THE SMART GRID ROADMAP AND REGULATION APPROACHES IN SWITZERLAND

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ABSTRACT

The present paper gives an overview on the Smart Grid Roadmap of Switzerland, which identifies barriers for the development of Smart Grids. Based upon the findings, regulatory instruments are developed and described. They comprise the mandatory roll out of smart metering, privacy and data security requirements, coordination mechanism between market players and network operators for the use of flexibility as well as incentive instruments for OPEX intensive smart grid solution in a cost+ regulation.

INTRODUCTION

Smart Grids have been discussed vigorously by the scientific community in the past, in response to different drivers. First, a general driving force for a change in the electricity sector is the discussion on environmental sustainability of electric power generation in the verge of climate change. This triggered the restructuring of the electric power sector. Pushing the expansion of renewable generation as well as efficiency in production and consumption have become major fields of political interest. This has subsequently led to new challenges for electricity distribution grids, which have appeared through the integration of large amounts of small, distributed and mainly renewable energy generators, such as photovoltaic and wind. Second, information, communication and computational technology have faced a major decline in costs, making it almost universally available. Third, the costs for electricity storage are falling continuously, coinciding with an increasing attraction to make use of it in small-scale applications.

Smart Grids are understood as a new way of planning and operating electricity distribution grids by using more computational measures. The utilization of measuring technology, control algorithms and devices adds intelligence to the passive infrastructure. This is necessary in order to cope with the fluctuating and distributed nature of electricity infeed into distribution grids.

BACKGROUND

The Swiss Electricity Supply Sector

At present, the Swiss power generation portfolio consists of mainly nuclear power (33,5%) and hydropower (59,9%), along with some minor contributions from other renewable energy sources (2.6%; primarily photovoltaic), and some small scale combined heat and power generation (4%). The Swiss electricity market is only partly liberalized. Consumers with a consumption of over 100 MWh/a are allowed to change their supplier. Everybody else is bound to their local utility. There are nearly 700 distribution system operators (DSOs) / utilities in Switzerland. Besides the natural monopoly of the network, the DSOs hold a legal monopoly on the metrology. The utilities are loosely unbundled; a separation of accounting and information is currently being demanded. The national regulatory authority (NRA) is kept rather small with its manpower counting around 40 people. As for the regulation of electricity grids, a cost+ regulation with a WACC of currently 3.83% after taxes has been established. Cantons, cities or communities publically own most utilities.

The Energy Strategy 2050

In 2011, after the incident in Fukushima, Japan, the Swiss Federal Council – Switzerland's highest political institution – decided to shift out of nuclear power and to replace it with renewable energy sources. Simultaneously measures should be taken in order to reduce electricity consumption until 2035 by 13% compared to the level of the year 2000. The regulation package is referred to as the Energy Strategy 2050 (ES2050). The expansion of renewable energy generation targets at around 2,3 GW of wind and around 11 GW of PV in 2050. The ES2050 provides for the current maximum amount of 1,5 centimes per kilowatt hour of this network supplement to be increased to a maximum of 2,3 centimes per kilowatt hour in order to promote the construction of more such installations. In addition, the feed-in remuneration will be brought closer in line with the market situation by virtue of the fact that most of the energy producers will have to sell their electricity directly on the market. As a result there will be an incentive to sell electricity when it is in short supply. The subsidy system is, moreover, of limited duration: promotional subsidies for new installations will only be granted for up to five years after the new law comes into force. Furthermore, regulations for self-consumptions have been expanded. With the ES2050, self-consumption communities can be established. Such communities are enabled to organize themselves and appear as an aggregate consumer. Also, the ES2050 features regulatory instruments for the nationwide smart meter roll out and the use of dynamic and intelligent tariffs. Notably, the ES2050 also features a regulatory framework for the coordination between market players and network operators utilizing flexibility, i.e. controlling demand, infeed and distributed storages. The law is not yet in force.

Other regulation projects

Although the ES2050 is a major regulatory revision project including approaches necessary for shifting towards a more sustainable energy sector, other regulations are under way. The Power Grid Strategy, currently discussed in the parliament and for complexity reasons separated from the ES2050, will establish a set of rules speeding up network expansion and supporting security of supply. Subsequently, a major revision of the Electricity Supply Law will be undertaken. It targets, among other goals, on an expansion of the regulatory framework for the use of flexibility, set up in the ES2050.

DRIVERS AND CHALLENGES FOR SMART GRIDS

Smart Grids have shifted into focus due to the challenges, which are posed to the grid by vast numbers of fluctuating, decentralized small-scale production sites. Grid expansion costs are of primary interest. Studies for Switzerland have shown substantial and hence costly distribution grid expansion needs. The costs for integration the renewable energy sources into distribution grids vary between 12,6 Mrd. CHF and 15 Mrd. CHF [1]. Smart Grids are envisioned to reduce expansion costs while contributing to a stable and secure system operation.

However, the major challenge for Smart Grids is their remaining indefiniteness. Additionally, market use cases were mingled with grid use cases. Hence, Smart Grid approaches often fail to consider regulatory requirements on unbundling, cross-subsidization or information asymmetry between NRA and DSOs.

The electricity network is a natural monopoly; DSOs are regulated and largely averse to risks. They request clear guidelines or regulations on what to do or what to avoid. However, regulation approaches for smart grids remain unclear. Studies demonstrate how different regulatory regimes have their pros and cons for incentivizing Smart Grids. Incentive regulation would be, economically spoken, the second best approach; however, this has been questioned [2-5] in the past. The Swiss cost+ regulation regime yet provides strong incentives for CAPEX-intensive investments, i.e. conventional solutions. Smart grid solutions are often more OPEX-intensive. DSOs in Switzerland will thus preferably choose conventional solutions as their rate of return is regulated. Additionally, Smart Grid solutions are often of a complex nature. They require computational abilities and maintenance.

THE SMART GRID ROADMAP

To provide a common understanding of Smart Grids and of obstacles they face, the Swiss Federal Office of Energy (SFOE), responsible for suggesting new regulation instruments, prepared a national Smart Grid Roadmap in cooperation with a large number of stakeholders [6].

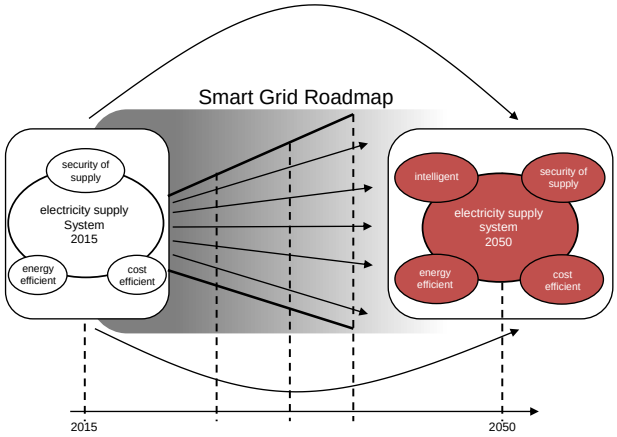

Figure 1: the Smart Grid Roadmap depicts different ways and options to develop the current into an intelligent system.

The Role of the Roadmap

The objective of the Roadmap, besides providing the common understanding of Smart Grids, is to achieve a consensus on current challenges for electricity networks – much needed with regard to the nearly 700 DSOs in Switzerland – and to identify future functionalities of electricity grids, which shall support the tackling of those challenges. As the Roadmap is based on a consensus, it should initiate a development in which all stakeholders work together in order to realize the functionalities. This is shown in Figure 1. However, the Roadmap should not point out only one possible way to achieve intelligent electricity grids. On the contrary, by identifying future grid functionalities and correspondingly needed technologies, it offers a toolkit for both network operators (TSO & DSO) and other stakeholders, thus providing different ways for progress. The functionalities are realized by combining different technologies. A Smart Grid is formed by the interaction of different grid functionalities (see Figure 2).

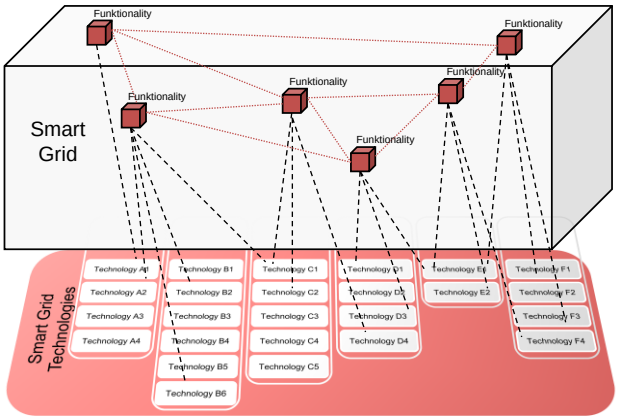

Figure 2: Different technologies combined offer new functionalities for grids. The combination of these functionalities forms a Smart Grid.

The roadmap identifies barriers for realizing the functionalities in different areas, including the availability of technologies, IT- standards, missing security and

privacy guidelines or doubts concerning the cost effectiveness of new technical solutions. The Roadmap is thus useful to every stakeholder and in particular for the NRA and the SFOE, as barriers in the regulation regime are identified as well.

Content and Major Findings

Studies have been carried out in order to develop approaches to reduce the identified barriers. The studies investigated: 1) current technologies, their state of play, their interaction and cost effectiveness; 2) a smart meter introduction; 3) a coordination mechanism between DSOs and market players in order to increase flexibility and make the best use of it in the system; 4) privacy and IT-security issues in the context of smart metering and coordination mechanisms for flexibility; and 5) additional regulative tools for the cost+ regime.

Figure 3 gives an overview of the analysis on current technologies [7] and their interactions. The market and the grid are strictly differentiated.

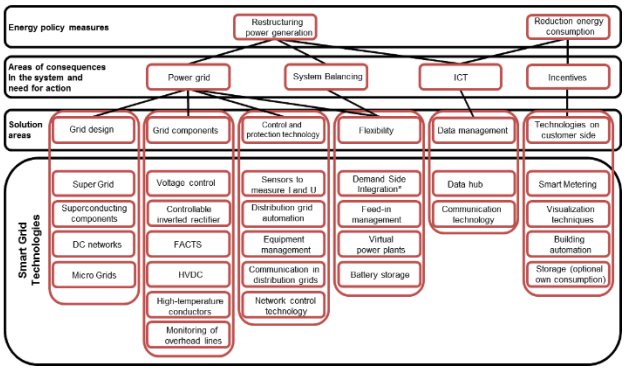

Figure 3: Overview of analyzed technologies and areas of application.

Concerning the smart meter roll out, cost-benefit analyses provided positive results. Net direct costs will reach 0.8 Mrd. CHF by 2035, while indirect benefits will reach up to 1.7 Mrd. CHF. A net benefit of up to 900 Mio. CHF was found. Consequently, an introduction of smart metering in Switzerland should be performed [8].

With regard to coordination mechanism for market and grid purposes of flexibility, the Roadmap demonstrates several barriers and vague rules for utilizing flexibility, i.e. demand side management, infeed management and control of distributed storage. Different players who are interested in using flexibility are found on the market. However, DOs currently have an advantage because they own a self-given privilege to use their ripple control on demand side resources at any time. Compensation, rights and duties are ambiguous.

In terms of privacy and data security, the Roadmap identifies a need for harmonizing the current regulations on privacy, since they are currently the responsibility of cantons or even cities. Furthermore, a risk analysis should be performed for smart metering systems and control systems, which are needed to make use of flexibility. In case an increased data security becomes necessary, approaches for securing the systems should be established under the supervision of the state. [9].

Finally, the Roadmap points out that additional incentive instruments are necessary in order to actually see DSOs investing in new technologies and more intelligence. A simple cost+ regulation, even in tight application, does not offer adequate incentives. The advantages of a CAPEX intensive strategy – commonly known as the Averch-Johnson-effect [10] – weigh too heavy in that current technological advances and requests for behavioural change could alter them. Particularly at times when market prices do not offer large profits, CAPEX in the regulated area offer a safe return on investment for a loosely unbundled utility.

REGULATION APPROACHES

Based on the findings presented in the Smart Grid Roadmap, several new regulations are considered or will actually be introduced in different legislative packages.

Smart Meter Introduction

The ES2050 incorporates a legal basis for a Smart Meter roll out in Switzerland. Consumers and producers will receive a smart meter. The costs for Smart Meter Systems are made accountable as network costs in the regulatory basis of the DSOs. They will have to inform the NRA separately about the costs for the introduction of the Smart Meter Systems. They need to possess certain minimum technical requirements, which will be defined on the level of ordonnances. In order to identify proper minimum technical requirements, the SFOE has initiated a stakeholder process and the consultation of external experts. A report delineating proper requirements, which found a broad and nationwide consensus, has been published in order to offer DSOs enough time to prepare their roll out adequately. It seems certain that a full but not too swift roll out, e.g. until 2025, would be received widely beneficial.

Privacy and Data Security

The ES2050 harmonizes the regulatory framework for privacy requirements of Smart Metering Systems and of control systems for flexibility on a federal level. The regulations on cantonal or community level will no longer be applicable. In general, 15 minute load curves of consumption or production data will be allowed. DSOs remain responsible for the data handling and their provision to other market players. Pseudonyms and anonymization processes, where possible, should ensure privacy. Smart Meter data can be used for optimization of network operation and planning, but must undergo the mentioned process if its personal data.

A risk analysis was performed for Smart Metering Systems and for control systems. In both cases a proper protection of the systems must be guaranteed. The recommendation is that a dedicated protection profile, covering organizational and product specific technical requirements, should be developed. This comprises the checking of the specific objects, their technical security requirements, and the respective test routine. In the final stage, an accredited testing center should perform a test for conformity. As the whole process does not require a certificate based on common criteria, it remains rather flexible. The respective regulation would then be expanded in the revision of the Electricity Supply law.

Innovation Budgets for Network Operators

In order to incentivize network operators to apply solutions of new kind in their network planning and operation, the legislative package on the Strategy for Power Grids suggests innovation budgets for all network operators. A certain percentage of their network costs should be used to make applied research and projects in order to realise new functionalities. The innovation budgets would be capped by relative means and absolute means. Network operators should follow guidelines set up by the NRA on how to publish their findings. The Roadmap will provide a profound basis in order to contribute to a clear definition of what a smart functionality in this context could be.

Considering Active Network Elements for Network Reinforcements

Based on existent regulation, DSOs have the opportunity to apply at the NRA for reimbursement of arising expenses for integrating renewable resources. They have to provide three different technical alternatives on how they would reinforce their grid as well as the estimated costs. The NRA examines the solutions and costs. It then decides for the cheapest alternative while considering further requirements. The TSO then reimburses the DSO and includes the expenses in his own network costs. These costs are borne by consumers nationwide. In contrast, the costs for grid reinforcement in consequence of load growth or other reasons, are merely borne by consumers connected to the respective distribution grid.

The results outlined in the Roadmap convinced the NRA to alter the requirements for such reimbursement. Cost-benefit analyses carried out for the Roadmap [11] show very clearly that substantial cost savings can be achieved by using variable transformers or line voltage regulators instead of conventional solutions. Hence, the NRA by now demands DSOs to hand in at least one alternative that examines variable transformers or line voltage regulators instead of conventional grid expansion. This reduces information asymmetry between the NRA and DSOs and incentivises to gain experience with such technologies.

Flexibility

The ES2050 contains a legal basis for creating a coordination framework between network operators and market players for the utilization of flexibility. The main principle of the coordination mechanism is held down legally: the owner of flexibility - typically the consumer or the producer - may decide freely whether to be controlled for grid purposes, i.e. by the DSO, or for market purposes, i.e. by a market player such as an aggregator. Consequentially, DSOs loose their privilege to control the flexibility exclusively. The revision of the Electricity Supply Law also aims at refining regulation approaches for flexibility already found in the ES2050.

The Roadmap and follow-up studies have examined a concrete design for the coordination framework. It incorporates a market-based approach, ensures network security, avoids discrimination and reduces information asymmetry (see e.g. [12]). The network operator may use flexibility to operate its network more efficiently. They should then be obliged to pass some of the benefits to the flexibility owner. An upper bound for the benefit should be the cost savings achieved by avoiding conventional grid expansion. Passing down the benefits could be performed via direct reimbursement or tariff reduction schemes. Then, DSOs should offer a tariff, which incorporates not using any flexibility of the consumer or producer. The schemes need to be transparent and publically available whereby information asymmetry between flexibility owners and other market players is reduced. Such OPEX would be accountable for the network costs, which are generally hard to regulate. Network operators would need to delimit these costs appropriately. Importantly, the TSO and DSOs should be allowed at any time to use control systems, i.e. flexibility, in order to ensure a secure operation of their network. As a means of avoiding discrimination, the network operator should inform the flexibility owner about the application, who can in doubt file a complaint against the NRA.

Sunshine Regulation

The cost+ regulation has several drawbacks. It may lead to inefficiencies since the enterprise faces an incentive to increase its costs above its true cost level [13, 14]. In order to ameliorate the cost+ regulation in Switzerland, the NRA aims at introducing a sunshine regulation based on the existent legislation A sunshine regulation is capable of increasing the efficiency of DSOs, especially when combined with a credible threat of penalties [15].

Innovation budgets and demands to consider active network elements offer some minor incentives. The general incentive for CAPEX in the cost+ regimes, however, remains strong. As to increase the incentive for application of intelligent solutions in a cost+ regulation, a separate indicator for the intelligence of the network is being debated. It should reflect cost savings achieved using intelligent solutions by showing: a) the annual cost savings through intelligent solutions over the annual investment in conventional grid expansion or b) the annual

investment over the capacity expansion of the grid. Similar approaches can be found in other countries [16].

Voluntary Comparison of Grid Measures

A new instrument referred to as Voluntary Comparison of Grid Measures (VCGM) could be introduced to increase incentives in the cost+ regulation for using intelligent means. It is currently under discussion in the revision of the Electricity Supply law. This instrument aims at compensating to the advantage of CAPEX intensive investments [16]. The VCGM uses reference cost parameters for expansion cases defined by the NRA. A DSO may prove that it is possible to stay under the reference costs using intelligent measures. It would then receive a share as a bonus, say 30%, of the savings caused and would hence receive an additional return to the investment in intelligence. Obviously, this instrument has some drawbacks, such as its regulation intensity and possibilities of abuse. It all comes down to the question of how well reference costs for expansion cases can be derived from the database of the NRA. However, the instrument also enables a decrease of the information asymmetry, as more and more cost information is disclosed to the NRA, which then is able to change the reference cost levels adequately. Still, windfall profits for DSOs cannot completely be avoided. The instrument could work well with a smart grid indicator that depicts the efforts and positive results of the VCEM [15].

CONCLUSIONS

The regulation for Smart Grids is a difficile issue. Regulatory changes have to be performed with care and based on profound knowledge. The Smart Grid Roadmap of Switzerland offers a much needed analysis of barriers for Smart Grids in Switzerland. It initiated a process that will lead to regulatory changes thereby fostering more intelligence in Swiss electricity grids, which is needed for increasingly distributed and a fluctuating infeed of renewable energy sources into distribution networks. Upcoming regulations comprise a Smart Metering roll out, requirements on privacy and data security, a coordination framework between market players and network operators for the usage of flexibility and several incentive instruments for the application of OPEX intensive, intelligent solutions in a cost+ regime.

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