Division Distribution

Vice-présidence Réseau

Direction Planification du réseau
Unité Orientations du réseau

Distribution System Automation Roadmap – 2005–2020

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1 Introduction

Automation plays a prominent role in the overall roadmap.

Unité Orientations du réseau undertook a study for the purpose of drawing up a roadmap for *Vice-Présidence Réseau (VPR)*[1]. This process covers all of the VPR's areas of activity. However, network automation, including decentralized generation and energy efficiency, plays a prominent role in the overall roadmap due to the fundamental change that is represents for the distribution system. This change takes the form of major distribution system capital investments as well as the impacts that automation will have on business processes, human resources, etc.

Over the last few years, a more in-depth analysis was done in the field of automation to determine a consistent vision as well as a tangible project that was proposed to *Vice-Présidence Réseau*, Hydro-Québec's board of directors, and the Régie de l'Énergie.

This document thus reflects the outcome of this analysis and presents the roadmap for distribution system automation. The comprehensive roadmap covering the other areas (e.g. management of distribution system assets, load supply, demand forecast, distribution system architecture, network protection, apparatus, power system operation) will be drawn up in 2006 in conjunction with the technical units part of *Direction Maintenance* and *Direction Expertise et Conduite de réseau*, including cooperation with the units part of VP SALC and *Direction Ventes GrandesEntreprises*. The distribution system roadmap should be updated at the same rate as the company's business drivers defined in the strategic plan.

The proposed distribution system automation roadmap considers the equipment already installed on the network and gradually adds applications based on the calculated gains. All of the projects that are proposed will be backed by technical and economic studies in order to maximize the equipment's output and minimize investment and operating costs.

For each new development project associated with the automation roadmap, a formal recommendation will be drawn up after having been validated by the following process:

1. Concept validation phase, including the economic analysis
2. Pilot project to evaluate the real gain potential
3. Change management
4. Deployment that targets the areas with the greatest gains
5. Transposition to the overall distribution system, if warranted

[1] Hydro-Québec's power system division.

Each project will be carried out with the aim of achieving the greatest possible benefit from the potential integration of the multiple functions found in the equipment already in place.

2 Background

Directions confirmed by an external benchmarking in 2004.

In 2002, the VPR undertook to fundamentally modify the future of the distribution system with the publication of its report entitled "*Orientations sur l'automatisation du réseau de distribution Horizon 2002-2012*." [1] This report advocates a distribution system automation vision that covers the following three facets:

1- Distribution system monitoring
2- Network component monitoring
3- Product monitoring

The integration of equipment on customers' premises, including smart meters, is proposed in the 2002 document for certain functions such as Power Quality measurement. Other applications are possible such as customer demand side management.

In July 2005, the Régie de l'Énergie du Québec authorized Hydro-Québec Distribution to start up the program proposed in Application No. (R-3565-2005) "Request for authorization to implement the distribution system automation program." The program consists in implementing 3,750 remote control points covering about 1,100 distribution lines on the existing distribution system with currently available technologies.

However, it has always been said that this project is the cornerstone of a distribution system that is progressing towards a more intelligent system. The project authorized by the Régie represents the tangible beginnings of network monitoring and establishes the basis for the other two facets of the vision put forth by *Orientations du réseau* that would lead, over the long term, to an intelligent distribution system.

This concept of intelligent distribution system is also found in several outside publications that will be covered in the next section. In fact, in January 2004, CEATI – DALCM published a technological roadmap [2] that covers more than 150 "technologies" that affect the entire electricity distribution industry. The study concluded that:

- The grid has to become more intelligent.
- Choosing to retain today's design standards and equipment, opting for small incremental changes in the way that business is done today, will result in an unprofitable future for a distribution utility.

Furthermore, it has been noted that 8 out of the 10 first technologies prioritized by the CEATI roadmap entail the automation of the distribution system, thus confirming Hydro-Québec Distribution's directions.

Another report published by EPRI on distribution system automation proposes a vision of a more intelligent distribution system in accordance with Hydro-Québec Distribution's 2002 report. It reached the same conclusions as the CEATI report and added that:

1. "The distribution system is expected to evolve into a power exchange medium."
2. "We are being revolutionized by the evolution of technologies."

These documents provide first-rate information since they have been written or are influenced by experts in the distribution system field.

Section 3 of this document covers the different technical reports available since 2002 that have served as a basis for discussions on the automation roadmap.

3 Technical reports that influence the distribution system automation roadmap

3.1 Directions in relation to distribution system automation (June 2002)

Corporate directions already unveiled in 2002

In 2002, *Unité Orientations du réseau* published its vision on the distribution system automation roadmap ("*Orientations sur l'automatisation du réseau de distribution*"). This automation roadmap incorporates three facets in its vision, i.e. distribution system monitoring, network component monitoring and product monitoring. The first facet pertains to dynamic system management, including control, while the other two facets implement the means to migrate from program-based maintenance to targeted preventive maintenance first, and ultimately to predictive maintenance and to ensure the quality of our product with customers.

These facets have been presented on a few occasions to Hydro-Québec's Automation Steering Committee (see figure below).

Hydro-Québec Distribution's automation vision is thus much more than the remote control of circuit breakers and load break switches authorized by the Régie de l'Énergie

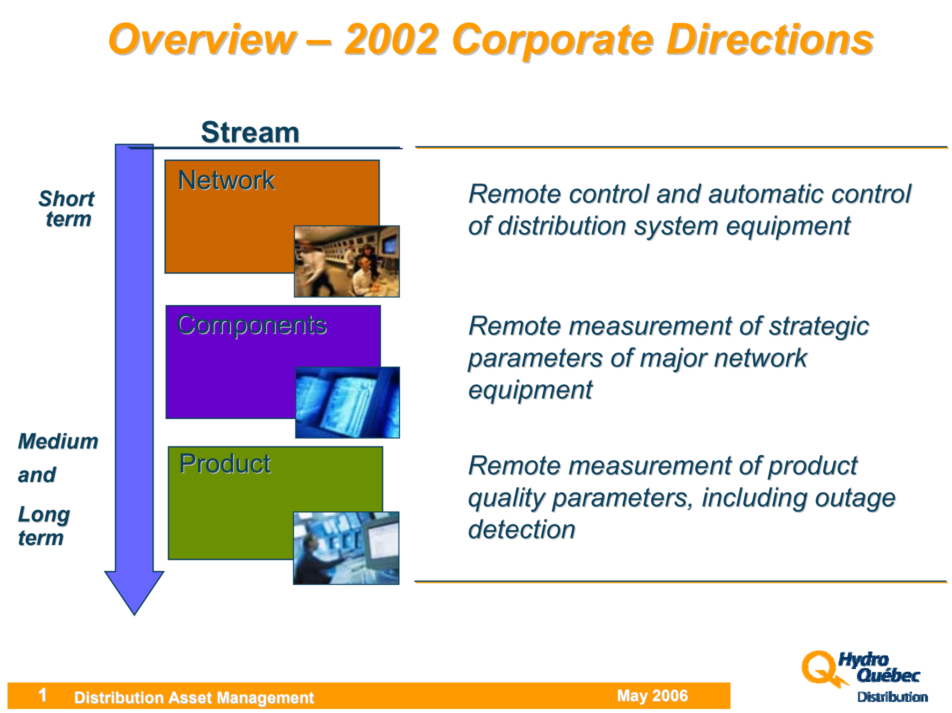

Figure 1: Hydro-Québec Distribution's directions on distribution system automation

Facet 1 aims at improving the reliability to customers, in particular with remote-controlled circuit breakers and load break switches. This first facet, which involved submitting proof to the Régie de l'Énergie and was authorized last July, basically aimed at improving reliability performance. The remote-control implementation is the foundation of a more intelligent distribution system that forms the basis for the implementation over time of facets 2 and 3 of Hydro-Québec Distribution's policy on distribution system automation [1]. During the demonstration of proof to the Régie de l'Énergie, the remote-control program was always presented as being part of a broader vision leading to a more intelligent distribution system.

The monitoring of the components and the product is intended to increase understanding of the distribution system in view of allowing real- and delayed-time response to improve the distribution system's overall performance, increase the load flow, and reduce operating costs. Hydro-Québec Distribution's automation vision is thus much more than the remote control of circuit breakers and load break switches authorized by the Régie de l'Énergie, and the automation roadmap must therefore allow these objectives to be attained.

The distribution system of the future must make use of the information available from distribution system equipment to increase understanding of the behaviour of distribution system components in real and delayed time so that their performance can be improved. For instance, such a network will lead to:

- An increase in distribution system energy efficiency (optimal load flow, voltage and loss optimization)
- Reduced reliance on calls from customers to learn about outages
- Real-time information on problems with major distribution system equipment (e.g. line circuit breakers, voltage regulators)
- Improved analysis of system behaviour during abnormal conditions
- Knowledge of the product being delivered
- Integration of distributed generation on the power system aimed at a bidirectional energy exchange

Improved knowledge of power system data will reduce the safety margins currently in use and increase the use of the power system components that have been installed. This greater knowledge of the power system will help optimize the criteria to be included in our standards.

Naturally, all of these options must be analyzed and prioritized based on the desired gains and the availability of the technologies. It is with this aim in mind that the AGIR[2] multidisciplinary group began analyzing the VPR's needs.

[2] French acronym for "Acquisition et Gestion d'Informations en Réseau" (acquisition and management of power system data)

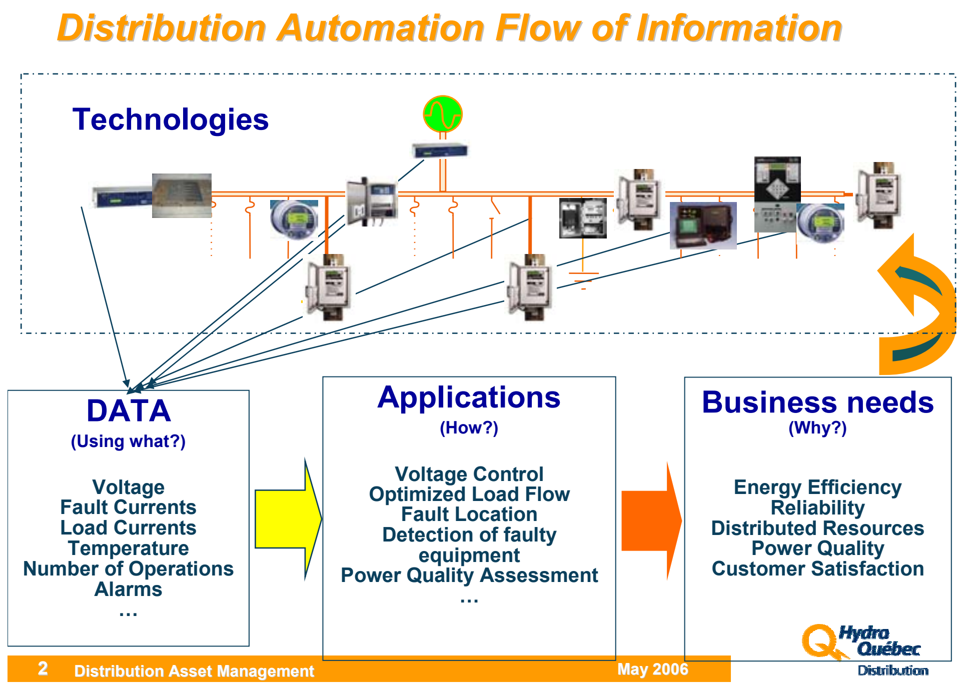

Figure 2: Management of automation-related data

The above figure illustrates the vision and automation concepts described in Hydro-Québec Distribution's 2002 corporate directions document. However, it cannot be implemented instantly; it requires a very realistic roadmap that is based on the possibilities of the industry in general as well as Hydro-Québec Distribution's capacities.

3.2 External reports – CEATI (May 2004) and EPRI (June 2004)

The generic conclusion from the CEATI study could be summarized as follows: "Increase understanding of the distribution system to improve decision-making." In the case of the EPRI study it would be "Enhancing existing assets through automation."

The concept of a more intelligent distribution system was proposed by several of the industry's companies and organizations and was confirmed in particular by the two reports previously mentioned which were published in 2004 (see references).

These two documents state that the distribution system must become more intelligent. It is fairly easy to summarize the vision of the future formulated by CEATI and EPRI in two sentences. The generic conclusion from the CEATI study could be summarized as follows: "Increase understanding of the distribution system to improve decision-making." In the case of the EPRI study it would be "Enhancing existing assets through automation." These are complementary and are based on the development of quality information in relation to the distribution system.

For instance, the EPRI report proposes transmission and distribution systems as illustrated below:

Transmission system *Distribution system*

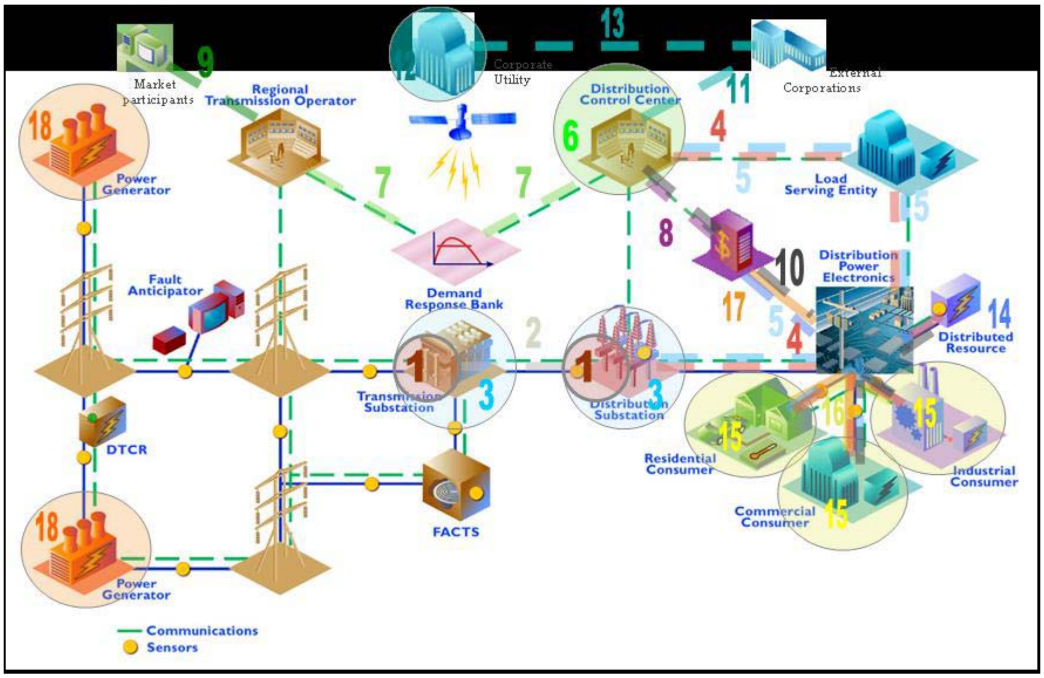

Figure 3: EPRI vision (transmission and distribution)

Source: EPRI Report, June 2004

This is an intelligent power system that includes the transmission and distribution systems on one side, and a telecommunications network that is tailored to the new needs of the networks and customers on the other. It also includes decentralized generation, which illustrates the trend toward a bidirectional distribution system. This network of the future requires close conformance of the power system and telecommunications architectures to ensure a flow of information that will allow the right power system management decisions to be made. Such a power system must obviously be supported by standards so that technologies can be integrated at least cost. The objective is a network of Plug and Play-type equipment built on similar principles. Several international standards already exist, in particular in the electricity transmission field where they are in the process of being implemented but where the transfer to distribution system equipment still has to be done.

EPRI's vision for the distribution system is illustrated in the following figure:

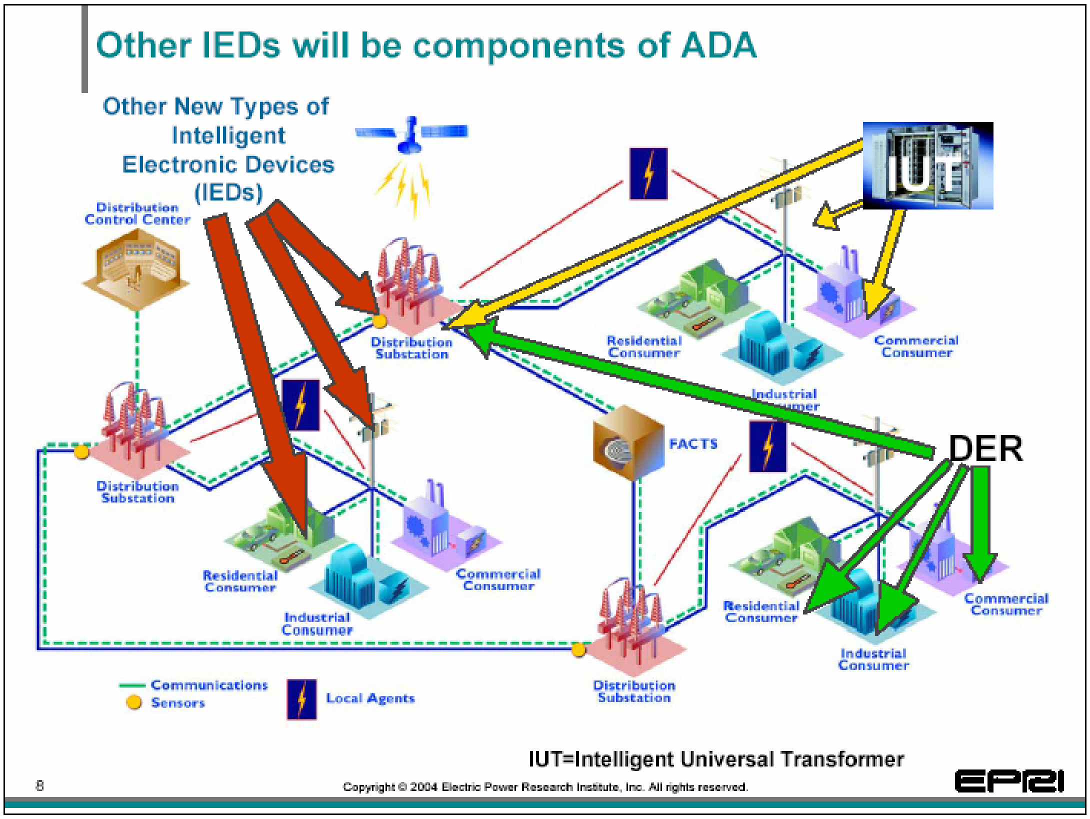

Figure 4: EPRI's vision of the distribution system

Source: EPRI Report – June 2004

The figure includes:

1. Distributed Energy Resources – DER
2. Intelligent Electronic Devices – IED
3. New power electronics equipment (Intelligent Universal Transformer IUT)

Based on the facilities and a telecommunications architecture used for electrical transmission as per IEC standards, the distribution system of the future proposed by EPRI confirms the vision developed by Hydro-Québec Distribution.

EPRI, like CEATI, sees the distribution system of the future as a power exchange network with controlled islanding possibilities.

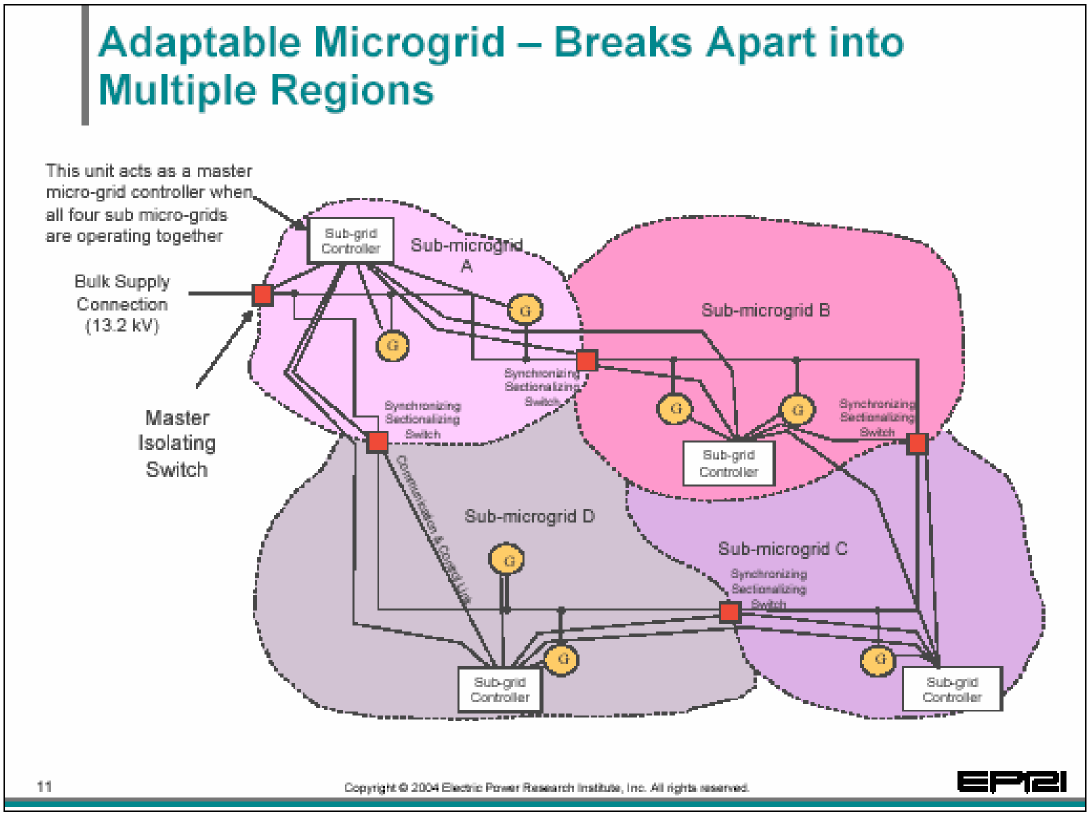

Figure 5: EPRI's vision of a distribution system with islanding possibilities

Source: EPRI Report – June 2004

EPRI is also proposing a "self-healing" network that includes automated restoration coupled with controlled islanding. Over the short term, with the remote-controlled line devices installed on the network, real-time optimization of the system configuration aimed at improving energy efficiency, through a reduction in power system losses, may become part of our practices.

Recent standards A5-04 on the distribution system architecture and A.21.1-01 on the deployment plan for distribution system automatic controls, published by *Orientations du réseau,* set up the network structure required for this future vision of an islanded network.

Since the various benchmarking documents have different scopes and methodologies, the focus should be on the main points in order to integrate everything that is applicable to Hydro-Québec Distribution's context. The sections that follow describe the directions resulting from the analysis of various documents as well as the distribution of the resulting actions over time.

4 Automation Roadmap

4.1 Roadmap structure

All of the technologies, ideas and projects resulting from the benchmarking documents were analyzed and scheduled, which led to categories being established to facilitate the structuring of the roadmap. Here are the three categories that underlie the roadmap:

1. Business drivers:
    - These drivers are obviously associated with the company's core activities and mission. They justify all of the actions undertaken on the automated system. They answer the question of "why" we should invest in the power system. The following are the main drivers identified to date:[3]
        - Energy efficiency
        - Power system reliability
        - Product quality
        - Customer satisfaction

2. Applications:
    - They represent the systems to be implemented in order to improve or attain the objectives set by the business drivers. They answer the question "how." Here are some examples (this is not an exhaustive list):
        - Energy efficiency can be improved through:
            - feedback control of power system voltage from the distribution system
            - optimized power flow
            - decrease in losses by reconfiguring the power system
        - Reliability will be improved by:
            - Locating faults
            - Remote monitoring of equipment
        - Product quality will be qualified by a power quality monitoring system

[3] Additional business drivers are taking shape in the U.S. regarding the security of the grid and related facilities following the events of September 11, 2001.

3. Technologies:
   - Linked to the applications, they provide the analysis data. They answer the question “Using what?”
     - Network sensors that provide voltage and current data
     - Obtaining the number of operations of major network equipment
     - Obtaining alarm signals on power system conditions

Among the technologies, it is important to stress telecommunications technologies. In fact, telecommunications have until now been the main obstacle to remote-control projects on distribution line feeders due to their cost and the difficulty in meeting remote-control-related requirements (e.g. reliability of links, service area covered based on the available technology.) In addition, these technologies are also rapidly evolving and require special attention. This is why a corporate project is under way to establish a coordinated vision of telecommunications at Hydro-Québec. From a distribution system standpoint, the need to adopt as quickly as possible a standardized data and telecommunications architecture such as IEC 61850 is crucial for furthering the development of distribution system automation.

4.2 General automation guiding principles

In order to migrate to a more intelligent system and in light of the observations made above, the following guiding principles have been retained:

The upgrading of the distribution system must be gradual in keeping with existing facilities and evolving standards and technologies.

- The upgrading of the distribution system must be gradual in keeping with existing equipment and evolving standards and technologies.
  - The roadmap does not propose any changes involving any large-scale replacement of equipment. On the contrary, it favours modifications that have been technically and economically analyzed to minimize investments while benefiting from technological advancements.

- Taking advantage of the remote-control infrastructure to obtain information on the intelligent equipment installed on the network to gain a better understanding of the network for improved real-time and non-real-time management.
  - These data will be used to analyze network and component behaviour for power system control, maintenance and planning. The data will have to be integrated into existing systems (e.g. DCartes, GIS, SAP, data warehouse).

- Take advantage of the technical possibilities available from the various equipment (smart meters, computer-based remote-controlled cabinets, etc.)

    - Take advantage of the implementation of technologies that use an intelligent base to obtain information for improved power system management by combining the available functions (e.g. intelligent meters that can be used to supply voltage data in addition to billing data)

- The distribution system must adapt to the growing presence of decentralized generation

    - The distribution system must prepare to transform into an energy exchange network.

- Capitalize on the experience with transmission systems where automation has been in use for a number of years

    - Transpose the practices and methods used at TransÉnergie to benefit from the experience acquired (transposition of automation training, maintenance and repair practices).

- Distribution lines must be seen as an extension of the substation bus bar

    - The technologies used on distribution lines must be as much as possible the same as those used in substations, in particular controls (e.g. CEPA and Schweitzer SEL-351-R). The VPR has begun applying these principles but they must push for the use of electronic control cabinets to benefit from their capacities.

- A telecommunications and data network architecture tailored to the needs of the distribution system but that conforms to the principles applied on transmission systems (IEC 61850 uniform architecture and infrastructure)

    - Over the long term, use of a communication architecture similar or complementary to the one recommended by the transmission system is proposed to facilitate data transfers for the various applications. The use of IEC international standards is recommended to benefit from the world market that is developing around this architecture, thus realizing savings on the costs and a closer relationship with TransÉnergie.

All of these directions must be integrated smoothly alongside the development of work methods without jeopardizing public or worker safety.

4.3 Chronological distribution system development

To ensure a harmonious development of the distribution system, the VPR must take into account both the internal and external environments along with their capacity to adapt.

The automation roadmap proposes sequential actions for each period as follows:

- Technology implementation
- In-house developments
- Outside influences

4.3.1 2005–2010 timeframe

The implementation of the automation program was authorized by the Régie de l'Énergie. The VPR therefore undertook to install 3,750 remote-control points over six years, while monitoring improvements to service reliability.

The proposed strategy consists in making use of the available equipment, including the available telecommunications protocols and links, while using these links to obtain additional information. This information will be available from the sensors that were installed to increase the efficiency of the company's activities (business drivers) such as energy efficiency, power system reliability, etc. In addition to impacting technical personnel in real time, the information will be used to study the performance of the equipment and power system in relation to maintenance and planning.

In-house developments will also be required to tailor the technologies and computer applications to the company's systems and to prepare the implementation of automatic controls on the distribution system such as automatic restoration.

In addition, it is important to let manufacturers know of our intention to comply with international standards, which over the long term will lead to a reduction in costs. To do so, the VPR will need to set up a structure of influence for these standards. The influence which Hydro-Québec (TransÉnergie, Hydro-Québec Production and Hydro-Québec Distribution) exerts on standardization is already substantial, but specifically for distribution system automation, Hydro-Québec Distribution's project is the most ambitious in North America and makes the VPR a technical leader with the potential to influence the entire industry.

4.3.1.1 Implementation of technologies in 2005-2010

To properly illustrate the roadmap, a sequence of figures shows the anticipated changes based on the proposed roadmap. The following figure shows the current state of the distribution system.

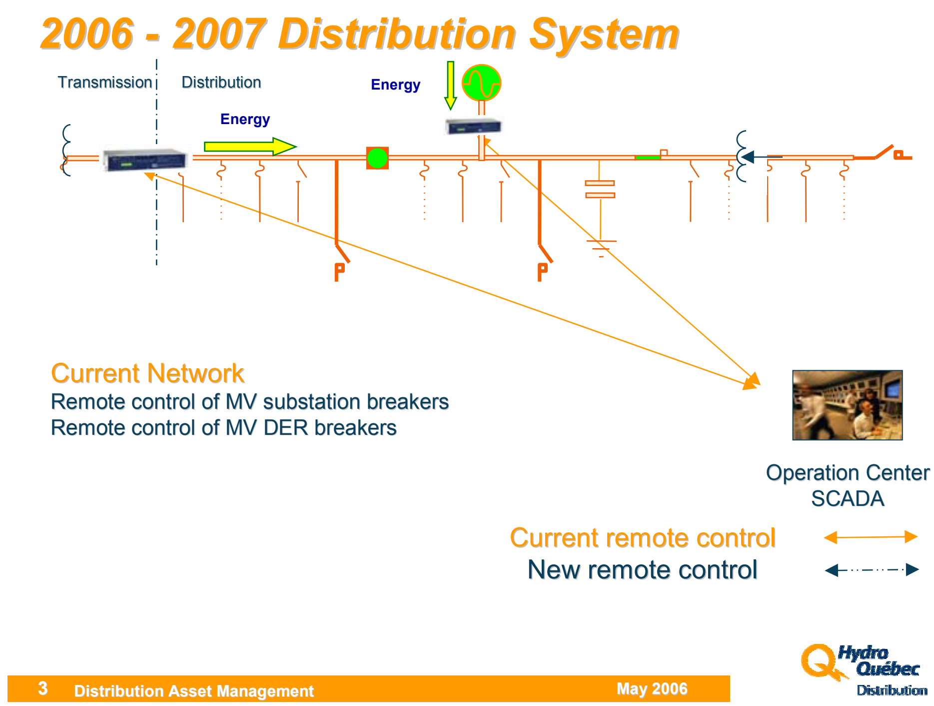

Figure 6: Current distribution system (2005)

Note that only substation circuit breakers as well as decentralized-generation breakers connected at medium voltage[4] are remotely controlled.

Two figures are used to better represent how the distribution system will be evolving from 2005 to 2010. The first figure shows the installation of the remote control points provided in the program which was started up in the fall of 2005. The figure also shows the most significant developments currently under way that will be implemented once they are completed (fault location and feedback control of power system voltage from the distribution system). This list is not complete since it is in the process of being drawn up, namely by the AGIR group. It is estimated that it will take until 2007 to see any technological implementations on the distribution system for the first applications for which studies are being conducted (fault location and feedback control of power system voltage from the distribution system).

[4] Medium-voltage generating stations now represent about 300 MW (50 facilities).

There are also longer term studies that are proposed for the development of the intelligent power system of the future (AGIR, studies on network capacitors and studies on telecommunications).

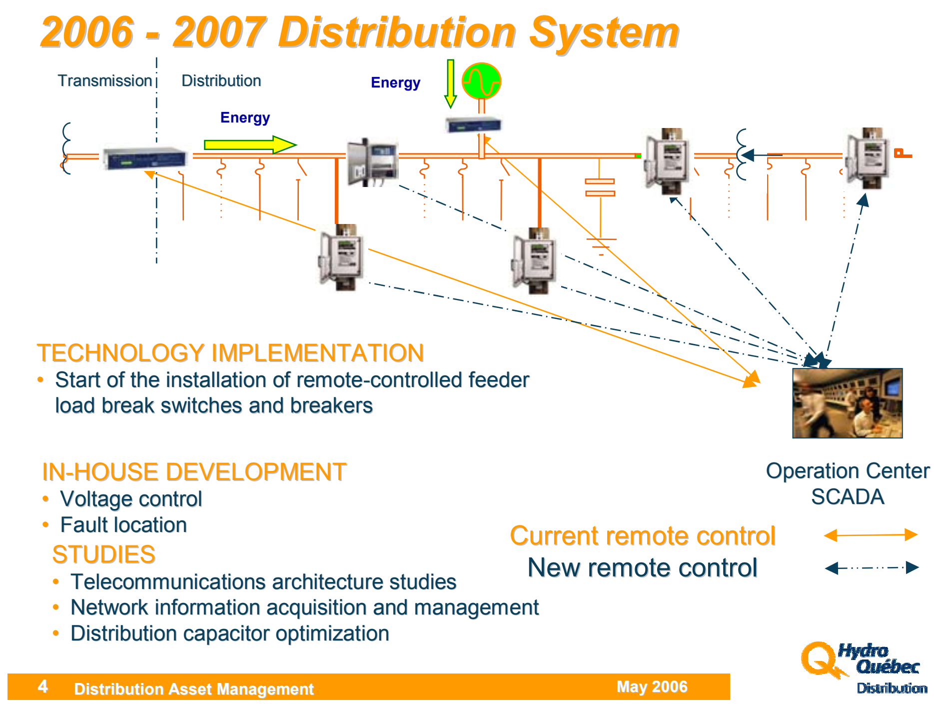

Figure 7: Distribution system in 2006-2007

Between 2007 and 2010, technologies from pilot projects and from studies currently under way will be implemented, including:

- Sensors and applications for fault location:
  - The results obtained from the research project on fault location will allow us to not only anticipate the location but also the cause of the outage using the signatures of the faults obtained on the network. We believe that we would even be capable of predicting certain types of faults. These results will form the basis for the implementation of predictive maintenance. The targeted selection of lines will be done on the basis of anticipated gains.

- Sensors and applications for feedback control of busbar voltage from the distribution system
  - The results obtained from the pilot project under way on the feedback control of power system voltage from the distribution system will be implemented on the lines identified as profitable. The possibility is also being studied of using the sensors installed for fault detection for the project on the feedback control of

busbar voltage from the distribution system but this has yet to be confirmed. Otherwise, specific sensors will be required.

- Sensors for qualifying the product
    - It is likely that the same sensors used for fault detection can be used to qualify the voltage. Obviously, it will be possible to also integrate readings from specialized power quality monitors, intelligent sensors, or sensors installed in the cabinets of major distribution system equipment provided that the resulting measurements comply with the measurement methods found in recognized international standards. The voltage quality data available at the distribution substation, which TransÉnergie is responsible for, can be integrated into the product's qualification system.

- Applications to collect the maximum amount of information from the remote-controlled control cabinets which are installed for the automation program.
    - Using the current signatures of the switch control box motors to detect required maintenance for the medium-voltage part. This application will be part of predictive maintenance.
    - Among the studies at the planning stage, we are looking into the possibility of remotely setting the protective relays and regulation devices

- Sensors and applications to make underground transformer vaults more intelligent

The study on the installation of capacitors will likely lead to stationary (non-remote-controlled) capacitors being installed during the first phase. The installation of remote-controlled capacitors will likely take place after 2010. A new impact of the results of this study is the possibility of optimizing the distribution system's power factor to reduce peak demand.

From 2007 to 2010, we will see the true impact of the decentralized generation programs that are currently being implemented and that will be developed over the coming years. This is an area where outside factors (e.g. price of energy, environmental and government pressures) will have a major influence but one that is little known for the time being. As decentralized generation is a world phenomenon and the cost of electricity in Quebec is favorable to us, it is likely that improved integration methods will be developed elsewhere and that we can benefit from them. This is why we have chosen to keep a close eye on the decentralized generation field while being actively involved in projects that will be in line with the energy policy that has been retained.

Though new telecommunications technologies will likely be implemented and used during this time, we believe that studies in this field should continue due to the technologies' ongoing development.

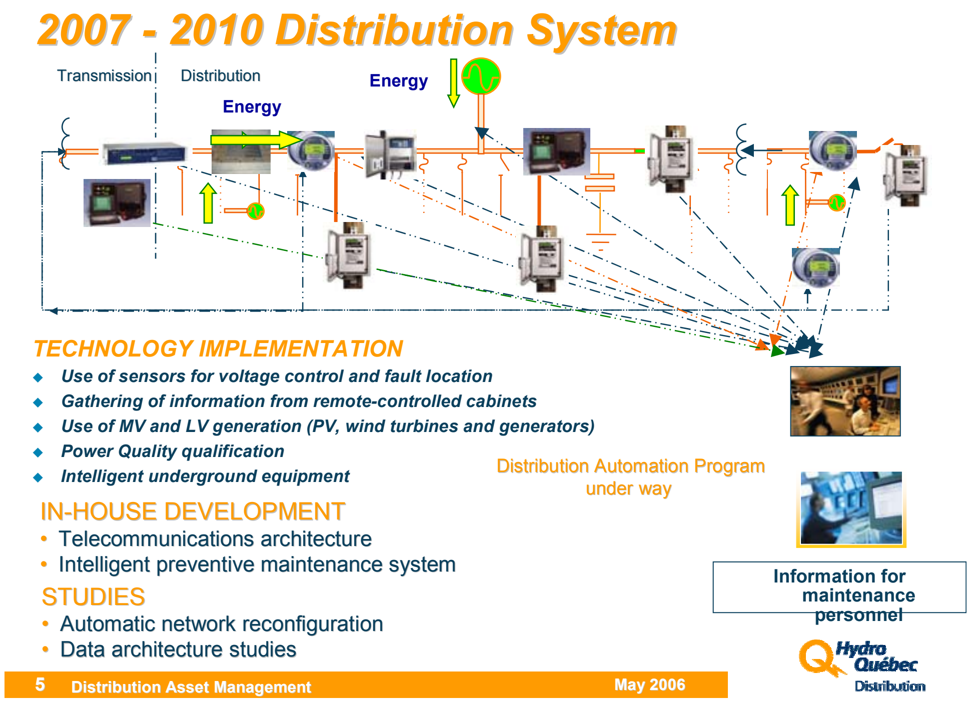

Figure 8: Distribution system – 2007-2010

Table 1: Implementations from 2007-2010

Business drivers Activities	Applications	Technologies
Network reliability	Remote control of network switching equipment	• Existing manufacturers of circuit breakers and switches • Existing telecommunication links
Energy efficiency	Voltage optimization	• Voltage sensors • Sensor data analysis software • Regulator control in substations
Network reliability	Accurate short-circuit position detection (application of the results of the R&D project)	• Voltage sensor (may be current sensor) • Position detection software to be implemented at the Distribution Control Centre
Network reliability	Use of fault signatures to prevent outages and improve voltage quality	• Voltage sensors
Network reliability	Integrate available data from existing cabinets and other sensors	• Network apparatus failure • Alarms, watchdogs
Product quality	Measure the quality of the product delivered to customers at the substation and on the distribution feeder Measure quality at sensitive customers' premises	• Voltage quality monitors • Intelligent meters • Control boxes • Acquisition software
Network reliability	Use of current signatures of the switch control box motors to detect the need for maintenance for the medium-voltage part.	• Switch control boxes • Signature detection software

4.3.1.2 In-house developments – 2005-2010

Table 2: In-house developments[5] – 2005-2010

Business drivers	Applications	Technologies
Network reliability	Determining data acquisition needs (sensors, data processing and storage) AGIR group	Existing manufacturers of circuit breakers, switches and sensors Existing telecommunications link Data acquisition software
Energy efficiency	Quantifying the benefits of installing stationary capacitors that are controlled automatically either remotely or non-remotely for the purpose of optimizing the voltage, the power factor and peak demand	Existing manufacturers
Network reliability	Developing the concept of intelligent underground transformer vaults	Existing manufacturers of sensors and major equipment
Network reliability	Studying and implementing ways to perform automatic transfers on a remote-controlled distribution system	Existing manufacturers of sensors and major equipment
Network reliability	Determining the potential of the various sensors (e.g. intelligent meters, control boxes)	Existing manufacturers of sensors and major equipment

[5] This list is not complete but it adequately represents the main activities that resulted from the brainstorming work done by the AGIR group

4.3.1.3 Studies and outside influences – 2005-2010

The following studies will be carried out:

Table 3 – Longer-term studies

Studies	Stakeholders
Determine the optimal data architecture and draw a link with existing systems (Dcartes, GIS, SAP, data warehouse)	In-house expertise including IREQ/LTE Outside manufacturers Standardization organization
Confirm with the other VPR units the interest in complying with IEC international standards by field (power system control, automatic controls, telecommunications) and study the stages involved in migrating from the company's existing systems to standardized IEC systems	In-house expertise including IREQ/LTE Outside manufacturers Standardization organization
Optimal telecommunications architecture for the distribution systems	In-house expertise including IREQ/LTE Outside manufacturers Standardization organization

Hydro-Québec Distribution has one of the most ambitious telecommand projects in North America. The in-house research program has to be tailored to support future development. Outside of the company, Hydro-Québec Distribution's technical capacities make it a recognized industry leader. Its influence is substantial among standardization organizations. This is why the following external influences are recommended.

Table 4: External influences in automation

Business drivers	Activities	Notes
Optimization of research costs	Bringing automation research projects in line with IREQ/LTE in-house research (distribution and strategic platforms)	The AGIR group will provide the research and development topics for both in-house and outside projects
Optimization of research costs	Implementation of the CEATI cooperative research network or other groups on automation	Group's business plan completed Project list under way. The AGIR group will provide the research and development topics for both in-house and outside projects
Reduction of costs through standardization	Influence IEEE and IEC automation-related standards	To attain cabinet interchangeability and interoperability (Plug & Play)

Hydro-Québec Distribution must take advantage of these influence meetings to follow up on the work related to decentralized generation since the latter is often associated with automation, and projects currently under way will likely lead to integration solutions or standards that will facilitate their integration.

4.3.2 2010–2015 timeframe

In 2010, the automation program will be very advanced, as will the acquisition of network data. Communication technologies will most likely have become more efficient and cost-effective but they will probably not be consistent across Quebec.

During this period, the average age of the distribution system will be such that major investments will be required. The replacement of several assets will coincide with the possibility of transposing over the entire distribution system the implementations targeted for 2005-2010, such as fault location, feedback control of busbar voltage from the distribution system, and voltage qualification. Applications will thus be transferred gradually to the entire service area based on profitability figures.

Automatic restoration systems will have already been implemented based on prior studies. The concept of a “self-healing power system” will gradually take shape.

With respect to decentralized generation, the advent of small wind farms connected to the distribution system is probably inevitable after 2010. The technology will be mature and this type of generation will be well accepted socially.

The penetration of decentralized generation into any kind of distribution system should still be less common in Quebec than the rest of North America mainly because of energy costs. It will most likely be integrated into buildings by incorporating photovoltaic generation, wind farms or micro-turbines. The heating of buildings through geothermal energy, proposed by the energy efficiency program, will no doubt be integrated into new buildings. The energy efficiency program will be updated, giving rise to new distribution system policies.

Efforts to influence standardization should lead to new distribution system and telecommunications equipment that will be more smoothly integrated. Automation will be integrated into company standards and will also likely have spread to the other distribution companies. New standardized equipment should be upgraded gradually to further benefit from the reduced costs arising from standardization.

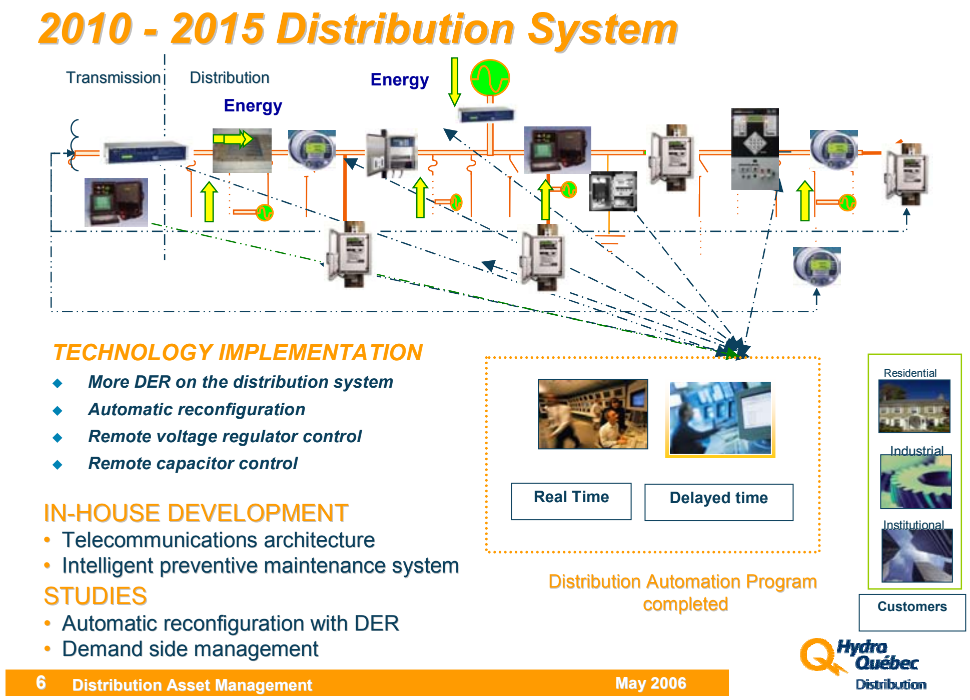

Figure 9: Distribution system – 2010-2015

4.3.2.1 Technology implementation – 2010-2015

The projects begun between 2005 and 2010 will include:

- Automation program
- Feedback control of power system voltage from the distribution system
- Accurate short-circuit position detection
- Automatic restoration
- Integration of available network data
- Preventive and predictive maintenance system

These projects will be gradually implemented across the distribution system as justified economically.

4.3.2.2 In-house development work – 2010-2015

Development work will be conditional to the successes achieved between 2005 and 2010. It is likely that certain development work begun during this period will continue. For the time being, it is expected that development work on preventive and predictive maintenance will continue, along with the development of the telecommunications network both in terms of the technologies to be applied across Quebec and the global architecture.

Automation projects related to decentralized generation (optimization of the load flow based on network losses, including micro-grids) will be implemented based on the rate at which generating stations are commissioned as well as business drivers. Development work will no doubt be required to bring corporate systems in line with these concepts.

Table 5: In-house development work – 2010-2015

Business drivers	Applications	Technologies
Reliability	Micro-grid – Controlled islanding	Network sensors Software
Energy efficiency and reliability	Optimization of the load flow based on network losses, including micro-grids	Network sensors Software

Obviously, the realization of high-risk projects (e.g. superconducting equipment, electronic transformers) would bring changes to our overall systems and possibly our automation systems as well.

4.3.2.3 Studies and outside influences – 2010-2015

Based on current data and according to the benchmarking, during 2010-2015 studies will focus on energy exchange networks and the islanding of networks that can be supplied by decentralized generation. Studies will probably be done on the potential linking of customers with the network as part of network energy exchanges.

The influence aspect, for its part, will be defined based on the results obtained until 2010 compared to the target objectives and costs. However, it is likely that the VPR will continue to exert an influence on standards due to its favorable position in the electricity distribution field.

4.3.3 2015 – 2020 timeframe

In 2015, the automation program will be completed over the entire distribution system and automation will be in widespread use. Communication technologies will no doubt have become more advanced and should be even lower in cost. However, it is likely that the telecommunications sector will be continuously monitored and will become part of our activities just like the delivery of power is today.

Equipment interoperability standards should be completed.

The controlled island and energy exchange network possibilities will be better known following the developments from 2010 to 2015, and more specific projects will be started up.

The distribution system of the future can therefore be represented as follows:

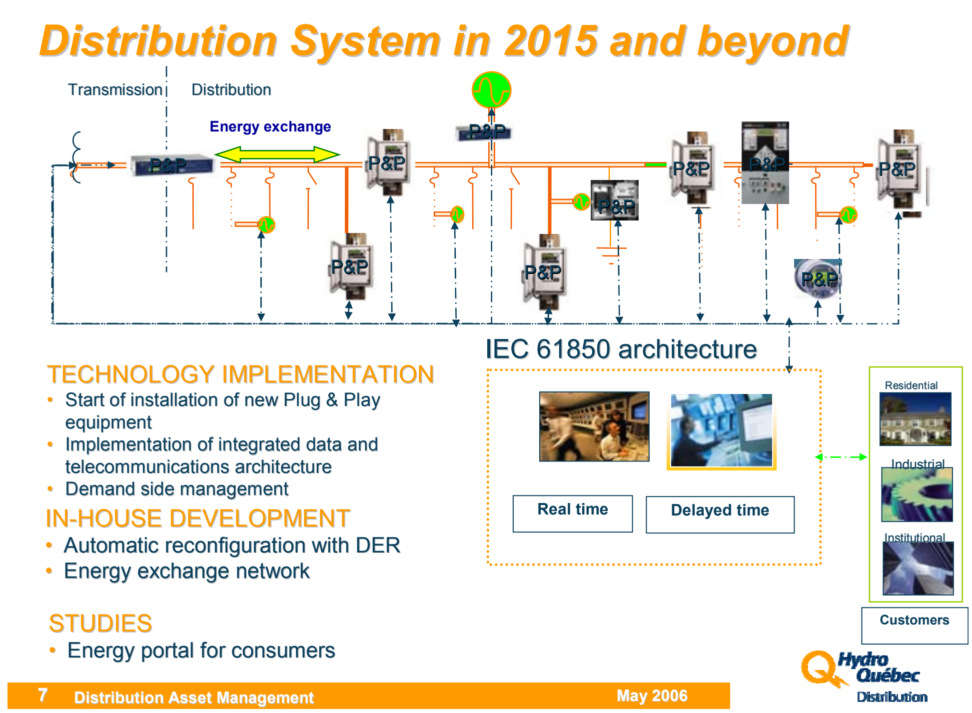

Figure 10: Distribution system in 2015 and beyond – vision of Hydro-Québec's distribution system

5 Conclusion

The automation program authorized by the Régie de l'Énergie in July 2005 has allowed Hydro-Québec Distribution to improve reliability to its customers, as well as set up an infrastructure to upgrade the distribution system to a more intelligent network.

This vision is shared by distribution system experts. In fact, electricity generation and transmission systems are heavily – if not entirely – automated, while distribution systems are only automated to a very small extent. Technological developments, both in terms of technical improvements and cost reduction, have led the distribution system industry to this crossroads.

The *Direction Gestion de l'actif* has presented a vision for the distribution system automation roadmap that is structured, open-ended and flexible and that can adapt to future technological advances and the Quebec context. The development of the distribution system will occur in stages in accordance with a validation process that includes business drivers, applications, the required technologies and the Quebec context.

The overall roadmap for the other areas (e.g. network asset management, load supply, demand forecast, network architecture, network security, apparatus, power system operation) will be drawn up in 2006 jointly with the technical units part of *Direction Maintenance* and *Direction Expertise et Conduite de réseau*, including cooperation with the units part of VP SALC and *Direction Ventes Grandes Entreprises*.

It is crucial that this development take place jointly with manufacturers and standards organizations. In this way, Hydro-Québec Distribution can respond to its business drivers while minimizing costs.

The frameworks produced in 2005 (architecture and automatic control implementations, generation integration standards) were done in accordance with the proposed distribution system upgrading. Furthermore, the possibility of obtaining more information from the distribution system will allow certain safety margins to be reduced in future frameworks, thus allowing better use of current and future distribution system components. The test line erected at IREQ will be used for this purpose.

In summary, it is an open-ended plan that will lead over time to a more intelligent distribution system and thus greater efficiency.

Appendix

Involvement in groups of influence

Group of influence	Group's role	Involvement	Influence
IEEE – Distribution Automation	Sharing of technical knowledge Drafting of IEEE guides and standards	Member in 2005 Secretariat in 2006	General information
CEATI Distribution Asset Life Cycle Management	Cooperative research	Member	Distribution system automation roadmap
CEATI Power Quality Interest Group	Cooperative research	Chairmanship 2005 Member 2006	Technical projects on power quality and automation
CEATI Distribution Automation Task Force	Cooperative research	Member 2006	Group in training; first meeting in March 2006
EPRI Advanced Distribution Automation	Sharing of technical knowledge Cooperative research	Member	First meeting in August 2004 Next meeting in October 2006
International Energy Agency	Cooperative research	Member (sponsored by Natural Resources Canada)	First meeting in November 2005 Specific role to be defined in 2006

In addition to these influences, Hydro-Québec Distribution has been monitoring the distribution system automation field and is aware of large-scale pilot projects such as those listed below:

Project	Comments
Intelligrid – EPRI project	Hydro-Québec is participating in EPRI's Advanced Distribution Automation project 124.005 “First generation Integrated sensor and Monitoring system for ADA”
DV 2010 By a consortium that includes BC Hydro	Hydro-Québec Distribution is following the DV 2010 initiative with interest

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Revisions

January 2006
- Name change for volt var control project for in French "Contrôle asservi de la tension par le réseau de distribution", Page 13 and image page 9

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