

EXPERIENCES FROM OPERATIONS AFTER A FULL-SCALE SMART METERING ROLLOUT

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BACKGROUND

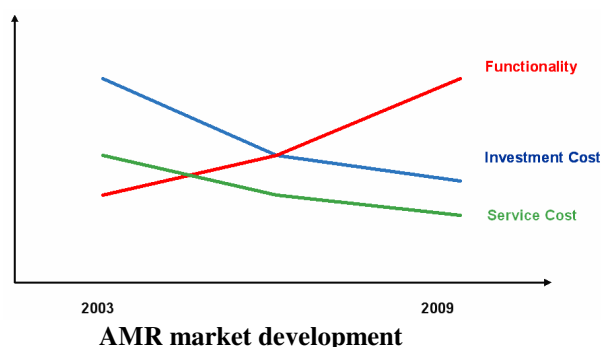
Vattenfall Distribution Nordic has now deployed 1 200 000 AMR meters, 830 000 in Sweden and 370 000 in Finland. The installations have been carried out in four mayor phases and different contracts with AMR vendors. It started in 2003 and was finalized 2009. The deployed solutions vary regarding meter communication and meter functionality. At the time for the first rollout phases the market for smart meters was not mature enough and they didn't have the same features as smart meters today. The communication infrastructure differs regarding the different 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 to read meter monthly for customers with a fuse size up to 63 amps and hourly metering above. No technical requirements from authorities regarding Smart Metering functionalities have been stated. 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 Smart 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.



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.

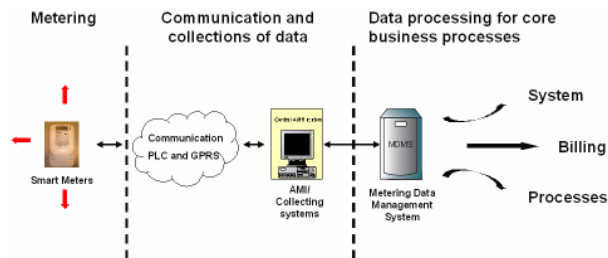
For all meters it's possible to do an on demand meter read and do a query to the meter remotely.

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 has also quality assured 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 2011.

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



An 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:

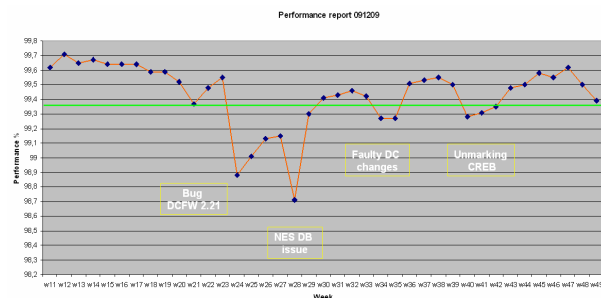
- Mainly GPRS from LAN to a metering service provider.
- From metering service provider to Vattenfall via VPN.

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.

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.



Typical performance figures

For future Smart Grid solutions communication between secondary substation and Smart Meters at customer sites must be extremely good.

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.

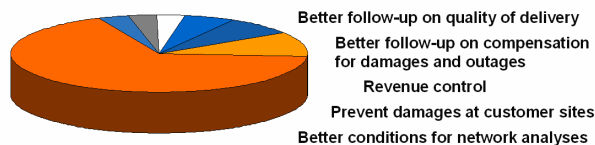
EXPERIENCES REGARDING DEVELOPMENT OF AMM SERVICES

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

Decreased cost for move in / move out reading
 Decreased cost for suppliers change reading
 Reduced customer service cost



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.

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 scheduled to the AMI Head-end and the back-end systems. This could also be done in real-time for some types of alarms.

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. 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 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 itself or the concentrator should work up or filtering the data and only if needed forward information to the users.

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 DMS-system must also have the capability for a fast 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.

By using Power Quality data from Smart meters such as voltage, current, phase loss 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. Technical- and administrative losses such as thefts, wrong installed meters, better regulate voltage levels, etc. 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 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's now 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 3rd parties with historical data. This will be done in the short term via a web interface but also in the long term through a B2B web service interface for retailers and 3rd parties.

Vattenfall Distribution Nordic has not equipped the Smart meters with a gateway to customers Home Area Network, HAN. This will probably 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 good 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 not the availability in communications and systems are sufficient high.

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

Communications will be crucial for a future Smart Grid solution where the Smart meters also will be the sensors / "RTU:s" communicating with the secondary substation and up-streams to the primary substation.