THE SWEDISH GOVERNMENT INQUIRY ON SMART GRIDS

Math BOLLEN, Rémy KOLESSAR, Bengt GUSTAVSSON, Daniel TORSTENSSON, Peter ALBERTSSON, Thomas WESTERGAARD
Energy Markets Inspectorate – Sweden
math.bollen@ei.se

ABSTRACT

The Energy Markets Inspectorate has conducted an inquiry on smart grids during 2010 and submitted the resulting report to the Swedish government. The inquiry has identified a number of barriers against the introduction of new technology and a number of proposals are made to remove the barriers: an independent council to gather and spread knowledge on smart grids; incentives for network operators to create new services and increase network performance; an action plan for the future development of the electricity network; a new structure of network tariffs to reduce peak loads and price peaks; and functionality requirements on information to customers to allow them to actively participate in the market.

INTRODUCTION

On 4 March 2010, the Swedish government instructed the Energy Markets Inspectorate to conduct an inquiry after "*smart meters and intelligent electricity networks*". The aim of the inquiry was to map how smart meters and smart grids ("intelligent networks") can assist in the transition to a sustainable energy system and also to identify and remove barriers against the introduction of smart meters and intelligent electricity networks. The inquiry resulted in a report that was made publicly available on the 1 December 2010 [1].

In parallel with this enquiry two related projects were conducted by the Energy Markets Inspectorate: one about hourly meter reading for small customers [2]; the other about net charging of small customers with their own electricity production [3].

In this paper we will summarize the need for smart grids and the status with their development and deployment in Sweden. We will also present the conclusions and main recommendations from the enquiry as well as give a summary of the conclusions from the two parallel projects.

BACKGROUND AND DEFINITION

The transition towards a sustainable energy system, as expressed by various national and European-level political aims, will not leave the electricity network unaffected. For the electricity network not to become a barrier against this transition, it should adapt itself to the transition. More specifically, the instructions given by the Swedish government to the Energy Markets Inspectorate contained the following four starting points or challenges faced by the electricity networks:

- ✓ Enabling an increased integration of renewable electricity production in the power system;
- ✓ Reducing power consumption during peak loads;
- ✓ Supporting more efficient use of energy;
- ✓ Allowing more active customers.

Based on these starting points and the definition used by the European energy regulators [4], the following definition and limitation of the scope of smart grids is proposed by the inquiry:

Intelligent network, or smart grid: the collection of new technology, functionality and regulation on the electricity market that cost-effectively

- ✓ *enables integration and use of renewable electricity production,*
- ✓ *results in reduced energy consumption,*
- ✓ *contributes to power reduction during load peaks,*
- ✓ *and creates conditions for more active customers.*

Note that the scope of smart grids is determined by the challenges faced by the electricity networks; in other words: the definition is technology-independent.

THE NEED FOR SMART GRIDS

New cost-effective technology, i.e. smart grids as defined in the previous section, can contribute to the four starting points of the inquiry in a number of ways. It is however important to map the areas in which new technology can make a significant impact. Such an evaluation of the need for new technology will give different results for different countries and even for different regions in the same country. As part of this inquiry a broad mapping of the need and possibilities of smart grids has been done. This is however only a very initial step and much further work on this is needed.

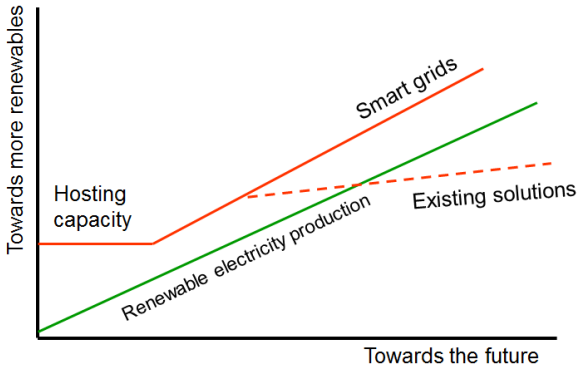

Figure 1. Smart grids to increase the hosting capacity of the electricity network for renewable electricity production.

Consider for example the ability of the electricity network to accept new renewable electricity production.

This ability is often referred to as the "hosting capacity" of the network, see Figure 1. The hosting capacity can in many cases be increased by building new lines, cables and transformer stations. But there is, or will be, new technology available that can increase the hosting capacity in a more cost-effective way. Part of this new technology is used in the network itself. Examples are the use of power electronics to reduce the risk of overvoltages with the connection of microgeneration; communication to prevent protection failures and unintended island operation; storage at suitable locations in the network to balance production and consumption.
Other solutions require that network users react actively on price and power signals. Different incentives are needed to make customers shift their consumption away from load peaks or to make them contribute in other ways to operational reserves and ancillary services. Such solutions require smart metering, registration of consumption at least every hour, together with a communication infrastructure.

CURRENT STATUS

An important part of the inquiry has been to identify what the current status is of research, development and deployment of smart grids, especially in Sweden. Here a distinction has again been made between the four starting points of the inquiry.

Enabling an increased integration of renewable electricity production in the power system

Activities towards allowing more renewable electricity production in the power system are of two completely different kinds. Investments in the transmission system create a larger balancing area and allow for example balancing of windpower by means of hydro power. Sweden maintains a leading position in the development of new technology for increasing the transport capacity of transmission systems, for example HVDC and FACTS.
Requirements on production units in the connection agreements minimize the impact of such units on the network and on other customers. Although one may argue that this is not part of smart grids, after all no improvements are made in the actual network, it might be the most cost-effective method and it has resulted in a flora of interesting research and development around the world.
This and other research and development on increasing the hosting capacity of the electricity network is going on at many places around the world, among others in a number of European projects, but such research is in Swedish only in the starting phase.

Reducing power consumption during peak loads

Reduction of the peak load has traditionally been done by means of time-of-use tariffs and time-dependent electricity price. The latter has however all but disappeared in Sweden, mainly due to the separation between the regulated and non-regulated parts of the electricity market. Also a reduced network tariff for curtailable electric heating, which is still offered by some network operators, is used less and less.
Many network operators have network tariffs based on monthly peak demand for their larger customers, but only two have such a tariff for smaller customers. A number of network operators will introduce maximum-demand-based tariffs for small customers in the near future. This is made possible by the high penetration of electricity meters allowing hourly recording of consumption.
The Swedish transmission-system operator, Svenska Kraftnät, has access to about 1900 MW of reserve to be used in case the market does not offer sufficient production capacity to guarantee operational security. About 600 MW of this emergency reserve is in the form of demand reduction. In future the total amount of emergency reserve will be reduced and it will all be in the form of demand reduction.
A number of small-scale demonstration projects have been performed in Sweden in which demand response was used to reduce the peak load. Further research and development is going on in a number of European projects, but Sweden has a limited role in these.

Supporting more efficient use of energy

Several manufacturers offer low-loss components for power transmission and distribution. These are used only to a limited extend by Swedish network operators.
Sweden has a leading role in providing feedback to customers on their actual electricity consumption. This is a consequence of the compulsory introduction of remotely-read meters. Many large customers already have access to hourly consumption data. For small (domestic) customers this is often still limited to monthly values, but more and more network operators are expected to give their customers free access to hourly consumption data. The data will give the customers the opportunity to perform a quantitative optimization of their energy consumption. A number of network operators even support their customers with advice on how to reduce electricity consumption.

Allowing more active customers

Sweden is one of the leading countries in the deregulation of the electricity market. There is a complete separation between the network activity (the regulated part of the market) and the production and retail of electrical energy (the deregulated part). Any customer is free to choose retailer and retailers have developed a number of different price offers, including fixed price, (monthly) variable price, and guaranteed electricity from renewable sources. The network tariffs on the other hand offer very limited choice and most customers cannot impact their tariff any other way that by reducing their total consumption.
The presence of advanced meters, allowing hourly recording of consumption, and their further penetration are expected to result in more choice, on the regulated as well as on the deregulated part of the electricity market.

BARRIERS

During the inquiry a number of barriers against the introduction of smart grids were identified that required additional analysis. These were grouped and summarized as follows:

- ✓ Lack of clarity about financing of research, development, demonstration and deployment of

smart grids.
- ✓ Lack of incentive for network operators to invest in smart grids.
- ✓ Network tariffs do not give incentive for customers to reduce their peak load.
- ✓ Lack of a national plan for the future development of the electricity network.
- ✓ Lack of knowledge about new technology and how to make use of it.

RECOMMENDATIONS

Based on a detailed study of the barriers mentioned in the previous section, the inquiry resulted in a number of recommendations, which are summarized below.

A knowledge platform for future electricity networks

The inquiry has identified a lack of knowledge among others where it concerns the needs for and the possibilities offered by smart grids. From the four starting points of the inquiry, the main challenge is to adapt the electricity grid (distribution and transmission) to the transition of the energy system. The lack of knowledge forms a concrete barrier against this adaptation.
Removing this barrier requires clear priorities in funding of research and a bigger integration of multidisciplinary research, including ICT and market models, than is currently the case.
The creation of a knowledge platform is proposed to gather and spread knowledge on research, development and demonstration concerning the adaptation of the electricity grid to the transition of the energy system. An independent council should be created, whose aim it is to coordinate all research, development and demonstration towards adaptation of the electricity network towards the transition of the energy system. The council should also be responsible for the spreading of all results and other knowledge in an effective and coordinated way to all stakeholders.

Financing of research, development, demonstration and deployment

There is no immediate need for changes in the way of funding for research, development and demonstration of smart grids. It was also concluded that the deployment of smart grids can be funded under the existing tariff regulation.

Action plan for adaptation of the electricity network

The Swedish transmission system operator should develop an action plan for the adaptation of the Swedish electricity network to achieve the political aims for introduction of renewable energy production and conversion of the energy system. The action plan should cover all voltage levels and consider the role played by network operators, small and large electricity producers, electricity traders, and small and large consumers. The action plan should further include a method for spreading of the costs with connection of renewable electricity production.

Incentives to invest in smart grids

Although the economic conditions for investments are offered by the existing tariff regulation, there are only weak incentives for network operators to invest in appropriate new technology because of the uncertainty that might be associated with new unproven technology. This is even the case when that new technology in the long term creates the opportunities for a more effective design and operation of the electricity network.
Incentives for investment in smart grids should therefore be included in the regulation. These incentives should be based on suitable performance indicators that form the base for a quality model that creates the right incentive to invest in smart grids. The incentives should preliminary be related to the adaptation of the electricity network towards the transition of the energy system and mainly consider the introduction of new network services or increased network performance.

Hourly meter reading

Hourly meter reading should be introduced for the majority of customers. Hourly meter reading forms the basis for the development of new markets and functionally, which is part of the smart grid as defined before.

Tariff structure to reduce peak loads

Under the existing regulation, network operators are largely free to choose the structure of the tariffs for their customers. Some minor limitations are set in the electricity law, for example that the tariffs shall not be discriminatory. Tariff regulation only limits the total income from tariffs, not the structure of the tariffs. As a result of this, different tariff structures are in use by different network operators.
It is therefore proposed that the structure of the network tariffs will be studied, with the aim of reducing load peaks. Reducing local load peaks will also enable the further integration of renewable electricity production and electrification of the transport sector.

Requirements on information to custumers

The introduction of hourly metering for the majority of customers, will allow the development of new markets and functionalities. Such markets and functionalities will only become effective when customers receive price and other information in a transparent and easy way.
Requirements should therefore be defined on information provided to customers so as to allow them to react actively to price signals from the markets.

Analysis of roles and responsibilities of different actors

It is important that the roles and responsibilities of the different actors on the electricity markets do not form any barriers for the transition towards a sustainable energy system. It is also important that the required separation between the players on the regulated and on the deregulated part of the market, does not, by preventing cooperation, become a barrier against certain smart-grid solutions.
It is therefore proposed that the roles and responsibilities of the different actors in the electricity markets will be

investigated, to remove further barriers against the introduction of smart grids.

Division between local, regional and trunk network

The Swedish electricity networks are divided into three types: "local networks" (lokalnät), "regional networks" (regionnät) and the "trunk network" (stamnätet). The trunk network covers the highest voltage levels (220 and 400 kV), connects the whole country, and is owned and operated by the transmission system operator, Svenska Kraftnät. The local networks cover the lowest voltage levels and are owned and operated by about 170 small, medium-sized and large network operators. The regional networks connect the local networks and the large industrial customers with the trunk network. There is no well-defined border between regional and local networks with some local networks being operated at voltage levels of 130 kV and 220 kV, whereas some lines operated at 20 kV are classed as part of the regional network.

There are several technical reasons, including the introduction of large amounts of windpower, which make that this subdivision should be reconsidered. It is therefore proposed to analyse if the existing subdivision still fulfils its aims.

HOURLY METER READING

Since July 2009 all 5.2 million electricity customers in Sweden have their electricity consumption recorded at least once per month (at midnight on the first day of the month). Customers with a connection of 63 A or more have their consumption recorded every hour. To allow more customers to participate in hourly-based markets, compulsory hourly-metering was investigated [2].

As a result of this investigation it is proposed that hourly-meter reading is made compulsory from 2015 for all customers with an annual electricity consumption of more than 8000 kWh. This involves 1.2 million customers. A cost-benefit analysis concluded that at this moment the gain for smaller customers is insufficient to justify compulsory hourly metering.

It is also proposed that balancing for customers below 63 A will not take place based on the actual measured hourly consumption but will make use of a template. The final balancing for such customers will take place on a monthly basis.

NET CHARGING

A third project was conducted to study the possibility for net charging of small network users that produce electricity some of the time and consume electricity the rest of the time [3]. (Such network users are sometimes referred to as "prosumers".)

The possibility for net metering was studied in the project because this would automatically result in net charging. It was concluded however that such net metering is not compatible with the existing tax legislation in Sweden. A direct consequence of this is the conclusion that separate metering is needed for consumption and for production on an hourly basis.

When treating the hourly readings of production and consumption, different rules apply for the price offered by the electricity retailer and for the tariff set by the network operator. The electricity retailer is part of an open deregulator market whereas the network operator is part of a regulator monopoly.

The proposal made by the Energy Markets Inspectorate in their final report, is that the network tariff should be based on the net consumption (sum of hourly consumption minus sum of hourly production) on a monthly basis. The electricity retailer will have to offer a combined contract for both production and consumption. However, the price setting for production and consumption is non-regulated and to be determined by the open electricity market.

CONCLUSIONS

The first stage of the Swedish metering reform has already resulted in a high penetration of meters allowing hourly recording of the consumption and equipped with two-way communication. This will allow the introduction of a number of services and functionalities. In fact several network operators are retailers are already making plans for new services and functionalities that will form a further step towards a more cost-effective utilization of the electricity network. Some examples are: participation of domestic customers in the hourly spot market; disconnecting individual customers in case of an operational emergency; more effective design of distribution networks by knowing accurate consumption patterns; feedback of consumption to customers; and power-based network tariffs.

The knowledge platform, the action plan and the other proposals made by this inquiry will further contribute to Sweden being able to fulfil its political targets for the reduction of carbon-dioxide emission.

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