REGULATORY ASPECTS OF ENERGY STORAGE IN SWEDEN

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ABSTRACT

This paper highlights the possibilities and limitations of investing in energy storage for use at distribution level under the existing regulatory framework in Sweden. The paper further gives a brief overview of possible applications and ownership models for energy storage in a distribution grid. It was concluded that it is allowed for a network operator to own an energy-storage installation; there are however restrictions in the use of the installation for trade in electricity. A general observation from the study was that there are uncertainties in the interpretation of the laws and regulations due to the complete absence of experience in the use of grid-size energy storage.

INTRODUCTION

The use of grid-size energy storage has recently become a very popular subject for technical conferences and for smart-grid demonstration projects. Today well over 100 000 MW of storage capacity exist world-wide in the form of pumped hydro [1]. However this new interest is mainly related to new storage technologies like batteries.

Demonstration projects are for the time being limited to distribution applications, but even applications of energy storage at transmission level are being discussed by several transmission-system operators. Papers at technical conferences discuss a huge range of applications and issues related to energy storage: from the use of battery storage in millions of electric cars to compensate voltage rise due to local PV installations all the way through the use of giant storage installations to compensate fluctuations in wind-power production at national level.

A lot of the theoretical work being published today is application independent but the recent demonstration projects are almost exclusively based on battery storage, which is seen as the most promising new technology for grid-scale applications. A 75-kWh demonstration project, shown in Figure 1, is in operation in Falköping, Sweden [2] and a platform for research, development and demonstration of smart grids, including battery, super capacitor and hydrogen storage, has been built in Ludvika, Sweden [3].

Starting in the United Kingdom by 1990, the electricity market in European countries has been split in two parts: a deregulated free market where electrical energy is

Figure 1. The 75-kW battery storage in Falköping.

produced, traded and consumed; a regulated monopoly containing the electricity transmission and distribution as well as system operation. Since then three European directives (97/92/EG; 2003/54/EC; and 2009/72/EC) have further defined these two parts. A clear separation of the monopoly part and the free-market part is an important foundation in this. With some exceptions, network operators are not allowed to own or operate production units or to be involved in electricity trade. In this way, it is prevented that network operators use their monopoly position to compete unfairly on a free market.

A storage installation is over time a net consumer of electricity due to energy losses. However, it operates part of the time as a consumer and part of the time as a producer. The rule that network operators are not allowed to own or operate production units is by many interpreted as that they are not allowed to own or operate storage installations. Also other laws or regulations could put a barrier against the use and ownership of storage installations.

This paper is the result of a study of the regulatory framework in Sweden in relation to the ownership and application of energy storage installations connected to the electricity distribution network. This study was in turn part of a larger study on the use of grid-size battery storage to support the distribution network [4]. After a brief overview of applications for energy storage, three different ownership models are discussed in relation to the regulatory framework, followed by possible economic barriers set up by existing laws and regulations.

DISTRIBUTION SYSTEM APPLICATIONS

As almost any textbook on power systems states: "electricity cannot be stored". Although this is not fully correct, the absence of affordable and sufficiently large energy storage for use in the grid is a determining factor in the design and operation of the power system. It makes for example that the design of the distribution network is based on the expected peak load plus a sufficient safety margin.

When cost-effective energy storage at distribution level would be available, the design of the power distribution network would change a lot. Some already anticipate a future situation where variations in power flow have almost disappeared. More realistic applications concern the removal of peak loads, either due to high consumption or due to high production. Some possible applications include:

- ✓ Increase the hosting capacity for wind or solar-power, without the need for building additional primary infrastructure. A dimensioning study for this case is presented in [5].
- ✓ Reducing the maximum power flow from the subtransmission network to the distribution network. This reduces the network tariff that the distribution network operator has to pay to the subtransmission network operator.
- ✓ Compensating non-predictable fluctuations in wind-power production. This makes the power flows more predictable, reducing the need for margins when it comes to dimensioning for the thermal limitations of lines and transformers and saving on balancing power.
- ✓ Reduction of losses by reducing variations in rms current. The series losses through a conductor are proportional to the square of the average current and the square of the standard deviation of the current. Energy storage can reduce the latter term, but additional losses in the storage installation should be considered.
- ✓ Preventing supply interruptions by enabling part of the distribution network to temporary operate in island.

OWNERSHIP OF THE STORAGE

There are two possibilities for a network operator to have access to an energy-storage installation to support the distribution network: either the network operator owns the installations or it purchases ancillary services from an external party that owns the storage.

There are several possible ownership constellations for an energy-storage installation in a distribution grid, which in turn lead to different business models. Existing laws and regulations set limits on ownership and on possible business models. Three ownership constellations plus the aggregator model, and the way in which they are impacted by existing laws and regulations are discussed below.

Storage owned by a network operator

Most of the applications mentioned in the previous section are related to operation of the distribution network. Energy storage could result in lower investment and/or operational costs for the distribution network with lower tariffs for the network users and/or a better economy for the network operator as a result, depending on the tariff regulation.

Under the Swedish regulatory framework, the network operator is not allowed to be involved in trade of electrical energy, with two exceptions:

- ✓ To cover the losses associated with the distribution of electrical energy;
- ✓ Counter trade to prevent overloading of the network.

The latter is, according to the explanatory document with the electricity law, considered as part of network activity because the aim of the trade is not to sell electricity to a consumer but to maintain the functionality of the network as shown in [5].

The Swedish electricity law stipulates that the energy needed to cover the losses should be bought in a transparent, non-discriminatory and market-oriented way. Buying this energy on the day-ahead market when electricity prices are low and using it when losses are high is not in conflict with this requirement. An energy-storage installation can thus be used to reduce the energy bill for the losses, although the total amount of energy lost will increase because of the losses in the energy storage.

The possibility was discussed that the network operator buys electricity to cover losses by placing down-regulation bids (increasing consumption) on the balancing market. It was concluded this would be participation by a monopoly player on an open market.

The electricity law also allows the network operator to temporarily produce electricity during a supply interruption. This application of storage is thus also allowed.

As long as an energy-storage installation is only used to maintain the functionality of the network, to cover the losses, or during supply interruptions, there does not appear to be any legal barrier in the ownership of a storage installation by a network operator.

The limitation is however in the use of the storage for other purposes than maintaining the functionality of the network. The energy in the storage can for example not be sold to any network user or on any of the wholesale markets for electricity. This will limit the economic possibilities and lead to the storage installation not being worth the investment.

Storage owned by an electricity retailer

When the storage installation is owned by an electricity retailer, there are no longer any limitations on the use of the installation to trade on the wholesale markets (day-ahead, intraday and balancing). This is likely to greatly increase the profitability of the installation.

All distribution-system applications of storage mentioned before remain possible. The network operator can buy storage as an ancillary service, the “storage service”, from the owner of the storage. This should be seen as an example of countertrade which is allowed under the Swedish electricity law.

When it comes to network tariffs the network operator is not allowed to discriminate between customers. When a certain network tariff is offered to a storage installation, the same tariff should be offered to any other storage installation even when that installation does not contribute anything to the network. Also negotiating about buying of storage services, should take place in a transparent and non-discriminatory manner. Network operator may however influence the location of the storages by decision on whether or not to contract ancillary storage services based on the contribution to the grid.

When the retailer that owns the storage is not a balance responsible party (BRP), such a party should be found to take the balance responsibility. When the storage installation or installations become a large part of the total energy traded, it might be difficult and/or expensive to find somebody to take this responsibility.

There could also be limitations in the possibilities for small storage installations to participate in the balancing market. This is however not due to any regulatory framework but because of certain details in the balance agreement and the structure of the balancing market.

Storage owned by another player

One possible business model is that the energy storage is owned by another player than a network operator or a electrical retailer, like for example a commercial installation with a battery storage as part of their UPS system. Most of the discussion in the section on ownership by an electricity retailer also holds in this case. The difference is however in the possibility to buy and sell electrical energy.

Only electricity retailers are allowed to sell electricity to end users; certain obligations come with this so that not everybody would want to become an electricity retailer. Therefore the electricity from the storage can be sold and bought on the wholesale markets, but not to end users. The owner of the storage also needs somebody to take the balance responsibility.

When the storage is owned by a consumer of electricity, energy tax has to be paid over the losses associated with the storage.

Storage owned by an aggregator

A special case, which is discussed a lot at all kinds of platforms, is when the storage installation is owned by a so-called “aggregator”. This is a model that not yet exists on the Swedish electricity market. The aggregator is envisaged to be somebody that buys and sells electricity and balancing services from small customers and trades this on the wholesale market in open competition with the existing players (being mainly producers and retailers). The customers of an aggregator are expected to include small owners of solar power, wind power, or combined-heat-and-power as well as customers that are prepared to reduce or increase consumption on demand.

The conclusion from our study is that such an aggregator model is already possible under the existing regulation in Sweden and that there are no fundamental barriers because all trading takes place on the deregulated part of the electricity market.

However if the aggregator sells electrical energy to consumers, contrary to only buying balancing services, the aggregator has to become a retailer and be subject to the regulation concerning retailers.

The issue of balancing responsibility could set barriers here as every retailer either is a balancing responsible party (BRP) themselves or needs to contract a BRP to cover this responsibility. This might be difficult when the business model is to earn money on the balancing market. The situation could even become more complicated when the aggregator buys balancing services from small consumers, to be able to trade on the spot market. The costs could in that case have to be carried by the BRPs for those customers.

A conclusion from the study is that there could be barriers in the structure and functioning of the balancing markets that make it difficult for aggregators to establish themselves. Even the uncertainty about the possible business models acts as a deterrent against the establishment of aggregators.

ENERGY TAX

Under Swedish law energy tax has to be paid on the electrical energy that is consumed. The tax is ultimately paid by the consumers and collected by the network operators. The energy tax on electricity varies from 0.5 öre per kWh for certain industrial installations up to 28 öre per kWh for most other consumers (28 öre corresponds to 3.2 Eurocent), For comparison, the average day-ahead price of electricity in Sweden was 27 to 29 öre/kWh during the period December 2011 through November 2012 [6]. Energy tax can thus be a large part of the total costs of electricity.

No energy tax has to be paid over the losses during production or transport of the electricity or over the consumption by producers or retailers. When a storage installation is owned by a network operator, a producer or a retailer, no energy tax has to be paid on the losses. However when the storage installation is owned by another player the owner may have to pay energy tax over the losses in the storage installation.

BALANCE RESPONSIBILITY

The balancing market in Sweden is operated by Svenska Kraftnät, the transmission-system operator. When it is necessary for maintaining frequency or for guaranteeing the operational security, Svenska Kraftnät buys up-regulation or down-regulation on the balancing market. The sellers on this market offer certain volumes of up or down regulation against a certain price. A market settlement is reached in the same way as for the day-ahead market.

The costs of the balancing power are charged by Svenska Kraftnät to a few dozen BRPs. Each BRP represents part of the production and consumption connected to the Swedish electricity network. Each producer or consumer is represented by exactly one BRP. For each BRP the deviation between the predictions used for the day-ahead and intraday market and the actual production and consumption are calculated every hour. Two values are obtained: the deviation for production and the deviation for consumption. If the deviation for production or consumption is in the same direction as for the system as a whole, the BRP has to pay Svenska Kraftnät. If the deviation for consumption is in the opposite direction as for the system as a whole, the BRP gets paid. No payments are made to the BRP for deviations in production, even if the deviation is in the opposite direction as for the system as a whole.

Any legal entity can in principle become BRP, after signing of a contract with Svenska Kraftnät. The latter will however make an estimation of the credibility of the intended BRP and require investment in among others a communication system. This could be a serious barrier for smaller companies.

The legal, regulatory and contractual details of the balance responsibility are rather complicated; in principle is every consumer and producer responsible for maintaining balance, i.e. to ensure that production or consumption during each hour are exactly the same as the accepted bids on the day-ahead or intraday market. In practice, this responsibility is carried by the electricity retailers and the balancing service is included in the price of electricity charged by the retailer (or deduced in case of a producer). Retailers that do not have an agreement with Svenska Kraftnät should buy this service from a BRP.

The appearance of new players, like aggregators and network users that sell storage services to the network operator, could make that this arrangement no longer functions as well as it should. Also here are there no obvious barriers but uncertainly could prevent new players from establishing themselves.

CONCLUSIONS

From our study of the Swedish electricity law, explanatory documents and discussions with legal experts and with the Swedish energy regulator, it was concluded that it is allowed for a network operator to own an energy-storage installation. There is in that case however a limitation to the use of that installation: it shall not be used for the trade of electricity beyond covering of the losses in the network.

When the storage installation is not owned by the network operator, there are several additional business opportunities available for the owner of the energy storage installation. The network operator is allowed to buy storage as an ancillary service from the owner of the installation; this is an example of countertrade. Such ownership will make the storage installation more profitable for the owner. Buying storage as an ancillary service could also be cheaper for the network operator than owning the installation themselves.

The issue of balance responsibility must be resolved for a storage installation not owned by the network operator or by a balance responsible party. Uncertainty into how to solve this issue may hinder rational decisions on building energy storage.

There is a need to clarify, and possibly extend, the current regulatory framework that governs how network operators can purchase ancillary services from an energy storage provider. This will become urgent if the number of energy storages were to become more common in the grid. Large-scale application of storage also requires clarification and possibly revision of current praxis of the Nordic balancing market.

A general observation from the study was that there are no obvious barriers against the use of storage (beyond the fact that a network operator cannot be involved in trade of electricity) but that there are uncertainties in interpretation of laws and regulations due to the complete absence of experience in the use of grid-size energy storage. A clarification of the regulatory framework is seen as an urgent necessity.

Currently there are no direct policy incentives in Sweden that promote investments in energy storage installations, other than general purpose R&D funding. A number of such projects are currently funded in Sweden.

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