

## EXPERIENCES FROM OPERATIONS AFTER A FULL-SCALE SMART METERING ROLLOUT REGARDING AVAILABILITY AND RELIABILITY.

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### ABSTRACT

Vattenfall Distribution Nordic has deployed 1 200 000 AMR meters. New law requirements stated monthly meter readings from July 1, 2009 in Sweden, no requirements in Finland. The AMR investment was based on a business case mainly related to decrease reading costs for the billing process and reduced costs for customer service. A lot of additional benefits have also been identified regarding a range of new smart metering related services.

This paper describes the status and experiences from operation after the full-scale smart metering rollout. The focus is on both possibilities and challenges for smart metering regarding new demands from market, regulators and future Smart grid integration. For new real-time AMM related services and Smart grid solutions availability and reliability will be crucial and improvements have to be done.

### BACKGROUND

Vattenfall Distribution Nordic has deployed 1 200 000 AMR meters in Sweden and Finland, 830 000 in Sweden and 370 000 in Finland. The installations have been carried out in four mayor phases and different contracts with AMR vendors. It started in 2003 and was finalized 2009. The deployed solutions vary regarding meter communication and meter functionality. At the time for the first rollout phases the market for meters was not mature enough and meters didn't have the same features as smart meters today. The communication infrastructure differs regarding the AMI solutions and the rollout phases.

The legislations in both countries have been defined during the rollout period and differ. In Sweden it's mandatory for meter reads monthly for customers with a fuse size up to 63 amps and hourly metering above. No requirements from authorities regarding the need for AMR metering and functionality in Sweden. In Finland it's mandatory earliest from 2012 to measure and settle all customers hourly who have AMR meters. At latest 2014 should at least 80% of customer have AMR-meters.

### EXPERIENCES REGARDING AMR AND AMI TECHNIQUE

#### Metering functions

In the Smart metering rollout different AMI infrastructure and AMR meters has been installed. At the time for the first rollout phases the market for meters was not mature and meters didn't have the same features as Smart Meters today.

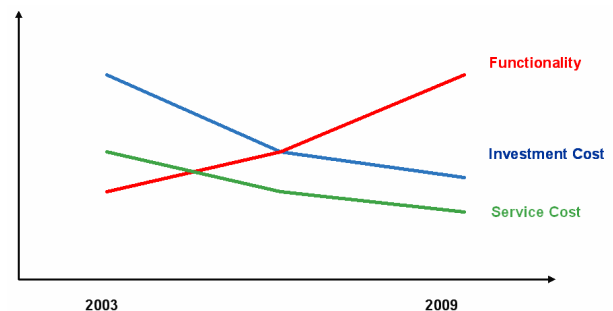


Figure 1 AMR market development

Improvements of the meters content and features have increased rapidly during the project time regarding:

- Firmware and parameters up-dated remotely
- Bi-directional meter readings supporting micro generation
- Power Quality information; voltage, current, zero faults
- Power Outage information; outage indications, statistics, phase loss
- Supporting disconnect/connect, demand response

The cost for investments and services has decreased during time for the rollout.

The principles for measuring differ between groups of installed meters for different rollout phases and vendors. A majority of meters and concentrators have capability to be remotely updated regarding software and firmware.

All installed meters and AMI infrastructure are in theory equipped to measure and handle hourly meter values for active energy, but for meters communicating via PLC has this not been tested in large volumes yet. Most of the meters could also handle reactive energy measured hourly.

To be able to use the installed Smart meters for measuring Micro generation the meters in some cases have to be

reconfigured for that purpose, this could normally be done remotely. In some cases the meters have to be changed. Customers always have to inform the DSO's when installing Micro generation as well as for any other distributed generation.  
 For all meters it's possible to do an on demand meter read and do a query to the meter remotely.

**Meter Data Management**

The system for meter data management has previously been used only for storage of metering values for billing purposes. The MDM-system quality assures meter values, meter stands and interval data, before sending them to suppliers and for billing.  
 The new situation with a lot of additional information from the Smart meters has resulted in a decision to purchase a new more complex MDM-system capable of handle the future Smart Metering requirements. The system has now been installed in Finland and will be installed in Sweden by 2012.

In a Smart Metering concept the MDM-system is an important hub and a source for historical information for a lot of back-end systems and work processes. When needed the information could be requested and delivered from the MDM-system.

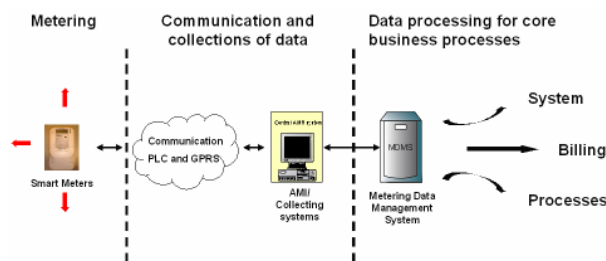


Figure 2 AMR process overview

The MDM-system will also be the unifier and the link from back-end systems to all AMI-systems and Smart meters. The system will support all metering aspects of consumption, production and handling of alarms and events. The system will also support other systems, actors and report functions with data on demand.

**Metering communications**

The concepts for communication with meters differ. Different communication concepts have been used in the AMR roll-out project. It differs between roll-out phases and AMI solutions.  
 In Finland, with a very high penetration of GSM/GPRS, the

majority of meters communicate point-to-point. In Sweden with less coverage for GSM/GPRS the majority of meters using PLC and in some cases radio and GPRS.

For LAN (from the meter):

- Radio with repeaters and collectors
- PLC with concentrators
- GPRS/GSM point-to-point

For WAN:

- Mainly GPRS from LAN to a metering service provider.
- From metering service provider to Vattenfall via VPN.

The performance in the meter collection process is today limited due to the shortcomings in the AMI communications. Other usage of AMR data and the AMI communication infrastructure also suffer due to not sufficient high availability and reliability.  
 Meeting the future demands from the market and regulators all this conditions matters. In general availability, reliability and performance is not sufficient high today and must be improved in the next generation Smart Metering solutions. Figure 3 represent a typical performance result regarding meter readings with monthly requirements. Proposal for a new common Nordic Electricity market indicates hourly meter readings for residential customers, this will be a challenge.

In the future to better meet the requirements in some cases the communication has to be in real-time and data to be processed in a more efficient way.

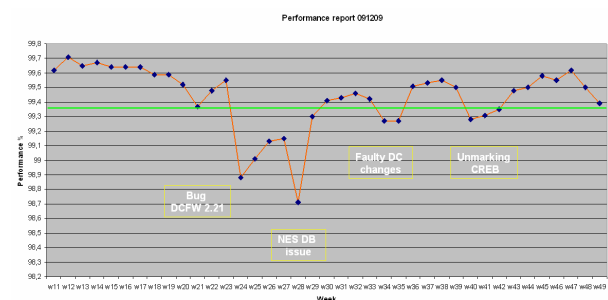


Figure 3 Typical performance figures

For future Smart Grid solutions communication between secondary substation and Smart Meters at customer sites must be extremely good. If Smart Metering will be an essential part of a SmartGrid solution requiring real time communication, availability and reliability can be a problem.

### System security

The entire AMI/AMR system infrastructure consists of different parts, systems, system integrations, communications and meters. The operations are carried out of different suppliers/actors and the system infrastructure consists of different technical solutions. The overall responsibility for system security in the metering collection process remains at the DSO.

System security could be divided in areas like:

- Intrusion protection
- Alerts to operators
- Traceability, logging of security events.
- Remote access
- Network separation
- Disaster Redundancy System

After the rollout of AMR meters it's possible to remotely affect customer's electrical distribution without visiting customer's site. This will give opportunity for delivering better services to customers but could also have a negative side if the tools will be used wrongly.

The measurements are in fact the basic conditions for billing and the cash flow. How to handle a disaster situation are therefore extremely important.

### **EXPERIENCES REGARDING DEVELOPMENT OF AMM SERVICES**

AMM services could be divided in two areas, internal and external. The internal services are related to improvements of the DSO's internal processes and operations. The external services are related to interaction with customers, retailers and 3<sup>rd</sup> party actors.

The AMR investment was based on a business case mainly related to decrease reading costs for the regular billing process but also for extra readings related to move in / move out and change of supplier. Reduced cost for customer service regarding fewer questions about the bill was also in the business case.

#### **DECREASED READING COST AND OTHERS**

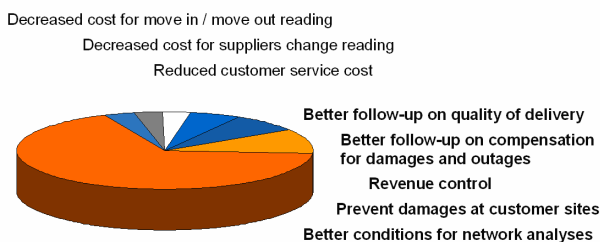


Figure 4 The business case and results so far

When looking back on the results a couple of years after the rollout compared with the business case its obvious that the benefits so far have been more extensive.

#### Achieved improvements through Smart Meters

- Remotely meter readings. Meters read daily.
- Monthly billing based on actual consumption
- Fewer Customer Service calls.
- Positive environmental impact due to less field crew activities.
- Customer complains can be handled more efficient and faster.
- ON-line web visualization of hourly consumption for all customers (Finland), Sweden by October 2011.
- Quality of supply: Power Outage and Power Quality measured at customer's site.
- Asset Management: Network calculations can be based on actual consumption and Power Quality data.
- Outage Management: Network operations more efficient due to Power Outage data and functions.
- Revenue Management:
  - Monitoring of network losses.
  - Monitoring of customers power usage.
  - Monitoring of illegal usage and damaged meters.
  - Remote switch off / -on used in the move out /-in process.

#### General conditions for the services

AMM Services could be based on one-way or two-way communication with the Smart meters. Normally meters register consumption, events, etc. and deliver the results daily scheduled to the AMI Head-end and the back-end systems. This could also be done in real-time for some types of alarms/events.

A service could also be triggered by a user in a two-way interaction with the meter. A request to the meter will be followed by a confirmation. The confirmation is normal when changing a parameter setting in the meter but could also be linked to an ordered delivery of meter information e.g. meter value, Power Outage data, etc.

Smart Meters today measure and deliver large volumes of data, the amount of data related to alarms and events could be significant higher than for meter values. Functions, applications and algorithms has in some extent been developed to aggregate, filtering and refine the AMR data so it could be more useful for the users. Today this function has been, in some cases, built up in the AMI Head-End, MDM-system or other back-end systems. To minimize the transportation of data and speed up the service in some cases the meter it self or the concentrator should work up or filtering the data and only if needed forward information to

the users. This is extremely important for real-time Power Outage data as proportion of irrelevant alarms are extremely high.

### **Internal services**

New internal services based on Power Quality, Power Outage and other information/alarms from AMR meters has now been used for a period in internal processes at Vattenfall to better understand what's happened in the grid and at customers site. A great potential for improvements in the net planning and net operation processes has been identified. Also in the dialog with customers regarding quality of delivery AMR data is significant vital. For example a situation when a customer complains about an outage or damage the errand could be solved very fast by follow up the situation through analyzing the AMR data. It's also possible to prevent damages as result of a zero point deviation, zero fault or broken high voltage fuse, the meter will alarm before a critical situation will occur at customers site.

Today SCADA and DMS systems cannot supervise and control the low voltage network, the last mile of the grid down to customers site is a blind area for the network operators. By integrate Smart metering functionality to the existing network operation systems it's possible to improve the Quality of Delivery for customers. This has been done at Vattenfall Distribution Finland with a very good result. The network operators could be aware of a problem quicker, react faster and solve the problem more efficient. The key issue to deliver that kind of service is the integration of AMI- and DMS-systems to make it possible to have a topological presentation of the low voltage grid combined with Smart metering data. The AMI-system must also have the capability for a fast and reliable two way interaction with the meters, a query to identified meters will then result in an up-date of the status for the DMS-system within an acceptable time frame. Situations with power outage, phase loss and zero fault deviation could be handled more efficient and problems for customers prevented.

By using Power Quality data from Smart meters such as voltage, current and hourly meter values it's now possible to do better network planning, avoid unnecessary network investments and analyze bottlenecks in the grid in order to give customers better quality of delivery. By doing network calculations based on real consumption / production the decision making will be more correct.

By using high resolution and more accurate meter values, hourly values, it's possible to measure and follow up network losses better. Administrative losses such as thefts, wrong installed meters and not measured consumption could be identified.

### **External services**

The external service has up to now mostly been related to measuring of customer's energy consumption for billing purposes. Earlier the demand was based on yearly metering but now monthly (in Sweden) and will in the future be hourly (in Nordic from approx. 2015).

Distributed generation (micro generation) will also be integrated in smart metering in that sense that the same AMR meter should be able to measure both energy consumption and energy production. Customers also want to have their energy behavior visualized in the future.

By using the full potential of the Smart meters, implement a powerful MDM-system and launch an ON-line web service it has been possible to deliver metering services based on hourly meter values for all customers in Finland from 2010 and in Sweden from 2011. As all Smart metering data will be stored in the DSO's MDM-system it's possible to support customers, retailers and 3<sup>rd</sup> parties with historical data.

Vattenfall Distribution Nordic has not equipped the Smart meters with a gateway to customers Home Area Network, HAN. This could be the case in the future but the situation today regarding communication standards for that kind of gateways for the future, the next coming 10 to 15 years, is not so clear and obvious.

### **IMPROVEMENTS FOR THE FUTURE**

When developing new AMM services reliable and effective Smart Metering functions must be available in the meter and a robust AMI infrastructure are crucial. Some of the services are not reliable if the availability in communications and systems not are sufficient high.

In some cases the communication also has to be in real-time to better meet the future demands and data be processed in a more efficient way.

Reliable communications will be crucial for a future Smart Grid solution where the Smart meters also will be the sensors / "RTU:s". Smart meters will be integrated with the DMS / Scada systems and LV grid automation.