

SMART METERS IN OPERATION CENTER

Lars Garpetun
Vattenfall Eldistribution AB-Sweden
lars.garpetun@vattenfall.com

ABSTRACT

Vattenfall are developing the Smart metering system from initially an AMR system with basic functionality for meter value collections in a direction to be a part of a Smart Grid conception. It has been possible by using the full potential of the AMI and Smart metering system with the possibility to monitor the low voltage grid regarding power interruptions and power quality. Up to know it has not been possible to follow up the quality of supply in the low voltage grid and for each customer's premises. By using "real-time" events from Smart meters the grid Operation Center can improve quality of supply by monitor power interruptions, actual incidents and preventing damages. Reduced cost for customer compensation and improved quality of supply is the main outcome. The main goal is to lowering SAIDI and increase customers' satisfaction.

The ambitions for the future are to detect power outages in the low voltage grid faster and regardless of customer calls. By set up rules for automatic filtering of "meter down" events from the Smart metering system real power outage situations could be identified with higher accuracy. Such an algorithm requires grid connectivity data with acceptable data quality. The quality of the grid documentation (NIS, network information database) is essential for this functionality.

Integration of the AMI / Smart metering systems with DMS / Scada systems will give the operators in the control center a better view of the low voltage grid and the status in the grid. Unacceptable situations like Power Outages, zero faults, etc. could easily be displayed and located to actual grid sections on the operators screen. With right system tools it's also possible to reorganize the work processes and let the Customer Service Center solve problems like phase loss and single outage situations at customers site directly with out involving the grid operation center.

BACKGROUND

Vattenfall Distribution Sweden has since 2003 built up an AMI/Smart meter-platform. The main reason for the installation has been to automate the meter value collection process and support the customer with bills based on actual consumption. Based on this, Vattenfall has taken the next step and uses the Smart meter information in new areas. Positive business cases have been established regarding improvements in grid operations for monitoring the low voltage grid by using smart metering data. Smart meters have the possibility to indicate customer's power outages and measure customer's power quality based on the meters basic functionality for measuring voltage and current.

Up to know it hasn't been possible to follow up customer's power quality and power outages in the low voltage grid at customer's sites. By using "real-time" events from Smart meters the grid Operation Center can improve quality of delivery by monitoring outages, actual incidents, preventing damages. Reduced cost for customer compensation and improved quality of supply is the main outcome. The main goal is to lowering SAIDI and increase customers' satisfaction.

OBJECTIVES

The aim of this work is to develop and adapt the Smart metering platform to be used for "real-time" monitoring of the low voltage grid down to customers sites. Real-time means normally 1 to 10 minutes depending on how many meters there are at a secondary substation and the resultant response time. The ambition are firstly to use existing smart meter at customers sites but if possible also to include smart meters placed in secondary substations.

A smart metering system could include one or more operational systems from different vendors. These systems are functionally merged at the AMI Head-end level and should be seen as one total smart metering system.

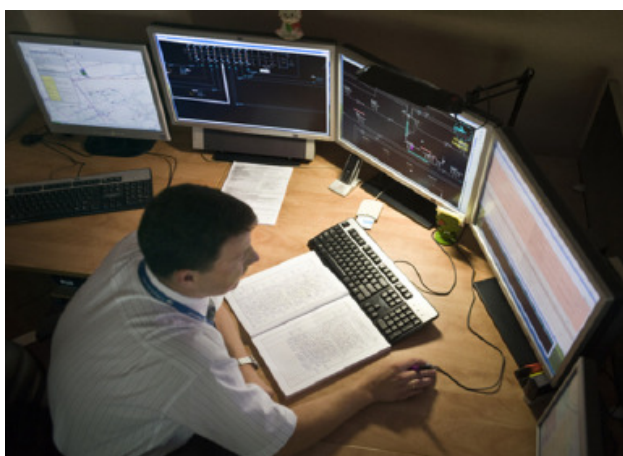
POWER INTERRUPTIONS

When a power outage situation occurs in the low voltage grid, regardless of faults in the high or medium voltage grid, will the fuses in the secondary substation for a specific LV feeder or a cable box be affected and normally only these customers will be in position to detect the outage.

If a customer phones in and complains it is not at first possible to understand the magnitude of the interruption, is it just that customer out of power or are there others? Is it a phase loss situation or a 3 phase outage? Before activate field crew recourses it's now possible to check-up information from the Smart meters and define if it's a grid issue or just blown fuses at the customer site.

In the aftermath of a large wind or snow storm it's possible to check if also the low voltage grid is affected. The procedure up to now have been relatively imprecise and resource intensive, telephone calls to customers or field inspections are the normal procedures.

Smart meters detect and communicate only what's happened based on voltage and current measurements for each meter, they can't understand the whole picture. Data concentrators located in secondary substations supervise the data communication for each meter by checking the meters availability (by a ping) continuously. Fewer meters connected to a concentrator will give shorter ping sequences and faster response time. When a meter not communicates (respond on a ping) an event is created and sent to the back-end systems. This event do not say anything about the reasons for failing, the reason could be a switched of meter, PLC communication problem or a power outage. The amount of power outages are normally less than PLC problems and switched of meters. Therefore it's not possible to use this functionality today for identifying outages with high reliability. But the other way around, if there are indications of outages in an area / grid section it's possible to check up if customers have power or not with relatively high reliability. The documentation of the grid connectivity, secondary substation and LV feeders, is essential for understanding the magnitude of the outages. If power outage events occurs for a group of customers in an area that already has been registered for outages it could be helpful to monitor the magnitude of outages and the relation to the grid sections.



Grid Operation Centre

POWER QUALITY AND VOLTAGE ISSUES

Normally the voltage is more or less inline with the nominal voltage 230V. If the voltage deviates from that level with more than +/- 10% the smart meters will create an event to be send to AMI Head-end and to other back end systems. The trigger threshold level is adjustable and new levels could easily be down loaded to the meter. This events regarding voltage deviations will be send in real time and stored in the MDM-system. As the time resolution for the events could be set very narrow, down to 260 milliseconds, the amount of data for the whole grid could be very extensive. To make it possible to handle and react on all this information data has to be filtered by an algorithm in AMI Head-end or other systems to make any sense. Based on these voltage events several new alarms could be generated to be handled in the grid Operation Centre, zero point deviation caused by an insufficient grounding are the most important and most severe to supervise. Other type of alarms based on voltage is identification of phase loss situations in the medium voltage grid which can't be detected by the protection system in the primary substation. An example of this kind of failures is a broken high voltage fuse in the secondary substation.

Smart meters measure voltage very accurately, phase by phase, and it's normally just used for calculating the energy consumption / production. In order to supervise customers power quality regarding acceptable maximum and minimum voltage levels thresholds have been downloaded to each meter. When these thresholds exceed an event will be created and be send in real-time to the back-end systems. These events could be used for identifying grid sections with unacceptable power quality to be used in network analyses or confirming customer complains. These events could also be used for identifying urgent conditions with extremely high voltage in the grid where customers and electricians safety could be jeopardized, an algorithm for identifying zero point deviation and alert will then be crucial. Information of grid connectivity, secondary substation and feeders, is essential to understand if the zero fault is located to the grid and where in the grid or only located to a customers site.

| Nr | Kod från | System från | Kod till | Datum till | Varaktighet | Nivå | Ref. Nivå | Säkr. |
|----|----------|---------------------|----------|---------------------|-------------|------|-----------|-------|
| 1 | PL11 | 2013-01-01 11.05.19 | | | | | | 16 A |
| 2 | SAG1 | 2013-01-01 11.05.09 | | 2013-01-01 11.05.23 | 0 00.00.14 | 0 | 207 | 16 A |
| 3 | SAG2 | 2013-01-01 11.04.35 | | 2013-01-01 11.04.37 | 0 00.00.02 | 159 | 207 | 16 A |
| 4 | SAG2 | 2013-01-01 11.04.33 | | 2013-01-01 11.04.34 | 0 00.00.01 | 36 | 207 | 16 A |
| 5 | SAG2 | 2013-01-01 11.04.26 | | 2013-01-01 11.04.32 | 0 00.00.06 | 31 | 207 | 16 A |
| 6 | SAG2 | 2013-01-01 11.04.23 | | 2013-01-01 11.04.23 | 0 00.00.00 | 181 | 207 | 16 A |
| 7 | SAG2 | 2013-01-01 11.04.21 | | 2013-01-01 11.04.22 | 0 00.00.01 | 91 | 207 | 16 A |
| 8 | SAG2 | 2013-01-01 11.04.20 | | 2013-01-01 11.04.20 | 0 00.00.00 | 182 | 207 | 16 A |
| 9 | SAG2 | 2013-01-01 11.04.19 | | 2013-01-01 11.04.19 | 0 00.00.00 | 191 | 207 | 16 A |
| 10 | SAG2 | 2013-01-01 11.04.18 | | 2013-01-01 11.04.18 | 0 00.00.00 | 180 | 207 | 16 A |
| 11 | SUR2 | 2013-01-01 11.04.16 | | 2013-01-01 11.04.17 | 0 00.00.01 | 302 | 253 | 16 A |
| 12 | SAG2 | 2013-01-01 11.04.14 | | 2013-01-01 11.04.16 | 0 00.00.02 | 158 | 207 | 16 A |
| 13 | SAG2 | 2013-01-01 11.04.13 | | 2013-01-01 11.04.13 | 0 00.00.00 | 200 | 207 | 16 A |

A typical "zero fault" situation

GOALS AND DEVELOPMENTS

Power interruptions

The ambitions are to set up rules for automatic filtering of “meter down” events in order to identify power outages quicker and not only to rely upon customer calls. The algorithm requires grid connectivity data with acceptable data quality. The quality of the grid documentation (NIS, network information database) is essential for this functionality especially the LV feeder and meter relationship.

If PLC communication is used for communication with meters it's possible to monitor the grid connectivity based on the signal to noise ratio. If this information not corresponds with data from the NIS system the data in the NIS system could be updated, temporary switching's in the grid caused by for example maintenance has to be handled.

Power Quality and voltage issues

The functionality for identifying zero point deviation is now in place and works well. In some situations e.g. thunder storms the lightning could be the reason for abnormal voltage levels but are also easy to detect. To be in position to prevent zero fault accidents gives the distribution company significant benefits to reduce costs for compensation for destroyed equipment in customer's homes and to avoid serious accidents.

Power Quality information will in general give the DSO a better position to improve the quality of supply to the low voltage customers.

Visualizing and monitoring

Integration of the AMI / Smart metering systems with DMS / Scada systems will give the operators in the control center a better view of the low voltage grid and the actual status in the grid. Unacceptable situations like Power Outages, zero faults, etc. could easily be displayed and located to actual grid section on the operators screen. With right system tools it's also possible to reorganize the work processes and let the Customer Service Center solve problems like phase loss and single outage situations at customer sites directly with out involving the grid operation centre.

CONCLUSIONS

By using “real-time” events from Smart meters the grid Operation Center can improve quality of supply by monitor power interruptions, actual incidents and preventing damages. The result will be reduced cost for customer compensation and improved quality of supply. The main goal is to lowering SAIDI and increase customers' satisfaction.

The ambitions for the future are to detect power outages in the low voltage grid faster and regardless of customer calls. By setting up rules for automatic filtering of “meter down” events from the Smart metering system it is possible to identify power outage situations with higher accuracy. Such an algorithm requires grid connectivity data with acceptable data quality. The quality of the grid documentation (NIS, network information database) is essential for this functionality.

Integration of the AMI / Smart metering systems with DMS / Scada systems will give the operators in the control center a better view of the low voltage grid and the status in the grid. Unacceptable situations like Power Outages, zero faults, etc. could easily be displayed and located to actual grid sections on the operators screen. With right system tools it's also possible to reorganize the work processes and let the Customer Service Center solve problems like phase loss and single outage situations at customer site directly with out involving the grid operation center.