A Case Study: How a Utility Automated and Integrated Data/Control for 4000 Pole-Top Switches and Protection Relays, and Reduced its SAIDI

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Abstract

The ability to cost-effectively monitor and control more than 4,000 pole-top devices spread throughout a large territory (958 189 square miles) is one of the great challenges that Hydro-Quebec faced in 2001 when it decided to integrate and automate its entire distribution network.

The main goal of this project was to reduce the duration of the interruption to its clients: with a faster means of identifying the interruption(s), customer satisfaction would go up! Moreover, because of the great distances covered by the distribution network in Quebec this item was identified as a priority by the utility. However, the question remained: On a project of this magnitude, would the goal of achieving a 20% reduction of the System Average Interruption Duration Index (SAIDI) be achievable?

The overall communications costs represent a major factor in this type of project. The paper presents the approaches selected by the utility in the implementation of this massive project on such a large territory, and how it also engineered the systems to provide high reliability and indirectly provide savings on the communications while targeting its 20% reduction in overall System Average Interruption Duration Index.

The case study will also explore how this colossal amount of data was brought back to the different systems and the approaches that Hydro-Quebec developed in the overall management of all these devices and their information.
A Short History

Since 1999, the SAIDI index in the Province of Quebec had reached a stable value at 2 hours per customer, per year. However, in the same period, 15% of Hydro-Quebec’s customers had a reliability index higher than 4 hours.

Since outages remained a major concern for customers, and they were addressing these concerns to the energy regulatory body.

A major study was undertaken in order to identify and survey the potential schemes that would help Hydro-Quebec reach a more equitable reliability for the same rates and reduce the outage duration in selected sectors. Some of the scenarios evaluated consisted of:

- Remote fault indication only
- Optimized recloser installation (1 per feeder) without remote control
- Remote control of actual switches and breakers
- Remote control of actual switches and breakers with addition of breakers when needed
- Remote control of actual switches and breakers, addition of breakers when needed and automatic reconfiguration

This study confirmed that the solution of choice was the “automated distribution line” and was in accordance with the current industry trend, especially:

- CEATI Distribution Roadmap (January 2004)
- EPRI Advanced Distribution (June 2004)

Initial Pilot Project

Like all potential major projects, Hydro-Quebec undertook a small-scale pilot project to validate the automation of the distribution network approach. The objectives were:

- To remotely operate control equipment already on the distribution network, of which:
  - 14 overhead line switches
  - 2 circuit breakers
- To install a telecommunication network (conventional dial-up telephone lines)

After a period of nine months, a gain of one (1) hour in service reliability (i.e. 22%) had been measured on the remote control feeders of the pilot project.
**Project Goals**

From the results obtained during the initial pilot project, Hydro-Quebec’s commitments with respect to the improvements provided by the Automation Program would be:

- The ratio of customers with a reliability index above 4 hours, was then at about 15% (500,000 customers) and it should drop to 8%;
- SAIDI should be reduced by 15 minutes per customer, per year in average;
- Labor costs should be reduced significantly;
- Total amount of customer claims should be cut down by about 20%.

The automation program would include the remote control of 3750 MV switches and breakers on 1100 feeders and be implemented in a time frame of approximately 6 years.

The final goals of the project are:

- *In the short-term, a Reliability gain* – the project’s main focus is that only technology is required to achieve the estimated gain;
- *In the long-term, an Intelligent network* – should be considered as a long term goal and focus on the real objectives.

**Technical Challenges**

The planning of a project involving some 3,750 pole top devices to be implemented over a period of nearly 6 years, of which the first equipment installations would be in 2006 thus only providing a time frame of 4 years to install the new equipment (approximately 1000 cabinets a year).

In integrating these devices across the Province of Quebec, which covers an area of 1,540,680 square kilometers (roughly 3 times the size of the state of California), the communications infrastructure required is critical to its success. Without the proper communications framework to control and receive data in a timely fashion, the project in itself would not be worthwhile. An overview of the telecommunications architecture is presented in figures 1 and 2.

Apart from the planning and manpower intricacies of the project; integrating the data that would be received from all of these new devices was also unique in its magnitude. These requirements can be summarized, has follows:

For Binary Inputs, the following provides a good representation:

- Equipment status
- Equipment position
- Recloser position
- Local mode
- Alternate mode
- Neutral protection
- Fault detection
- Power status
- Battery status
- Power supply status
- Charger input status
- Environment
- Cabinet door position
- Handle stowed
- Water penetration (underground)
- Pump working (underground)
- Miscellaneous
- Decoder problems (drift, calibration, checksum)
- Over current, undershoot, etc.
- Counters

From the previous list, one can easily see that on average there are by far more than 100 binary inputs per equipment.

As for the analog data, the following presents a summary of the potential inputs per equipment:

- Current, angle and magnitude (A,B,C,N)
- Voltage, angle and magnitude (A,B,C,N)
- MegaVar, MegaWatt.
- Indoor and outdoor temperature.

From this list the reader can easily visualize a possibility of more than 20 analog pieces of data per equipment.

When one adds up these 120 binary and analog data points for each of the 3750 nodes, the total is 450,000 data points at any given time for the whole system!

Hence, the first technical challenge in reading and integrating this massive amount of information was coming up with front end gateway systems to handle all of these devices, and allowing for the next level of deployment, which would potentially add another 3000 devices to the network at a later date.

To manage the 450,000 data points generated from the first phase of the project, 5 regional control centers front end systems were setup to receive the information. Splitting up the information amongst the regional control centers has
made data more manageable. Within this subdivision, each control center front end system has been designed to handle a peak load of 250,000 data points.

The front end communication processor (FEP) developed for this project is located at the 5 regional control centers, to collect and distribute the information from the different geographical areas. The FEP performs the following tasks:

- Manages communications with all field devices
- Performs data acquisition
- Provides information to the distribution control centers
- Allows remote control of the switches and protection relays
- Provides for redundancy of systems
- Supports security requirements (NERC)
- Supports multiple protocols such as:
  - DNP3
  - IEC870
  - 61850
  - Modbus
- Supports cluster architecture (fail over)
- Supports multiple communication links:
  - Modems
  - Serial line
  - Cellular
  - TCP/IP

**The Unforeseen Challenge: the Human Factor**

With the implementation phase underway, this far-reaching project is now subject to the human factor: from human resources and training needs to quality issues and installation challenges, Hydro-Québec has resolved to meet each of these head-on.

First and foremost, this project’s span is unprecedented in Hydro-Québec’s recent past: more than 2000 persons are involved with the project, directly or indirectly. The sheer quantity of data produced by the pole-top devices makes it attractive and useful to a wide range of groups:

- Installation technicians
- Automation engineers and technicians
- Communications specialists
- Operators and their technical support teams
- Logistics and planning groups
- Device maintenance groups
The high number of interested parties makes project management more difficult. One must ensure not to end up with too many cooks spoiling the soup. Also, labor unions are a delicate matter to manage. For example, the project is affected by the installation personnel's ongoing negotiations for their work contract, which slows down the speed of installation.

Another example of the human-resources challenges is related to new abilities that are now required to perform certain tasks. For example, equipment operators can now perform a lot of control tasks remotely, such as opening and closing switches. This requires that operators receive supplemental training with the new software. Also, it will have an impact on the way personnel is promoted to dispatch, since the dispatch task now requires computer and software skills. In a setting where promotions were given based on seniority, this change already has a profound impact on the project's advancement: as a pressure method during negotiations with Hydro-Quebec, operators have not taken training nor participated in the project meetings.

The second human factor has to do with quality issues. The cabinets were assembled by a third party, and there were some quality issues with the general workmanship of the cabinets. This has required a lot of vigilance and some adjustments with the cabinet supplier.

The third human factor is completely external to Hydro-Québec. The cabinets were designed to be installed at four feet from the ground, so that operators could access it without needing a ladder. Unfortunately, in urban areas, especially in Montreal, these cabinets have been judged to take up too much sidewalk space, and city authorities have forbidden Hydro-Québec from installing the cabinets as designed. Engineering teams must now find a solution to be as unobtrusive as possible to pedestrian traffic, while still being able to operate the equipment without needing to climb up the pole.

These unforeseen issues have had an effect on the rate of installed cabinets in the network. It is expected that only half of the planned installations will be performed in 2007 (400 instead of the planned 800), and that the expected rate of 1000 installations per year will only be reached by 2008.

Conclusion

We had planned the technology side in detail and very carefully, we also had planned the human factor (we thought). Today, looking back, we realize the technology aspects have been easy to handle and work with when required, but the sheer number of people involved has created an environment which is currently slow to react.
From a technology point of view, the integration at the Enterprise level of this magnitude of pole top devices with the planning of the communications infrastructure and of all the associated applications to provide the timely information at the different levels within the organization have been interesting to implement and put on line.

As of the writing of this paper, we have not had a chance to properly measure our SAIDI within the new architecture, but we are more than confident that, from the preliminary results we are seeing, we will be meeting the targets given to the energy regulatory body.

References

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