environment (initiatives, regulations)

[1] Lithuania was excluded due to missing data, as explained in footnote above.

though market level activities such as innovation diffusion (pilot projects, rollouts) offers space for private actors.

Third, no relationship was found between the state control and smart meter diffusion therefore we are not able to add findings to the general discussion on state control and innovation diffusion. Even though slightly negative relationship was found among the validation countries (-0,192386), it does not qualify for any statements or implications. Nevertheless, even though state controls over 50 percent of smart metering activities in all CEE countries, the Figure 26 enables us to recognize three different segments based on the state control dimension. The countries where state has the highest share of control in carried out smart metering activities are Slovenia, Latvia, Romania, and Lithuania[1]. On the further end where state is only slightly more active then private actors in smart metering activities are Bulgaria, the Czech Republic, Slovakia, and Hungary. In between are Poland and Estonia with approximately 80 percent state control.

Overall, thematic analysis and data on ownership structures of actors involved in the diffusion process enabled us to identify differences in diffusion process among individual countries. Large differences were identified in percentage of state control and in diffusion rates as of 2010. Furthermore, the validation countries enabled us to compare diffusion characteristics of CEE to market leaders and also validate the methodology applied. The figure below presents summary of drivers of smart meter diffusion in Central East Europe.

[1] We may observe Lithuania's State Control % and Activity variables, however the size of its bubble representing SM % of Total Electricity meters is irrelevant, due to missing data for 2010. All other variables and countries are comparable.

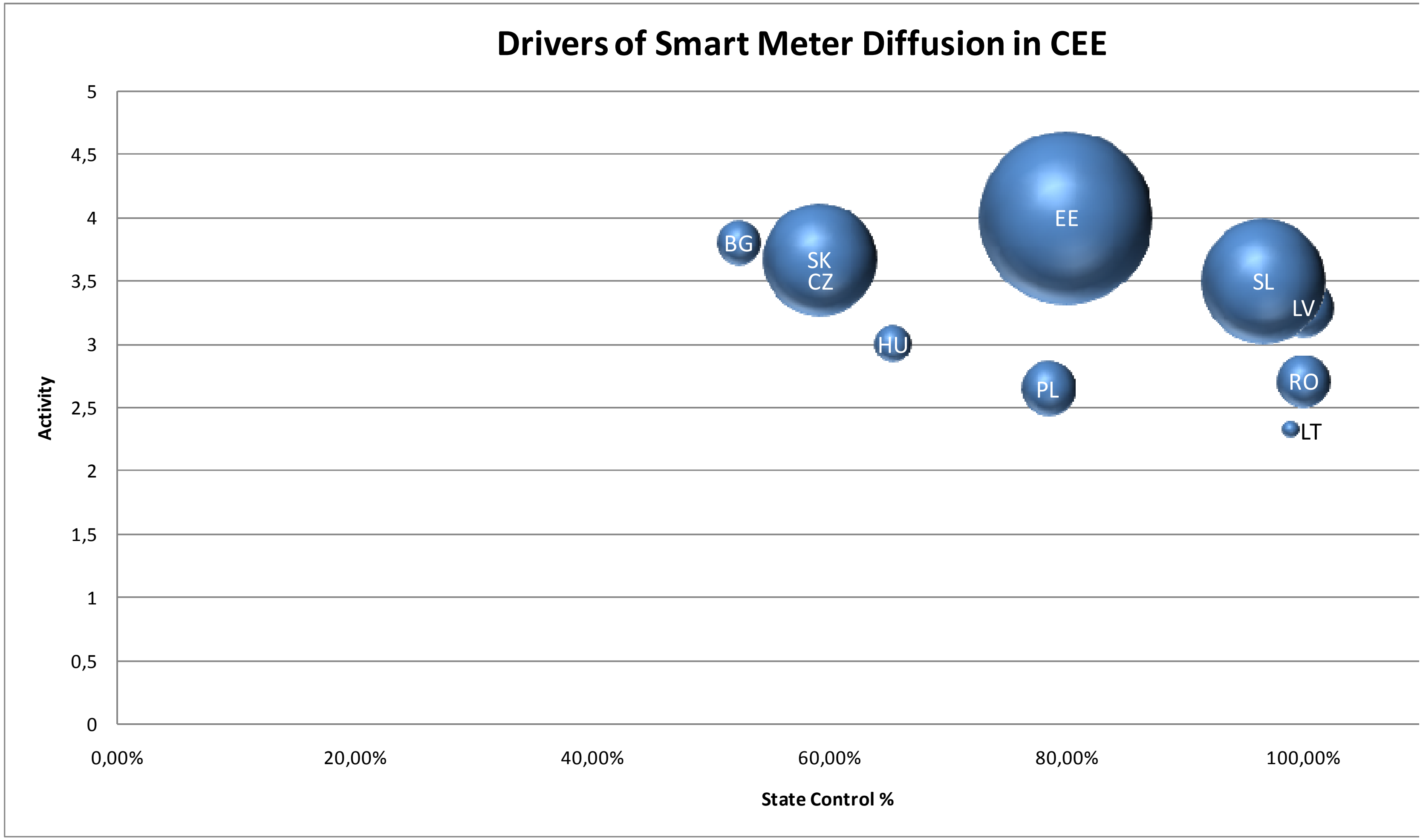

Figure 26 Drivers of smart meter diffusion in Central East Europe

3.6 Managerial implications of smart meter diffusion

The final section highlights findings that are most relevant for managerial and policy level readers and attempts to answer the last research question: “What are the managerial implications of smart meter diffusion in CEE?”

The total diffusion curve mapping development of smart meters in Central East Europe reveals exponential growth during the next ten years. The current study has worked only with explicitly and coherently revealed data on smart meter diffusion however we expect the growth to be higher due to lowering technology costs and increasing benefits derived from smart metering. Explicitly mapped, visualized and analyzed smart meter diffusion serves as an important performance indicator especially for commercial and policy actors. Up-to-date knowledge of SM diffusion shapes business decisions as well as policies applied by national and European level agencies. The current study also identifies differences in scale and scope of smart meter diffusion between individual countries therefore country specific actions should be considered.

From a strategic point of view the currently evolving market represents a business opportunity mainly for well established and experienced providers of smart metering solutions. We mention established and experienced providers because current customers are seeking security and experience in highly dynamic and risky environment (lack of standards, technological obsoleteness, financial losses, sunk costs, etc.). In order to successfully cross what Moore (1999) calls the “chasm” providers have to, in addition to references, offer complete smart metering solutions which will persuade the pragmatists to adopt. Consequently, the electricity smart metering mass market can take off influencing the conjoint segments of water and gas metering.

4 CONCLUSIONS

The present study attempts to capture market evolution of emerging and dynamically moving technology in electric power industry. Current situation represents time in transition when new value chains, business models, and services are being formed. Smart meters are seen as the key enablers of the wide-scale industry shift towards smart grid which is, as disruptive innovation, creating a new operating paradigm.

The application of innovation theories and frameworks to smart metering enables to tangibly and coherently conceptualize often only assumed characteristics of this technology. The study's argument that smart meters are disruptive discontinuous systemic innovation facilitating open innovation aids to the common understanding and mainly to the managerial and policy making practices. The dynamism of smart metering market studied in this work revealed fundamental changes in regulatory and policy environment as well as in business setting. Utility meter manufacturers are intensively adding intelligence, forming strategic partnerships with ICT companies, and attempting to create standards to gain the first mover's advantage on global markets. ICT and telecommunication companies are aggressively expanding fields of operations because their expertise in data management and communication technologies lies in the heart of smart metering.

Electric power as such is a strategic asset and majority of CEE countries demonstrates a tight control over utility companies through state ownership (esp. Latvia, Estonia). Energy utilities are most often one of the largest corporate entities in a country providing large employment and economic opportunities which are demanded to be controlled by public authorities. However, as the analysis proved, the diffusion of smart meters follows a gradual bottom-up process where state controls mainly the initial and regulatory activities, but the actual market level adoption activates are carried out by more privately controlled actors.

Despite the identified rapid growth of smart meter market in coming years, the results and benchmarking prove CEE’s laggard position in smart meter diffusion. Majority of the Central East European countries carefully monitor SM development and carry out related initiatives but adopt only small numbers of smart meters. In contrast, the benchmarked segment of dynamic movers quickly turned to large scale rollouts of smart meters over a short period of time. Factors that have slowed down and negatively influenced the diffusion of smart meters are several. As the European Commission (2011) puts it, the recent economic crisis has increased the gap between actual and optimal deployment and led to outflow of investments. Also, the highly problematic issue of pan-European smart metering standards led to one year delay however is expected to be resolved by the first deliverables in 2012. The establishment of standards, lowering technology costs, experience and knowledge sharing will all facilitate the smart meter diffusion in coming years.

Further research recommendations

In contrast to traditional retrospective studies of innovation diffusion, the current study analyses innovation which is only currently spreading throughout the market. That is why it is recommended to repeat the study in another phase of the diffusion process which enables among others access to precise historical data. Next, the growing number of smart meters in the market enables to study diffusion from the consumers’ (residents’) perspective across countries. A method developed by Steenkamp, Hofstede and Wedel (1999) serves as an inspiration. Finally, smart meters should be studied in the context of related innovations, especially those constituting the smart grid.

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APPENDIX I Innovation framework, typology and models

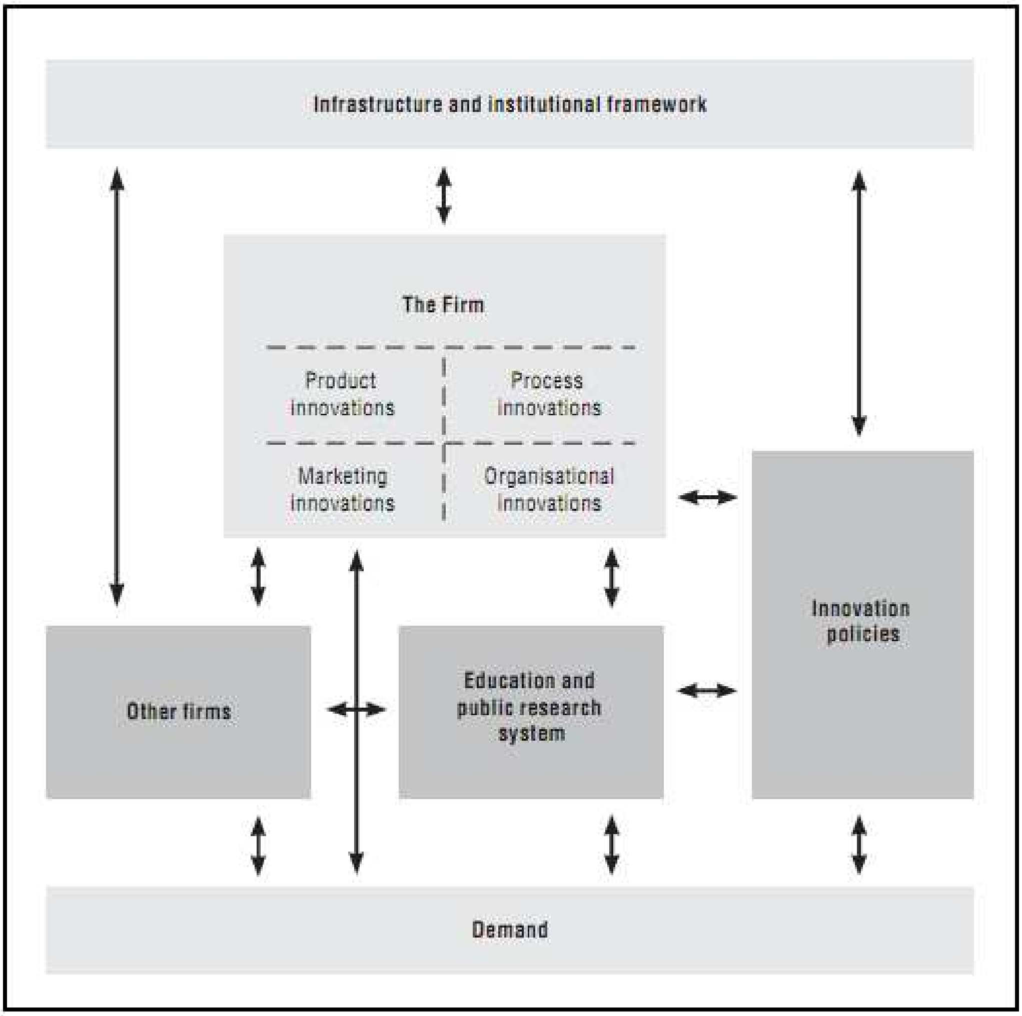

Figure 1The innovation measurement framework (OECD, 2005, p. 34)

Table 1 Definitions of innovation typology (OECD, 2005)

Type of innovation	Definition
Product	The introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.
Process	The implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
Organizational	The implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
Marketing	The implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

Table 2 Summary of models of technology diffusion and factors influencing it (Geroski, 2000)

Model	Factors affecting diffusion	Authors
Epidemic model	Common source	Mansfield (1989)
	Word of mouth	Rogers (1995); Griliches (1957); Romeo (1977); Oster (1982)
	Mixed information source	Lekvall and Wahlbin (1973); Mahajn et al. (1990); Karshenas and Ireland (1992); Zettelmeyer and Stoneman (1993); Betrholomew (1973)
Probit (Economic) model	Firm size	Davies (1979); Rose and Joskow (1990); David (1975); Metcalfe (1970); Romeo (1975); Ingham and Thompson (1993); Karshenas and Stoneman (1993); Nasbeth and Ray (1974)
	Suppliers	Bass (1980); Metcalfe (1981); Ireland and Stoneman (1982); David and Olsen (1984, 1986, 1992)
	Technological expectations	Geroski (2000)
	Learning and search costs	Stoneman (1981); Jensen (1982); Tonks (1986); Rosenberg (1976); Balcer and Lippman (1984)
	Switching costs	Wozniak (1987); Cohen and Levinthal (1989); Teece and Pisano (1994); Gruber and Verboven (1999)

	Opportunity cost	Cabellaro and Hammour (1994); Oulton (1989); Geroski and Gregg (1998)
Density dependent population growth model	Legitimation	Hannan and Freeman (1989); Hannan and Carroll (1992); Katz and Shapiro (1985); Farell and Saloner (1985; 1986); David and Greenstein (1990)
	Competition	
	Pre-emption effect	Reinganum (1981); Quirmbach (1986); Chatterjee et al. (1998); Tirole (1988); Stoneman and Kwon (1994); Oster (1982); Christensen (1997)
	Rent displacement	
Information cascades		Bannerjee (1992); De Vany and Walls (1996); Bikhchandani et al. (1998); Arthur (1989); Schmalensee (1982)

APPENDIX II Country specific diffusion data

Table 1 Electricity meters and population in Bulgaria

Total Electricity Meters	5889000
Population of Bulgaria	7585131
Share of Meters	0,776387382
Approx. % of Total	78%

Table 2 Smart meter diffusion rates in Bulgaria

Year	SM Deployed	Cumulative	% of Total Meters	Actor
2009	30000	30000	0,51%	CEZ Bulgaria
2010		30000	0,51%	
2011	83000	113000	1,92%	E.ON Bulgaria
2012	83000	196000	3,33%	E.ON Bulgaria
2013	83000	279000	4,74%	E.ON Bulgaria
2014	83000	362000	6,15%	E.ON Bulgaria
2015	83000	445000	7,56%	E.ON Bulgaria
2016	83000	528000	8,97%	E.ON Bulgaria
2017	83000	611000	10,38%	E.ON Bulgaria
2018	83000	694000	11,78%	E.ON Bulgaria
2019	83000	777000	13,19%	E.ON Bulgaria
2020	83000	860000	14,60%	E.ON Bulgaria

Table 3 Smart meter activity coding in Bulgaria

Activity	Code	Actor	State Control
Pilot project	4	E.ON Bulgaria	41
Rollout	5	E.ON Bulgaria	41
Regulation	2	Government of Bulgaria	100
Pilot project	4	Mobiltel, Sensus, Akwaror	0
Pilot project	4	CEZ Bulgaria	80
Average	3,8		52,4

Table 4 Electricity meters and population in the Czech Republic

Total Electricity Meters	5764914
Population of the Czech Republic	10489970
Share of Meters	0,549564393
Approx. % of Total	54,96%

Table 5 Smart meter diffusion rates in the Czech Republic

Year	SM Deployed	Cumulative	% of Total Meters	Actor
2006	4000	4000	0,07%	E.ON
2009	7214	11214	0,19%	CEZ, PRE
2010	7531	18745	0,33%	CEZ, PRE
2011	6531	25276	0,44%	CEZ
2012	6531	31807	0,55%	CEZ
2013	6531	38338	0,67%	CEZ
2014	6531	44869	0,78%	CEZ
2015	6531	51400	0,89%	CEZ

Table 6 Smart meter activity coding in the Czech Republic

Activity	Code	Actor	State Control
Pilot project	4	ČEZ	69,78
Pilot project	4	ČEZ	69,78
Pilot project	4	E.ON	5
Pilot project	4	PREdistribuce	30,1
Pilot project	4	PREmereni	30,1
Cost benefit analysis	3	Ministry of Industry and Trade	100
Cost benefit analysis	3	CEZ	69,78
Regulation	2	Ministry of Industry and Trade	100
Average	3,5		59,3175

Table 7 Electricity meters and population in Estonia

Total Electricity Meters	680000
Population of Estonia	1340345
Share of Meters	0,507332067
Approx. % of Total	51%

Table 8 Smart meter diffusion rates in Estonia

Year	SM Deployed (k)	Cumulative (k)	% of Total Meters	Actor
1995	3,438	3,438	0,51%	Jaotusvõrk OÜ
1996	3,438	6,875	1,01%	Jaotusvõrk OÜ
1997	3,438	10,313	1,52%	Jaotusvõrk OÜ
1998	3,438	13,750	2,02%	Jaotusvõrk OÜ
1999	3,438	17,188	2,53%	Jaotusvõrk OÜ
2000	3,438	20,625	3,03%	Jaotusvõrk OÜ
2001	3,438	24,063	3,54%	Jaotusvõrk OÜ
2002	3,438	27,500	4,04%	Jaotusvõrk OÜ
2003	3,438	30,938	4,55%	Jaotusvõrk OÜ
2004	3,438	34,375	5,06%	Jaotusvõrk OÜ
2005	3,438	37,813	5,56%	Jaotusvõrk OÜ
2006	3,438	41,250	6,07%	Jaotusvõrk OÜ
2007	3,438	44,688	6,57%	Jaotusvõrk OÜ
2008	3,438	48,125	7,08%	Jaotusvõrk OÜ
2009	3,438	51,563	7,58%	Jaotusvõrk OÜ
2010	3,438	55,000	8,09%	Jaotusvõrk OÜ
2011	55	110	16,18%	Jaotusvõrk OÜ
2012	55	165	24,26%	Jaotusvõrk OÜ
2013	55	220	32,35%	Jaotusvõrk OÜ
2014	69	289	42,50%	Jaotusvõrk OÜ
2015	69	358	52,65%	Jaotusvõrk OÜ
2016	69	427	62,79%	Jaotusvõrk OÜ
2017	69	496	72,94%	Jaotusvõrk OÜ

Table 9 Smart meter activity coding in Estonia

Activity	Code	Actor	State Control
Pilot project	4	Jaotusvork OÜ (DSO)	100
Rollout	5	Jaotusvork OÜ (DSO)	100
Rollout	5	Jaotusvork OÜ (DSO)	100
Pilot project	4	VKG Elektrivõrgud OÜ	0
Regulation	2	Ministry of Econ.Affairs and Communic.	100
Average	4		80

Table 10 Electricity meters and population in Hungary

Total Electricity Meters	5510571
Population of Hungary	10022302
Share of Meters	0,549831
Approx. % of Total	54,98%

Table 11 Smart meter diffusion rates in Hungary

Year	SM Deployed	Cumulative	% of Total Meters	Actor
2006	6000	6000	0,11%	E.ON Hungary
2007	6000	12000	0,22%	E.ON Hungary
2008	7000	19000	0,34%	E.ON Hungary
2009		19000	0,34%	E.ON Hungary
2010		19000	0,34%	E.ON Hungary
2011	4500	23500	0,43%	E.ON Hungary
2012	4500	28000	0,51%	E.ON Hungary

Table 12 Smart meter activity coding in Hungary

Activity	Code	Actor	State Control
Cost-benefit analysis	3	HEO, World Bank; FM, ATK	100
Regulation	2	Ministry of Economy and Transport	100
Regulation	2	HEO, Government, Expert	89
Pilot project	4	HEO, Industry	50
Initiative	1	HEO	100
Regulation	2	HEO, Expert, Government	89
Rollout	5	HEO, Industry	50
Pilot project	4	E.ON Hungary	5
Pilot project	4	E.ON Hungary	5
Average	3,00		65,33

Table 13 Estimation of total number of electricity meters in Latvia

Total Population of Latvia	2255128
Approx. 50% with Electricity Meter	1127564

Table 14 Smart meter diffusion rates in Latvia

Yeas	SM Deployed	Cumulative	% of Total Meters
2004	18	18	0,0016%
2005	1150	1168	0,1036%
2006		1168	0,1036%
2007	224	1392	0,1235%
2008	45	1437	0,1274%
2009	8563	10000	0,8869%
2010	8563	10000	0,8869%

Table 15 Smart meter activity coding in Latvia

Activity	Code	Actor	State Control
Regulation	2	Ministry of Economics	100
Pilot project	4	AS Sadales tikls	100
Pilot project	4	AS Sadales tikls	100
Pilot project	4	AS Sadales tikls	100
Pilot project	4	AS Sadales tikls	100
Pilot project	4	AS Sadales tikls	100
Initiative	1	FPEE	100
Average	3,29		100,00

Table 16 Electricity meters and population in Lithuania

Total Electricity Meters	1555000
Population of Lithuania	3339550
Share of Meters	0,465631597
Approx. % of Total	46,56%

Table 17 Smart meter diffusion rates in Lithuania

Year	SM Deployed	Cumulative	% of Total Meters
2011	1250	1250	0,08%
2012	1250	2500	0,16%
2013	1250	3750	0,24%
2014	1250	5000	0,32%

Table 18 Smart meter activity coding in Lithuania

Activity	Code	Actor	State Control
Pilot project	4	Lietuvos Energija, Enica	96,5
Initiative	1	Ministry of Economy	100
Regulation	2	Government of the Republic of Lithuania	100
Average	2,33		98,83

Table 19 Electricity meters and population in Poland

Total Electricity Meters	16040000
Population of Poland	38149886
Share of Meters	0,420446866
Approx. % of Tot.	42%

Table 20 Smart meter diffusion rates in Poland

Year	SM Deployed	Cumulative	% of Total Meters	Actor
2008	33333	33333	0,21%	RWE Stoen Operator
2009	33333	66667	0,42%	RWE Stoen Operator
2010	56619	123286	0,77%	Enea, Energa, RWE
2011	100000	223286	1,39%	Energa
2012	442202	665488	4,15%	Energa
2013	548869	1214357	7,57%	Energa, EnergiaPro
2014	548869	1763226	10,99%	Energa, EnergiaPro
2015	548869	2312095	14,41%	Energa, EnergiaPro
2016	442202	2754298	17,17%	Energa
2017	442202	3196500	19,93%	Energa

Table 21 Smart meter activity coding in Poland

Activity	Code	Actor	State Control
Initiative	1	URE	100
Initiative	1	URE, KAPE	100
Pilot project	4	Energa Operator	87
Pilot project	4	Energa Operator	87
Rollout	5	Energa Operator	87
Pilot project	4	RWE Stoen Operator	1,57
Pilot project	4	EnergiaPro (Tauron)	27,51
Rollout	5	EnergiaPro (Tauron)	27,51
Pilot project	4	Enea Operator	57,9
Pilot project	4	Enea Operator	57,9
Regulation	2	Ministry of the Economy	100
Initiative	1	URE, ARP, NFOSIGW	100
Initiative	1	HEO, UKE, NFOŚiGW, WBK	100
Regulation	2	Ministry of Economy	100
Initiative	1	Energy Institute Gdansk	100
Initiative	1	PSE Operator	100
Initiative	1	PSE Operator	100
Average	2,65		78,43

Table 22 Electricity meters and population in Romania

Total Electricity Meters	8000000
Population of Romania	21482395
Share of Meters	0,372397957
Approx. % of Total	37%

Table 23 Smart meter diffusion rates in Romania

Year	SM Deployed	Cumulative	% of Total Meters
2003	470	470	0,006%
2004	30	500	0,006%
2005	500	1000	0,013%
2006	2000	3000	0,038%
2007	3500	6500	0,081%
2008	5500	12000	0,150%
2009	23500	35500	0,444%
2010	23500	59000	0,738%

Table 24 Smart meter activity coding in Romania

Activity	Code	Actor	State Control
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Pilot project	4	Electrica S.A.	100
Regulation	2	State	100
Initiative	1	ANRE	100
Initiative	1	ANRE	100
Initiative	1	ANRE	100
Initiative	1	ANRE	100
Initiative	1	ANRE	100
Initiative	1	Electrica S.A.	100
Regulation	2	Government of Romania	100
Average	2,71		100

Table 25 Electricity meters and population in Slovakia

Total Electricity Meters	2355488
Population of Slovakia	5418156
Share of Meters	0,43473979
Approx % of Total	43,47%

Table 26 Smart meter diffusion rates in Slovakia

Year	SM Deployed	Cumulative	% of Total Meters
2009	40000	40000	1,70%
2010	40000	80000	3,40%

Table 27 Smart meter activity coding in Slovakia

Activity	Code	Actor	State Control
Pilot test	4	Vychodoslovenska Energetika	51
Initiative	1	Vychodoslovenska Energetika	51
Initiative	1	Zapadoslovenska Energetika	51
Rollout	5	Stredoslovenska Energetika	51
Rollout	5	Stredoslovenska Energetika	51
Regulation	2	Slovak Government	100
Average	3		59,17

Table 28 Electricity meters and population in Slovenia

Total Electricity Meters	890000
Population of Slovenia	2043241
Share of Meters	0,435582489
Approx. % of Total	43,56%

Table 29 Smart meter diffusion rates in Slovenia

Year	SM Deployed	Cumulative	% of Total Meters	Actor
2008	6600	6600	0,74%	Elektro Ljubjana
2009	15000	21600	2,43%	Elektro Ljubjana
2010	15000	36600	4,11%	Elektro Ljubjana
2011	108840	145440	16,34%	El. Gorenjska, El. Ljubjana
2012	28840	174280	19,58%	Elektro Ljubjana
2013	28840	203120	22,82%	Elektro Ljubjana
2014	28840	231960	26,06%	Elektro Ljubjana
2015	28840	260800	29,30%	Elektro Ljubjana
2016	28840	289640	32,54%	Elektro Ljubjana
2017	28840	318480	35,78%	Elektro Ljubjana
2018	28840	347320	39,02%	Elektro Ljubjana
2019	28840	376160	42,27%	Elektro Ljubjana
2020	28840	405000	45,51%	Elektro Ljubjana

Table 30 Smart meter activity coding in Slovenia

Activity	Code	Actor	State Control
Cost benefit analysis	3	EIMV	100
Cost benefit analysis	3	EIMV	100
Pilot project	4	Elektro Ljubljana	79,5
Rollout	5	Elektro Ljubljana	79,5
Rollout	5	Elektro Ljubljana	79,5
Rollout	5	Elektro Gorenjska (DSO)	79,5
Regulation	2	Government of Slovenia	100
Initiative	1	SODO d.o.o.	100
Rollout	5	SODO d.o.o.	100
Average	3,67		90,89

Table 31 Electricity meters and population in Italy

Total Electricity Meters	36000000
Population of Italy	60221211
Share of Meters	0,597796
Approx. % of Total	60%

Table 32 Smart meter diffusion rates in Italy

Year/Bins	SM Deployed	Cumulative	% of Total Meters	Actor
2001	5400000	5400000	15,00%	Enel SpA
2002	5400000	10800000	30,00%	Enel SpA
2003	5400000	16200000	45,00%	Enel SpA
2004	5400000	21600000	60,00%	Enel SpA
2005	5400000	27000000	75,00%	Enel SpA
2006	2800000	29800000	82,78%	Enel SpA
2007	725000	30525000	84,79%	Estimate
2008	725000	31250000	86,81%	Estimate
2009	1500000	32750000	90,97%	Acea Distribuzione
2010	725000	33475000	92,99%	Estimate
2011	725000	34200000	95,00%	Estimate

Table 33 Smart meter activity coding in Italy

Activity	Code	Actor	State Control
Regulation	2	Energy regulator	100
Rollout	5	Acea Distribuzione	100
Rollout	5	Enel SpA	26,08
Regulation	2	Ministry of Economic Development	100
Average	3,5		81,52

Table 34 Electricity meters and population in France

Total Electricity Meters	35789474
Population of France	62616488
Share of Meters	0,571566289
Approx. % of Total	57%

Table 35 Smart meter diffusion rates in France

Year	SM Deployed	Cumulative	% of Total Meters	Actor
2007	3400000	3400000	9,50%	ERDF
2008	3400000	6800000	19,00%	ERDF
2009	3400000	10200000	28,50%	ERDF
2010	3400000	13600000	38,00%	ERDF
2011	3400000	17000000	47,50%	
2012	3400000	20400000	57,00%	
2013	3400000	23800000	66,50%	
2014	3400000	27200000	76,00%	ERDF
2015	3400000	30600000	85,50%	ERDF
2016	3400000	34000000	95,00%	
2017	89474	34089474	95,25%	ERDF
2018	89474	34178947	95,50%	ERDF
2019	89474	34268421	95,75%	ERDF
2020	89474	34357895	96,00%	

Table 36 Smart meter activity coding in France

Activity	Code	Actor	State Control
Regulation	2	Government	100
Pilot test	4	ERDF	84
Cost benefit analysis	3	CRE commissioned Capgemini	50
Initiative	1	CRE Survey conducted by IFOP Institute	100
Rollout	5	ERDF	84
Initiative	1	ERDF	84
Initiative	1	ERDF and local distribution companies	84
Initiative	1	CRE	100
Initiative	1	CRE	100
Initiative	1	CRE	100
Pilot test	4	ERDF	84
Regulation	2	French authorities	100
Average	2,1667		89,1667

Table 37 Electricity meters and population in Finland

Total Electricity Meters	3000000
Population of Finland	5338395
Share of Meters	0,561966659
Approx. % of Total	56%

Table 38 Smart meter diffusion rates in Finland

Year	SM Deployed	Cumulative	% of Total Meters
2006	500000	500000	16,67%
2007	63000	563000	18,77%
2008	37000	600000	20%
2009	200000	800000	27%
2010	200000	1000000	33%
2011	500000	1500000	50%
2012	500000	2000000	67%
2013	500000	2500000	83%
2014	500000	3000000	100%

Table 39 Smart meter activity coding in Finland

Activity	Code	Actor	State Control
Cost benefit analysis	3	Fortum and Landis & Gir	54,5
Initiative	1	VTT	100
Pilot project	4	Multiple	100
Initiative	1	VaasaETT	0
Regulation	2	Ministry of Employment and the Economy	100
Regulation	2	Ministries	100
Pilot project	4	Fortum Espoo Oy	51
Pilot project	4	Helsinki Energy	100
Rollout	5	Haukiputaa Electricity Cooperative	100
Pilot project	4	Jyväskylän Energia	100
Pilot project	4	Kainuun Energia (E.ON)	54,5
Pilot project	4	Kemin Energia	100
Pilot project	4	Satapirkan Sähkö Oy	0
Pilot project	4	Tampere City Electric Works	100
Pilot project	4	Tornion Energia	100
Rollout	5	Vattenfall Lämpö	100
Average	3,4375		78,75

Table 40 Smart meter diffusion rates in the context of CEE electricity meter market

Year	SM Deployed	Cummulative	% of Total El. Meters in CEE	BG	CZ	EE	HU	LV	LT	PL	RO	SK	SL
1995	3437,5	3437,5	0,01%			0,01%							
1996	3437,5	6875	0,01%			0,01%							
1997	3437,5	10312,5	0,02%			0,02%							
1998	3437,5	13750	0,03%			0,03%							
1999	3437,5	17187,5	0,04%			0,04%							
2000	3437,5	20625	0,04%			0,04%							
2001	3437,5	24062,5	0,05%			0,05%							
2002	3437,5	27500	0,06%			0,06%							
2003	3907,5	31407,5	0,07%			0,06%					0,00%		
2004	3485,5	34893	0,07%			0,07%		0,00%			0,00%		
2005	5087,5	39980,5	0,08%			0,08%		0,00%			0,00%		
2006	15437,5	55418	0,12%		0,01%	0,09%	0,01%	0,00%			0,01%		
2007	13161,5	68579,5	0,14%		0,01%	0,09%	0,03%	0,00%			0,01%		
2008	55915,83333	124495,3333	0,26%		0,01%	0,10%	0,04%	0,00%		0,07%	0,03%		0,01%
2009	149018,119	273513,4524	0,57%	0,06%	0,02%	0,11%	0,04%	0,02%		0,14%	0,07%	0,08%	0,05%
2010	166680,7857	440194,2381	0,92%	0,06%	0,04%	0,12%	0,04%	0,02%		0,26%	0,12%	0,17%	0,08%
2011	439120,9524	879315,1905	1,84%	0,24%	0,05%	0,23%	0,05%		0,00%	0,47%			0,30%
2012	621323,2857	1500638,476	3,14%	0,41%	0,07%	0,35%	0,06%		0,01%	1,39%			0,36%
2013	723489,9524	2224128,429	4,65%	0,58%	0,08%	0,46%			0,01%	2,54%			0,42%
2014	737489,9524	2961618,381	6,19%	0,76%	0,09%	0,60%			0,01%	3,69%			0,49%
2015	736239,9524	3697858,333	7,73%	0,93%	0,11%	0,75%				4,84%			0,55%
2016	623042,3333	4320900,667	9,04%	1,10%		0,89%				5,76%			0,61%
2017	623042,3333	4943943	10,34%	1,28%		1,04%				6,69%			0,67%
2018	111840	5055783	10,57%	1,45%									0,73%
2019	111840	5167623	10,81%	1,63%									0,79%
2020	111840	5279463	11,04%	1,80%									0,85%

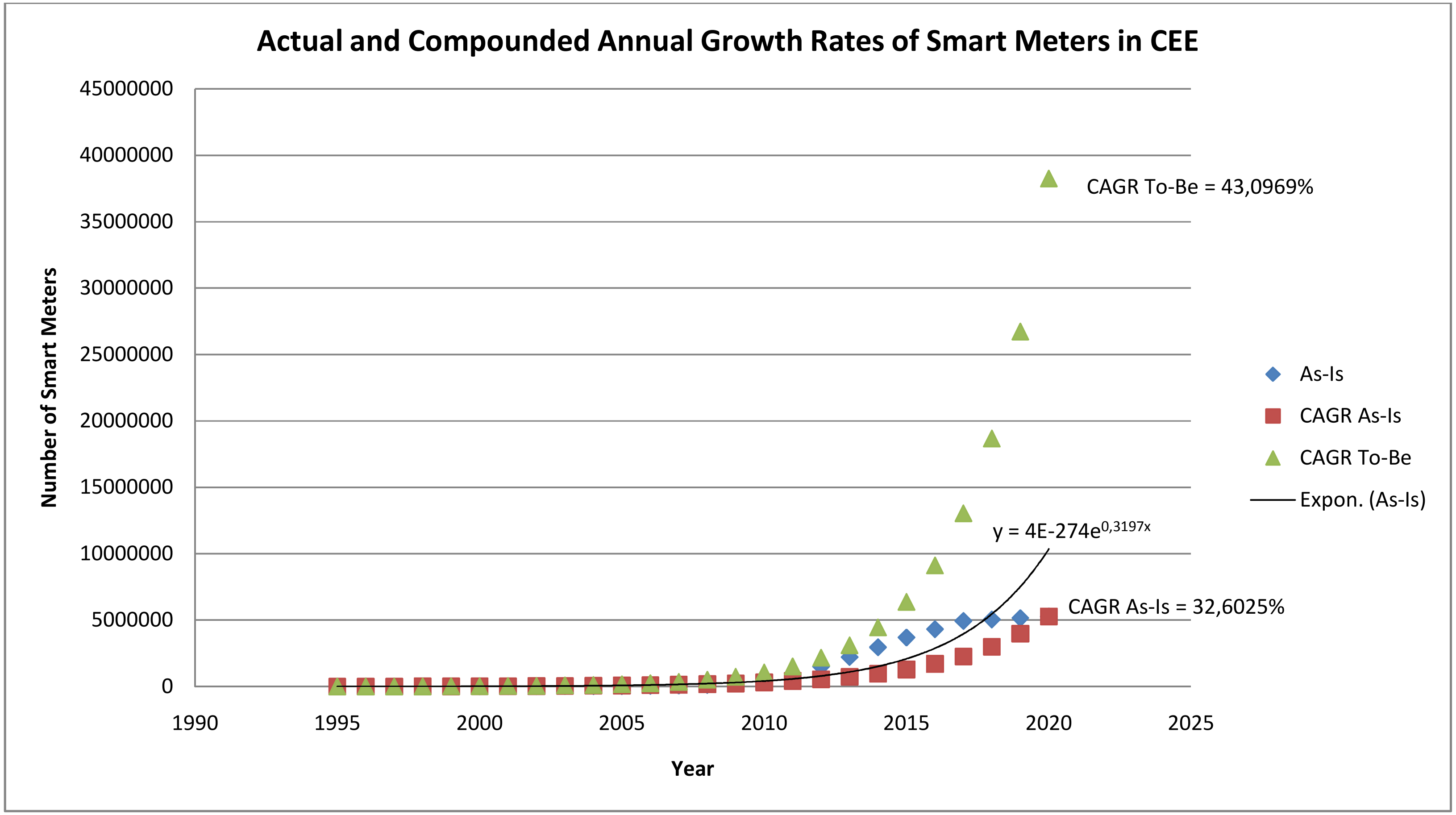

Figure 2 Actual and compounded annual growth rates of smart meters in Central East Europe

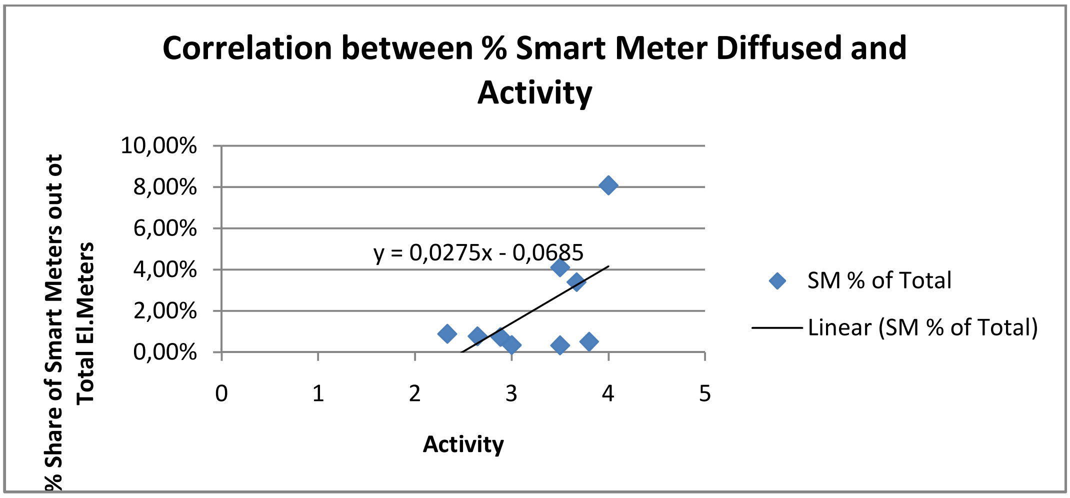

Figure 3 Correlation between % Smart Meter Diffused and Activity

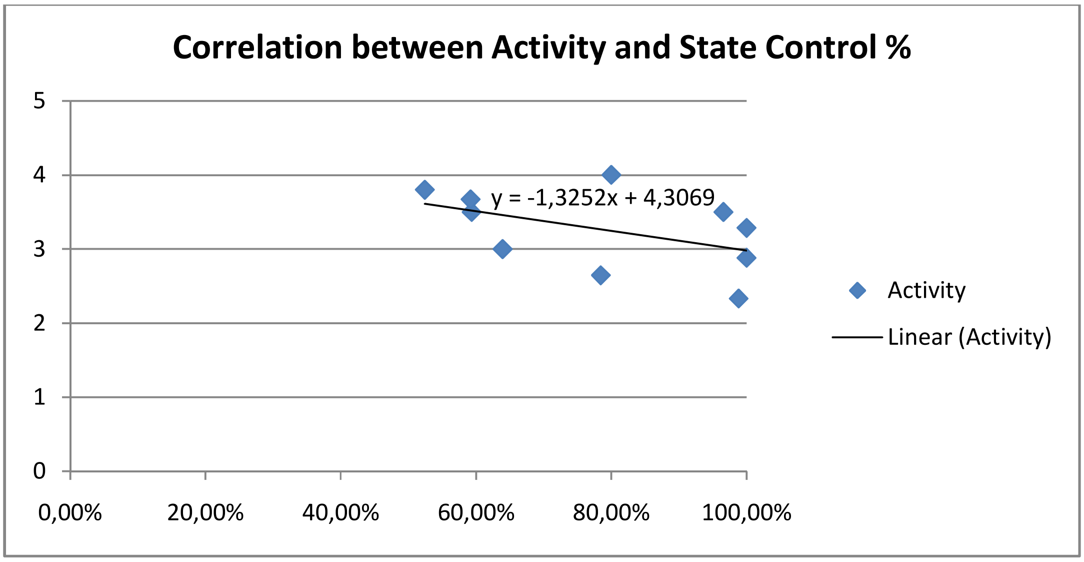

Figure 4 Correlation between Activity and State Control %