HYDRO-QUÉBEC'S SMART GRID ROADMAP UPDATE AND SMART GRID ZONE

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ABSTRACT

This paper presents Hydro-Québec Distribution's (HQD) smart distribution vision and roadmap. HQD has established development pillars which will help HQD to increase its operational efficiency and reliability while preparing its network for the challenges of the next decades.

INTRODUCTION

Today's distribution network is not much different to the one which could have been seen 20 or 30 years ago. However, the world around it has evolved. Today we live in a highly connected world in which smart phones connect to smart appliances and other smart devices. This unique technological push has brought down the cost of technology to a never before seen low. Never has the world been so interrelated and connected. The electric distribution industry is now at a crossroads, SMART is the new buzzword. The smart grid has been promising lots of benefits; however how smart and how connected does the distribution network really need to be?

2008-2023 DISTRIBUTION VISION AND ROADMAP

In 2009, Hydro-Québec published its Distribution Vision and Roadmap, based on industry benchmarking, customers' expectation, and Hydro-Québec's business objectives [1]. A summary of this vision can be found in **Figure 1**.

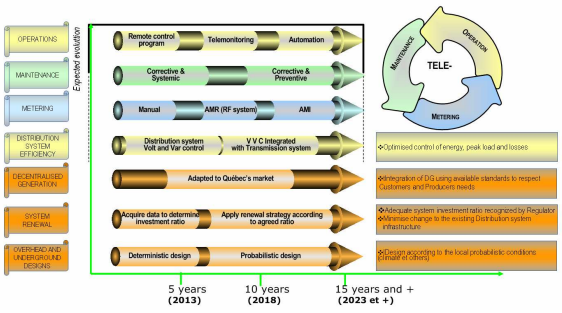

Figure 1: Hydro-Québec's Distribution Network Vision and Roadmap

2010-2025 SMART DISTRIBUTION ROADMAP

In 2010, HQD updated its 2008 roadmap. This update was done in order to renew the industry status as well as include the progress HQD had accomplished since 2008. To represent the business objectives, HQD developed its Smart Grid Framework (see **Figure 2**).

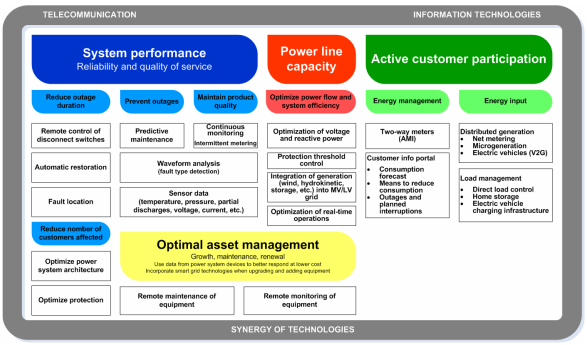

Figure 2: Hydro-Québec Distribution Smart Grid Framework

The goal of this framework is to organise the vision that outlines the different projects. Most Distribution utilities have the same objectives but the priorities may differ depending on the national and/or regional needs or regulatory mandates. The **e8** Group has developed a report comparing the business objectives from different countries.

Due to Quebec's particular context, Smart Grid initiatives will focus mostly on the improvement of the system performance power line capacity and the active customer participation.

Each new smart grid project shall fit in HQD's framework and be justified on a case by case basis. To do so, HQD has created a management structure based on a stage process to review these projects and guarantee that the several HQD departments involved in each project will be integrated to the level they need to be.

Each technology will be implemented gradually. The development of the design will be done through computer simulations, the proof of concept will be done on the HQD/IREQ distribution test line. The initial demonstration will be done at HQD's Smart Grid Zone[1]. This demonstration will allow HQD to evaluate the interaction(s) an initiative will have with other deployed systems (smart and non smart technologies).

Following all of the above-mentioned steps, a decision can be taken regarding the massive deployment of this initiative to the appropriate distribution system.

The roadmap was segmented in 0-5 year and 5-15 year objectives in each business sector. These objectives relate to three separate pillars: System Performance, Power Line

1 The Government of Canada by its Natural Resources Department is part of this project through the Clean Energy Fund. This project is also part of the Worldwide EPRI Project. The HQD Smart Grid Zone is located in Boucherville near Hydro-Québec's research centre (IREQ).

Capacity, and Active Customer Participation. To achieve these business objectives, significant efforts are needed on Smart Grid infrastructure projects as regards to telecommunication and information technologies.. **Figure 3** shows HQD's Vision and Roadmap for 2010-2025.

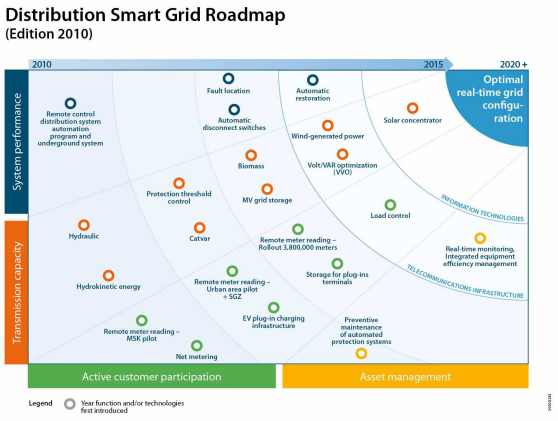

Figure 3: HQD Vision and Roadmap - 2010-2025

System Performance

This objective follows what was proposed in 2008 and targets an improvement of the SAIDI to 100 minutes, without exceeding 110 minutes with a 95 % probability throughout Québec. In Montreal's downtown core, the SAIDI should not exceed 60 minutes during business hours (6:00 AM – 9:00 PM). On the power quality side, HQD is committed to continue information and support services for its customers and measuring the power quality in order to qualify it and help satisfy customers.

0-5 Year Timeframe

In order to reach these objectives, several initiatives have been and will be put forth by HQD in the next few years. These projects are:

- Overhead and Underground Automation

This project is part of HQD's distribution automation program, which has been approved by Québec's regulatory board (*Régie de l'Énergie)* in 2005. Through this project 3,446 points will be automated (switches and breakers). Since the start of this program, 2,400 points have been automated on the overhead system and more than 100 on the Montreal underground system, leading to a reduction of 11 minutes of the global SAIDI. In the Montreal downtown core, a fibre optic cable was installed which will allow not only an optimal control of the automated systems, but also allow for additional monitoring in the near future.

- Fault Location

This project will allow HQD to locate precisely distribution network faults. This will be done through a mix of regular ways (call coincidence, automated equipments, etc.) and new ways (reactance to fault and voltage dip location).

- Advanced Usage of Automated Switches

This project will use the newly installed automated switches as auto-sectionalizers. Although this is not a new concept, the large scale deployment on already installed equipment will contribute to improve the system SAIDI.

- Automated Restoration

This project is complementary to the automatic disconnect switches as it will allow an automatic isolation of the fault and recovery of regions around the fault. Currently recovery requires an operator to validate the feasibility of the recovery. Through this system which will take into account loads and profiles, the operator's involvement will be minimized. This will allow the customer to experience a seamless recovery, minimizing customers experiencing outages.

5-15 Year Timeframe

In a longer timeframe, several other initiatives will be undertaken by HQD in order to improve overall system performance. These initiatives will include:

- Single Phase Protection on Three Phase Feeders

Through this initiative, whenever a single phase fault is experienced on a three phase feeder, only one of the three phases will be opened. As a result, two phases will be kept up and running and the number of customers experiencing an outage will be reduced. Three phase customers will need to review their protection systems as to ensure that they will not experience issues related to the loss of a phase.

- Pulse Closing

Through pulse closing, the breaker will only let a portion of the fault energy through after it closes. This will reduce the stress which the equipment is subjected to.

Power Line Capacity

In order to make its network ready for future loads, HQD will be enabling some projects which will increase its power line capacity while also contributing to the corporate energy efficiency mandate.

0-5 Year Timeframe

To reach these objectives, several initiatives have been and will be put forth by HQD in the next few years. These projects are:

- Volt/Var Optimization

Through this major project, HQD will optimize the voltage levels on its distribution feeders as well as manage every reactive power on its grid. This project will not only optimize the grid's operation but also contribute to 2 TWh of energy efficiency.

- Medium Voltage Distributed Generation

Since 1991, HQD has allowed generation to be connected directly to its medium voltage grid. In 2000, over 300 MW were already generated directly on the distribution grid. Since then, new technologies using power electronic inverter/converter systems came to market, which can also be connected to HQD's network. In 2010, HQD issued tenders to integrate 500 MW of additional wind, biomass and small hydro onto its distribution grid. In addition to the announced "standard" generation sources, HQD is currently demonstrating a hydrokinetic turbine in the St. Lawrence River near Montreal.

- Medium Voltage Grid Storage

The goal of medium voltage storage is to defer capital investments on the grid by installing devices which can shave the peak when required. This peak shaving can be done for a period of a few hours and can complement distributed generation sources.

- Protection Threshold Control

Through this initiative, the thresholds currently programmed on substation relays will be remotely increased in case of contingency in order to allow more power to flow (cold load pickup after outage, abnormal peak condition, etc.). Through these temporary threshold changes HQD intends to defer capital investments which are related to load growth (such as building new distribution feeders).

5-15 Year Timeframe

In the long term, other initiatives will be undertaken by HQD to improve the Power Line Capacity. These initiatives will include:

- Load Modelling

Load modelling is one of the most promising areas of research in distribution. Better load modelling will allow superior simulation and distribution management systems in the future. These more precise load models will then be integrated in the planning and operation tools. If precise enough, these models could also be integrated in future distribution expert systems.

- Power Line Capacity

Depending on the context, HQD will have to re-evaluate periodically its initiatives to raise its power line capacity. Additional grid technologies or customer participation may be required. Other more novel technologies such as superconducting cables may also need to be considered towards the end of the timeframe.

Active Customer Participation

Due to the relatively low cost of electric energy in Québec, active customer participation does not have the same strategic importance, as it can be noticed in other jurisdictions. However, HQD will still increase customer awareness and its participation.

0-5 Year Timeframe

- Remote Meter Reading

According to the 2008 version of its Vision and Roadmap, HQD is now planning to implement gradually an AMI system after validating the technology during different pilot projects, along with the Boucherville Smart Grid Zone.
This project will lead to the replacement by 2016 of 3.7 million electromechanical meters by AMI meters. Thanks to a new AMI infrastructure, HQD will not only be able to obtain remote meter reading, but also use the meters as electric sensors for the grid, which will be relaying information back to HQD's distribution management software.

- Net Metering

HQD's net metering program has been offered to its residential customers since 2006. This program promotes the integration of "green" energy sources, such as solar or wind energy. However the low cost of energy in Québec (7¢/kWh) has made customer enrolment slow into this program (only 16 participants in 2010). Nonetheless, HQD will continue to support it, for all interested customers.

- Plug-in Electric Vehicle Charging Infrastructure

One of the objectives of Hydro-Québec's strategic plan was to provide support for electric vehicle charging. As such, HQD has decided to install level two charging stations (240V/40A) within the Boucherville Smart Grid Zone. Some charging stations will be smart while others will be "dumb". Through this demonstration program, HQD will be able to better understand the impacts on the grid as well as customer's reaction to loading and control signals. Within this initiative, DC fast chargers will also be installed to better understand how and when they will be used by customers.

- Vehicle to Grid (V2G)

Electric vehicles will likely be the first truly smart appliance to interface with the electric grid. Not only will the EVs be smart, but they also have the unique property of containing on-board electric storage. Through this, it is now possible to imagine using this energy as distributed generation when the grid may require it. As such, HQD will launch a pilot program which will aim to evaluate peak shaving possibilities of this technology hence reducing the energy supply costs. This technology could then be applied (either in Québec or in other jurisdictions) to facilitate renewable energy integration as well as load balancing.

- Load Control

In this project, smart meters will be used to control smart appliances. As such, during contingencies (or unexpected peaks), a signal could be relayed through the AMI infrastructure to control different appliances. This technology will be tested within Boucherville's Smart Grid Zone, and carried out with other similar projects set in collaboration with organizations such as EPRI. After the pilot project, HQD will then determine if such an initiative is to be rolled out across the entire customer base, in some select markets or not at all.

5-15 Year Timeframe

For many electric distribution companies, active customer participation is of paramount importance. However, for HQD the specific context makes it less of importance. Many developments will be taking place over the next few years around smart appliances, communication and control schemes. Although they may not be applicable in the current regulatory context, HQD will continue building upon the projects developed in the 0-5 year timeframe in order to better establish its long term strategy. HQD will also operate an active technology watch program such that it can learn from experiences elsewhere in the world.

Smart Grid Infrastructure

All the above mentioned initiatives will lead to HQD's smart grid. This smart grid was designed in accordance with HQD's unique context and situation focus on Distribution system applications. There are however several challenges to meet to facilitate the implementation of the Distribution system projects. These challenges are not only for HQD, but for the industry as a whole.

- Telecommunications

The electric distribution industry has to get acquainted with new skills which will come from the telecommunications industry. In order to make a grid "smart" telecom is at the heart of the needs. A reliable and safe telecom network is required and needs to be built at least cost.

- Information Management

All of the above mentioned projects will need data. This data will flow through the telecom network; however it will need to be processed. The quality of a smart grid will hence lie in how the information is managed. New powerful databases and expert systems will need to be developed or implemented to be able to manage and process this vast quantity of data which will be coming from the smart grid.

- Standardization

The multiplication of technologies leads to a multiplication of standards and protocols. However, in order for one technology to become the industry reference, standardization is required. This is why HQD will continue to support efforts currently being conducted at the International Electrotechnical Commission (IEC) and the National Institute of Standards and Technology (NIST). These efforts are key to obtaining a reliable, cost efficient and adaptable smart grid. Without standardization, smart grid implementation will be slower.

- Distribution – Transmission Interactions

The distribution smart grid will also affect the transmission grids. It will hence be vey important for both the transmission and distribution entities to collaborate in order to invest in the right initiatives. If this hurdle is crossed large benefits can be achieved for Hydro-Québec.

CONCLUSION

After the first edition of its Distribution Vision and Roadmap in 2008, Hydro-Québec Distribution has updated its document in 2010. The major business objectives remain the same and are now presented in the HQD Smart Grid Framework:

1- System performance,
2- Power line capacity,
3- Active Customer participation,

supported by an improved Smart Grid infrastructure for telecommunication and information technology.

In the Québec context, smart grid projects remain focused on medium voltage technologies as it was in the 2008 roadmap.

In order to follow the evolution of technology and to coordinate and integrate all the involved departments for a specific project, HQD has implemented an organisational structure. It has also developed an approach to validate Smart Grid technologies including a Smart Grid Zone.

HQD will hence continue to show its involvement and leadership in the development of the Distribution Smart Grid.

REFERENCES

[1] CIRED Paper 0222, 2009, *" Hydro-Québec's Distribution Vision and Roadmap 2008-2023"*

[2] e8, Tokyo Summit 2010, 2010 *"Smart Grid Technology Innovation Group Report"*