Economic evaluation of smart grids and smart metering

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CONTENT

1. INTRODUCTION AND GENERAL INFORMATION

This work deals with the Smart Grids concept. We chose the topic, because it is very actual and quite controversial. Raises many debates and has both hardened supporters and opponents.

The aim of this work is to explain what actually means Smart Grids and to compare czech and Austrian approach.

First, we describe the initial formation of the idea of following the situation in the energy sector. This is followed by the development of ideas and the creation of the first documents, projects and studies - in this paper we focus on the environment of the European Union. Member States formulate their opinions on the concept. At the end we describe the statement of the Czech Republic and Austria to the concept.

2. ABSTRACT

The concepts of the current energy system seam more and more unsuitable for providing solutions to the issues of climate change and resource scarcity. Since increases in energy consumption are persistent, one way of dealing with this challenge is to improve efficiency, not only of the technologies itself, but of the whole system. A promising field of action is Smart Grids. The aim of the concept is to allow more renewable sources to be implemented. Clearing the market system in the energetic field, actual pricing of electricity, these are the basic ideas, which should finally lead to some kind of automatic regulation and should help to keep a balance between consumption and production.

This article deals with the concept Smart Grids. The first part is a theoretical description of the concept, its principles, assumptions, benefits and difficulty. A comparison of different perspectives on the concept. The second part of this paper contains a description of the the model concept Smart Grids and its economic evaluation. In order to create an evaluation, it is necessary to know the costs and benefits of the project. In this work especialy cost-benefit-analysis on smart metering were evaluated.

3. APPROACH

The presented article contains a literature review based introduction into the technical terms of smart grids and smart metering and leads to an economic evaluation of the implementation of a smart metering system, also based on literature review. The review material includes European commission strategy papers and guidelines as well as national roadmaps and rollout plans which are based on accomplished cost-benefit-analyses for the Czech Republic and Austria. These cost-benefit-analyses have also been taken into account.

4. CONCEPT OF SMART GRIDS

Energy is a very complex system, it is even considered to be the most complex man-made system. It includes electricity generation, transmission and distribution, control system within the Czech Republic, and cross-border cooperation. Hand in hand with the control system works well as specific market system. Energy market is not the same, as the market for other commodities, it is not possible to store electricity effectively and in large enough quantities yet.

In 2005, the European Technology Platform for the electricity network of the future (ETP SG) started its activities. Its aim was to formulate and promote a vision of the development of European electricity networks in 2020 and beyond. ETP SG focuses on the concept of the energy system of the future Smart Grid.

In the document, Strategic Deployment Document for Europe's electricity networks of the future [1] is specified the concept in the following way: "Smart Grids is an electrical network that can intelligently connect activities of all parties involved - the production of electricity consumption, or both together - in order to effectively ensuring sustainable, economic and secure electricity supply. Smart Grids use of innovative products and services together with intelligent monitoring, control, communications and automated technologies in order to:

- facilitate the connection and operation of manufacturers of all sizes and technologies
- enable consumers to participate in the optimization of system operation
- provide consumers with better information and choice of supply
- significantly reduce the impact of the energy system, environmental
- increase the level of reliability and security of supply

It is necessary to consider not only the technology, market and financial balance sheets, the impact on the environment, legal framework, information and communication technologies and migration strategy but also societal requirements and government regulations. "

Mr. Beran said at the Conference on Smart Grids [2]: “In 2007 ETP SG the Strategic Research Agenda (SRA), which describes the main technical and non-technical research areas in Europe in terms of short-term (the medium term). This document subsequently initiated a number of research and development programs in the national institutions of the EU. SRA included the recommended five research areas:

- **Research area** 1: Infrastructure Smart Distribution (small customers and the draft system)

Research tasks:

Distribution system of the future - a new architecture for system design and customer participation

Distribution system of the future - new concepts for the study of the integration of distributed production planning system

- **Research Area 2**: Smart operation. Flows of energy and adaptation customers (small customers and system)

Research tasks:

In the power of the future - a system engineering approach to the study of the operation of the integration of distributed and "active" customers

The strategy of innovative energy management for large-scale penetration of distributed generation, accumulation and reflection needs

Distribution system of the future - markets "controlled" customers

- **Research Area 3:**

Smart Grid activities and their management (Transmission and Distribution)

Research tasks:

Sustainable operations and dispatching a low voltage level

Advanced predictive techniques for sustainable operation and energy supply

Architectures and tools for operation, renewal and defense plans

Progressive traffic - Seamless Smart Grids

Pre-standardization research

- **Research Area 5:**

Smart Grids implementing revenue and catalysts “

Figure 1 is a simplified explanation of the idea of the concept. Smart Electric (smart meter) will be installed all consumers will and will periodically send information about current consumption. Meters will handle the consumption of the building. If you will be equipped with so-called smart appliances or generators of electricity (photovoltaic panels, ...), each of them will be connected to the meter separately. Use appropriate communication channels to get information to a central control center, where they will be evaluated and reported on the electricity market (or exchange). Will be determined by the current price for electricity depending on the need - if the network surplus or shortage of electricity. Information about the current price of electricity will be provided back to the consumer, who will have a choice - when and how much electricity to consume. In addition, Smart Grids calculated with the assumption that creates a system of devices that will be able to accumulate electrical energy or vice versa provide available when needed. These include electric vehicles.

Picture 1: Schéma konceptu Smart Grids
Source: http://tushneem.wordpress.com/2009/08/04/4g-evolution-and-Smart Grids

Part of the concept are also called smart home appliances and that the consumer may be set so as to optimize its consumption. Turns on when the electricity price is the lowest,

while the surplus in the network. This system is therefore essentially to a certain extent automatically regulate fluctuations in the network (unbalance). The concept of so promising that it will be possible to continue the current trend - increasing levels of renewables in the energy mix of the country.

4.2 Smart Grids as a solution to current energy issues

As already mentioned in the introduction, the Smart Grids concept of so-called smart grids, whose main task is to reduce the deviation between actual production and consumption of electricity. "It includes an innovative approach to distribution network that can effectively integrate the operation of all connected users, centralized and local energy production, customers with the possibility of an active role and incorporate new features of the distribution network using bidirectional communication between production resources and appliances". [3]

Due to the requirements increasingly use renewable sources for energy production becomes less and less predictable. Power consumption is indeed roughly predictable, but it is necessary to constantly regulate the amount of energy supplied. With the development of renewable energy sources is becoming increasingly difficult to control. Therefore, the project of Smart Grids, which seeks in essence to regulate consumption based on current production that motivates customers different prices for the consumption of energy corresponding to market principles. This trend can be described as a turning point in the development of the electricity market. Unlike classical system can track the price of electricity being removed and adapt their consumption. The project also envisages involvement in any small electricity producers such as households with solar panels, etc. The electricity market and start a new work of classical market principles, the main assumption is that people are guided by the invisible hand of the market.

Many opponents argue that this system is utopian - the costs of implementation are extremely high, it is necessary to substantially modify the entire transmission and distribution system and the whole project is based on the willingness of consumers to participate actively invest their funds. Even though the concept is considered to be the future of energy.

4.3 From traditional networks to Smart Grids

The idea of Smart Grids is relatively young, but is related to the relatively distant future, counts with a number of assumptions. You either based on current trends, anticipated development, or simply assume that the company gradually finds answers to questions and requests, which are not able to answer or produce.

ABB realizes the development of modern technologies and Smart Grids describes as follows: "The distribution network of the future will be an expanded version of the current network with more monitoring and communications systems, new links, two-way flow of energy and information and a greater share of local energy production and renewable energy. The system is highly automated to ensure reliable, energy-efficient power supplies to power consumers in the industrial, commercial and private sectors. "[4]

Reguirements

European Technology Platform, already mentioned in Chapter 1, specifies the prerequisites for the successful implementation of the concept. It divides the issues into five areas: Electronic Technology, Information Technology (ICT) Compatibility with Europe's electricity grids (EEGI compatibility), legal framework and market structure, socio-economic incentives. [5]

Electrical Technology

Platform Smart Grids and encourages research and development of the following technologies:

In order to facilitate the achievement of the required quality control and security of energy supply is necessary to build technologies that provide regulated power consumption. What most technologies should be able to participate in the regulation of the power grid in time and areas as needed.

There are also electrical energy storage technology and management, for the purpose of processing electrical energy from unstable sources.

Development of high voltage cable direct current to achieve safe switchable transmission of electrical energy from areas rich in renewable resources to areas where there is a shortage.

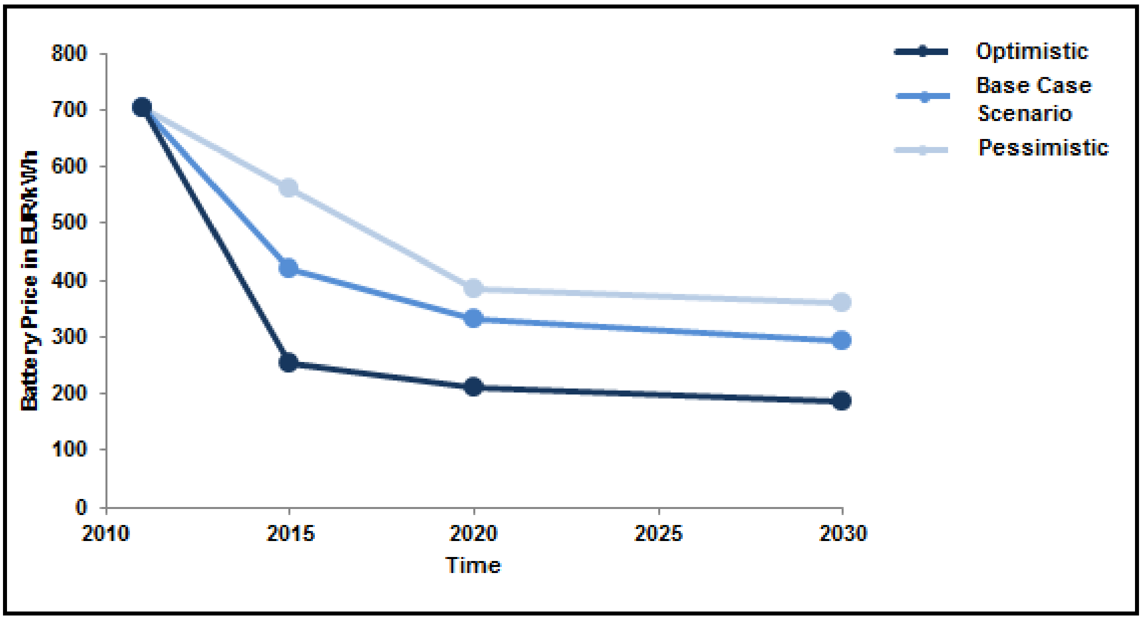
Improved materials distribution elements: robust, flexible, cost-effective materials that should avoid sudden disturbances in the system. In the event that a malfunction occurs in any part of the distribution network, activates the immediate and best automated system of redress, the users will have damaged the uninterrupted network access and services. [6]

Electromobility

The development of electromobility is one of the main requirement for the successful implementation of the concept of Smart Grids. Electric connected to the system should work, among other things as a backup source, respectively. appliance from which it will be possible to draw electrical power or recharge it in time of need. It is thought to be the battery of the future. Electric, however there is still a long way to go in order to use them in this way. The vast majority of vehicles is not fueled Although diesel (gasoline), but this trend is changing over time.

A study conducted at the University of DuisburgEssen states that by 2020, had a number of electric vehicles to reach 7% of the total amount of vehicles and by 2030 this figure is expected to reach even 31%. [7]

According to Mrs. Ajanovic the main reason why it is not widely used jet is the high price of the battery. The price per car is between 20,000 and 100,000 euros, of which the battery is around 6 000 to 16 000. [8] In the future, however, feel that this price will be



lower, viz. Chart 2 The price is in Euro per kWh.

4.3.1 Information Technology

In the field of Information Technology Platform Smart Grids encourages research and development in the following areas:

Sensors, communication technologies, and advanced computing platforms for better monitoring and measurement capable of operating in real time. This will be the key technology for monitoring, measuring various electrical equipment and critical system parameters for determining the current state of the network. The information obtained will then be used as input for various predictive algorithms whose outputs will support decision making for achieving these goals SG. [9]

4.3.2 Generation, transmission and distribution of electrical energy

The concept was created as a response to the request the ecological production of electricity. It should therefore enable an increase in the amount of electricity produced from renewable sources of electricity. Or should partially solve the problem that brings with it RES - increasing fluctuations in manufacturing. Should be a means to regulate deviations. Furthermore, the concept allows for the expansion of decentralized production of electricity.

The role of transmission system operators (TSO) and distribution (DSO) system is very important. It must be installed by the concept of measurement systems and customize various elements of the system.

4.3.3 End customers

The concept envisages active involvement of electricity consumers. They can be divided into small and medium-sized or large industrial enterprises. Smart meter will be instaled to the all comsumers. They measure the consumption of electricity as well as classic continuously, but store data every 15 minutes in its memory. In addition, can evaluate and record even the "quality of delivery", ie overvoltage, undervoltage, deviations from the desired frequency, etc. It also notes the attack, such as mechanical interference with the meter or assault magnetic field. The data without human intervention are transmitted to the data center, where it is used for better technical network management for better business management of purchasing electricity, etc. [10]

Consumers will be provided by the actual price of the electricity. Then they will be alow to choose when to consume the electricity, to monitor the price range and to actively monitor the consumption or savings. The next step is that customers can purchase so-called intelligent appliance, or smart home. It will be connected to the grid and in direct contact with electricity suppliers will provide current conditions, which automatically adjusts. Some homes can then use the micro-cogeneration units - mostly internal combustion engines, produced jointly by both electricity and heat. [11]

4.4 Pilot project

To invite the European Union to participate in the development of pilot projects Smart Grids listened to many countries. In addition to the structural funds, the EU offers to fund applied research and innovation also community programs, of which the largest budgetary framework programs of the EU.

At present, for the years 2007 - 2013 declared the Seventh Framework Programme (FP7). It is the largest community program and the main instrument to support research and development in the EU. Its budget for 2007 - 2013 is around € 50.5 billion.

Obrázek 2: Pilotní projekty EU, Zdroj: ČEZ a.s. http://www.futuremotion.cz/Smart Grids/cs/-index.html

5 SMART GRIDS IN CZECH REPUBLIC

The purpose of Smart Grids is to ensure the safety and quality of electricity supply to the consumers. The question remains, will the Smart Grids concept achieve this goal? What may be effective in one country may be totally unnecessary in the second. And for this reason the definiton of the concept is so vague. The European Union is aware of this.. Therefore encourages Member States to develop usability evaluation of Smart Grids and set their own attitude towards their substantiated by factual arguments related studies.

In the next chapter we will discuss the possibility to put the concept of Smart Grids in the Czech and austrian energy sector.

5.1 System HDO

In the Czech Republic there are more than 50 years of sophisticated power management system called ripple control. HDO is a set of technical means (such as transmitters, receivers, central automation, transmission lines, etc.) allowing to transmit commands or signals for switching on or off appliances, switching tariffs. HDO used to transmit power lines. Its scope and use of the MRC unique in Europe. It is a reliable (reliability higher than 99%) and powerful tool used to:

- optimal use of networks,
- direct regulation of consumption,
- direct control of the production,
- implementation of tariff policy.

The basis for the use of the HDO Customer agrees that the heating appliance will the distribution system operator remotely unlocked in a predefined time zone, and for this he is in this time zone calculated consumption by the low rate, which is cheaper. In plants, the system is used to HDO stepped capacity control according to established rules.

A customer with a distribution system operator closes the deal, which agrees with the fact that in times of high network load (high tariff), or a state of crisis is taking its heating appliances blocked. The benefit for the customer is the lower price in other times of the day (low tariff).

Through the HDO today the distribution system operator controls the power level from 400 to 700 TWh (roughly 6-9% load) limits the tip load diagram of the system, reduces losses and also manages the production in small decentralized sources, which significantly contributes to the optimization of distribution networks. With HDO distribution system is built optimized manner with minimal investment costs. [12]

This system thus conceals the basic ideas of Smart Grids. Using a transmitter and receiver signal HDO system is in a crisis, able to regulate the consumption of the connected užvatelů. Although it is only one component of the whole concept of network security of this system is very practical and functional. The disadvantage is that the HDO are not connected all the participants in the energy field. Another fact is that not only works exchanged within the country and thus does not provide cross-threatening risk.

5.2 Implementation of the concept Smart Grids in Czech republic

Although generally-described concept of Smart Grids at European Union level, it is not easy to find the best way to integrate it in the Czech Republic. Each power system is very specific in terms of the energy mix, layout / capacity / security distribution system, consumers tracks, etc.

Because this is an area very little flexibility to implement any change is a long process. It's virtually impossible "by the day" transform the entire system. It is necessary to introduce changes gradually, within the framework of reconstruction and modernization. To achieve the goal, however, it needs to identify and unite. Experts in the field of energy trying to unify the Czech Republic's approach to the concept and to find a platform that would be efficiency across the entire energy system. [13]

The next section will describe the issue of introducing the concept of SG (meaning i component of the concept) in the Czech Republic from the perspective of three main areas. A introduction to the level of the transmission, distribution and local distribution systems.

5.2.1 TSO

Operation and management of the transmission system in the Czech Republic is provided by CEPS. This part of the development, maintenance and modernization of distribution networks to implement projects such as WAMS, SCOPT, E-set, TSC, functionality TRIS, whose task is to ensure the network smarter, more responsive, capacitive and improve its operation, maintenance and supervisory control. [14]

As in the Czech Republic, there is only one transmission system operator is thus relatively easy to perform this level of consistent, efficient and nationwide changes. CEPS has invested in the development of new monitoring system has achieved not only increase safety, but also reduce costs.

5.2.2 DSO

The issue of Smart Grids at the level of distribution system deals with are CEZ, E.ON and PRE. The document updates the state energy concept Czech Republic from July 2012 noted: Ensure by 2030 in distribution systems renewal and expansion of resources for remote power management, distributed generation and energy storage based on the principles of smart grids and smart metering to optimal use and reliability of distribution systems. [15]

5.2.3 Document of the department of industry - economic evaluation of the implementation of AMM (automatioc metering management)

The Ministry of Industry and Trade invented the document entitled Economic assessment of long-term costs and benefits to the market and individual customers with the introduction of smart metering in the electricity the country. The document focuses on the management of high and low voltage and describes:

- The current situation of electricity, including the HDO, a description of the technological principles of its functioning, the method of its use, the genesis of the deployment and optimization of load diagram
- The expected trend of consumption and assess the potential for power management
- The planned introduction of AMM variations in the electricity CR FACE project and schedule
- Qualitative evaluation of the benefits, costs and risks
- Investments and costs of implementing AMM
- Experience from pilot projects in terms of technology and legislation, benefits and business customer
- Economic evaluation of the implementation and comparison of alternatives, evaluation of compliance with the recommendations of the European Union
- Recommendations for the introduction of smart metering in the electricity CR

Power Management in the Czech Republic is currently applying HDO system that allows power control at the level of 400-700 MW (about 6-9% load). In the annual energy such proceedings may constitute 4-7 TWh. More power management options beyond the current level, at the level of low-demand will be limited. Even in the case of full utilization of the full potential direct and indirect management will only be a minimal increase in the current level of management in the Czech Republic using the HDO. The real use of indirect management (ie voluntary customer reaction to new price signals) at the level of low-demand will be small and will be determined by the possibility of price among their customers.

The use of intelligent systems to ensure the balance is limited. The direct management (HDO) seems to be more perspective. It should be mentioned that the mere installation of smart metering required by Directive 2009/72/EC must be accompanied by adequate development and modernization of the transmission and distribution systems. [16]

5.2.4 Conclusion

The resulting expression for the economic evaluation of the project's final recommendations:

On the basis of this economic assessment conducted qualitative and economic evaluation of the project implementation of smart metering in the Czech Republic, taking into account past performance and experience of the ongoing pilot projects in the Czech Republic and installations in some EU countries, recommends the following:

Not to hold a general introduction of AMM in 2018 and continue to operate and technological development through pilot projects.

Extend the possibilities of the current system HDO supplementing tariffs without direct management appliances, based only on the transmission of economic signals to customers. At the same time stimulate more customers to participate in the HDO and use the extended tariffs.

Continually monitor new technological developments in the field of smart grids and smart metering particularly in terms of the development parameters and prices of key components relevant to the decision to start the preparation and implementation of AMM.

In 2017 set national communications standards, standards of measurement equipment and major elements of the AMM and set technical and legislative conditions for ensuring cyber security system AMM.

Evaluate the adequacy and effectiveness especially the introduction of smart metering by the year 2017.

By 2018, the process for evaluation of pilot projects and evaluate the impact of extending the use of the HDO plan implementation of smart metering as part of a smart grid project in the country.

5.2.5 Explanation to the conclusion

In the Czech Republic are compared with other countries that are considering the implementation of AMM, other initial conditions. It used a two-tier product for heating and electricity storage water heater, works in practice efficient and reliable power management (smoothing peaks) with HDO. With a functioning system of advance payments is not present a major problem with the management of non-payers, non-technical losses are low. It is fully functional system operator market. It can be said that a significant part of the benefits that lead other states to introduce AMM, are already available in the CR and market participants actively used. The system's robustness is highly resistant to cyber attacks and is characterized by high reliability.

Production technology and application equipment components for the implementation of AMM (gauges and peripherals, telecommunications) are not yet at a level that provides a guarantee of efficient, reliable, affordable deployment and after the operation is more likely to achieve the expected benefits. The MRC system fulfills most of the functionality expected in other EU countries after the introduction of AMM.

The conditions for competition in the electricity market and the current state of HDO allows the creation and offer of the tariffs and price options for end customers and thus a much greater number of customers using price and tariff signals within the simple replacement of meters and using the existing management system, ie without any the additional investment. All the consistent fulfillment of the conditions of non-discriminatory access to networks.

Area of services provided to customers and adapting to their real needs and requirements and develop a motivational tool for broad application possibilities AMM will require a lot of time in the design and marketing training.

Any introduction of AMM in the CR is not currently economically efficient, having a negative impact on the one hand to the management of grids operators and in particular in regulated prices for end customers. Most of the expected benefits of the Directive and EC recommendations are already being implemented existing ripple control systems for power management, load and tariffs, with the further expansion of the number of collection points can be managed easily and quickly achieve additional effects with minimal investment.

National legislative requirements and technical standards should be carefully prepare for the introduction of AMM, so that during the preparation and implementation could lead to confusion or misunderstanding and to ensure the safety and protection of data.

6. Smart Grids in Austria

The Definition of Smart Grids is rather imprecise because of a big variety of concepts, approaches and demo-projects. The austrian energy-mix has already a high share of renewables most of all as small and big hydro power plants but also as wind-, solar- and biomass- power plants. The future challenge is to fill the gap to a hundred percent renewable electricity-supply. Since there are still unexploited reserves in water power it is by far not enough to cover the whole demand. Especially in Burgenland the actual and the potential use of wind energy is quite high, but since it is a volatile resource big storage capacities are needed, which are available in a relatively high share in Tyrol. But the high voltage transmission capacities are too low. On a smaller scale private photovoltaic contains a huge potential but problems arise when the hierarchical organized, historical risen top down electricity network is stressed with a high number of unsynchronized consumers and producers. Since Austria is constantly facing yearly increases about two percent, it seems obvious that increasing energy efficiency and demand response can also have a big impact on the electricity system. Network driven approaches to the mentioned fields can be summed up as Smart Grid. There are lots of ongoing demo-projects and strategy papers concerning active distribution grids on getting consumers, buildings and vehicles into the grid. The only concrete action on the implementation of s smart grid concerns the rollout of smart meters in the distribution network.

6.1 Implementations Concepts of Smart Grids in Austria

6.1.1 TSO

Since Smart Grids as stated by most definitions is located in distribution networks there are no particular actions or action plans in the 2030 Masterplan [17] of the Austrian Transmission System Operator APG (Austrian Power Grid). However there are plans to establish a 380kV circle and improvements of the transmission system for covering load and power peaks for example from the wind power plants in Burgenland to the hydro pump storages in Tyrol. APG, as a member of ENTSO-E, is working on the integration of the national grids into a European compound grid. Plans to implement a Super Grid for the transmission of energy from the high production areas to consumers across the continent or even above (e.g. Desertec) are nowadays rather a concept than a plan of implementation.

6.1.2 DSO

Most potential for smart grids lays in the field of the distribution network operators. According to [18] the DSO has to provide the following services in a future smart grid:

- Flexibility services: provide the ability to adapt and anticipate to uncertain and changing power system conditions of distributed generation and flexible loads by feed-in management, load management (demand response) active distribution networks equipped with on-load tap changer in medium voltage grids and smart inverter in low voltage grids
- Infrastructure provision for electric vehicles: the forecasted growing use of electric vehicles needs structures that can manage the loads and appropriate charging points. Electric vehicles can also serve as flexible storages
- Energy efficiency services: efficiency increase can substitute expensive upgrades of the transmission system by providing information to the customers by smart meters about energy prices and can therefore provide the ability to govern the loads based on different tariff models.
- Ownership & management of metering equipment: Setting up and management and maintenance of a bi-directional smart metering system have to be done by the DSO. However the implementation cost will mainly affect the customers, which is a critical discussion issue in those days.
- Data handling: A smart grid requires the ability to store and manage the data provided by smart meters in a secure and safe manner.

6.2 Implementation status and Smart Grid Roadmap

The goals defined in the Smart Grids SRA 2007 (Strategic Research Agenda) [19] released by the European Technology Platform Smart Grids were transferred into the Roadmap Smart Grids Austria [20] in 2010 by the Austrian Technology Platform Smart Grids which states the research goals. Four main areas where found:

- System operation and management
- Communication- and information infrastructure
- Intelligent components
- Customer and market regulation

Besides most activities in the field concern research and demonstration projects smart metering has reached the state of a legal enacted implementation plan as described in the following chapter. A list and selection of finished and ongoing demonstration projects can be learned from chapter 6.2.6.

The implementation of smart metering in Austria is based on ElWOG (Elektrizitätswirtschafts- und Organisationsgesetz) [21] which implements the third energy package of the EU (Directive 2009/72/EC). It authorizes the Minister of Economy to introduce smart metering, preceding a cost-benefit analysis. The main objectives to be considered are

- Customer Information,
- Billing and
- Energy efficiency.

A cost-benefit-analysis for the introduction of smart metering for electricity and gas was published in spring 2010, conducted by PricewaterhouseCoopers [22] and commissioned by E-Control (the Austrian Energy Regulatory Authority) , finding that the implementation of smart metering will lead to a strong economic benefit. A study conducted by Capgemini (2010) [23], commissioned by the Austrian energy industry found a negative assessment. The Austrian legal framework determines that the network operator has the obligation for metering, billing of the network charges and forwarding the necessary date to suppliers and other market players involved.

Due to the Electricity Act the E-Control issued a decree (Intelligente Messgeräte-Anforderungs [24]) defining the functional requirements of smart metering systems, which include

- Bi-directional communication-connection
- Possibility of saving meter counts and average power or consumption values in 15-minutes-periods as well as the daily consumption
- Storage of meter data for at least 60 days
- Possibility of exporting all data via communication ports at least once a day
- Communication ports which allow at least four external meters

- All Communication have to be encrypted and protected to avoid unauthorized access
- Facilitation of remote disconnection of customer systems, remote release for reconnection by the customer and limitation of the maximum load
- An internal clock with remote synchronization
- Possibility to receive and process remote software updates
- Compliance with the national weights and measures regulation

Following the EU-directive which states a that 80% of the customers should be equipped with smart meters in to 2020 in 2012 the rollout plan for smart metering devices in Austria was determined as a mandatory timetable, as follows:

The electricity network operators have to equip at least

- 10 % of all metering points by the end of 2015
- 70% of all metering points by the end of 2017
- 95% of all metering points by the end of 2019

with smart metering appliances complying with the regulators decree.

In 2012, according to, approximately 150.000 electricity customers were equipped with smart meters.

6.2.1 Business economy / national economy

The financial effects of the implementation of smart grids and smart meters are discussed rather controversial, depending on the stakeholder's point of view. The Study Green ICT in Austria [25] conducted by Energieinstitut der Wirtschaft Gmbh and IWI (Industriewirtschaftliches Institut) on behalf of BRZ (Bundesrechenzentrum GmbH), FEEI (Fachverband der Elektro- und Elektronikindustrie) and Vereinigung der Österreichischen Industrie (IV) estimates energy savings in the business usual scenario from about 676 GWh/a in the year 2020 compared to 2010, corresponding to 100 million euro, or 1229 GWh/a and 184 million euro in the best case scenario. The overall Austrian electricity consumption in 2013 was 62,2 TWh. The Reduction of CO_2 emissions is estimated with 1,2 million tons in 2020 in the business as usual and 2,3 million tons in the best case scenario. That corresponds to monetary savings of about 38 to 76 million euro or 41 to 82 million euro, due to the reduction of needed CO_2-emission certificates. The final energy savings is mainly referable to adaptions of customer behavior due to the rollout of smart meters, whereas the CO_2 emission reduction is mainly explained by integration of renewable energy generation.

A smart meter field test from Linz AG to determine the electricity savings in households was conducted in 60.000 households. Through regular information via internet a reduction of 4,3% was been found. Combined with scaled tariffs a reduction of 6% was found. .The E-Control estimates a 3,5% reduction for households, industry and agriculture, based on results the conclude a 2,44% reduction in the business as usual scenario and 4,43% in best case scenario.

6.2.2 The financial impacts of smart meters

In [26] a comparsion of the earlier mentioned cost-benefit-analyses is revealed. The goal of the earlier mentioned PricewaterhouseCoopers study [22] is to make an objective macroeconomic cost-benefit-analysis. To determine the costs in detail the calculation is divided into consumers, suppliers and grid operators. Four different scenarios of different penetration levels and implementation points are assumed. The study reveals expenses and savings for a review period of 15 years (until 2025) and an 80% penetration in the year 2020. All in all it reveals a significant reduction of electricity expenses for customers at the expense of the grid operators and power companies. But it can be assumed that the costs will be transferred to the customers through tariffs. So the remaining economic effects are at least the implementation of the smart meter and ICT infrastructure, the provided services and CO_2 emission reduction. The positive net effect for customers is about 2,0 to 2,7 billion euro. The grid operators face a negative net effect of 1,4 to 2,0 billion euro. The impacts an suppliers are lower but have to estimated negative because of the decrease in electricity consumption. Tab. 1 shows the overall costs in detail.

	Savings (bn €)	Expenses (bn €)
Customer	2,014 to 2,595	0
Grid operator	0,272 to 0,381	1,743 to 2,299
Electricity Supplier	0,272 to 0,378	0,557 to 0,769
Overall	2,568 to 3,551	2,301 to 3,195
net effect	0,267 to 0,356	

Table 1: summary over all savings and expenses in electricity

The results also reveal positive effects on the national economy of a value added increase of 775 million euro and 547 created workplaces every year.

The Capgemini study [23] to economically evaluate the rollout of smart metering in Austria commissioned by Austrian Energy reveals considerably higher cost for the rollout of smart metering. In contrast to the PricewaterhouseCoopers study the NPV (Net Present Value) method was used for the investment appraisal. Producers and customers show a positive NPV, whereas the overall result reveals a negative NPV and therefore macroeconomic cost of 1,7 to 2,4 billion euro.

6.2.3 Demostration Projects

Austria has big variaty of ongoing demonstration projects. Most of them are conducted by universities or reserach facilites or organized in cooperations of townships, universities and industry. [27] and [28] show exemplarily the projects in the Modellregion Salzburg which is the most integrated ongoing projects. Smart Metering field test are conducted by nearly every distribution system operator.

Smart Grids Modellregion Salzburg:

It is the most comprehensive research project in Austria. It was founded 2009 with industry partners and research institutes. The Goal is to integrate completed an ongoing projects into an model region Salzburg. The key aspects are

- Active distribution networks und medium and low voltage grids
- Virtual power plants, combined heat and power
- Demand response/demand side management
- Integration of electro mobility
- New technologies

The following projects provide real network data and practice related results:

Smart Distribution Grid Bioshärenpark Großes Walsertal

The existing network infrastructure has reached the maximum workload which means the existing generation potential cannot be exploited. In this demonstration project the concepts of active distribution networks resulting in interventions in the voltage level for moving the critical voltage narrow is tested.

Smart Commnity Großschönau

In Addition to an existing zero energy building park the moving potential of different loads in households, like heatpumps, pumps of water and district heating supply and public ventilation and clarification plants is examined .

Smart Infosystems Vöcklabruck

In the pioneer region already in 2009 10.000 smart meters were installed. Research goals are an intelligent information/measurement/control-system Customer-Retailer and the Power Snap-Shot-Analysis, a method of gathering net conditions with smart meters.

Smart Microgrid Murau

The strategy of the township Murau is to increase the value added by using electricity from local production, moreover the relief of higher ranked grids and the ability of island operation as Microgrid.

Smart Services Linz

The project focus is to build up an information and communication net for the infrastructure grids in the metropolitan area Linz. Through demand side management the electricity, water and gas grid as well as electric fillig station will be regulated. Already realized Services:

- Smart Passenger Information System
- Smart Meter Reading
- Smart Public Lightning control

6.3 Concerns

There are still concerns regarding data protection and security. Also a point of discussion is the metering periods and der level of detail. The threat of cyber-attacks and the insecurity of data integrity are imminent, although there are available technologies like smart cards for proper encryption. Also the aspect of remote customer disconnection is critical.

6.4 Conclusion

A direct comparison of the results is rather difficult because of the different methods and scenarios, but trends can be seen. Different assumptions for customer use are also a problem for comparison. From an macroeconomic point of view the effects of the implementation of smart meters seem positive. Capgemini states that from an economic point of view the smart meter rollout is not reasonable, but concedes that technical circumstances could lead to other decisions. PwC states the it would lead to positive economic effects as well as energy savings and a CO_2 emission reduction.

7. REFERENCES

[1] MINISTERSTVO ŽIVOTNÍHO PROSTŘEDÍ. Klimaticko-energetický balíček [online]. [cit. 2013-10-17]. Dostupné z: http://www.mzp.cz/cz/klimaticko_energeticky_balicek

[2] BERAN, Jaromír. Summary of priorities for Smart Grids research topics, Conference Smart Grids & Metering – Aktuální trend v energetice, Cyklus seminářu 2014, Praha 23. 4. 2014

[3] ČEZ, a.s. 2012. Smart Grids. FUTUR/E/MOTION. [Online] 2012. [Cited: Říjen 17, 2013.] http://www.futuremotion.cz/Smart Grids/cs/index.html.

[4] ABB. 2013. Úvod do problematiky inteligentních sítí. [Online] 2013. [Cited: listopad 17, 2013.] http://www02.abb.com/global/czabb/czabb018.nsf/0/a5a3d03331846f55c125773d004a5ede/$file/Smart+grids_cz.pdf.

[5] European technology platform for the electricity networks of the future. 2010. Strategic Deployment Document for Europe's electricity networks of the future. [Online] 2010. [Cited: Listopad 17, 2013.] http://www.Smart Grids.eu/.

[6] SITU, Lixin. 2012. Electric Vehicle Development: The Past, Present & Future. 3rd International Conference on Power Electronics Systems and Applications. [Online] 2012. [Cited: listopad 23, 2013.] http://80.ieeexplore.ieee.org.dialog.cvut.cz/stamp/stamp.jsp?tp=&arnumber=5228601.

[7] KILIAN, Dominik. 2012. Competitiveness of the EU Automotive, Final Report. Chair of General Business Administration and International Automotive Management. [Online] Prosinec 19, 2012. [Cited: Listopad 22, 2013.] http://ec.europa.eu/enterprise/sectors/automotive/files/projects/report-duisburg-essen-electric-vehicles_en.pdf.

[8] AJANOVIC, Amela. 2013. Promoting environmentally benign electric vehicles, 2013 ISES Solar World Congress. Vienna University of Technology , Austria, Gussgausstr.25-29-370-3 : s.n., 2013.

[9] European technology platform for the electricity networks of the future. 2010. Strategic Deployment Document for Europe's electricity networks of the future. [Online] 2010. [Cited: Listopad 17, 2013.] http://www.Smart Grids.eu/.

[10] ČEZ a.s. Seriál - 3. Chytrý domov. Futur emotion energie zítřka. [Online] [Cited: Prosinec 6, 2013.] http://futuremotion.cz/cs/serial/3-chytry-domov.html.

[11] ČEZ a.s. 2012. Smart Grids. FUTUR/E/MOTION. [Online] 2012. [Cited: Říjen 17, 2013.] http://www.futuremotion.cz/Smart Grids/cs/index.html.

[12] MPO, Sekce 3000. 2012. Ekonomické posouzení přínosů a nákladů při zavedení inteligentních měřicích systémů v elektroenergetice. Ministerstvo průmyslu a obchodu. [Online] Září 4, 2012. [Cited: Prosinec 7, 2013.] http://www.mpo.cz/dokument106754.html.

[13] ROUBAL, Jiří. 2013. Smart Grids v lokálních distribučních soustavách. Energetika, ČSZE, ISSN 0375-8842, Český svaz zaměstnavatelú v energetice. Měsíc, 2013, Vol. 006, 1.

[14] VRBA, Miroslav. Interview. 2013. ČEPS. Praha, Listopad 29, 2013.

[15] MPO, Sekce 3000. 2012. Aktualizace státní energetické koncepce. Praha : s.n., Únor 2012.

[16] HABRYCH, R., JAROLÍMKOVÁ, G. 2013. Implementace Smart Grid v lokálních distribučních soustavách průmyslových podniků. Energetika, ČSZE, ISSN 0375-8842, Český svaz zaměstnavatelú v energetice. Měsíc, 2013, Vol. 001.

[17] APG, Austrian Power Grid: Masterplan 2030, 2013

[18] Paul van den Oosterkamp et al.: The role of DSOs in a Smart Grid environment, 2014

[19] European Technology Platform SmartGrids: SmartGrids SRA 2035 Strategic Research Agenda Update of the SmartGrids SRA 2007 for the needs by the year 2035, 2012

[20] Andreas Lugmaier et al.: Roadmap Smart Grids Austria, FEEI – Fachverband der

[21] Elektrizitätswirtschafts- und –Organisationsgesetz 2010 – ElWOG 2010, BGBLA 23.12.2010

[22] PWC, PRICEWATERHOUSECOOPERS GMBH: Studie zur Analyse der Kosten-Nutzen einer österreichweiten Einführung von Smart Metering, 2010

[23] CAPGEMINI, CAPGEMINI CONSULTING ÖSTERREICH AG: Analyse der Kosten – Nutzen einer österreichweiten Smart Meter Einführung, 2010

[24] Intelligente Messgeräte-AnforderungsVO 2011 – IMA-VO 2011, BGBL, 25.11.2011

[25] Energieinstitut der Wirtschaft GmbH, IWI Industriewissenschaftliches Institut: Green ICT in Österreich, Potentiale und Möglichkeiten zur Steigerung der Energieeffizienz und Reduktion von klimarelevanten Emissionen, BRZ Bundsrechenzentrum GmbH, FEEI - Fachverband der Elektro- und Elektronikindustrie, Vereinigung der Österreichischen Industrie (IV), 2013

[26] Michael Holzinger, Masterarbeit: Smart Metering und sein Einsatz in Österreich, 2011

[27] Broschüre: Intelligente Energiesysteme der Zukunft: Smart Grids Pioniere in Österreich, Bundesministerium für Verkehr, Innovation und Technologie (bmvit), 2010

[28] David Reiter, Masterarbeit: Intelligente Effizienzsteigerung in Anbetracht zukünftiger dezentraler und volatiler Stromerzeugung in Österreich, 2013