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Metering as an Enabler for Consumer-Focused Flexibility in Sweden

Factsheet

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This fact sheet presents some insights into metering as an enabler for consumer-focused flexibility, and gives a brief overview of the two generations of smart meter roll-outs in Sweden, as well as the national regulation of minimum functional requirements for electricity meters.

Significance of metering

Metering is a prerequisite for consumer-focused flexibility

Access to hourly meter data (or the smallest market time unit used) is essential for energy market actors to be able to design attractive customer offerings where the customer can benefit from their flexibility. When designing customer offerings, third-party actors, such as aggregators, need historical hourly meter data to identify customer flexibility potential and to be able to calculate the benefits and costs of demand side flexibility for a specific customer. Information on hourly meter data is also necessary for customers to be incentivised to influence their electricity consumption in order to decrease their electricity cost. A survey conducted by Umeå University shows that most household customers want more information on its historical energy consumption[1]. For the customer, and third-party actors (with the customer's consent), to access hourly meter data, the metering must take place on an hourly basis, the hourly meter data must be saved, and the customer should get access to the hourly meter data in an appropriate format.

Functional requirements for meters as enablers of consumer-focused flexibility

Varying functionalities of smart meters between different DSOs endanger the consumers' right to be treated equally. It is important that consumers have equal opportunity to, for example, utilise services from energy suppliers or energy service providers. In Sweden, smart meters are owned by the DSOs. Therefore, a need to define minimum functional requirements for smart meters was identified. The Swedish case is further described in the next section, **Error! Reference source not found.**.

Well-defined functional requirements for smart meters are the basis for the further development of smart meters. It ensures that all electricity customers, electricity suppliers and service providers have equal opportunities. Some requirements can facilitate the development of energy service markets, such as information on real-time electricity consumption. With this information, customers can react to relevant price signals from the markets and can evaluate different energy services. Requirements to provide more information in near real-time 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.

[1] Broberg, T. et al., 2014. "En elmarknad i förändring - Är kundernas flexibilitet till salu eller ens verklig?" (in Swedish). Eskilstuna: Energimarknadsinspektionen.

The situation in Sweden

Electricity meters play a key role for the efficient function of the Swedish electricity market. The meters are also important in the development of smart grids and can help us meet some of the long-term challenges we face in ensuring an affordable and sustainable energy supply. For DSOs, who are also the owners of smart meters in Sweden, smart meters offer a range of possibilities that can contribute to a more efficient network operation, decreased energy usage, and improved possibilities for the integration of micro production. For electricity customers, smart meters provide more detailed information about their energy consumption and, in turn, the potential for a more flexible use of energy and lower costs.

The Swedish Energy Markets Inspectorate has been tasked to promote demand side flexibility in the electricity market. In 2016, the Swedish Energy Markets Inspectorate was tasked by the Swedish Government to propose measures that can stimulate demand side flexibility. It is stated in the subsequent report[2] that meter data per the smallest market time unit used, currently per hour in Sweden, is a prerequisite for several measures for increased demand side flexibility. The following sections describe the first and second generation of smart meter roll-out in Sweden, including lessons learned from the first generation. Sweden's development of functional requirements for smart meters is also a continuation of the EU recommendations from 2012[3].

First generation – from monthly to hourly metering

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 customers and hourly metering for larger customers by 2009. This led to the roll-out of the first generation of smart meters in Sweden.

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

Before 2003, nearly all electricity meters in Sweden measure, on an annual basis. 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. A major driver for the monthly meter reading in Sweden was to increase consumer awareness and to reduce energy consumption. Therefore, smart meters have been rolled out gradually since 2003. These meters could be automatically read at least once a month for customers and hourly for producers[4]. By 2009, nearly all Swedish customers 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.

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. However, the associated systems also require the ability to handle the measurements to fully use this functionality. In 2012, new rules entered into force which meant that customers who had a fuse below 63 A and subscribed to an hourly-based electricity supply contract had the right to meters that can measure data hourly at no extra cost. Customers who did not have hourly-based electricity

[2] The Swedish Energy Markets Inspectorate, 2016. "Åtgärder för ökad efterfrågeflexibilitet i det svenska elsystemet" (in Swedish).
[3] 2012/148/EU Commission Recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems
[4] Therefore, they were also referred to as automatic meter reading (AMR) systems.

supply contracts or did not yet have the hourly metering, had to pay for the meter that enabled hourly metering if they wanted the meter. When a customer requested an hourly-based contract, the electricity supplier should inform the DSO for it to install hourly meters and report the hourly metering data.

In 2017, a new amendment was made to the legislation. All electricity customers could now request hourly metering at no extra cost, regardless of having a monthly-based or hourly-based electricity supply contracts. In Sweden, the DSO is responsible for the registration and reporting of values. The DSO is obliged to report the 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.

Functionalities of the first generation

The first generation of smart meters in Sweden fulfils the requirements of EU Directive 2012/27/EU. However, in terms of functionality, 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 contracts. There was no requirement on communication or visualisation of consumption data. However, most meters are connected to communication systems that can transfer hourly meter values and are capable of two-way communication[5]. However, the associated systems also require the ability to handle such measurements to fully use this functionality. Some of the meters are connected to visualisation 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 real-time consumption.

Many new functions in smart meters are continuously being developed. However, lack of European standards for functional requirements for smart meters has been shown to be a barrier for facilitating demand side flexibility. On a European level, work is in progress on standards in the area of smart meters, communication and smart grids[6]. This is expected to continue for a long time to come, and may have a long-term impact on the development of electricity meters. Many first-generation smart meters need to be replaced in the coming years since they will have reached the end of their economic service life.

Lessons learned from the roll-out of the first generation

In 2013, the Swedish Energy Markets Inspectorate was tasked by the Swedish Government to evaluate the impact of the legislation that enabled certain household customers to request hourly metering at no extra cost[7]. The results showed that few electricity suppliers offered contracts based on hourly prices. About a third of these electricity suppliers did not actively market their hourly-based contracts, meaning that customers needed to contact the suppliers to be informed about the possibility of taking out hourly contacts. Few electricity suppliers published information about prices and contract terms on their website. Therefore, it was found to be difficult to compare offers from different suppliers.

Furthermore, it was difficult for customers 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 customer base[8] in Sweden, had chosen hourly price contracts up to October 2013[9]. However, most of the DSOs stated that their smart meters could measure data on an hourly basis. About one million customers had meters

[5] NordREG, 2014. “Common Nordic Metering Methods”.
[6] https://ec.europa.eu/energy/topics/markets-and-consumers/smart-grids-and-meters_en#smart-grid-projects-in-europe
[7] J. Nilsson, J. Leymann and S. Näselius, 2014. “Uppföljning av timmätningsreformen” (in Swedish)
[8] Customers with fuse contract of maximum 63 amperes.
[9] J. Nilsson, J. Leymann and S. Näselius, 2014. “Uppföljning av timmätningsreformen” (in Swedish)

prepared for hourly metering. A few suppliers that offered hourly price contracts to customers also offered equipment or services (e.g. mobile applications that visualise consumption and price) that could enable customers to react to price signals[10].

Second generation – introducing functional requirements for household customers and small industries

In 2014, the Swedish Energy Markets Inspectorate was tasked by the Swedish Government to analyse and suggest functional requirements for future electricity meters in Sweden. The task included a cost-benefit analysis (CBA) on implementing different functions in smart meters. The CBA was based on the method recommended by the EU commission[11]. In 2015, the Swedish Energy Markets Inspectorate published recommendations for functional requirements for smart meters in the low voltage networks, which is less than 230 V[12]. 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 grids and establish a platform for competition in demand side flexibility services.

In December 2016, the Swedish Energy Markets Inspectorate was tasked by the Swedish Government make proposals for the regulation concerning minimum functional requirements for the next generation of smart meters. In November 2017, the Swedish Energy Markets Inspectorate presented the report to the Government. Market participants in the electricity market (DSOs, manufacturers of smart meters, etc.) were invited to give their views during the work. The ordinance came into force in September 2018 and the Swedish Energy Markets Inspectorate was tasked to develop regulations to implement the ordinance concerning the minimum functional requirements for smart meters. These requirements should be implemented by 1 January 2025.

List of minimum functional requirements

The ordinance defines five functional requirements for smart meters and metering systems. The functionalities and their purposes are briefly summarised in Table 1. Customer-related purposes are highlighted in bold font in the table**Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.**. Some of the five functionalities are already implemented in a large proportion of the meters that are installed in Sweden, such as the remote collection of measured data and the registration of power interruptions. However, regulating the functions ensures that all meters and metering systems fulfil the requirements, guaranteeing that all customers will have access to the same information and opportunities.

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

The minimum functional requirements are based on the assumption that the meters will produce more data on the individual customer's electricity use. It is of the utmost importance that customer integrity remains intact by protecting personal data and that the security of the electricity system is kept at a high level. Therefore, besides the minimum functional

[10] J. Nilsson, J. Leymann and S. Näselius, 2014. "Uppföljning av timmätningsreformen" (in Swedish)
[11] EU, "Commission recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems (2012/148/EU)," Official Journal of the European Union, 2012.
[12] D. Norstedt, S. Persson and T. Ny, 2015. "Funktionskrav på framtidens elmätare" (in Swedish). The Swedish Energy Markets Inspectorate, Eskilstuna.

requirements, the functionalities shall be implemented in such a way that unauthorised persons shall not have 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 remotely, it is important to consider the integrity and security aspects.

Table 1: The minimum functional requirements for smart meters. Customer specific purposes are highlighted in bold font.

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' opportunity to be active in the market.** **Facilitate opportunities 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 update of software, settings and control of the power of the meter	Provide options for new functionalities to be introduced in a cost-efficient way. Avoid expensive site visits.

As presented in Table 1, the purposes of functional requirement no. 2 ("Registration of active energy every hour or fifteen minutes and power outages") and functional requirement no. 3 ("Customer interface") are directly aimed at benefiting the customer. Therefore, a more detailed description of those functional requirements and their justification, respectively, are presented below. For detailed information about all five functional requirements, see Appendix A.

Functionality no. 2: Registration of active energy every hour or fifteen minutes and power outages

The meter should be able to save the reading for the transferred active energy in both directions every hour and be able to change to every fifteen minutes on demand. This will allow increased customer awareness of consumption. The interval of fifteen minutes is adopted from the recommendation of the EU commission. Hourly data or fifteen-minute data resolution is an important prerequisite in order to develop demand side flexibility services and electricity contracts, which facilitates the transfer of vital market information to customers.

The meter should also be able to register data at the beginning and the 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. In addition, it helps the customers 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 its reliability. It also helps the regulator have better supervision of the reliability of the system.

Functionality no. 3: Customer interface

The meter should be equipped with a customer interface, supported by an open standard, for the customer to be able to monitor the measured values (see more details on functionality no. 1 “Extended measurement” in Appendix A) in near real time. The interface should only enable access to this information upon the customer’s request. This agreement is set up between the DSO and the customer requesting to activate the interface. The DSO must deactivate the interface when the customer decides to terminate its contract, e.g. when the customer moves to another residence. Furthermore, the interface allows one-way communication from the meter to the customer, and it is not technically possible to send information from the customer through the interface.

The requirement ensures that the customers have access to the near real-time data. This increases the awareness on the part of customers of their electricity consumption. Electricity customers can also use this information to decrease their energy consumption and to evaluate different electricity contracts, which may lead them to change their supplier of electricity or to be more active in the energy market. The quantified benefit of visualising the near real-time data is that the customers reduce their consumption.

Insights for other countries

When considering relevant functional requirements, the guiding principle for the Swedish approach is to create usefulness for the customer while referring to a solution that is both understandable and possible to convey. Originally, the proposal of the functional requirements did not stem from a demand side flexibility point of view. However, one of the underlying purposes of the requirements is to provide customers, and, with the customers’ consent, also third-party actors, with more detailed information on the customers’ energy consumption. This in order to facilitate increased customer activity in the energy market. Following the minimum functional requirements, the meters will collect more data on the individual customer’s electricity usage. It is of the utmost importance that customer integrity remains intact by protecting personal data and that the security of the electricity system is not compromised. As noted, market participants in the electricity market were invited to give their views during the work. Public consultation is always recommended when creating new regulations in order to promote public acceptance.

It is important to note that the regulated functional requirements express the minimum level required. The DSOs are encouraged to implement additional requirements if they have a need for them, such as with regard to voltage quality measurements at a higher measurement class. One example for how to further harmonise the implementation of the functional requirement for a customer interface in Sweden is that the Swedish non-profit energy industry and special interest organisation Swedenergy (Swe. Energiföretagen) has developed an industry recommendation for the customer interface[13]. The industry recommendation is a detailed technical specification of the functional requirement for a customer interface and is based on the Dutch implementation, which in turn is based on IEC 62056-21 Mode D. Not all DSOs, although most likely many, will follow the recommendations, meaning there may be discrepancies even if industry recommendations are available.

The ability to compare prices and other factors that influences the choice of electricity supplier is a prerequisite for active customers. To strengthen customers' position in the

[13] https://www.energiforetagen.se/globalassets/energiforetagen/det-erbjuder-vi/kurser-och-konferenser/elnat/branschrekommendation-lokalt-granssnitt-v2_0-201912.pdf

electricity market, the Swedish Energy Markets Inspectorate offers a website for price comparisons[14], where customers can compare prices and terms for the most common electricity contracts from all electricity suppliers. The Swedish Energy Markets Inspectorate is constantly working to develop and improve the price comparison website in order to facilitate opportunities for customers and to enable expanded searches. Today, price comparisons can be made in 13 languages.

Conclusions and looking forward

When smart meters are owned by the DSOs, minimum functional requirements enable customers of different DSOs to have the same prerequisites to access their data. Thus, the minimum functional requirements give the consumers equal opportunity to, for example, utilise services from energy suppliers or energy service providers.

Sweden has around 5.4 million electricity meters in the low voltage network, all expected to be replaced by new meters that fulfil the functional requirements by 1 January 2025. 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, including demand side flexibility. New regulations[15] were published in 2019 by the Swedish Energy Markets Inspectorate to ensure the implementation of the minimum functional requirements as stated in the ordinance. Information on the minimum functional requirements and related frequently asked questions are available in Swedish on the Swedish Energy Markets Inspectorate's website[16]. The English version of the website provides a summary of the Swedish Energy Markets Inspectorate's report on the functional requirements from 2017[17].

In February 2020, the Swedish Energy Markets Inspectorate proposed a national implementation of five legislative acts in the Clean Energy Package to the Government[18]. In the Electricity Market Directive (EU) 2019/944[19], Article 19 and Article 20 concern smart meters. In the implementation proposal, Article 19 was assessed as being fulfilled within existing regulations. Article 20 was assessed as being partly fulfilled. To completely fulfil Article 20, which concerns the end customers' right to appropriate advice and information before, or in connection with, the installation of smart meters, measures were proposed to implement Article 20(f)[20]. The Swedish Energy Markets Inspectorate assessed that the provision has already been introduced for consumers through the Electricity Act, which states that network concessionaires shall ensure that consumers receive appropriate information in connection with the installation of new meters. The measure proposed was that the Electricity Act needs to be supplemented with a provision for customers who are not

[14] **https://www.elpriskollen.se**
[15] The Swedish Energy Markets Inspectorate's regulations on functional requirements for measuring systems and measuring equipment EIFS 2019:5 (in Swedish). Available: **https://ei.se/download/18.5b0e2a2a176843ef8f5b79/1608639227245/EIFS-om-funktionskrav-f%C3%B6r-m%C3%A4tsystem-och-m%C3%A4tutrustning-EIFS-2019-5.pdf**
[16] **https://www.ei.se/bransch/funktionskrav-elmatare**
[17] **https://www.ei.se/ei-in-english/publications/publications/reports-and-memos/2017/summary-of-the-report-smart-meters-ei-r201708**
[18] The Swedish Energy Markets Inspectorate, 2020. "Ren energi inom EU - Ett genomförande av fem rättsakter" (in Swedish). Ei R2020:02.
[19] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU
[20] 2019/944 (EU) Article 20(f): "appropriate advice and information shall be given to final customers prior to or at the time of installation of smart meters, in particular concerning their full potential with regard to the management of meter reading and the monitoring of energy consumption, and concerning the collection and processing of personal data in accordance with the applicable Union data protection rules".

consumers[21]. Currently, the Swedish Energy Markets Inspectorate is awaiting the ministry's response.

[21] The Swedish Energy Markets Inspectorate, 2020. "Ren energi inom EU - Ett genomförande av fem rättsakter" (in Swedish). Ei R2020:02.

Appendix A: The five minimum functional requirements for smart meters in detail

The functional requirements for smart meters listed below apply to meters in the low voltage networks, which is less than 230 V[22]. Typical customers in the low voltage networks are household customers and small industries. More information on functional requirements with regard to meter categories can be found in The Swedish Energy Markets Inspectorate's regulations on functional requirements for measuring systems and measuring equipment [23].

1. Extended measurement

The meter shall be able to measure voltage, current, active and reactive power in both directions for every phase. 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 single-family buildings are likely to benefit more than those who live in apartments in multi-family buildings due to their extended possibility of influencing their consumption. In addition, customers who live in single-family buildings tend to have higher electricity consumption and thus a greater potential for economic savings.

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

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

The meter should also be able to register data at the beginning and the 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 allows the customers 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 its reliability. It also helps the regulator have better supervision on the reliability of the system.

[22] EU, "Commission recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems (2012/148/EU)," Official Journal of the European Union, 2012.
[23] The Swedish Energy Markets Inspectorate's regulations on functional requirements for measuring systems and measuring equipment EIFS 2019:5 (in Swedish). Available: https://ei.se/download/18.5b0e2a2a176843ef8f5b79/1608639227245/EIFS-om-funktionskrav-f%C3%B6r-m%C3%A4tsystem-och-m%C3%A4tutrustning-EIFS-2019-5.pdf

3. Customer interface

The meter should be equipped with a customer interface, supported by an open standard, for the customer to be able to monitor the measured values (see functionality no. 1) in near real time. The interface should only enable access to this information upon the customer's request. This agreement is set up between the DSO and the customer requesting to activate the interface. The DSO must deactivate the interface when the customer decides to terminate its contract, e.g., when the customer moves to another residence and moves out. Furthermore, the interface allows one-way communication from the meter to the customer, and it is not technically possible to send information from the customer through the interface.

The requirement ensures that the customers have access to the near real-time data. This increases the awareness on the part of customers of their electricity consumption. Electricity consumers can also use this information to decrease their energy consumption and to evaluate different electricity contracts, which may lead them to change their supplier of electricity. The quantified benefit of visualising the near real-time data lies in that the consumers reduce their consumption.

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 intended to promote efficient data collection. To read the measured values remotely reduces personnel costs. Furthermore, to automatically send the outage information also increases the accuracy of the outage information and reduces the workload on DSOs. In addition, the real-time measured values and the outage information are valuable to the network operation.

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

The DSO should be able to update software and change the settings of the meter remotely. This requirement aims to reduce the costs of future updates of smart meters. With the development of smart meters, more requirements may be defined, and more security measures may need to be implemented. It can also decrease the operational costs if the site visit can be replaced by remote control.

The DSOs should also be able to turn the power on and off 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 site visit. This function can be useful for customers when they move in or out. It can potentially decrease the energy consumption during the moving in and out period.