Smart meters in Sweden – Lesson learned and new regulations

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SMART METERS IN SWEDEN- LESSONS LEARNED AND NEW REGULATIONS

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Summary

Sweden was one of the first countries in Europe to roll out smart meters. The first regulation regarding smart meters was adopted in 2003, which required monthly metering for small consumers and hourly metering for larger consumers by 2009. This led to the roll-out of the first generation of smart meters in Sweden. The functionality of smart meters has since then evolved from automatic reading of data once a month to more frequent data measuring and remote control. Based on the lessons learned from the first roll-out of smart meters and on the development of functionality of smart meters, the national regulatory authority for energy in Sweden (Ei) has developed new regulations on minimum functional requirements for smart meters.

In Sweden smart meters are owned by the distribution system operators (DSOs). Varying functionalities of smart meters between different DSOs endanger the consumers' right to be treated equally. It is important that consumers have equal possibilities to e.g. utilise services from energy suppliers or energy service providers. Therefore, minimum functional requirements for smart meters need to be defined.

In 2013, Ei evaluated the impact on market participants of the first roll-out of smart meters in Sweden. The availability of hourly price contracts, the number of consumers who reacted to the electricity price and the competition among different metering service providers were studied. Based on the results of Ei's study and the development of functionality of smart meters, Ei submitted a report to the Swedish Government in 2015 suggesting that minimum functional requirements for smart meters should be regulated and presented a preliminary proposal of requirements based on a long-term cost-benefit analysis (CBA). The CBA was performed in accordance with the EU Commission recommendation on preparations for the roll-out of smart metering system. The reference scenario was defined as the smart metering system in Sweden in 2012. For each proposed functional requirement, the costs and the benefits for both the consumers and DSOs were quantified. Sensitivity analysis was then performed to identify critical variables for the positive roll-out conditions. The proposal was open for public consultation and all responses were reviewed by the government office. In 2016 the government concluded that it is necessary to develop minimum functional requirements for smart meters before the roll-out of the next generation. In 2017, Ei was tasked by the Swedish Government to propose new rules concerning minimum functional requirements for smart meters, based on the previous suggestions in 2015.

Ei's study from 2013 showed that lack of hourly price information, lack of knowledge on electricity contract, and lack of standardisation on smart meters were the main reasons that have limited the benefits of using smart meters. After restudying the proposal from 2015 and the outcome of the public consultation, Ei presented a final proposal concerning minimum functional requirements for smart meters to the government in November 2017. The proposed functional requirements focus on both providing more information to consumers to increase their interest in being active and more information to the DSOs to increase their efficiency. Furthermore, the proposal also states that the new functionality should be implemented in a way that protects consumer privacy and data security. The minimum functional requirements, which were then included in the ordinance for metering, calculating and reporting electricity, cover the following areas: 1) Extended measurement, 2) Registration of active energy every hour or fifteen minutes and power outages, 3) Customer interface, 4) Remote collection of

measured data and power outages, 5) Remote updating of software, settings and control the power of the meter. All the meters in the low voltage network should fulfil these requirements lasted by 2025.
Within the next few years, many of the current electricity meters in Sweden will be replaced, as they have reached their economic lifespan. Introducing minimum functional requirements for smart meters will ensure all consumers the same right to the technical solutions and data security, furthermore, it facilitates a fair competition among commercial developers.

1. Introduction

1.1 The electricity market in Sweden

The electric power system in Sweden underwent a major reform in 1996. Since then, generation and trading of electricity are exposed to competition. Network operations, i.e. the transmission and distribution of electricity, are however considered as natural monopoly since it would be both economically and environmentally unreasonable to have competing infrastructures to the same customer. Due to the lack of competition in the transmission and distribution networks, network operators are subject to regulation to promote efficiency and quality of supply and to ensure fair prices for customers. The national regulatory authority (NRA) for energy in Sweden, the Swedish Energy Markets Inspectorate (Ei), monitors whether the network operators comply with existing rules. Ei is tasked to ensure that customers have access to a power distribution system with reasonable and non-discriminatory tariffs, to provide incentives for network operators to operate network cost effectively while maintaining acceptable reliability [1].

1.2 The electric grid in Sweden

There are currently more than 150 distribution system operators (DSOs) and one transmission system operator (TSO) in Sweden. The Swedish TSO, Affärsverket Svenska kraftnät, is owned by the Swedish Government. The TSO owns and operates all parts of the transmission system (in Sweden defined as 220 kV or higher) with a few exceptions. All other entities that operate power systems in Sweden are defined as DSOs. The DSOs are of varying size and ownership structure (state, municipal, private and other), and they each have at least one so-called concession (permission) for the distribution of electricity, either for a defined geographical area or for a specific line. The concession means a privilege with rights, but also comes with several obligations, which are stipulated in the Swedish Electricity Act.

1.3 The electricity regulation revolution in Sweden

From 1996 to 2002, the Swedish DSOs were regulated based on a rate of return (ROR) approach. The revenues of the DSOs were based on their actual costs ex-post. In 2003, the first performance-based tariff regulation was introduced, the so-called network performance assessment model (NPAM). Under the NPAM approach, the revenues of the DSOs were based on the costs of fictive reference networks (more information can be found in [2] and [3]).

In 2005, a severe storm struck Sweden (referred to as Gudrun or Erwin) and caused outages for about 450 000 customers; out of which approximately 100 000 customers had an outage that lasted for longer than four days. This event increased the focus on continuity of supply. In 2006, two legislations entered into force. It implied new mandatory requirements for DSOs, which is to present annual risk and vulnerability analyses with action plans, and to provide compensation for customers with outages longer than 12 hours. From 2011 outages longer than 24 hours are not tolerated by law. At the same time, additional minimum requirements of the reliability of supply were defined by Ei; one example is that more than 11 outages per customer in a year is not tolerated.

In 2012, an ex-ante revenue cap regulation was implemented in Sweden. During the first regulatory period of 2012-2015, the revenue cap of the DSOs was adjusted according to their level of continuity of supply (CoS), which was measured by SAIDI[1] and SAIFI[2] (more information can be found in [4]). For the second regulatory period of 2016-2019, the CoS incentive scheme was improved, and at the same time a new incentive scheme for the efficient utilization of electricity networks was introduced. The incentive scheme for CoS aims to discourage unreasonable differences in CoS between and within power distribution systems and to tie the interruption cost to the socio-economic cost of outages [4]. The incentive scheme for efficient utilization of networks aims to improve efficiency in network investment and operation [5]. More specifically, it aims to reduce the losses in the network and to even out the load profile to reduce the risk of over dimensioning the capacity of the networks. The incentive schemes are under continuous improvement.

The future development of power systems is characterized by major changes on both the supply and demand side. On the supply side, more power generation from renewable sources, both small- and large-scale, are integrated in the power system. On the demand side, the load characteristics are changing with e.g. micro generation, electric vehicles and more flexible load. The flexibility of loads comes from the combination of demand response program, local energy storage and distributed generation.

The electricity meter is the bridge that communicates the supply side and the demand side. Meters provide consumption data to the demand side that in combination with price signals can be used to activate the flexibility of loads. At the same time meters provide information from the demand side to DSOs and to the electricity market. The development of smart meters will enable the integration of more renewable production and empower the demand side. It also increases the possibilities to evaluate DSOs investments and to evaluate the impact of flexible load. However, with development of data analysis techniques and different needs in the meter market, there are different levels of smartness of smart meters available on the market. For example, some smart meters can offer real-time consumption data and dynamic tariffs to customers. From a regulatory point of view, it is important to continuously and carefully adapt the regulation to accommodate these challenges whilst to foster fair competition for the digital solutions.

1.4 EU rules concerning smart meters

The existing EU Electricity Directive 2009/72/EC [6] includes provisions on smart meters. According to the directive, the introduction of intelligent metering systems within the EU should be based on an economic assessment. The economic assessment should consider all the long-term costs and benefits to the market and the individual consumer and the timeframe to carry out. The objective was to equip at least 80 % of consumers in EU with intelligent metering system by 2020 based on positive impact assessments in each country. The directive

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[1] System average interruption duration index (SAIDI) = total outage time / number of customers [minutes/customer and year]

[2] System average interruption frequency index (SAIFI) = total number of outages / number of costumers [1/customer and year]

does not include a detailed definition of intelligent metering systems; however, it is stated that the meters shall assist the active participation of consumers in the electricity supply market. In 2012, intelligent metering systems was defined in the EU Energy Efficiency Directive 2012/27/EU as an electronic system that can measure energy consumption, providing more information than a conventional meter, and can transmit and receive data using a form of electronic communication [7].

On 30 November 2016, the European Commission presented, "Clean energy for all Europeans", which is a package of legislative proposals to facilitate the clean energy transition [8]. The package covers among other things the topic of electricity market design. The proposal aims at putting consumers at the heart of the energy markets by ensuring that they are empowered and better protected. According to the proposal, minimum functional requirements for smart meters should be set up in line with several principles in the member states. These principles include for example to measure actual electricity consumption and provide easy-to-understand information to the customer on actual time of use, and if the customer requests, to provide metering data via a local standardized communication interface. It also includes to follow security and privacy legislation, to measure injected energy to the grid, to give the customer appropriate advice and information at the time of installation, and to enable final customers to be metered at the same time resolution as the imbalance settlement period in the national market.

2. First generation of smart meters in Sweden

A major driver for rolling out smart meters in Sweden was to increase consumer awareness and to reduce energy consumption. Introducing smart meters also improved DSOs' understanding of the load pattern. Better understanding of the load pattern allows DSOs to better allocate their costs and reduce the risk of over dimensioning of the network capacity.

The roll-out of the first generation of smart meters in Sweden took place through two major steps. The first step was the introduction of monthly metering, and the second step was the gradual introduction of hourly metering.

2.1 Monthly metering

Before 2003, nearly all electricity meters in Sweden measure on a yearly basis. The customers received their bills based on the previous year's consumption, and then received a reconciliation bill for the difference between the previous year's consumption and the actual consumption [9]. Hourly metering was only required for consumers who had fuses above 200 A or rated power above 135 kW and for producers. In 2003, the Swedish Parliament decided that by 2009 all electricity customers should have monthly billing based on actual consumption. This initiated the roll out of the first generation of smart meters in Sweden. Therefore, since 2003 smart meters have been rolled out gradually. These meters could be automatically read at least every month for consumers and hourly for producers; therefore, they were also referred to as automatic meter reading (AMR) systems. By 2009, nearly all Swedish consumers had smart meters that could be remotely read at least once a month. The DSOs are responsible for the meter reading and data reporting. The costs of the smart meters are included in the DSOs' asset base in the revenue cap regulation (more information in section 4).

2.2 Hourly metering

In 2006, the fuse limit for which hourly metering was required was lowered to 80 A from 200 A. In fact, most of the meters that were installed for measuring automatically every month can measure every hour as well and can be read remotely. In May 2010, 91% of the meters could register hourly values remotely [10]. In 2012, new rules entered into force which meant that customers who had a fuse below 63 A and subscribe to an hourly-based electricity supply contract had the right to meters that can measure data hourly without extra cost. Customers who did not have hourly-based electricity supply contracts or did not have the hourly metering yet, needed to pay for the hourly metering. When a customer requested an hourly-based contract, the electricity supplier should inform the DSO to install hourly meters and report the hourly metering data.

In 2017, a new amendment was made to the legislation. All electricity consumers can now request hourly metering without extra cost. In Sweden, the DSO is responsible for the registration and reporting of values. The DSO is obliged to report values in the common standard electronic data interchange format, upon request from the customer. If the customer has opted for hourly metering, the DSO must make the metering data available online [10]. A timeline of the reform and the status of smart meters in Sweden is shown in Figure 1.

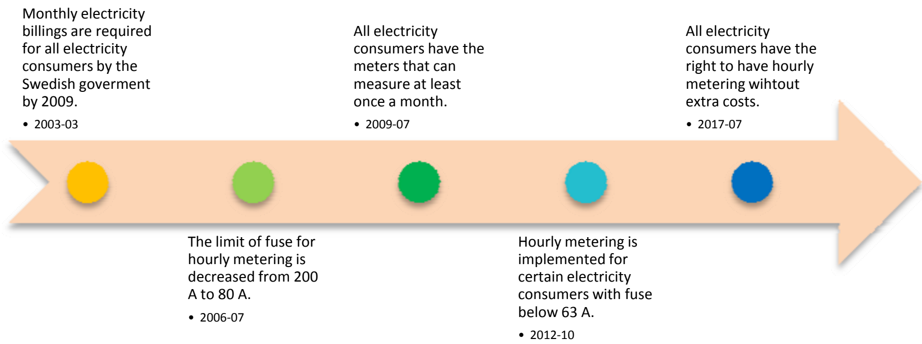

Figure 8 - **Timeline of the development of smart meters in Sweden**

2.3 Functionalities of the first generation of smart meters

The first generation of smart meters in Sweden fulfils the requirements in the EU Directive 2012/27/EU. However, in terms of functionality of meters, the first-generation smart meters vary significantly. In the early stages of the roll-out, the basic requirement for smart meters was to read the meter hourly for the customers with hourly-based electricity supply contract. There was no requirement on communication or visualization of consumption data. However, most meters are connected to communication systems that can transfer hourly meter values and are capable of two-way communication [10]. Some of the meters are connected to visualization tools to enable the customers to monitor and control their consumption. Some meters are equipped with other platforms to show the real-time price of electricity and their consumption. According to an investigation in 2013 which included about 90% of the household consumers in Sweden, around 66% of the meters in Sweden can send alarm signal to DSOs when there are outages or abnormal voltage levels in the system [13]. Furthermore, around 76% of consumers have access to hourly measurements and around 40% of the meters can measure both input and output energy until 2013 [13]. Many new functions of smart meters are continuously being developed. However, lack of standards for functional requirements of smart meters has shown as a barrier for facilitating demand response. Within the coming years many first-generation smart meters need to be replaced since they will reach their economic lifetime.

2.4 Lessons learned from the roll-out of the first-generation smart meters

In 2013, Ei was tasked by the Swedish Government to evaluate the impact of the legislation that enabled certain household consumers to request hourly metering without extra cost [12]. The results showed that very few electricity suppliers offer contracts based on hourly prices. More than 55 suppliers provided hourly price contract according to the investigation in 2013 [12]. Consumers needed to contact the suppliers to find out this information. Therefore, it was found to be difficult to compare offers from different suppliers. Around 10% of the total consumers, which is about 600 000 consumers, have switched supplier between 2012 and 2013 [12]. Furthermore, it was difficult for consumers to understand and evaluate the hourly price contracts. Given the lack of information, it was not surprising that only around 8 600 customers, which is less than 2% of the total customers, had chosen hourly price contracts until October 2013 [12]. However, most of the DSOs stated that their smart meters could measure data hourly. About one million customers had hourly metering. A few suppliers that offered hourly price contracts to consumers also offered equipment or services (e.g. mobile applications that visualize consumption and price) that could help consumers to react to price signals [12]. One reason can be that it takes up to 3 months for the DSO to change a monthly reading meter to hourly read meter, which reduces the interest from consumers to react.

3. Second generation of smart meters in Sweden

In 2014, Ei was tasked by the Swedish Government to analyse and suggest functional requirements for the future electricity meters in Sweden [13]. The task included a cost-benefit analysis (CBA) on implementing different functions on smart meters. The CBA was based on the method recommended by the EU commission [14]. In 2015, Ei published recommendations for functional requirements of smart meters in the low voltage networks, which is less than 230 V [15]. In the rest of the paper, we will only discuss the meters in the low voltage networks. Typical customers in the low voltage networks are household customers and small industries. One of the conclusions from the study was that minimum functional requirements should be defined for the second generation of smart meters in Sweden. Functional requirements will facilitate the development of smart grid and establish a base for competition on demand response services.

In December 2016, Ei was tasked by the Swedish Government to propose the regulation concerning minimum functional requirements for the next generation of smart meters. In November 2017, Ei presented the report to the Government. Ei has during the work with the report consulted The Swedish Board for Technical Accreditation(Swedac), The Swedish Data Protection Authority, The Swedish Armed Forces and The Swedish Security Service. Market participants in the electricity market (DSOs, manufacturers of smart meters, etc.) were also invited to give their views during the work. The ordinance came into force in September 2018 and Ei was tasked to develop regulations to execute the regulation concerning the minimum functional requirements for smart meters. These requirements should be implemented by 1 January 2025.

3.1 Why functional requirements?

Well defined functional requirements on smart meters are the basis for the further development of smart meters. It ensures that all the electricity consumers, electricity suppliers and service providers have equal opportunities. Some requirements can facilitate the development of energy service markets, for example, information on real-time electricity consumption. With this information, customers can react to the price signal from the markets and can evaluate different energy services. Requirements on providing more real-time information can motivate DSOs to accelerate the journey towards a smarter grid. By providing useful information to network operation the network can be used in a more efficient way. The development of functional requirement on smart meters is also a continuation of the EU recommendations from 2016.

3.2 List of minimum functional requirements

The ordinance defines five functional requirements for smart meters and metering system. The functionalities and its purposes are shortly summarized in Table 10.

Some of these functionalities are already implemented in a large share of the meters that are installed in Sweden, for example remote collection of measured data and registration of power interruptions. However, by regulating the functions it makes sure that *all* the meters and metering system fulfil the requirements. That will ensure that all consumers have the same information and opportunities.

The main difference between the future meters and the meters of today is that the future metering systems will be able to handle more and more detailed information that will be accessible to and benefit both the customer and the DSO.

Besides the minimum functional requirements, the functionalities shall be implemented in such a way that unauthorized persons shall not get access to information or functionalities in the meters, and consideration must be given to the EU regulations GDPR, General Data Protection Regulation (2016/679). Since more information will be handled by the metering system and more actions will be possible to do remotely, it is important to consider the integrity and security aspects.

Table 10- **The minimum functional requirements for smart meters**

No.	Functionality	Purpose
1	Extended measurement	Promote efficient network operation Facilitate integration of micro production in the network
2	Registration of active energy every hour or fifteen minutes and power outages	Increase the customers' possibility to be active in the market. Facilitate for the DSOs to pay compensation to the customer due to outages. Empower the customer.
3	Customer interface	Create conditions for a developed energy services market Promote demand side flexibility and energy efficiency Empower the customer.
4	Remote collection of measured data and power outages	Promote efficient collection of data
5	Remote updating software, settings and control the power of the meter	Provide the condition that new functionalities can be introduced in a cost-efficient way. Avoid expensive field visits.

A more detailed description of the functional requirements and the motivation are presented below, together with a reference to the cost-benefit analysis for each requirement. A quantitative analysis for all functional requirements is also represented afterwards. A more comprehensive cost-benefit analysis can be found in [13]

1. Extended measurement

The meter shall for every phase be able to measure voltage, current, active and reactive power for both directions. The meter shall also be able to measure and register the total withdrawal and input of energy.

This requirement ensures that the DSOs have sufficient information to operate the network efficiently. Electricity consumers can also use this information to evaluate different energy services and to evaluate the possibility to install microgeneration or energy storage. However, these benefits are difficult to quantify. At the same time, the extended measurement data are beneficial only if these data are accessible to customers. Therefore, some of the benefits are analysed in the next functional requirement. Moreover, the benefits depend on the type of consumers. Customers who live in houses are likely to benefit more than those who live in apartments. The costs for implementing this requirement is estimated as 0-30 SEK[3] per meter [13]. The benefits from extended measurement are believed to be higher than the costs.

2. Registration of active energy every hour or fifteen minutes and power outages

1) Registration of active energy every hour or fifteen minutes

The meter should be able to save the active energy in both directions every hour and be able to convert to every fifteen minutes. This will allow for increased customer awareness of their consumption. The interval of fifteen minutes is adopted from the recommendation from the EU commission. Hourly data or fifteen minutes data is an important condition to develop demand response services and electricity contracts which can send out the right market signals.

The benefit of consumers having a better understanding of their consumption and taking actions to reduce its consumption is estimated to be 35 SEK per household per year. This estimation assumes that consumers reduce their consumption by 1% per year in average. The benefit for the DSO is estimated by assuming that the DSO will use the information to provide better services and to reduce the operational cost. The benefit is estimated to be 15 SEK per meter and year. This requirement is also expected to reduce the possibility of over dimensioning the network capacity and to facilitate demand response. However, these potential benefits are more difficult to quantify.

To fulfil this requirement, the DSOs need to invest in a better data colleting system and registration system. The cost for investing in such colleting system is estimated to be 23 SEK per meter, while the cost for such registration system is estimated to be 50 – 150 SEK per meter. Nevertheless, there will be the additional operational cost to fulfil this requirement, which is estimated to be 84 SEK per meter per year. To benefit from this requirement, consumers need to change their behaviour. The cost or the value of a consumer to change its behaviour is estimated to be 10 SEK per meter per year. There is also cost for the regulator because contacts from consumers may increase. The estimated cost for the regulator is between 8 000 and 160 000 SEK per year.

Given these quantified costs and benefits, registration of active energy for every hour or fifteen minutes has higher costs than benefits. However, it is believed that the costs of the technologies are going to decrease, and the unquantified benefits will contribute to increasing the efficiency in the whole society.

[3] 10 SEK ~= 0,97 Euro, November, 2018

2) Registration of power outages

The meter should also be able to register data in the beginning and end of a power outage in one or more phases if the outage lasts three minutes or longer. This requirement gives more accurate information on outages. Therefore, it helps the customers to receive the right amount of compensation for the outage. More accurate information on outages can also help the DSO to monitor the network and eventually improve the reliability. It also helps the regulator to have better supervision on the reliability of the system. These benefits are difficult to quantify. However, this requirement does not imply extra cost for the meters if the function 1 would be in place.

3. Customer interface

The meter should be equipped with a customer interface, supported by an open standard, for the customer to be able to take part of the measured values (see function no. 1) in near real time. The interface should only display these information after the customer's request. The DSO must deactivate the interface when the customer moves out. Furthermore, it is not possible to send information from the customer through the interface.

The requirement ensures the customers have access to the near real-time data. This increase the awareness of the customers on their electricity consumption. Electricity consumers can also use this information for decreasing the energy consumption and evaluating different electricity contracts which may lead to change supplier of electricity. The quantified benefit of visualizing the near real-time data lies in that the consumers reduce their consumption. If the reduction is around 5% per household and year, the benefit of having such requirement is about 173 SEK per household and year.

The cost for a physical interface on the meter to fulfil the requirement is estimated to be between 20 and 50 SEK per meter. To see all the near real-time data, consumers need to invest in a display which can obtain the information through the interface. The cost of such a display is estimated to be between 200 and 1 000 SEK per meter. There is no other extra cost for the consumers or the regulator if the function 2 is in place.

4. Remote collection of measured data and power outages

The DSO should be able to read the measured values (see function no. 1) and the outage information remotely (with remote control). This requirement is to promote efficient data collection. To read the measured values remotely reduces the personal cost. Furthermore, to automatically send the outage information also increases the accuracy of the outage information and reduces the workload of DSOs. In addition, the real-time measured values and the outage information are valuable for the network operation. There is no extra cost for implementing this requirement in the meters. It may increase the cost for the DSOs depending on their communication and reporting system.

5. Remote updating software, settings and control the power of the meter

The DSO should be able to update software and change settings of the meter remotely. This requirement aims to reduce the costs for future updates of smart meters. With the development of smart meter, more requirements may be defined, and more security measures may need to be implemented. It also can decrease the operational costs if the field trip can be replaced by remote control. Each trip costs about 300 - 600 SEK. However, many current meters already have this function in place.

The DSOs should also be able to turn on and off the power through the meter with remote control. This requirement only applies for meters that are not connected by current transformer. This requirement also aims to decrease the operational cost by avoiding the field trip. This function can be useful for the customers when they move out or in. It can potentially decrease the energy consumption during the moving out and in period.

There is no extra cost for implementing remote updating software and settings since most of the meters already have this function in place. The meters that are equipped with current transformer are exempted from this requirement, because it may lead to excessive costs.
The cost for enabling turn on/off the meter remotely is estimated to be between 100 and 200 SEK per meter. But most of the existing meter already have such function in place. It is assumed that only 5%-20% of the meters need to be reinvested.

4. The cost of smart meters

Ei determines a revenue cap for each DSO for a period of four years at a time. The revenue cap indicates the total amount that the DSO may charge their customers. The purpose of the revenue cap is that DSOs shall obtain reasonable coverage for their costs and reasonable return on the invested capital. The minimum functional requirements may increase the cost for smart meters. Therefore, it is important to consider how costs related to meters are handled in the revenue-cap regulation to facilitate the roll-out of the next generation smart meters. The current Swedish revenue cap regulation is described more in detail in [16].
There are both operating expenses (OPEX) and capital expenses (CAPEX) connected to meters. The OPEX can for example be affected by changes in the costs associated with reading and using meter data. Changing to more advanced meters can both increase and decrease OPEX. On the one hand, more data should be handled. IT security issues, more expensive software, more competence requirements etcetera will increase OPEX. On the other hand, better IT systems, more automation and more information from meter data possibly lead to more efficient operation in the distribution system. The OPEX part in the revenue cap regulation is based on the DSO's actual historical OPEX with annual efficiency requirements of 1.00-1.82 % per year based on a data envelopment analysis (DEA). Hence, new meters do not change the OPEX part in the revenue cap, which means incentives for the DSOs to reduce its actual OPEX as much as possible.
When the DSO invest or re-invest in a new component such as a meter, the CAPEX part of the revenue cap increases. Ei has a norm price list of component categories, so first the DSO must identify which component category that best fits the actual investment. The norm cost is then input to the CAPEX calculation. The CAPEX consists of two parts: return and depreciation. All meters have a regulatory depreciation time of ten years (for most other power system equipment the depreciation time is much longer). So, if the norm price for example is 10 000 SEK (~1 000 EUR), then the DSO would be compensated with 1 000 SEK/year (10 000/10) for ten years. The return part is based on the norm value, the age and the rate of return (a WACC method is used). If the meter in the example is seven years old, it has lost 60 % of its value (6 000 of 10 000 SEK, 1000 SEK/year depreciation for the first six years), which gives an age adjusted value of 4 000 SEK (10 000 – 6*1 000 SEK). The annual return is the equal to WACC*4 000 SEK. To dis-incentivize the DSO to replace well-functioning equipment, the depreciation time can be increased two years for meters (i.e. totally up to 12-year depreciation).
The revenue cap regulation also includes incentive schemes based on several indicators for continue of supply, losses and for having a more even load. Smart meters can have indirect impact to help the DSO improve such indicators in a longer perspective. Ei has published papers in English, for example [16], which describe the revenue cap regulation in more details.

5. Smart meters in Sweden-- to be continued

Sweden have around 5.4 million electricity meters in the low voltage network. The installation of new smart meters is expected to bring benefits both to the DSO and to the customers by for example supporting the development towards a smart grid by providing information that will enable new energy services and demand response. New regulations will be drafted by Ei to ensure the implementation of the minimum functional requirements that are stated in the ordinance.

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