Regulatory requirements to support the deployment of Smart Grid from the perspective of a DSO

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ABSTRACT

In this paper the investments needed for the deployment of a Smart Grid are evaluated. In this regard the impact of demand side changes including e-mobility, heat pumps and electric heating as well as the impact of the generation side (Distributed Generation) on the Berlin grid within the next 20 years was examined in a net model study.

Referring to the future requirements the paper gives some recommendations for adjusting the current economic regulation system to foster Smart Grid investments.

INTRODUCTION

For achieving 20 % Generation from Renewable Energy Sources (RES) and a 20 % increase of energy efficiency by 2020, smarter grids will be a necessity. Thus net automation electric vehicles, Smart Metering and storage technologies will play an important role in the future. Still the specific investment needs depend on the regional characteristics. In particular there will be a difference between urban and rural areas. As Vattenfall operates the distribution grids of the two biggest cities in Germany – Berlin and Hamburg – the first part of this paper focuses on the challenges for metropolises.

In the second part it is discussed whether regulation sufficiently encourages Smart Grid investments. In Germany the economic regulation of Electricity Distribution System Operators (DSOs) is based on a revenue cap system. The existing insufficiencies of the current regulatory framework lead to a major reduction of the achievable rates of return hampering investments in new technologies and therefore the development of Smart Grids. Part three covers a brief discussion of possible solutions and some recommendations for the adjustment of the current regulatory system.

WHAT KIND OF SMART GRID INVESTMENTS WILL BE NEEDED FOR THE CITY OF BERLIN?

The definitions of a "Smart Grid" usually refer to the required functions related to the aimed transformation of the energy system. As an example the European Technology Platform Smart Grids defines Smart Grids as "electricity networks that can intelligently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable and secure electricity supply."[1] This paper will refer to the investments of the metropolitan area of Berlin which will be necessary to fulfil the described role of the DSO.

General definition of Smart Grid investment needs

Using the European definition as a reference, *necessary smart grid investments* are on the one hand determined by the individual characteristics of the area supplied. On the other hand they depend on the requirements of the overall system corresponding to the interdependencies between the transmission and distribution system operators.

According to that the term "*necessary investment*" can be defined in two different ways. Firstly concerning the *minimum of investment* needed to avoid congestions, a loss of quality of supply and bottlenecks for RES in the specific area. Secondly concerning the *optimum of investment* needed to use the potential of a specific region best in the context of the whole system. Regarding the ambitious climate targets an *optimum of investments* is needed to provide the most efficient solution.

The Smart Grid development of DSOs supplying German *rural areas* is mainly driven by high amounts of Distributed Generation (DG) leading already to a direct push for investments.

Smart Grids in *metropolises* like Berlin will be driven in a different way. The potential of these cities is distinguished by the high density of customers. This delivers a platform for electric vehicles including intelligent charging and therewith storage facilities (vehicle to grid concept). Further on demand side management and the integration of distributed generators will be part of the future smart grid concept. The optimal exploitation of this smart potential has a considerable impact. This potential and its possible

1 www.smartgrids.eu

influence on the overall system will be characterized in the next section.

Characteristics of the Berlin grid

With 2,500 MW peak, around 900 MW minimum load and a yearly energy consumption of 13,800 GWh the Berlin grid is an important centre of load within the Brandenburg region. Figure 1 illustrates examples for a typical load curve.

Figure 1: Examples for load curves (Berlin)

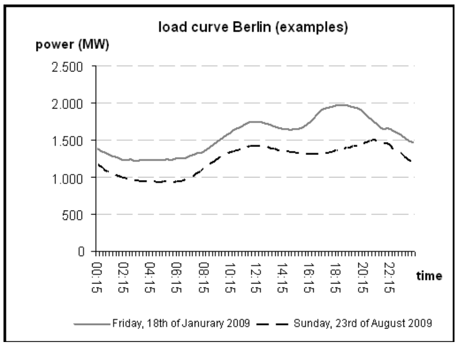


Table 1 shows the detailed technical data of the Berlin grid. As around 3.4 million people live at a geographical area of 892 km^2 the average population density of Berlin is more than 16 times higher than the average of Germany. However there are significant differences between the inner districts compared to the suburban areas of the city. On the whole, the distribution grid consists of more than 35,000 km cables and overhead lines. In 2009 the System Average Interruption Duration Index (SAIDI) was 12.3 minutes per year and therewith below the German average.

Table 1: Technical data of the Berlin grid

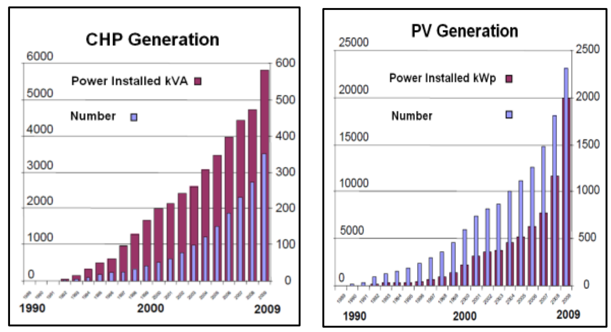
Cables and overhead lines (97 % of these are underground cables)	35,700 km
Number of transformers 110/10 kV	80
Number of substations 10/0,4 kV	7,600
Number of connection points /meters	2.4 million
Average household’s consumption (kWh/a)	2,200
SAIDI (2009, minutes per year)	12.3

Future Challenges for Metropolises

The promotion of RES in Germany (particularly by the Renewables Energy Act) has initiated a significant increase of volatile DG. In metropolitan areas such as Berlin wind power does not play a major role, still photovoltaic (PV) generation is increasing continuously. Besides Combined Heat and Power (CHP) generation is growing substantially. Figure 3 shows the development of CHP and photovoltaic generation in Berlin from 1990 to 2009. Further challenges result from changes on the demand side as the increase of energy efficiency is an important issue and customers are supposed to play an increasingly active role in the future. Changes on the demand side will also include the development of e-mobility, heat pumps and/ or electric heating

The effects of the changing demand and the increased DG on the Berlin grid within a range of 20 years was examined on the basis of network models. For this purpose three representative parts of the low voltage network were modelled (“City Area”, “Suburban Area with a relatively young asset base”, “Suburban Area with a relatively old asset base[2]”). The analysis included the influence on network parameters like voltage quality or load flow in the component.

Figure 3: Development of CHP and PV generation



Preliminary Analyses

The analyses show that the investment needs of a metropolis like Berlin can hardly be derived from the average development within the city area. Instead the impact on specific districts varies significantly. The deployment of a smart grid is therefore in a first step based on an extended grid monitoring including the low voltage level.

Investment needs will further on result from changes on the demand side, especially caused by the development of e-mobility, heat pumps and/ or electric heating. Concerning electric vehicles, intelligent charging will be a necessity. Further on the network analysis reveals that the integration of the increasing amounts of DG into the distribution grid of Berlin also leads to investments within the next years. Still Berlin has a relatively low share of DG as wind does not play a major role.

Within the *surrounding* areas of Berlin the situation is totally different; challenges are *mainly* driven by the increasing share of DG. The amount of intermitted RES of these rural areas is dramatically higher than in Berlin. In eastern Germany the installed capacity is already twice as high as the energy demand during periods of strong wind, so that the present electricity flow reverses and the generated

2 The planning parameters for the grid change over time

surplus of electricity is feed in from the distribution grid into the transmission grid. Perceptively an advanced system management at the distribution level will secure the high quality of electricity supply while allowing the connection of RES to the distribution grid without any constraints and helping consumers to participate more actively in the market.

Since Berlin has nearly no wind power connected to the grid, its future role as "energy sink" is a promising solution for an efficient relief of the transmission system which will be increasingly challenged e.g. by rural areas with high amounts of wind power. Hence the future DSO should be capable of managing DG as well as the demand. The demand offers the greatest smart potential within small and medium enterprises (SEM) and consumer groups which use heat pumps or electric heating. Further potential can be found in decentralized heat storage facilities and electric vehicles. The latter will bring benefits to the electric system using intelligent charging strategies.

Concluding in Berlin the direct push for investment resulting from Distributed Generation (DG) is lower than in rural areas with a higher amount of volatile DG. Investments in large urban areas will mostly be driven by changes on the demand side. Even though the transformation of the existing grids to Smart Grids will avoid some investments for grid expansion and reinforcement and is a key to an efficient grid operation, the needed optimum of investments leads at the outset to higher capital expenditures. The next part analyses if the current regulation in Germany matches these investment needs.

STATUS QUO OF THE GERMAN ECONOMIC REGULATION AND THE ON EFFECTS ON SMART GRID INVESTMENTS

Whether Smart Grid investments will be done is significantly influenced by the economic regulation of the DSOs. The characteristics of the economic regulation in Germany will be subject in the following before disincentives of the system are analysed.

The economic regulation of German DSOs

Since 2009 the grid tariffs in Germany are based on a revenue cap system with regulation periods of five years. The development of revenues during the regulatory period is determined by a cost review with including the possibility of cost cuts by the regulatory authority. The cost review refers to the influenceable costs (operational and capital expenditures) and is carried out two years before the beginning of the following regulatory period. Because the cost review refers to the actual costs at the year before, the minimum time delay between relevant costs (*cost base*) and the initial revenue cap of the next regulatory period is three years - and because of the five year regulatory period the maximum time delay is seven years. The non- influenceable costs like taxes, downstream costs and concession levies are not subject to that process and are taken into account within the revenue cap with a two years delay.

Concerning the efficiency requirements, a general as well as an individual cost reduction requirement (x-factors) are set. The latter is calculated by means of a benchmarking of the German DSOs considering their influenceable costs and various structural parameters. Due to the probability of cost cuts within the cost review and the additional cost reduction requirement based on the benchmarking, the German regulatory system imposes an enormous pressure on the influenceable costs.

Investments which are not included in the cost base for the current revenues are considered in three different ways during the regulatory period: Firstly a lump sump transfer (maximum 1 % of CAPEX-annuities) is applied if capital expenditures have increased. This transfer is only supposed to be approved in the first regulation period. Secondly revenues are adjusted in case the area supplied, peak load or the number of customers and/or distributed generators has risen. This adjustment does not depend on the actual cost increase but on a rough estimation. Thirdly investment budgets may be approved. Due to the fact that this instrument focuses on investments in transmission grids investment budgets can be approved only in exceptional cases for distribution grids.

In 2012 a quality regulation will be implemented which intends to incentivize the equilibrium between cost reductions and grid performance. In a first step the System Average Interruption Duration Index (SAIDI) will be used to evaluate the quality of supply. The German regulatory authority intends to take the average quality of supply of a comparable grid operator to calculate the individual bonuses and penalties.

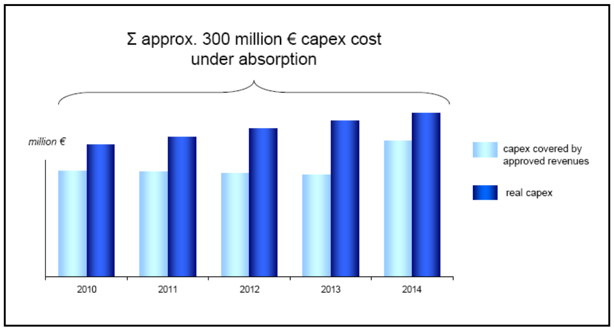
Summarizing the German incentive regulation scheme aims first and foremost at cost reductions. The existing instruments of the present system are not designed for pricing Smart Grid investments. On the whole it does not match the new dynamics and Smart Grid needs and is based on the assumption of a static environment.

Disincentives of the current regulation

Investments are taken when the rate of return exceeds the risk adjusted comparable rate of return which can be earned on alternative investment opportunities on the capital market. Assuming that the currently approvable 7.82% return on equity equals this rate, its achievability is a necessary condition. Otherwise the effected DSOs could favour strategies implying the reduction of investments to the minimum.

Expertises [1] on regulatory investment conditions have verified that these 7.82 % are systematically not achievable - even for efficient grid operators[3]. This mainly results from the time delay of three to seven years between the investment and its consideration in the allowed revenues (CAPEX time shift). According to the expertises the achievable rate of return is ca. 4%. The following figure shows the real capital expenditures of the DSO in Berlin in comparison to the capital expenditures covered by the approved revenues.

Figure 5: Real and covered CAPEX (Berlin grid)



Smart Grid investments

Because of the relatively unknown technology and its outcomes Smart Grid investments are riskier than investments in standard grid components:

- The development of the Smart Grid requirements is insecure and depends e.g. on the concrete penetration of RES, e-mobility and the activity of customers. Therefore the risk of sunk costs is getting higher.
- Cost also may be ex post evaluated to be "inefficient" within the benchmarking.
- For important technologies like Smart Metering the minimum standards are not yet defined. Components that are installed today may not match the standards defined tomorrow.

Regarding Smart Metering Germany currently counts on a market driven implementation. Therefore not only the technical standards but also roles and responsibilities are not explicitly defined.

CONCLUSIONS AND RECOMMENDATIONS

The transformation of the energy system towards a low carbon generation will have a significant impact on distribution grids. Model case studies show that the impact differs strongly between the different types of grids. While cities as Berlin will probably supply storage capacity to the overall system, rural grids will have to deal mostly with influences caused by DG. However, all possible transformations will require Smart Grid investments.

In order to incentivize Smart Grid investment a review of the regulation system is indispensable. Therefore either the realistic achievable rate of return has to be increased to a risk related level or the risks for the investor have to be reduced. The German Energy Act will be amended in 2011 which offers the chance to improve investment conditions for Smart Grids. This paper will conclude with some recommendations from a grid operator's point of view.

Because of the expected short-term changes of the grid infrastructure the CAPEX time shift has to be repealed. Besides it becomes increasingly problematic to set future allowances on costs that reflect the traditional needs. As a conclusion clear rules for adjusting the revenues with a higher frequency are needed to reduce the barriers to investments significantly. Despite there does not exist a "one fits all approach" as the international regulatory practise gives valuable input. In France, Portugal or Slovenia a planning cost approach was implemented which also may solve the time shift problem in Germany. Still it might cause a lot of time and effort due to the large number of nearly 900 DSOs operating in Germany. The argument also holds for an extended use of investment budgets if all DSOs apply for several budgets each year. A different approach was chosen by the Norwegian regulator who has introduced an adjustment parameter that compensates the CAPEX time shift ex post. Here another problem occurs due to the fact that the time shift in Germany is up to seven years: Particularly small companies may face problems concerning the liquidity. For that reason a shortening of the time lag is of great importance.

A yearly adjustment based on the development of the book values - similar to the approach that was introduced by the Austrian regulator- reduces the time shift to two years. The remaining time shift can be compensated ex post by means of an adjustment parameter.

The success of the upcoming Smart Grid development depends also on technical innovations. Appropriate incentives for innovations are needed to secure efficient investments. If projects are evaluated suitable to foster the Smart Grid development, they should be recognized by the regulatory framework regulation without delay.

Finally clear roles and responsibilities as well as minimum standards for smart meters are indispensable to enhance the planning reliability.

REFERENCES

[1] Ballwieser, 2008, *"Investitionsrechnungen für Netze im Rahmen der Anreizregulierung"*, Gutachten

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3 according to the benchmarking results