COST ANALYSIS FROM SMART GRID IMPLEMENTATION IN MEDIUM VOLTAGE DISTRIBUTION GRID

Stian REITE
ABB – Norway
stian.reite@no.abb.com

Magnar BJØRK
EPOS Consulting – Norway
magnar.bjork@eposconsulting.no

Åshild HELLAND
Lyse Elnett - Norway
aashild.helland@lyse.no

ABSTRACT

Utilities are facing large challenges in the medium voltage (MV) distribution grid. Ageing infrastructure, urbanization, implementation of renewables and new load-patterns are challenges to be handled by the distribution grid. The need for reliable and effective supply of electrical energy in the coming years cannot be met only by conventional grid-solutions. New smarter MV distribution grids with new technology must be used.

In the city of Stavanger in Norway, the local utility company Lyse Elnett is cooperating with ABB and EPOS Consulting on a large-scale smart grid demonstration program. The project is set in an urban area downtown Stavanger with 1400 end customers, annual consumption of 63 GWh, underground cable network and 25 compact secondary substations.

Main objectives for the smart grid program is to identify an optimal level of functionality of network components and systems (Scada, DMS, smart metering) in order to build a more cost effective grid for the future. In the demonstration area, smart grid related technologies will be demonstrated on a larger scale and in a live operating environment. The program starts early 2015 and will run for 3 years.

This paper will discuss current results from practical experience in the program in analysis of investment costs for building conventional grid vs. smart grid.

INTRODUCTION

In the years to come, an increasing part of the world's population will be living in cities due to urban growth. Thus energy consumption and CO2 emissions will increase more in urban than in rural areas.

Electrification of the transport sector and other smart city solutions are vital in coping with these trends. A key factor in such a transformation of a city's energy system is an upgraded power grid. Cities have challenges with ageing infrastructure and limited accessibility to technical installations. This complicates the process of renovating and upgrading the power grid.

In Norway, the average age of the components in the medium voltage distribution grid is going up, and according to NVE [1], the need for investments in upgrading and building new MV grid is estimated to 28,5 BNOK for the period 2014-2023. With such large investments in the years to come, choosing the right and future-proof technology is fundamental.

Utilities with extensive investment plans for the distribution grid, need to know the investment cost for building a smart grid versus building a conventional grid.

Why Smart Grid

Smart Grid is often referred to as functionality for remote monitoring of vital parts of the MV distribution grid via sensors, and functionality for remote control of switches and breakers in strategic important key nodes in the network. These solutions have been a part of the power distribution network for quite some time, but mostly on the higher voltage levels and especially in power generation plants and transmission networks. In the recent years some of this functionality has also been introduced in the low voltage distribution levels in the various Smart Metering systems.

On the MV level, Smart Grid functionality has not been implemented to any significant extent yet. This will have to change in the coming years. The rapid increase in renewable power generation, often connected directly to the MV network in weak areas, puts new demands on the operation of the network. Intermittent renewable energy sources such as wind and solar lead to a much more complex energy flow.

New loads such as fast-charging of electrical buses and cars, and shore-to-ship solutions, will be more common, especially in urban areas. A modern society is also ever more dependent on a reliable power supply, with increasing expectations of a good Quality Of Service. More extreme weather conditions and aging electrical infrastructure, represent a challenge to handle. In order to secure a reliable power supply under all conditions, Smart Grid technology will be important also in MV distribution networks [2].

Functionality for monitoring and control of the MV distribution network will be very important for the Utility to be able to provide a reliable and cost-effective power supply. The Secondary substation (SS) will be the key node in the grid to equipped with smart grid functionality, particularly because of easy access and full right of property [2], [3].

DEMO PROJECT

The Smart Grid Demo project is part of Lyse Elnetts activities for building the grid of the future based on new technology. This project will start early 2015 and run for 3 years, 1 year related to implement solutions and 2 years to complete different demonstration activities.

Some of the objectives of the demo project at Lyse Elnett:

- To get practical experience on how to renovate and upgrade the power grid in an urban city area with limited accessibility.
- Verify smart grid functionality in an urban grid under operating conditions.
- Verify investment cost, operational cost and functionality in a conventional grid versus a smart grid.

Figure 1 Demo area downtown Stavanger

Demo area

The demo area for the project is set in an urban area in downtown Stavanger, see Figure 1. All 25 secondary substations under a substation feeder will be renewed and upgraded with smart grid functionality. The grid is all underground cable, operated on 11 kV, but all new equipment installed will have 24 kV rating. Most of the arrangements in the secondary substations is from the 1980´s with open breaker cells. Almost all the secondary substations are situated in basements or in buildings. As a city naturally evolves and the use of buildings in a city center changes, these secondary substations now are located in restaurant basements, behind hotel receptions, in parking garages etc. This will of course add to the complexity of doing necessary upgrading of the various electric components in the grid in an urban city center. See Figure 2 and Figure 3.

Figure 2 Example of a secondary substation in the demo area

Figure 3 Open MV breaker cells

First installations of smart secondary substations will take place during spring 2015. Smart meters will be installed at all end-customers in the demo area during 2015. Lyse Elnett has plans for testing impacts on grid operation from shore-to-ship solutions, EV fast-charging and end-user load controlling in the area, and this presupposes a grid with smart grid functionality. Establishing Smart Meters and solutions for electrified Mobility are outside the primary scope of the demo project, but testing and verification of system integrations, interoperability and increased operational flexibility will be incorporated in the demo- and verification activities.

Smart grid functionality

The setup for smart grid functionality that is used for cost calculations in this project is corresponding to "Level 3 – Measurement" in ABB's solution levels for Smart Secondary Distribution, see Figure 4. This means that all 25 secondary substations will be equipped with online monitoring on LV and MV side, and remote control of MV switches. The smart grid components are embedded into the Ring Main Unit and comes ready to install from the factory. As discussed in [2] secondary substations usually will have different level of smart grid functionality depending on location, operation of the grid etc. This will lead to a higher cost estimate of the smart grid functionality in this demo area than can be expected in a regular upgrade to a smart grid.

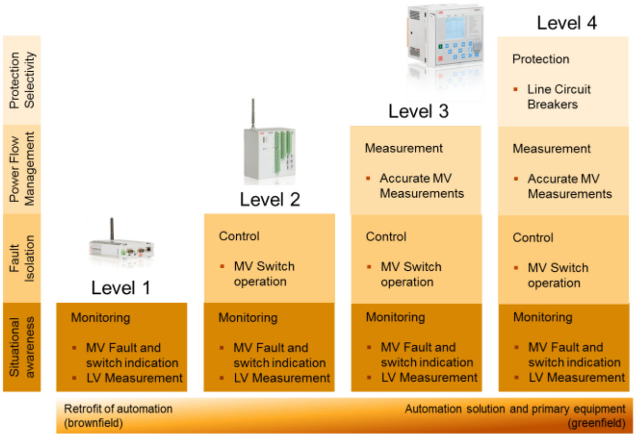

Figure 4 ABB solution levels for Smart Secondary Distribution

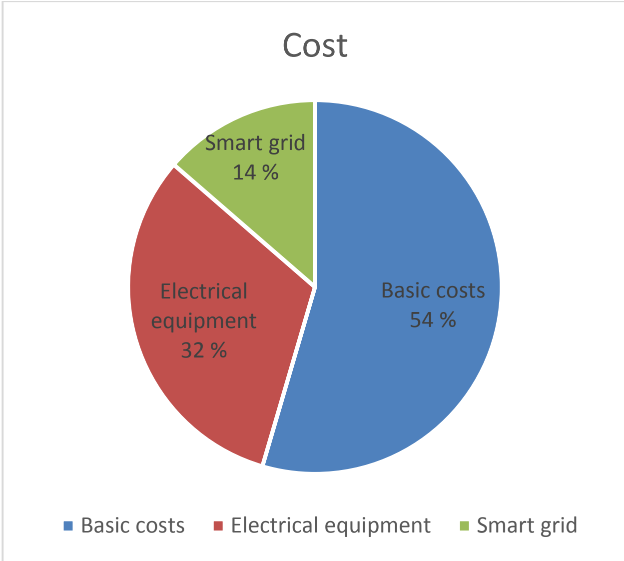

Figure 5 Distribution of cost

Cost analysis

In preparation for the project, an inspection of all the secondary substations was held for all the participating parties in the project in order to prepare for the upgrading. Based on this and information on components, switching schemes, energy consumption and load patterns, new configurations of secondary substations with smart grid functionality were specified.

Cost calculations of the various elements in an upgrade of the secondary substations has been performed. Cost elements:

- Basic costs
  - Labour cost
  - Cost related to planned disconnections and outages
  - Civil works
- Electrical equipment
  - 24 kV Ring Main Unit
  - LV switchboard
- Smart grid equipment
  - RTU and communication
  - Motor controlled switches
  - Fault passage indicators
  - LV monitoring
  - Battery backup

Conventional grid versus smart grid

This cost analysis show that implementing a high level of smart grid functionality in this demo area with 25 secondary substations, will add 14% to the total cost for upgrading and renovating, see Figure 5. This is compared to upgrading the secondary substations with only conventional components.

As the market penetration of Smart grid equipment in the distribution grid increases and volumes go up, one could expect the prices and the Smart grid portion of the cost to come down.

A strategy of building conventional secondary substations and retrofitting smart grid equipment at a later time when needed, will increase the cost. This is because a large part of the smart grid cost is related to manual work installing the components like RTU, modem, motor, fault passage indicators etc. into the secondary substations. These operations are done far more efficiently during the assembly process at the factory.

Introduction of new smart grid-elements such as communication, electronics and batteries into grid components might lead to a higher maintenance cost. It is expected however that a smart grid will have substantial cost benefits compared to a conventional grid mainly related to:

- Reduced capital costs through lower dimensioning cost for the distribution grid, better utilization of the grid capacity and postponing investments and refurbishing.
- Reduced operational- and maintenance costs through automated work-processes, reduced number and duration of outages, and improved monitoring, information and decision support.

To study the cost elements and to verify the cost benefits is an important activity in the demo project for Lyse Elnett.

CONCLUSION

Important drivers for change in the way a distribution grid is built and operated will be megatrends such as urbanization and population growth, ageing infrastructure, push for lower carbon emissions, integration of renewables and an increasing demand for power in the grid. Utilities must prepare for the challenges these changes will lead to and think that in the wake of these changes comes new and interesting opportunities.

Grid reinforcements and upgrading are necessary to ensure sufficient grid capacity, but the requirements from prosumers, distributed generation; increased automation and need for cost efficiency in the distribution grid cannot be met by conventional methods and components alone. The introduction of Smart grid functionality will be a cost efficient tool to enable the grid to meet the requirement of the low-carbon-emission society in the future.

For a Utility facing large needs for investments in the grid, it is important to have information on the investment costs for building a smart grid versus a conventional grid. In this demo project, a cost analysis has been made based on estimations of specific refurbishment of an urban area with 25 secondary substations. The cost analysis shows that building a grid with high-level smart grid functionality will add 14 % to the investment cost compared to building a conventional grid.

Substantial benefits are expected in lower operating costs in a smart grid than in a conventional grid. To verify this under operating conditions is an important goal for Lyse Elnett in the demo project.

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