THE "SMART PENINSULA" PILOT PROJECT OF SMART GRID DEPLOYMENT AT ENERGA-OPERATOR SA

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ABSTRACT

The paper presents the scope and results of engineering, and the scope of Smart Grid deployment in the Hel Peninsula. The following functionalities are described: Fault Detection, Isolation & Recovery - FDIR function, Integrated Volt/Var Control (IVVC) function, advanced supervision of LV grid, including distributed energy resources. Communication solutions for control and monitoring in MV and LV smart electric networks are described. Planned activities related with the Smart Grid project deployment are summarised.

INTRODUCTION

ENERGA-OPERATOR SA (EOP) is a distribution company that provides electricity to 2.8 million customers over one quarter of the total territory of Poland. In pursuing its strategy of being a leader of the Distribution System Operator (DSO) in Poland, the company considers essential the use of innovativeness and new solutions in the key areas:

- Product types - creating new products and services;
- Technology - changes in the provision of services;
- Organization - changes in internal organization;
- Marketing – changes in the way of serving the customer.

The company's strategy, changes within the environment and customers' expectations naturally lead the company to the use of broad opportunities introduced by new technologies in the field of power equipment, the area of ICT and management systems. Both the environment and changes within the company lead to the next step in DSO network development: the transition from "traditional" network and management systems to solutions described today as the Smart Grid.
Key projects undertaken in this area include inter alia:

- AMI - implemented in the entire area of the company's activity (2.8 mln consumers);
- MV network automation;
- Computer support system of network assets management including GIS;
- IT systems integration;
- Smart Grid pilot project in the area of the Hel Peninsula.

PILOT AREA OF THE PROJECT THE SMART PENINSULA

Following major challenges within ensuring the quality of electricity supply, improving the efficiency of the power system and enabling offering the energy consumers new products and services the EOP implements Smart Grid concept over the pilot area. The Hel Peninsula has been chosen as a pilot area. It comprises about 200 km of MV cable lines, 100 MV/LV substations, 150 km of LV lines. The network supplies about 10 000 consumers. The project is being implemented in three stages. The first stage involved the development of the concept of the network transition from "traditional" to the Smart Grid, including the feasibility study, and was completed in 2011.
Stage II included the construction of a Smart Grid within the pilot area and was completed in 2012.
Stage III includes the solution tests, analysis and examining the scalability possibilities over the whole EOP area.
The basic requirements to be met by the Smart Grid are:

- development of a model control system for the Smart Grid area. The main function will be an integrated voltage control and active and reactive power management system to enable the adjustment of network load level to distribution capacity and power grid parameters at a time (by adjusting the load or generation of individual connected objects characteristics to network conditions);
- creation of opportunities for Smart Grid cooperation with smart buildings equipped with microgeneration;
- network equipment with appropriate infrastructure, including measurement systems enabling remote reading of measurement data and consumers energy supply control. This solution is to enable companies involved in electricity trading market the introduction of new products and services.

The main project elements are:

- implementation of smart meters at consumers premises;
- implementation of monitoring and control in MV and LV networks;
- implementation of DMS solutions and monitoring of LV network (SCADA LV);
- automatic detection and location of failures;
- automatic network reconfiguration;
- advanced voltage control and regulation system in MV network;

- network visualization in a geographical view;
- integration with GIS system;
- creating the basis for the provision of new services and integration with dispersed generation.

While implementing the project EOP cooperates with the Institute of Power Engineering - Research Division Gdańsk, which contributes to project development, commission and evaluation.

NETWORK INFRASTRUCTURE RETROFIT

The aim of the modernization of medium and low voltage networks (MV, LV) was to improve the observability and control capabilities. An extensive network provides data for advanced computer systems supporting network management and provides a flexible network reconfiguration.

All MV/LV transformer stations are fitted with a balancing system providing information about active and reactive power flows.

AMI system has been implemented within a pilot area. Nearly half of the MV/LV substations have been equipped with fault current passage detectors. The pilot area serves as a test location for different technologies and technical solutions in this field.

In key stations, MV distribution substations with remote control connectors have been applied. In selected areas additional monitoring has been implemented in the circuits of LV distribution feeders, where the power flows are measured.

Additionally fuse blowing signalling in LV distribution substations has been implemented.

Load switches and remotely controlled breakers as well as fault current passage detectors with remote signalling have been installed in an overhead line.

SCADA-DMS NEW FUNCTIONALITY

Modernization and expansion of the network enabled the implementation of systems supporting dispatching services in leading the operation, by expanding the scope of network monitoring and control within the pilot area. The most important implemented systems are: Fault Detection, Isolation & Restoration - FDIR, Integrated Volt/Var Control- IVVC, Outage Management System - OMS. SCADA system has been extended to the LV level. Network Management System - NMS has been extended with visualization within geographical system of MV and LV network.

LV network advanced supervision

For the pilot area SCADA has been expanded with low-voltage network monitoring, thus allowing dispatchers to carry out automatic switching at the lowest voltage level near the consumers' location.

Network status information is obtained from analytical modules and balance systems that are installed at MV/LV substations, which in turn were installed as part of the AMI project. Network wiring diagrams have been integrated with geographical maps and GIS database, which resulted in topographic mapping of the network.

The project has been integrated with AMI infrastructure of both MV and LV. This has allowed better assignment of individual users to power supply points. Consequently dispatchers obtain full knowledge on the number of consumers lacking power supply. This allows to better schedule the work planned and create detailed plans of power supply restoration at the time of failure. The actual assignment of consumers to power supply points has to a large extent affected the accuracy of estimating power supply quality indicators and has improved the procedure of planned outages. The implemented SCADA LV system is designed to monitor and control the renewable energy sources attached to the network at the low voltage level.

Fault Detection, Isolation & Restoration - FDIR function

FDIR module installed as part of DMS system enables automatic detection and location of MV network failure and automatic reconfiguration.

The module can significantly reduce the area of the occurrence and duration of failure and can also minimize the number of consumers lacking the power supply. The logic used in the algorithm optimizes the number of users that after the switch-over will have power supply restored automatically.

The application performs a series of calculations and options of power supply recovery. It aims at minimizing the number of consumers without power supply while taking into account a number of imposed guidelines. Any switching is performed in less than 3 min. It affects significantly the reduction of the value of power supply quality indicators SAIDI and SAIFI. In spite of implemented procedures which are to ensure maximum safety, the dispatcher has an ultimate control over all executive actions.

Other functions

Owing to automatic detection of the failure location and topographic mapping of the network, field crews have got precise information on the failure location. This reduces to a very large extent, the time required to eliminate the failure. Information about the failure location obtained from the SCADA has also been used in the visualization module of supplied areas. Information on areas and the number of consumers lacking power supply is accessible through a web browser. This allows the consumers to obtain information on areas and number of consumers lacking the power supply.

The above mentioned solutions can be used in the future to expand DMS with a module of field crews management, and once it is integrated with the current management

system, OMS complete functionality will be achieved.
The module that allows to perform detailed analysis of the profitability of new technologies i.e. Smart Grid was implemented during the pilot work.
The module allows to specify technical and financial benefits. It takes into account numerous factors i.e. change in power quality indicators (SAIDI, SAIFI, MAIFI), expenditure on investment, reduced mobility of field crews and limited length of distances covered by teams while at field work. This module can be used for any investment and is not limited to the pilot project area exclusively.

Integrated Volt-VAR Control - IVVC function

The basic aim of the IVVC is to maintain desired voltage level at the dispersed MV/LV substations by On Load Tap Changer (OLTC) controlling two 30/15kV transformers. Additional benefit was a possibility to utilize data from two simultaneously running projects: Smart Grid (described in this paper) and Smart Metering.
It was planned to use the voltage measurements from customers energy smart meters as the input for the IVVC algorithm. However due to delay in implementation of the remote collection of voltage measurements from smart meters in AMI system, it has been decided to use the voltage measurements from the secondary side (LV side) of the all transformers supplied from the two 30/15kV transformers in the main substation Jurata. This whole area is supplied by 34 MV/LV substation linked (assigned) to one out of two transformers. In a normal operation state TR1 supplies 6 out of 34 substations and Tr2 all the remaining substations (Fig. 1).
For analog data (including voltages used for IVVC algorithm) within the whole project the event driven acquisition method has been deployed.
It means that all measurements are "pushed" to the SCADA/DMS application in Regional Dispatching Center (RDC) only when the change of the measured value exceeds the defined margin. It saves a significant bandwidth requirement for communication with SCADA/DMS in Regional Dispatching Center.
Before every LTC control action the actual network configuration (topology) is verified in order to recheck the MV/LV transformer allocation to the proper 30/15kV subnetwork.
It is planned after a trial exploitation to build in the algorithm the voltage criteria based on network needs e.g. grid losses minimization, conservation voltage reduction or others.

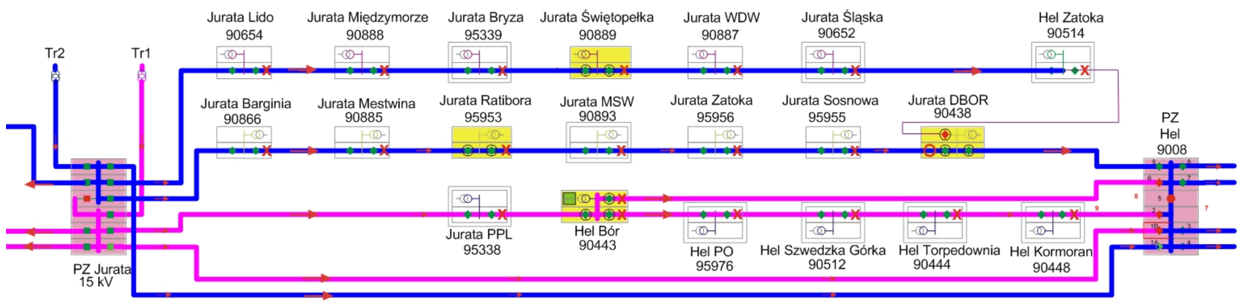

Fig 1. MV network covered by IVVC function (example)

COMMUNICATION SOLUTIONS FOR CONTROL AND MONITORING IN MV AND LV SMART ELECTRIC NETWORKS

An important role of numerous and geographically dispersed nodes of the distribution network, generators associated with the generation of renewable energy sources, consumers and prosumers requirements, new flexible communication solutions, necessary for the broader two-way exchange of information.
The described in this paper solution is an example of deploying two different communication solutions for two purposes.
Within the AMI project communication between data concentrators and WAN is based on MV PLC solution. For the Smart Grid the wireless GSM/GPRS based communication is used. The reason for wireless communication selection was simple the fear of the miss-operation of PLC based communication during the earth fault. Another reason was the potential necessity to install additional devices (MV network couplers) in order to provide communication in the "open" state of the load switches.
The advantage of GPRS and EDGE services is their availability in almost the whole area of the country. The disadvantage is that the telecommunication infrastructure necessary for the implementation of these services is not in the competence of power industry (DSO). In case of a catastrophic failure of the power system no availability of these services is expected, and thus the lack of data connected with control and monitoring in MV and LV networks.
All control units installed in the network are equipped with communication interface used for the exchange of information with a DSO and RDC centre.
Communication protocol of the application layer in the

relation "RDC – Control unit" is the protocol compliant with DNP 3.0 standard. This protocol is embedded on the TCP/IP communication stack (profile). The Control unit implements DNP3 Outstation over WAN/LAN using TCP packets.

Practical experiences based on more than 500 remote controllers installed in the 2004-2012 in the MV network have proved sufficient availability. In the first years of operation, it amounted to about 97% (in 2004), now it is 99.7% (at the end of 2012). The observed average number of control actions performed by remote control unit is 27,5 per year (in 2011).

CONCLUSIONS

The pilot project is designed to test the technology and solutions that will improve the efficiency of the company while ensuring high standards of power supply. The elements already realized and these planned for the next steps (power flow, management of microgeneration, enhanced OMS functionality) are to allow the company to meet the challenges ahead.

A key question emerging with the development of the project is the issue of scalability of the implemented solutions. The response to the needs and the ability to implement a variety of solutions from the area of Smart Grid is to be provided by being developed Smart Grid Road Map.

Completion of work within this area is planned for 2013. The project aims at defining a detailed plan for the implementation of specific technologies from the area of smart grids to support ENERGA-OPERATOR SA's strategic objectives till 2020, in such areas as: improving the continuity of energy supplies, improving efficiency, development and implementation of innovative solutions, creating and implementation of new areas of OSD activity.

The project is being implemented in three stages:

a. Stage I, the purpose of which is to define all the activities and issues, related to smart networks, which are carried out in the company. As part of this stage the analysis and evaluation of current activities and projects carried out in ENERGA-OPERATOR SA will be performed and their current impact on the achievement of strategic objectives will be estimated. The analysis will be carried out basing on question polls distributed to employees, the knowledge of selected experts on the jobs and projects developed by the company, as well as by obtaining information from the Branches. The analysis of ongoing activities in ENERGA-OPERATOR SA will cover key areas of the company's activity (the operation of the network, network asset management, network development, merge of renewable energy resources, the area of consumer service, work on the network, information and communication technology (ICT), etc).
b. Stage II will consist in the preparation of a general road map of smart grids implementation. The document will take into account such elements as : priorities of implementation, integration strategy, system approach strategy, scope and scalability of the implementation of modern technology and defining models for economic and financial evaluation of the economic efficiency of functionality of each smart grid.
c. Stage III includes the preparation of detailed executive plans for specific technologies broken down into projects. The details of this stage will be identified and prepared at the end of Stage II - based on analysis and the results of financial models and the proposed road map.