IMPROVED NETWORK ANALYSIS BY USING HOURLY METER VALUES

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BACKGROUND

Vattenfall Distribution Sweden has since 2003 built up an AMR/AMI-platform including remote controlled smart meters. 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 AMR information in new areas. Business Cases have been defined and presented in the "AMR+" project report (2007-12-12). Two of the business cases in the report have been studied in this project. They are:
- BC2 "Power Quality Measurements/ Net analysis" is about using AMR data in network planning.
- BC3 "Net losses" is about better control and supervise the network losses by measure the energy both in the secondary substations and on customer sites.

The load at customers site are today not align with the past and are also in general unknown and will in the future be more complex regarding EV (electrical vehicle) and PV (photo voltaic). Network calculations will then be more important for distribution companies in order to optimize the grid and deliver acceptable power quality.

OBJECTIVES

This project, PAM (Project Area Measurement), will investigate how Smart metering data could be used to improve network analysis in order to optimize the asset management process and hopefully reduce the investment costs. The project is divided in these three parts:

1. Load profiles

Compare customers' real consumption patterns with what is currently used for network planning (traditional method) and calculations based on hourly metering values.

2. Power quality

A topologic view of real power quality alarms in the LV grid gathered from the AMR meters. A comparison will then be made with calculated values (hourly / traditional)

3. Network losses

Aggregate meter values from customer sites and compare with meter values gathered from the secondary substations. The result is then compared with calculated figures based on hourly meter values and traditional methods. Other factors such as thefts, metering problems should also be studied in relationship with "real" network losses. Is it possible to monitor these factors compared with the real network load?

PROJECT SET-UP

AMR-meters and meter collecting system for areas and sites in this project has been adapted to register hourly energy values.
14 secondary substations have been equipped to measure hourly meter values for more than one year.
Appr. 740 customers consumption powered from those 14 stations have been measured hourly for more than one year.
The distribution grids are both rural and urban. Six urban grids are located in the town of Uppsala.
Powel Energy Management has developed the program prototype NetBas TIM and a special portal for viewing calculation results as well as Power Quality meter events.
Hourly meter values and meter events has been collected and stored in the systems MDMS and PER. Data have been accessed only when viewing events, run calculations and presenting results.
Traditional calculations are based on static load curves and customers yearly electricity consumption (kWh), stored and maintained in the billing system.

Project set-up; grid and customer info

Network ID	Network Name	Network area / location	Amount of customers	Trafo. size kVA	Load category
61124316AL	Bången	Uddevalla	20	200	Residential, farms, electrical heating
HU0870	Juringe väg 32	Huddinge	53	630	Resid. (homog. load), el. heating
76120202AL	Huuki	Paiala	23	100	Resid., farms, cottages?
TY2118	Tjärnstigen	Tyresö	41	800	Resid. (homog. load), el. heating
61220106AL	Riekkola	Haparanda	25	100	Mostly resid., industry?
N205422AL	Ekenäs hamn	Säffle	6	315	Residential, farms
62130126AL	Tjärn	Örnsköldsvik	12	100	Residential., farms
81440041AL	Hackhyttan	Nävekvarn	7	100	Residential., farms
UP33170AL	Fornby	Uppsala	67	800	Townhouses, heat pumps
UP31703AL	Slakthuset	Uppsala	18	1000	Industry, district heating
UP34976AL	Brantingstorg	Uppsala	208	800	Distr.heating, flats, stores, schools
UP35419AL	Mältargatan	Uppsala	7	800	Distr.heating, offices, workshops
UP37669AL	Markegångs-vägen	Uppsala	188	800	Townhouses. (homog. load), el. heating
UP37102AL	Nåntuna villastad	Uppsala	74	315	Distr.heating, resid. (homog. load)

Fig 1: Project set-up

RESULTS FROM THE PROJECT

Pmax, the hour with the largest aggregated load at the substation has been identified for calculations.

Load profiles:

Analysis of Pmax; measured and calculated hourly
Comparison of measured maximum energy fed in to the LV grid at secondary substations and calculated maximum energy fed in to the low voltage grid based on individual measured customer consumption for that specific hour.

Comments:

- For 57% of measured areas (8 areas) Pmax and energy are corresponding with calculations based on hourly meter values. This means that calculations based on hourly meter values in general gives good results.
- For 22% of the areas (3 areas) are calculated Pmax and energy (27/19%) extremely lower than measured. The reason could be bad documentation (connectivity), incorrect measuring or thefts.
- For 7% of the areas (1 area) are calculated Pmax and energy (21/25 %) extremely higher than measured. The reason could be bad documentation regarding network connectivity.

Analyse calculations based on hourly measurements vs traditional or just aggregation
Comparison of calculations based on customers real consumption hourly and identified peak hour and calculations based on yearly consumption, load curves and aggregation based on Velander (traditional method)
and also
aggregation of daily and hourly meter values (customers >63 amps measured hourly but daily meter stands for <=63 amps, common load profile and network losses estimated)

Comments:
In general traditional methods (standard Netbas) gives to high results, Pmax >17% in 7 cases of 14 (50%). Worst case 145%.
Just in 1 area results from traditional methods was extremely lower, Pmax -23%.
If the results from traditional methods also compares with the results from area measurements in secondary substations the comments still will be valid but with some remarks. For Juringeväg 32 are the results from traditional methods higher (17%) than for calculations based on hourly values but more inline with the area measurement results, the reasons has to be investigated.
Pmax could also be defined by aggregation of daily and hourly meter values available in the "meter to bill" process. For customers <=63 amps peak hours has been estimated based on daily energy consumption (meter stands), common load profiles and network losses. The results shows that:
Estimations of daily load profile works well in networks with many customers e.g. town (Sw. tätort) and city areas.
Pmax can occur at different times compared to calculations based on hourly measured power.
Good for long term trends.

2. Power Quality analyze

Planned analyzes in rural areas for grids with documented bad power quality has not been done. The reason for this are:
The identified grids (4 grids) has been rebuilt during the project time, therefore has it not been possible to do the analyzes and use the developed portal for viewing calculation results as well as Power Quality meter events.
The analyze will be done in a follow-up project.

3. Analysis of load profiles and network losses; measured and calculated hourly

The purpose is to analyze the measurements regarding load profiles and network losses and compare with calculated based on hourly measurements.

District heating, heat pumps and electrical heating have normally a mayor impact on the load profiles and Pmax. Summer cottages will normally extend the time of use for the network losses.

If customers are residential or commercial / industrial will normally have a strong impact on the load profiles and network losses.

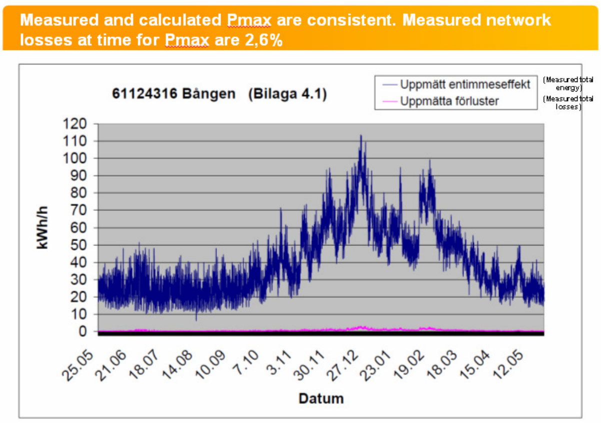

Fig 2: Measured network losses 2,6% (normal level)

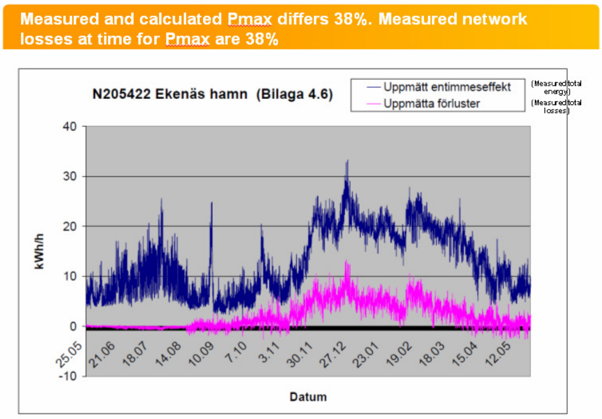

Fig 3: Measured network losses 38% (abnormal level)

Comments:

- Load characteristics differs very much between areas and also between similar customer groups.
- The results indicates that industrial load is not a homogenous group as the measurements and time of use for network losses differs quite significant.
- When studying areas with large amount of residential houses time of use for network losses in some cases don't differ irrespective of heating systems. This could probably be explained by wrong information in the customer information system.
- When network loss deviation between calculated and measured is almost zero it could be explained by the fact that measured and calculated network losses are more or less the same. The fact that his occurs for so many as 3 areas of 14 makes it likely that the analyzing system for network calculations based on hourly meter values are calculating the losses with good accuracy.
- 2 areas have high (~7%) and 4 have extremely high (20-38%) network losses of whom 1 have negative losses. The explanation is:
  - *Large negative differences in network losses indicates that none measured energy are fed in to the grid.* The reason could be none measured loads (e.g. street lightning), bad documentation (connectivity in the network information system are incorrect), incorrect measuring or thefts.
  - Incorrect documentation will result in failures in analyses, since the meter values will have wrong matching to each secondary substation. This means that both calculations and aggregation of meter values will give wrong results.
  - *Large* network loss deviations, positive as well as negative or with alternating characters, indicates that the grid is connected to surrounding grids in one or several connections. Negative loss deviation indicates leakages of energy to neighboring grid. Positive loss deviation indicates the opposite i.e. leakages of energy from neighboring grid.

CONCLUSIONS: GOALS AND RESULTS

Calculation method:

The comparison in this project regarding calculated yearly maximum peak hour, Pmax, based on traditional methods and using AMR hourly meter values shows that results from traditional methods are significant higher. In 11 areas of 14 the deviation are larger than 10%, there are deviations up to 145%. The result in this project confirms previous corresponding investigation done in Uppsala between 2005 and 2006 on 25 measured secondary substations. In that investigation the deviation was >10% for 18 areas of 25.

In average traditional calculation methods (standard Netbas) in this investigation resulted in 35% higher Pmax than calculation based on hourly meter values (using Netbas TIM) in 79% of the analyzed LV grids. In 3 cases traditional methods gave in average 15% lover Pmax.

Just aggregate daily energy consumption will not give satisfying results due to lack of load profiles.

If these results are significant for the rest of the grid calculations based on exact consumption measured hourly will give benefits regarding avoiding oversized assets in general, possibility to postpone asset investments and allow new customer sites without any asset investments. The quality of the grid documentation (network connectivity) has also a big impact on the results of calculations but has no impact on this statement.

Network losses:

The results from this project will not give a clear picture if it's realistic to monitor and control the network losses regarding none measured energy consumption by measure fed in energy at secondary substations and compare with individual aggregated meter values. It's very easy to understand if aggregated meter values doesn't match what's fed in to the LV grid but it's not so easy to understand why. Normally the losses should be between 2 to 4 % and losses above could therefore be related to abnormal losses for example none measured sites, faulty measuring or thefts. Are the mismatch related to bad documentation and the grid is connected to surrounding grids in one or several connections it's not possible to monitor and discover abnormal losses.

Is it possible to maintain high quality in documentation of the network connectivity? If so, the resolution in measuring and presentation are probably enough to identify none technical network losses if they are significant high.

Field investigations in order to follow up and control the network connectivity could be complex and costly. A method should be developed to quality assure the network connectivity.

QUESTIONS NOT BEEN ANSWERED IN THIS PROJECT

- Power Quality events vs network calculations has not been verified.
- Reasons for abnormal network losses, to high or negative, has not been identified
- "Is it possible to supervise network losses by install meters in secondary substations?". The question can't be answered based on results from this project.

The open questions will be handled in a separate follow-up project, PAM2, during 2012.