RAPPORT D'ÉVALUATION DU PROJET LECTURE À DISTANCE (LAD) D'HYDRO-QUÉBEC DISTRIBUTION D'ACCENTURE – VERSION PUBLIQUE

(VERSION EXPURGÉE DES RENSEIGNEMENTS CONFIDENTIELS)

VERSION TRADUITE EN ANGLAIS

LE RAPPORT D'ÉVALUATION DU PROJET LECTURE À DISTANCE D'HYDRO-QUÉBEC DISTRIBUTION DE ACCENTURE A ÉTÉ TRADUIT EN ANGLAIS POUR FACILITER LES ÉCHANGES DANS LE CADRE DU DOSSIER DE LA RÉGIE R-3770-2011.

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ASSESSMENT REPORT ON HYDRO-QUÉBEC DISTRIBUTION'S "LECTURE A DISTANCE" (LAD) PROJECT

JANUARY 18, 2012

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ENGLISH TRANSLATED VERSION

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1. Introduction

1.1. Accenture and Smart Metering / Grid

1.1.1. Accenture Group

Accenture is a global management consulting, technology services and outsourcing company. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments.

With over 220,000 employees working in over 120 countries, Accenture generated 21.6 billion USD in sales during the fiscal year ending August 31, 2010.

Accenture is recognised by analysts as a leader in information systems integration. With over 230 innovative offerings as well as its world-class network of alliances, Accenture is the world's leading independent integrator.

Accenture operates in many different industries, including the Resources industry, which includes its Utilities practice.

1.1.2. Accenture's Utilities practice

Our experience with electricity, gas and water Utilities goes back to the 1950s and Accenture's first client, Commonwealth Edison Co. – at the time, the largest provider of electricity in the Western United States. With our help, Commonwealth Edison became the very first electricity provider to carry out its billing operations using a large-scale central computer. Since then, our Utilities practice has become increasingly specialised:

- Accenture has over 10,000 professionals in the Utilities industry
- Accenture collaborates with over 300 Utilities in 43 countries
- Accenture serves 40 million Utilities customers (including application outsourcing and business processes) in North America and Europe; every year, 60 million invoices are processed, over 15 million meters are read and over eight million customer requests are processed by Accenture.

Today, Accenture boasts over 50 years of experience with electricity, gas and water companies. Accenture is also very involved in the electricity distribution industry, particularly through world-leading associations and organisations (ex.: EEI, World Economic Forum, Department of Energy & Climate Change, NIST, IEEE, IEC, Gridwise, EPRI).

1.1.3. Accenture's Smart Metering / Grid practice

Over the years, Accenture's Utilities division developed strong expertise in the area of smart networks. Accenture created a dedicated practice, called "Accenture Smart Grid Services (ASGS)." This practice has been responsible for over 100 Smart Metering and Smart Grid projects in more than 20 countries.

The practice's service offering covers 4 areas:

- Smart Distribution
- Smart Transmission
- Smart Engineering
- Smart Customer

In North America, Accenture has over 500 Smart Metering / Smart Grid specialists who support Utilities in their initiatives and who are actively involved in the industry (for example, Smart Grid advisers to the World Economic Forum, "Smart Grid Leadership Network" coordinators, consultants to the IEEE, NIST and IEC).

The practice also publishes numerous white papers and reference reports pertaining to the challenges faced by Utilities in their Smart Metering and Smart Grid initiatives.

1.1.4. List of leading Accenture specialists who contributed to the report

Here is a list of the leading Accenture specialists who contributed to the present report:

Sharon Allan

- Senior Executive in charge of Accenture's global Smart Metering business practice. Over 25 years of experience in technology services.
- Previous experience: several executive positions, including at Elster and ABB

Casey Wells

- Senior Executive in Accenture's North American "Utilities" business practice
- Over 15 years of experience in the fields of Utilities and Energy
- Spent over five years on AMI initiatives – and in particular MDMS systems deployment – in North America and throughout the world

Wade Malcolm

- Senior Executive in Accenture's North American Smart Grid business practice
- Over 25 years of experience in technology services, and in particular in distribution automation networks

Eric Rasmussen

- Senior Executive in Accenture's North American Smart Metering business practice
- Adviser for the "Entergy Smart Meter" project in New Orleans and its territory
- Responsible for delivering the Smart Metering project at Allegheny Energy
- Responsible for the Smart Metering implementation project at Northeast Utilities

Bruno Lafeytaud

- Senior Executive in Accenture's management consulting practice, Utilities industry
- Managed several studies and surveys for AMI projects and technologies

Nathalie Viens

- Senior Manager in Accenture's North American Smart Grid business practice
- Piloted several Smart Grid / "Distribution Automation" opportunities
- Carried out benchmarks for distribution network management operations

Christophe Bouchet

- Senior Manager in Accenture's management consulting practice, Utilities industry
- Managed several AMI initiatives in North America, Europe and Asia
- Specializes in strategy development, organisational design and business case

Geneviève Chartrand

- Consultant in Accenture's North American Smart Grid business practice
- Specialises in AMI deployment projects

1.2. Purpose of the present report

This report's purpose is to provide an assessment of Hydro-Québec Distribution's LAD project, in order to inform the Régie de l'énergie du Québec as relates to document R-3770-2011 (Request for authorisation to execute the LAD project - Phase 1).

Please note that, specifically for this analysis, we brought in Accenture subject matter advisors who are not directly involved in the ongoing consulting mandate which we are carrying out on behalf of the LAD project's management.

This enabled us to bring together, for collaboration purposes, both consultants with in-depth knowledge of Hydro-Québec Distribution's LAD project and international specialists with a broader understanding of the project's overall context.

1.3. Methodology used

To provide an assessment of Hydro-Québec Distribution's LAD project, we felt strongly that the first step should be to introduce electricity measurement activities in general and define Hydro-Québec Distribution's project context, by covering:

- Major observable trends in the industry
- Features common to AMI initiatives, as well as their particularities
- The Smart Grid concept and existing links with AMI projects

We also called upon our recent experiences on other AMI projects in order to identify the industry practices that allow for this type of initiative to succeed.

Our second step consisted in identifying specificities directly related to both the reality of the Québec environment and Hydro-Québec, so that these would be taken into account in our LAD project analysis.

Next, we divided Hydro-Québec Distribution's LAD project into different themes and analysed each of these themes through the lenses of industry practices and past experiences:

- Functional scope
- Project governance and methods
- Acquisition strategy
- Technology choices
- Evolutivity
- Deployment strategy
- Organisation and process
- Internal and external communication
- Preparatory work and pilots

Note: Accenture takes no position, in the present report, as relates to the project's cost-benefit analysis or any other associated financial considerations.

Finally, we gathered all of the report's conclusions and used our observations to produce concrete recommendations for the massive roll-out phase of Hydro-Québec Distribution's LAD project.

2. AMI and Smart Grid - background information

Section not available due to confidential content.

3. Specificity related to the Québec context and Hydro-Québec

3.1. The Québec context

Generation sources mainly based on hydroelectric with reservoirs

While in other countries or States, the production of electricity is generated by nuclear or thermal power plants (gas or coal); the electricity production in Québec is mostly hydroelectric. In addition, the majority of plants that feed the Québec network are storage reservoirs.

Hence, the production may be distributed in a few minutes and can timely meet the daily power demands (ensuring network balancing).

This specificity must be considered when prioritising the development of applications such as "smart grid."

Low electricity fees in comparison to other provinces or States in North America

The electricity prices in Québec are low in comparison to other provinces or States. Hence, the demand management strategies (for example, introduction of differential fees in time) must take into account this specificity.

Development of decentralised and intermittent production capabilities

Wind power-generated production is going to expand in Québec in the next few years. Such production is difficult to predict (due to its intermittent nature) and hence the Québec network will depend more and more on the balance provided by the large hydraulic plants in order to reconcile the inherent variations of this production with the increasing peaks in the local demand.

Even if the local production (coming on the distribution system in medium and low voltage) should increase in the next few years, it should remain marginal and hence have little impact on the state of the distribution system.

Hydro-Québec, a vertically integrated public corporation

Hydro-Québec covers electricity generation, transmission and distribution in the province and is the property of the Québec government. The efficiency of its operations is a major development axis. The diversification of its offers and services, with the purpose to attract more customers, is not a challenge similar to that of competition-open markets.

This specificity must also be considered when prioritising the development of applications such as "Smart Grid."

Currently, the efficiency of Hydro-Québec is at the core of its priorities, while certain aspects (such as demand response and peak management) have less impacts in the Québec context

3.2. Specificity of Hydro-Québec Distribution

An issue of life-expectancy of the meters stock

At the beginning of January 2012, 44% of the Hydro-Québec Distribution meters stock is more than 25 years old and the average age of a meter is 22.4 years.

A new standard of Measurement Canada, which is already in effect for the electronic meters, and will become effective in 2014 for the electromagnetic meters, will tighten the sampling standards. The projections performed demonstrate that Hydro-Québec will have to replace 300,000 meters per year in the next few years pursuant to this very standard.

Hence, Hydro-Québec Distribution will make the best of such opportunity by replacing the majority of its meters stock with AMI meters. In its proactive approach, Hydro-Québec Distribution may also minimise the operational impacts that may occur if the status quo was maintained.

Clear and precise business priorities

The objective of Hydro-Québec Distribution is to improve its operational efficiency as well as the quality of its service. In the latest strategic plan of Hydro-Québec, which covers the 2009-2013 periods, each business unit (generation, transmission and distribution) has defined its own priorities but they all have "performance improvement" as one of their key objectives.

Hence, several investment projects conducted by Hydro-Québec Distribution contribute to operational efficiency.

It is worth noting that the potential of gains from the metering activities is significant at Hydro-Québec Distribution. Indeed, recent benchmarking shows that the company is in the third quartile in terms of costs per customer of the metering process among all the marked public corporations (this information is based on the Hydro-Québec Distribution evidence).

The LAD project is part of the process of improvement of the operational efficiency of Hydro-Québec Distribution by aiming in particular the metering processes

Smart Grid initiatives already ongoing

Hydro-Québec Distribution has already deployed and used various smart electric grid applications, in particular with a view to increasing the reliability and efficiency of the distribution system. Here are a few examples: PARD, CATVAR initiatives, and the "Interactive Network Zone."

PARD program (Distribution System Automation Program)

In 2006, Hydro-Québec Distribution launched a project of automation the sectioning equipment of its distribution system (PARD) in order to reduce the duration of service outages. This equipment communicates, through a telecommunication infrastructure (with information systems that managed the network).

At the end of 2010, 2,500 automated equipments are already deployed on the distribution grid of Hydro-Québec Distribution[1]. The objective is to deploy a total of 3,500 and consequently integrate this type of technology into the current activities.

[1]Source: 2010 annual report of Hydro-Québec

CATVAR project (Distribution System Voltage Regulation and Reactive Power Control)

This project has been launched by Hydro-Québec Distribution with the objective to decrease the energy consumption, through remote management of controlled devices utilizing a public and internal telecommunication infrastructure.

"Interactive Network Zone" (Smart Grid demonstration site)

A special project called "Interactive Network Zone," located in Boucherville, aims to implement a demonstration site for:

- Fault location and automatic service restoration
- Advanced protection (automatic disconnecting switches)
- Charging stations for electric vehicles
- Energy storage (medium voltage and charge ports)
- Decentralised production (solar concentrator)
- Wireless telecommunication technologies (for example Wimax)

Due to its innovating character, this project has been selected to be part of the EPRI Smart Grid demonstration sites.

We should also note that "Smart Grid," in its extended version, also covers the (high voltage) electric transmission system. Nowadays, the main electric companies, including Hydro-Québec, have a highly automated transmission system.

A connection with the AMI infrastructure under study

The three initiatives mentioned above represent for Hydro-Québec Distribution the first concrete actions towards the establishment of a smart grid. Even if these initiatives are not currently based on the AMI network of Hydro-Québec Distribution, studies are currently underway on the potential contribution of the AMI network to Hydro-Québec Distribution other initiatives. To this end, it is worth mentioning that Hydro-Québec Distribution has already launched several projects, such as:

- A study on the fault location function in collaboration with Landis+Gyr team
- A proof of concept for the functionality pertaining to the detection of energy theft (on the medium voltage lines) and using the AMI telecommunication network

These initiatives represent a first step towards the establishment of a smart grid; the LAD project will progressively integrate in due time

4. Evaluation of the LAD project of Hydro-Québec Distribution

4.1. Introduction

The LAD project launched by Hydro-Québec Distribution in 2010 is part of a strategic plan aiming to increase in particular the efficiency of the metering activities. Hydro-Québec Distribution's choice to implement an advanced metering infrastructure (rather than implementing an AMR [advanced meter reading] technology) was a consequence of market observations.

Indeed, the AMI technology progressively became the industry standard. Several market indicators were in favour of the above, mainly:

- The decrease in prices and improvement of technology capabilities
- The electronic switch of the meters manufacturers and the discontinuation of electromechanical meters production in North America
- The regulatory pressure to force deployment of the technology in certain countries / States
- The new expectations of the customers which are increasingly more demanding with respect to their Utility, their more and more "green" awareness as well as their wish to receive diversified, quality and more customised services
- The business requirements of the Utilities, in particular on peak demand management
- The massive use of the technology by the American and European Utilities and the boom of the Asian market

Moreover, AMI would enable Hydro-Québec Distribution to facilitate the integration of Smart Grid components into its electric network. Through the AMI technology, it is effectively possible to implement many optimisation approaches for the electricity distribution activities.

The evolving character of the AMI technology may be mainly explained by:

- The bidirectional nature of the technology
- The performance of the telecommunication network and the analytical capacity of information systems that support the technology
- The addition, through AMI, of measurement points along the AMI network

Finally, even if the motivations behind Hydro-Québec Distribution's initiative to go forward with the acquisition and deployment of an advanced metering infrastructure are closely connected to the company's strategic context (efficiency and cost reduction across all operations), the initial functional perimeter of the project covers the functionalities that are usually targeted on the market.

The following sections deal with the analysis of the LAD project of Hydro-Québec Distribution along with an initial synthesis of the evaluation (section 4.2) followed by a detailed topic-based evaluation (section 4.3).

As a reminder, this evaluation is structured around the following nine topics:

- Functional scope

- Project governance and methods
- Acquisition strategy
- Technology choices
- Evolution and scalability
- Deployment strategy
- Organisation and process
- Internal and external communication
- Preparatory work and pilot

4.2. Summary of the evaluation

A summary of the evaluation of the LAD project of Hydro-Québec Distribution is presented in a table on the following pages. This summary, built around the nine analysis topics, is based on the good practices outlined in this report and lists the main points of our analysis of Hydro-Québec Distribution LAD project, divided into two categories (strong points and recommendations).

	AMI good practices	Evaluation of the Hydro-Québec Distribution's LAD project	
		Observations	Recommendations
Functional perimeter	*Not available due to confidential content*	− The initial scope has been set and aligned with the business requirements − The possibility to develop additional functionalities has been considered	− Continuing to focus on the initial scope and plan the development of complementary functionalities, according to business priorities
Project governance and methods		− A structured governance framework has been implemented, including a project management office − IT, Telecom and HR specialists have been appointed for the project (part of the operational structure)	− Focusing on the project mode for the massive deployment phase in order to improve the overall swiftness and coherence
Acquisition strategy		− A rigorous acquisition process has been established and monitored − The request for proposals have been safely launched (firm commitments, fixed prices) − The best companies answered and submitted their solutions	− Keep playing the role of partner's integrator and lead, in particular with respect to the service level agreement indicator of the various contracts

	AMI good practices	Evaluation of the Hydro-Québec Distribution's LAD project	
		Observations	Good points
Technology choices	*Not available due to confidential content*	− The technological choices have been largely influenced by the market trends of North America (for example the RF mesh networks, the ZigBee protocol) − A selection of the "best of breed" solutions has been completed − The two brands of the retained meters have already proven their interoperability	− Monitoring and contextualising the evolution of the MDMS development scope - Due to its flexible and configurable nature, HQ has to be careful in limiting the operating costs
Evolution and scalability		− To cover the initial scope, the AMI system uses less than 5% of the total bandwidth − Promising work on advanced functionalities is currently underway (fault detection and localisation, theft management)	− Integrating the AMI network with other Smart Grid applications whenever possible − Continuing the NAN [near-me area network] tests and measurements (latency time, reactivity and security)
Deployment strategy		− Hydro-Québec Distribution is responsible for the deployment and has a plan of involving its suppliers to optimize the approach − The telecommunication networks has been deployed early − Deployment area prioritisation has been made to demonstrate early benefits	− Ensuring proactive external communication, highlighting the main events of the massive deployment, in order to facilitate customers support (or at least their neutrality) − Refining the complaint management system

	Good practice related to the AMI initiatives	Evaluation of the LAD project of Hydro-Québec Distribution	
		Observations	**Recommendations**
Organisation and process	*Not available due to confidential content*	− A dedicated metering operating center (MOC) is implemented - its organisation and operation are based on industry good practices of the industry − The future AMI operators are involved in processes and tools definition	− Consolidating MOC strategy allocation and operational procedures before massive deployment − Outlining the transition steps towards the nominal (basic) operating mode
Internal and external communication		− The internal entities are aligned on a common vision of the LAD project objectives and challenges − External communication is currently limited but mastered − A more ambitious and proactive external communication plan must be launched as soon as the Energy Board has made their decision	− Being proactive and disseminating information about the anticipated changes, while focusing on the tangible benefits for the customers

	Good practice related to the AMI initiatives	Evaluation of the LAD project of Hydro-Québec Distribution	
		Observations	**Recommendations**
Preparatory work and pilot	*Not available due to confidential content*	− The various aspects of the project have been analysed, tested and tweaked − A sound plan has been followed − The appropriate Hydro-Québec entities have been mobilised − Laboratory tests as well as several representative pilot projects have been successfully conducted − The interoperability of the end-to-end system has been checked − The review of the data integrity (billing) has been emphasised − The (modified and new) business processes have been properly used and stabilised	− Capitalising on the lessons learned of the preparatory work in order to refine the massive deployment strategies − Improving the knowledge about the NAN network, in particular the interactivity and dynamics of the RF mesh network and the reliability of command center − Continuing the studies and proofs of concept on the advanced functionalities (for example, energy theft, fault location), and initiating the link with the related activities (for example, network usage and customer-relation experience)

4.3. Detailed topic-based evaluation

4.3.1. Functional perimeter

The Hydro-Québec Distribution LAD project's scopes include the basis functionalities of an AMI system, i.e. remote reading (and the related consumption profile management) and connect/disconnect functions.

Hydro-Québec Distribution followed the industry practices and the various lessons learned available by clearly highlighting the scope of its project early on. The advantage of the above is the ability to focus on development of precise functionalities and being able to stay on track with the business case.

This functional perimeter is directly linked to the specificity and business requirements of Hydro-Québec Distribution (oriented towards operational efficiency) whose objective is to obtain short-term tangible benefits.

It is worth recalling that, regarding the launch of an AMI initiative and the choice of the initial functional scope, precise motivations depend on each Utility and on its particular context:

> *For example, in Brazil and Italy, the functionality of energy theft has been included in the initial scope in order to reduce the significant number of cases, such initiative taking place as soon as the AMI system has been deployed.*
>
> *Another example is Florida and Oklahoma who, within the scope of their AMI initiatives, wished to develop functionalities for fault location, due to a continuity index which was lower than the average of the sector.*
>
> *As for California and Ontario, which have specific energy contexts, the governments pushed for the introduction of time of use tariffs, and this as of the installation of the first AMI meters, with a view to better managing the peak demands and enabling better management of the energy demand.*

In addition, in Québec, the regulatory context is not prescriptive in this matter and hence, Hydro-Québec Distribution retained the functional perimeter that best meet its business requirements and leads to the improvement of customer satisfaction.

Even if all of the advanced functionalities, made possible by the AMI technology, are not necessarily obvious in the current Québec context (for example, implementation of differential tariffs in time in order to manage the peak demand), Hydro-Québec Distribution wished to ensure it was possible to validate the possibility of developing them at a later time, if applicable and required (see section 4.3.5 on evolution and scalability).

To this end, it is worth noting that Hydro-Québec Distribution has already launched several proof of concept projects, in particular:

- A study on the fault management function in collaboration with the technical teams of the provider of the advanced metering infrastructure solution (Landis+Gyr)

- A proof of concept for the functionality pertaining to the energy theft (on the medium voltage lines), using the telecommunication network and the AMI head-end system

More generally and as previously mentioned in this report, AMI projects should not be mistaken with the Smart Grid visions of some Utilities.

The AMI initiatives must definitely align with a bigger Smart Grid roadmap and action plan in order to make technological choices that do not compromise the development of future functionalities. It is entirely sensible to limit and clearly set the initial scope of the AMI project in order to deliver the expected benefits.

The development of advanced functionalities, going beyond the initial scope, must be subject to an opportunity analysis and demonstrate benefit from the initial investment made in the advanced metering infrastructure. A proper integration of the various entities of Hydro-Québec involved will be necessary in order to obtain all the anticipated benefits. Hydro-Québec Distribution must however first concentrate on the initial scope of its opportunity analysis before studying, on a per-case basis, the development of advanced functionalities.

The functional scope of the LAD project is directly linked to the specificity and business requirements of Hydro-Québec Distribution whose objective is to obtain tangible benefits.

4.3.2. Project governance and methods

The execution of the LAD project works requires the mobilisation and synchronisation of a significant number of internal and external participants of Hydro-Québec Distribution. In order to make this possible, Hydro-Québec Distribution implemented a structured **governance framework** which would allow sharing the information, to address risks and make decisions based on concerted opinions.

This framework consists of the following governance bodies (by order of importance):

The ultimate decision-making body: the board of directors of Hydro-Québec

The project governance bodies:

- The LAD executive committee
- The LAD steering committee

The project management bodies:

- The LAD project committee

- The LAD coordination committee

The operational activity bodies:

- The steering committee
- The operational watch

Each of the bodies listed above has a defined scope of responsibilities and ratifies the positions proposed by the subordinated body.

There are working groups for each one of these bodies, whose objectives are to identify, propose and then operationalize solutions with specific topics (for example integration of the solution, pilot projects, deployment strategy).

In order to animate this governance system, Hydro-Québec Distribution implemented a **project management office** whose objectives are:

- To update a registry of outstanding issues
- To be the warrant of the decisions made
- To define the charts of activities (deliverables, schedules, roles, responsibilities, etc.)
- To supervise and mitigate the project risks
- To generate the status reports and project management dashboard

It is worth noting that the governance structure as described above has been adapted following the project progress, the nature of the activities, or the phase of the works. Here are a few examples:

- Evaluation committees and sub-committees existed during the periods of evaluation of the responses to the request for proposals in order to ensure the integrity, rigor and objectivity of the approaches
- In spring 2011, the integration and deployment work groups have been highly involved in implementing the pilot projects based on the pre-established schedules
- In the summer of 2011, once the pilot projects had started, operational watch groups have been established at a more or less significant pace, depending on the issues raised

When the massive deployment starts (and when the number of meters deployed increases), Hydro-Québec Distribution will need to operate more and more in project mode in order to animate all entities involved, to align the contract management activities, to ensure the coherence in the deployment of telecommunications and meters, and to meet the challenges of customer management and AMI solution operations. We should note however that Hydro-Québec, since the beginning of the LAD project, has successfully mobilised the operational structure of the internal staff, which provided the expertise required in the critical fields of IT (information technology), Telecom (telecommunications) and HR (human resources).

The establishment of a solid management structure, with tasks and responsibilities as well as the rules of business are clearly defined and respected, and therefore remain a key factor in the implementation of the LAD project striving to prepare for the challenges to come.

In the interest of operational efficiency, the discipline and flexibility of the governance structure implemented at Hydro-Québec Distribution must be maintained.

4.3.3. Acquisition strategy

It is important to understand that Hydro-Québec Distribution plays the role of the main integrator, as well as the project manager of the program. Consequently, Hydro-Québec Distribution has, first and foremost, prepared an acquisition program as well as an integrated structure, to help it sustain its AMI approach.

The business requirements have been clearly defined and communicated. Furthermore, there has been a validation of these requirements at each key stage of AMI implementation.

The acquisition of advanced functional end-to-end measurement tools were divided into four main sections. Four tenders were subsequently launched sequentially, namely:

- The acquisition of a MDMS (“Meter Data Management System”) including the integration with Hydro-Québec Distribution systems, at a fixed-price, by a system integrator
- The purchase of meters, NAN (“Neighbourhood Area Network”) telecommunication systems, basic AMI network technology equipment and installation systems at a set price
- Selection of an installation service provider
- The choice of network telecommunication technology for WAN (“Wide Area Network”)

The structure of tenders was based on internal constraints as well as on the intention to deal with the best companies in the domain, without ignoring any of the initial requirements. Furthermore, the fact that a company has been selected for one tender does not presuppose that it will be selected for another.

Such approach has allowed Hydro-Québec Distribution to diversify the offers, without being exclusive, ensuring the best expertise for each tender available on the market.

Based on this strategy, for the second tender, Hydro-Québec Distribution required the purchase of meters and NAN telecommunication systems to be included, in order to enable the main supplier to act as a guarantor of the AMI solution. It ought to be mentioned that not all suppliers of AMI solutions are able to provide both these components and in some cases, two separate suppliers are required.

Hydro-Québec Distribution also requires that the AMI solution should incorporate two meter suppliers (one main supplier, for a maximum of 80% of total meters, and a second supplier for at least 20% of meters) reducing the risk of a shortage in technology or supplies.

The level of service and requirements were both clearly identified in the tender instructions, facilitating the selection of successful candidates and negotiation of the contracts. Furthermore, in its acquisition strategy, Hydro-Québec Distribution required from the contractors, at several stages, to make formal commitment, which allowed for a more thorough assessment of candidates.

> For example, a set price for AMI country-wide coverage (100%) including all known meters, at a set, capped price (at supplier's cost), a maximum number of additional routers, at a set rate based on individual meter installation (obligatory cost breakdown per main activities) were all required.

Throughout the acquisition process, from putting together a tender to signing of a contract, Hydro-Québec Distribution adheres to strict rules. Technical specifications included in the tender are arranged in a matrix mode by specialist groups, from Hydro-Québec different units, ensuring an optimal alignment of tender requirements. These specialist groups defined the specifications for individual technological components based on a logical sequence, with a focus on clear and uniform expression of Hydro-Québec Distribution requirements:

- High level requirement definition
- Definition of usage scenarios
- Description of the required functions

The same group was then used to conduct a meticulous analysis of the submitted tenders.

The preparation of the contractual clauses was carried out by another group of Hydro-Québec, and separate approval procedures were set for each tender.

Confidentiality of information processed as part of these procedures was also subject to good practices imposed by Hydro-Québec Distribution. For example, all information relative to the preparation of tenders was carried out over a secure intranet.

During the evaluation phase, only a small, designated group of individuals had access to financial information on the candidates, which would be filed in a special sealed envelope, provided as part of the technical tender, and analysed after the completion of technical evaluation.

By imposing a rigorous acquisition procedure, Hydro-Québec Distribution has, therefore, ensured that only the best quality offers were accepted and that the choices made were clear. Hydro-Québec Distribution must remain vigilant in terms of internal operational structure when it comes to large-scale deployment in order to fulfill its role as the project manager of the solution, notably where it concerns the monitoring of adherence to the contractual obligations of various partner organisations.

By segmenting the tenders and acting as the integrator of the IMA solutions applied, Hydro-Québec Distribution ensured respect of its security principles.

4.3.4. Technology choices

In this section, we will review the main technological choices made by Hydro-Québec Distribution for its AMI infrastructure, that is to say:

- MDMS ("Meter Data Management System")
- The meters and NAN telecommunication networks ("Neighbourhood Area Network")
- WAN ("Wide Area Network") telecommunication networks

MDMS

Ericsson has been selected as the integrator for the MDMS (EnergyICT). This product was chosen mainly for its flexibility, its open platform, its configuration diversity, its functions and the commercial terms offered.

Hydro-Québec Distribution's choice was in line with its acquisition strategy, the decided technological architecture and the overall solution structure. It ought to be pointed out that the EnergyICT MDMS was quoted by Gartner[2], in 2010, amongst "10 top of mind vendors" on the American market also appearing in another independent review of MDMS suppliers, with best growth potential.

The acquisition of EnergyICT, in autumn 2009, by Elster who is one of the key players on AMI market, contributed to a reinforcement of the company's financial credibility as well as certainty over the future development of their systems.

In late 2011, Gartner[3] predicts that EnergyICT has a capacity for a 30% increase in the number of new contracts, compared to previous years, confirming the growth potential of this supplier, identifying them as one of the best placed suppliers on the market to achieve such growth.

Nevertheless, whilst Hydro-Québec Distribution remains confident that MDMS systems have not yet reached maturity on the market and that Energy ICT's product is flexible and open, it is important to continue to monitor and analyse the considered functionality scope.

Meters and NAN telecommunication networks

For the provision of meters, NAN telecommunication networks ("Neighbourhood Area Network") and basic technological equipment for AMI networks (e.g. collectors and head-end) Hydro-Québec Distribution initially relied on main suppliers. Subsequently, a secondary, meter supplier was selected.

Considering the size of the North American market segment controlled by Hydro-Québec Distribution (with some 3,75 million meters), all considerable AMI suppliers applied to the pre-tender qualifying call.

In their tender, Hydro-Québec Distribution unambiguously stated its commitment to radio-frequency (RF) grid technology, however, without excluding other AMI technologies. Hydro-Québec Distribution was looking to align itself with the current market trends, where RF grid technologies are the preferred technology for AMI systems in North America.

Similarly, Hydro-Québec Distribution requested for all meters to include a ZigBee information card (which, according to a study conducted by Chartwell in 2010, amongst 138 electric component

[2] © Gartner: "Magic Quadrant for Meter Data Management Products" (December 2010)
[3] © Gartner: "Magic Quadrant for Meter Data Management Products" (December 2011)

suppliers[4], uses the HAN protocol - "Home Area Network" - the most widely used) on which future development of AMI networks will be based. Compliance with high-level security norms, such as NISTIR 7628 and NEMA SG-IMA 1-2009, was also required from the suppliers. Furthermore, the supplier selected by Hydro-Québec provides a high level of security in terms of both the data transfer and network information. The selected AMI solution, furthermore, uses advanced encryption mechanisms: encoding keys generated several times in various key segments of the AMI network; split data packages for sending over the AMI network which are reassembled only when reaching the head-end system. For the acquisition of meters, the conformity with the regulations of Measurement Canada and ANSI C12 norms was required. For telecommunications, compliance with Canadian Industrial Standards was also required.

By acquiring meters from two suppliers in a two-step process, Hydro-Québec Distribution dealt with the compatibility issues often encountered in AMI technologies. In order to avoid these issues, Hydro-Québec Distribution included contractual terms and conditions encouraging compatibility between tendered equipment, minimising the risks. Consequently, two main suppliers on the market (Landis+Gyr and Elster) came together to offer and integrate one's technology (information card) with that provided by the other.

Finally, Landis+Gyr were proven the most beneficial of the suppliers of meters and NAN technology, as well as the auxiliary equipment for AMI networks (data collectors and head-end systems) for Hydro-Québec Distribution, as they met the stated requirements whilst offering competitive rates. In a recent report by IDC Energy Insights[5] asserts Landis+Gyr's leading market position in 2011 in North America.

WAN telecommunication networks

The last technological task Hydro-Québec Distribution had to make was to choose a provider for WAN ("Wide Area Network") providing a basis for data traffic between the collectors and head-end systems.

By proposing a high-performance solution, combining cellular (in most cases) and satellite information technologies, in order to ensure a thorough coverage of the Québec province, Rogers was selected for its reliability, speed and the ease of installation.

The balance between the cost and the quality of the service proposed, as well as the data transfer security were some of the strong points of Rogers' product.

In brief, one could say that Hydro-Québec Distribution implemented the "best of breed" approach in its choice of technologies.

The technological choices made by Hydro-Québec Distribution are in line with the market trends, ensuring that the technology acquired is a "best of breed" future-proof AMI technology

[4] © Copyright Chartwell "Smart Grid Series: Communications Networks" (March 2011)
[5] © Copyright "IDC MarketScape: North American AMI information Network 2011 Vendor Assessment" (2011)

4.3.5. Evolution and scalability

First and foremost, let us reassert, once more, that AMI systems are above all, measurement mechanisms, and that the addition of advanced functions should be decided upon on a case-to-case basis, founded on a positive business case.

To this end, let us also state that Hydro-Québec Distribution has already undertaken several steps in two advanced functionality directions:

- Outage management : a preliminary study was conducted, in collaboration with the suppliers' technical teams, examining their advanced measuring infrastructure solution (Landis+Gyr)
- Theft detection : a test on medium tension lines which, to date, provided very encouraging results

Furthermore, relying on such technological choices, Hydro-Québec Distribution sought to keep many options available in order to develop other advanced functions in the future.

For example, in its tender for the purchase of meters and NAN technology, Hydro-Québec Distribution also defined its future requirements, demanding that they are met by the chosen AMI solution. Notably, we can point out the request to include a ZigBee card, in the meters, enabling the equipment, where necessary, to use the HAN protocol ("Home Area Network") as well as the feature allowing the meter's individual components to be reconfigured remotely (in simultaneous broadcast).

Once Landis+Gyr was selected, Hydro-Québec Distribution proceeded to analyse the potential for advanced features of Landis+Gyr's NAN network "GridStream," furthermore, as well as the possibility of using the system for purposes other than transfer of profile and consumption logging data (e.g.: measurement of voltage, operation of current breakers etc).

Below are several conclusions drawn recently, concerning the selected AMI solution and its scalability:

- The portion of the bandwidth used to transfer profiles and logs accounts for less than 5% of the overall capacity.
- The "GridStream" network can be re-gridded dynamically, querying the meters to obtain information such as current presence and/or its level, to transmit information on added value such as the "last gasp" from the acquisition head-end system, which could enable the addition of future functions.

In order to provide a greater number of advanced functions and to integrate Smart Grid components into its AMI network, Hydro-Québec Distribution should focus on their integration and group them by type of functionalities. One such example is the analysis of the functions relative to the operation of electric grid, fault location and restoration.

However, before proceeding to large-scale development of new AMI functions (future functions), Hydro-Québec Distribution it should further analyse the "GridStream" network as well as continue testing, notably in the initial period, the reactivity level as well as security.

Hydro-Québec Distribution's IMA network capability for providing new advanced functions should be ensured in accordance with the strategy and in stages

4.3.6. Deployment strategy

In the implementation of the advanced measuring structure in its grid network, Hydro-Québec Distribution applied established market practices, starting with the installation of the telecommunication network (routers and collectors) and then proceeded with the installation of meters.

Such an approach is ideal as it allows for the AMI network to gradually integrate measuring centers, consolidating the grid, which can be readily identified remotely, without compromising the network robustness. In this way, Hydro-Québec Distribution can control specific efficiency gains, obtained through remote reading of meters as soon as they are installed.

Implementation of the AMI telecommunication structure

The deployment of AMI telecommunication infrastructure is based notably on a risk-mitigation strategy, following industry practices.

The implementation of an AMI telecommunication infrastructure (routers and collectors) consists of several stages, starting with the design of the AMI network architecture for a given region.

Hydro-Québec Distribution has required, in its contract that the official architecture of the AMI network should be a priori produced for each new region, as earmarked for implementation.

In order to draw up a conceptual architecture, the supplier's work is subject to rounds of validation. Furthermore, it was Hydro-Québec Distribution that decided on the installation of collector(s), based on availability and proximity of premises belonging to Hydro-Québec Distribution and the installation of routers, based on local environmental criteria and town planning.

In this way, the collectors are placed primarily in secure locations, accessible to Hydro-Québec Distribution (distribution centers, Hydro-Québec Distribution's information beacons, public and parapublic building roofs). Hydro-Québec Distribution's level of control on these devices is then maximised.

The routers, on the other hand, are installed in a way that is most accommodating for urban environment and its inhabitants. Nevertheless, Hydro-Québec Distribution and its provider is sometimes forced to find a compromise in locating a critical location, to reinforce the mesh network.

In general, as soon as the placement for a collector has been approved by both parties, Hydro-Québec Distribution can go ahead with the installation of both the collector and the surrounding routers. In the final stage, once all equipment has been installed, the supplier will carry out performance tests, whereby some routers may be moved, based on the test results, in order to optimise the AMI network performance.

Installation of AMI meters

The installation of AMI meters is also organised in a manner ensuring the quickest achievement of benefits, where higher density zones are prioritized.

Such approach, based on meter installation, categorized into three main categories (urban, semi-urban and rural) allows Hydro-Québec Distribution to place the AMI technology in those areas

which are most predisposed for grid configuration (urban areas). In the second tender, for the acquisition of meters, NAN telecommunication systems and AMI systems, Hydro-Québec Distribution acted wisely by leaving the rural and isolated areas for the very end of the installation schedule, assuming that a grid AMI technology would mature over the years, its performance in such areas becoming higher.

Always conscious of the need for rapid benefits, taking into account organisational constraints, the full installation plan of all meters (3.75 Million items) provided by Hydro-Québec Distribution was scheduled over a 5 years period. In order to achieve this, due to the lack of sufficient internal resources, Hydro-Québec Distribution called a tender, for contracting the installation services, and chose Capgemini Québec as the service provider. Bound by a turnkey contract, the contractor is responsible not only for the installation of the majority of meters in urban and semi-urban areas, but also for providing a request management center, in charge of scheduling appointments, as well as the logistical support for storage and transportation of meters from the depot to the place of installation.

Hydro-Québec Distribution decision to take on the role of supervisor was wise as such setup allowed a higher control of the sequence of high-level installation, was able to meet internal constraints (set invoicing period, availability of skilled workforce etc.) as well as monitored the installation and handled more complex installation cases. We saw that the installation strategy was refined with the launch of the pilot projects, allowing Hydro-Québec Distribution to better understand the impact of the installation activities on its operations.

Hydro-Québec Distribution adopted a strategy which ensures the company's control over the installation with maximum involvement of the suppliers

4.3.7. Organisation and process

In the beginning of the program, late 2010, the LAD project consisted of two functional units, "Technical processes and pilot projects" and "Installation and Exploitation Measuring Center (CEM)," as well as a transversal unit, the "Project Office" (see section 4.3.2 - Project management and mode).

Hydro-Québec Distribution judiciously secured dedicated resources right from the outset, such as TI, Telecom and HR, on the project.

During 2011, with the completion of pilot projects, the structure of the LAD project was transformed. The Installation and Exploitation Measuring Center units were reorganised into two distinct units. The Installation unit took over the installation activities while the CEM looked after operations and monitoring of AMI components.

Installation and strategic planning

For pilot projects, the tasks of meter installation and coordination with the providers were entrusted to the Installation unit whilst those pertaining to certification of instruments, technical

tests on the AMI network and the installation of telecommunication devices were given to the Technical Processes and Pilot Project unit. For wide-scale deployment, the same tasks distribution will apply with the only one difference being that the Installation unit will also look after the strategic planning for the installation of the AMI system.

By the end of 2011, Hydro-Québec Distribution also delegated the strategic planning for the current operations to the Installation unit which is now referred to as "Installation and Strategic Planning". As long as the installation of the AMI system is not completed, this unit will continue to implement the process, maintaining a clear distinction between its current operations planning activities and AMI installation. Furthermore, amongst the challenges identified by the Installation unit, for a large-scale installation, are the implementation of a close follow-up process with the provider, as well as the internal customer services and information. To date, the Installation unit has managed to successfully involve internal partners in order to ensuring the implementation of operational adjustments needed for pilot projects.

Exploitation Measuring Center (CEM)

Since this is a new functional unit in Hydro-Québec`s Distribution organization, the CEM unit relied on the industry's best practices to design its target organization. Benchmarks have been performed and on site visits to other Utilities (more advanced in the AMI deployment) will take place in early 2012 in order to share best practices and lessons learned.

To date, the target structure of AMI's exploitation is based on two main activities (below), sharing functional expertise:

- Data acquisition
- Data management (service provision)

Since the start of the pilots projects in the summer of 2011, the development of a cross functional expertise in this field was facilitated and accelerated by the integration of an experienced operator team into the CEM unit; they were familiar with this kind of activities has they were operating the C&I remote meter system. The role of coordinators was created, to ensure that the synchronisation of operations and transverse units (especially IT and Telecom) is running well.

As the CEM is at the same time involved in the exploitation of meters which have already been installed (as part of the pilot projects) and in project definition and setting up of tools (ticketing, knowledge base, MDMS data management), the challenge for this unit is to develop the skills of its staff in a uniform manner.

Given the low volume of meters deployed to date, the CEM has so far been successful managing future operator's involvement in the definition of processes and tools.

The CEM should, however, redefine its allocation strategy, for the large-scale installation in 2012. Moreover, the new processes aiming to provide the new CEM services as well as the precise transition terms towards a pure exploitation mode should be clearly defined. The current CEM organization is still not at risk: there is a good understanding of future challenges (notably the management of increased volumes) and the resources needed to overcome them have been identified and planned.

Hydro-Québec Distribution can already proceed with large scale installation, with the existing organisation, however, certain processes could still be defined or clarified

4.3.8. Internal and external communication

A communication strategy, covering both the external and internal aspects of this sector has been developed as part of the LAD project.

Internal communication

There was a requirement to maintain the confidentiality of information during the acquisition period; information was always kept at a very high level from the outset of the project, mainly in the form of formal newsletters, even though a personalised intranet site was created on the project in 2010. Explanatory brochures were distributed to all employees, over the intranet. Several presentations of the project were made to executives, through management committees, to allow them to familiarise themselves with the project.

External communication

The external communication strategy was launched with an announcement of the technological choices in the press; it was made by top management of Hydro-Québec Distribution, in the spring of 2011. Then, there has been the launch of pilot projects and since the main objective has been to ensure local acceptability for the AMI installation project. The external information strategy is concentrated on the groups directly affected by the installation: municipalities and clients.

Hydro-Québec Distribution has been responsive to questions asked by journalists, as well as providing an open access web site, explaining the main features of the projects.

Hydro-Québec Distribution plans to intensify its communication effort once the official announcement of the project approval will be made by the Energy Regulator. Hydro-Québec Distribution considers the current project phase as a pilot phase, using it to reconsolidate its practices and procedures. A proactive communication approach, placing the client at the heart of the efforts will be progressively implemented.

Certain points remain to be refined and particularly at the distribution level, proactively, information on anticipated changes, focusing on the tangible benefits for customers.

The information effort already made will be refined, as experience is gathered from pilot programs, with the view to providing better support for a large scale deployment

4.3.9. Preparatory work and pilots

4.3.9.1. The scope of preparatory works

Hydro-Québec Distribution launched its LAD project two years ago. During this period, numerous preparatory works have been carried out, based on the overall schedule, in a logical order of activities. Amongst these works the following are noted:

- The acquisition of a MDMS and head-end system, as well as their integration into Hydro-Québec's technological infrastructure
- The selection of a group of partners (meter manufacturers, telecommunication network suppliers, installation service providers etc)
- Testing of AMI components, through the implementation of pilot projects
- Defining the installation strategy
- Designing and implementation of operational processes both transitory and final

Initially, Hydro-Québec Distribution wished to select its Meter Data Management System (MDMS) in order to initiate at the earliest the IT work of integration with existing systems, which often take a long time.

> *Certain AMI projects in which the IT works were underestimated, are finding themselves in a more or less long transition period, with AMI meters installed on the ground, incapable of communicating or being integrated with the company's "back-office" information systems (such as the invoicing systems).*

Hydro-Québec Distribution then launched the chosen meters and NAN telecommunication networks ("Neighbourhood Area Network") in order to ascertain how these two components would integrate. Then, the selection of partners, who would look after the installation of meters and WAN telecommunication networks ("Wide Area Network"), was made.

Pilot projects were launched at the same time to carry out operational pilots, and test the AMI solution end-to-end, both from a technical and an organisational point of view.

Furthermore, the project teams also used this period to define the deployment strategy as well as design and implement transitory and end-state operational processes.

The preparatory works involved all aspects of the project allowing the large scale installation stage, to be approached in the most prudent fashion

4.3.9.2. Pilot projects

As part of preparatory work, Hydro-Québec Distribution dedicated major efforts to testing activities by conducting laboratory tests and conducting several pilot projects.

These activities are an important added-value preparation step for Hydro-Québec Distribution that can thus take the time to stabilise its business procedures and gradually integrate the AMI solution generally.

- Laboratory tests (prior to the completion of pilot projects) have allowed Hydro-Québec Distribution to become familiar with the AMI solution, to partially approve the meters and to partially certify the AMI equipment at the level of security and ICT (Information and Communications Technologies)
- Pilot projects were carried out in three separate territories in order to have samples representing the base of meters served by Hydro-Québec Distribution:
    - A first pilot on the order of 5,000 meters started in June 2011 at Boucherville (semi-urban setting, residential and industrial meters)
    - A second pilot project of smaller scale, approximately 1,500 meters, was launched in the month of August 2011 in the Memphrémagog MRC (regional county municipality) (rural setting, lots of vegetation)
    - A third pilot project targeting approximately 19,000 meters was launched in September 2011 in the Villeray neighbourhood in Montreal (urban setting, mostly indoor residential meters)

The duration of these pilot projects is not a criterion of importance. Let's remember that the total duration of this preparatory work conducted by Hydro-Québec Distribution (two years) is comparable to what can be seen elsewhere.

The volume and especially the representativeness of installation types (e.g.: outdoor/indoor meters) and the areas selected for these pilot projects (e.g. rural/urban) are important criteria for a real-life experiment on all used cases that will occur in a large-scale deployment. Hydro-Québec Distribution covered an adequate number of meters (more that 25,000) and conducted pilot projects in geographic locations representative of the Québec province landscape.

Beyond these several pre-requirements, an assessment of the pilot projects was performed, in the pages hereafter, on the basis of main requirement to be validated in the pilot phases of the AMI projects (diagram below). This list is a summary of our many experiences.

Principal requirements to be validated during the pilot phases of AMI projects

1 Ensure the integration and robustness of the **SYSTEM**

- 1.1 **Integration** : tests from beginning to end (meters-NAN-collectors-FA-MDMS-« back-office » systems)
- 1.2 **Performance**: simulation of the targetted volumes (on all the elements listed above)
- 1.3 **Security** : specially intrusion tests on the NAN and WAN networks

2 Check out the coverage of the **FUNCTIONALITIES** of the initial scope

- 2.1 **Operation**: functional tests and validation of the data outputs
  - 2.1a Remote reading
  - 2.1b Connection /disconnection
- 2.2 **Integration**: data integrity tests (specially billing)

3 Strengthen the **ROLLOUT METHODS**

Rollout of meters:

- 3.1 **Planning**: scheduling of installation, evaluation beyond the load envisaged
- 3.2 **Performance** : installation time, level achieved/envisaged, volumes in exceptional cases
- 3.3 **Quality** : feedback on customer satisfaction surveys, complaints and claims, quality assurance

Network deployment:

- 3.4 **Homologation**: process of homologation of the devices
- 3.5 **Planning** : specially network topologie

4 Test the **ORGANIZATION** and the operational **PROCESSES**

- 4.1 **Process of rollout** :supply chain management, installation/removal, recycling, customer service
- 4.2 **Operating processes** :operations center with its transitional and target processes
- 4.3 **Supplier relations** : management of contracts, penalties

5 Evaluate the means of external **COMMUNICATION**

- 5.1 **Proactive mode**: information on the project, the conditions of installation, the benefits for the customers
- 5.2 **Reactive Mode**: management of media and critics (reaction time, execution quality)

6 Confirm/update the parameters of the **BUSINESS CASE**

- 6.1 **Cost parameters**: value of the contracts, revalued internal costs
- 6.2 **Benefits parameters**: revalued benefits envisaged

7 Show scalability of the system through **PROOF OF CONCEPT**

- 7.1 **Demonstration or model mode**: on certain advanced functionalities

Diagram 1 - Main requirements to validate in the pilot phases of AMI projects

You will find the following here below:

- A summary of the evaluation of the Hydro-Québec Distribution pilot phases (level of coverage of the requirements presented above)
- A specific analysis for each of the categories of requirements listed above.

Summary of the analysis of the evaluation of the pilot phases of Hydro-Québec Distribution:

The pilot phases were concentrated on the validation of certain technical aspects of the AMI solution and gradually integrated the functional changes within the company before focusing on validating the organisational aspects of the solution.

As shown in the diagram below, most requirements were well covered by Hydro-Québec Distribution during its pilot projects phase and nothing of major importance was left out. The third pilot project is still underway and some subjects not yet totally tested will be completed before the phase of major large-scale deployment.

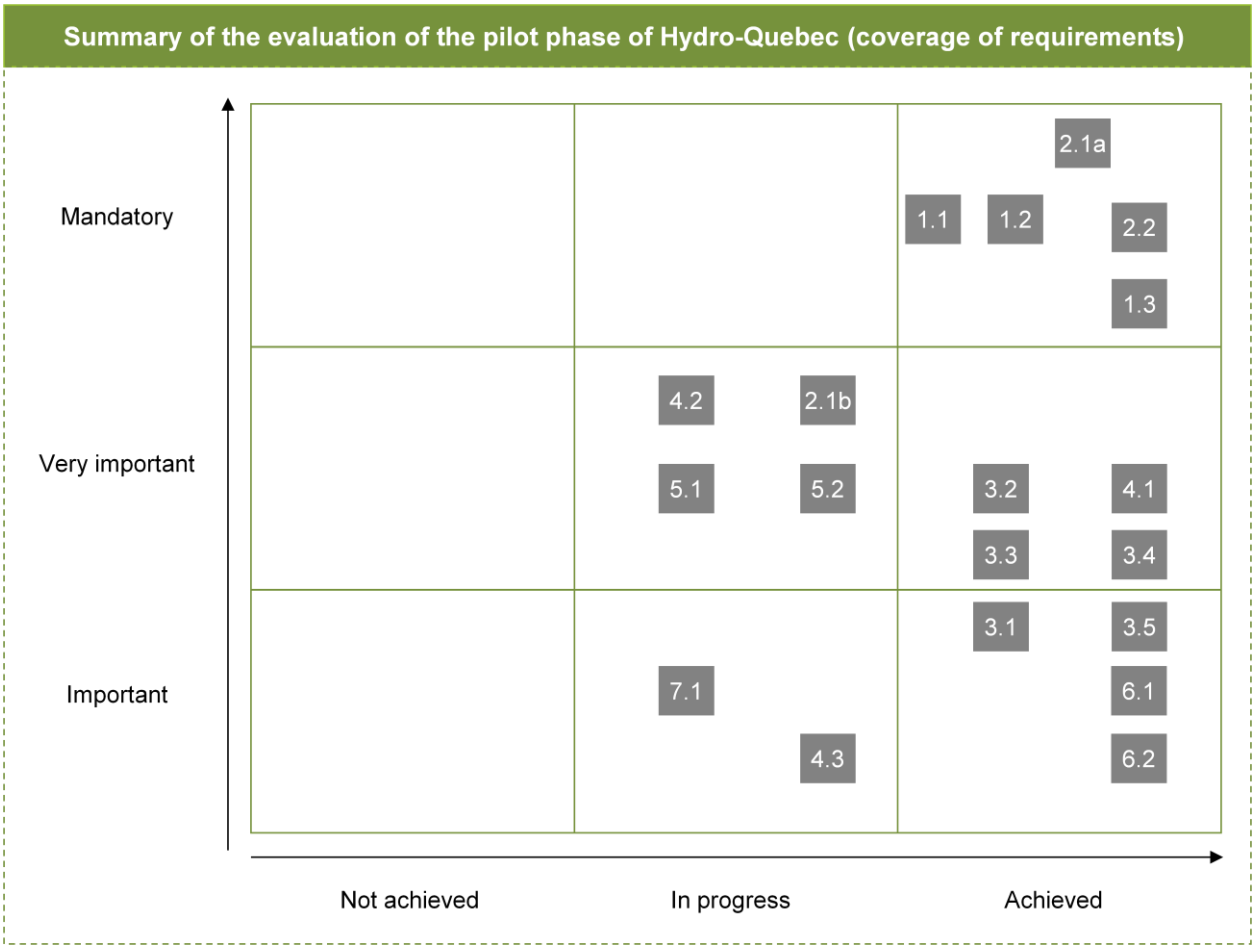


Diagram 2 - level of coverage of requirements of AMI pilot projects by Hydro-Québec Distribution

By conducting representative projects, Hydro-Québec Distribution is sure to well understand the challenges linked to deployment and the use of AMI and to be ready to face such challenges

A specific analysis for each of the categories of requirements:

[1] - Integration and robustness of the SYSTEM

The IT integration work was organised into delivery, corresponding to units of delivery that allowed flexibility and adaptability in the management of work. Each focus of delivery was subject to decision markers that were used to prioritize the work according to different scenarios as the project needs changed and got more specific.

The first activity conducted by Hydro-Québec Distribution was to integrate and test the selected MDMS with the AMI meters already deployed as part of its "Heure Juste" dynamic rate pilot project, in order to get an early start and anticipate the IT work as soon as possible.

The AMI projects depend on a complex technological environment: devices spread out on the communicating area through several telecommunication networks, with information systems requiring elaborate interfaces. Good practice consists in testing as soon as possible this chain of elements from end to end.

Tests were used to verify the end-to-end interoperability from the meter to the MDMS, passing by the collectors, the telecommunications networks and the acquisition front-end hardware:

- Reading the meters at the acquisition front-end: for each pilot project, a formal "Go/No-go" used to evaluate the compliance of the data sent from the meters to the head-end took place after the installation of the first 100-300 meters.
- Integration of the head-end system with the MDMS (and storage of the data)
- Integration of the MDMS with the enterprise systems such as SAP

At the level of system performance, Hydro-Québec Distribution conducted tests on the level of use of bandwidth of the NAN network, which represents less than 5% of the total capacity (this portion is currently used to essentially transmit the data from profiles and registries).

In addition, during the pilot projects, as soon as the equipment was installed (collectors, routers), Hydro-Québec Distribution had mandated the supplier to carry out performance tests in order to move certain routers, when necessary, to improve the optimisation of the AMI network.

Simulation tests for volumes of transactions were carried out in order to validate the performance of the solution. The results are positive using a volume of data greater than that of the large-scale deployment.

Tests were also carried out to see the compatibility with other means of communication (e.g.: communication using fibre optics on the Boucherville pilot project).

At the level of system safety Hydro-Québec Distribution carried out a lot of work en ensure compatibility with the norms and standards of the company, in particular through simulations of cyber-attacks that confirmed the solidity of the solution.

In addition, an analysis of safety, conducted in September 2011 by the firm Lofty Perch, shows no issue with the quality of safety measures of the AMI system. This firm considers that the measures put in place by Hydro-Québec Distribution are efficient and robust.

Concerning the effects of RF waves emitted by the AMI meters deployed in each of the three pilot projects (Memphrémagog MRC, Boucherville, Villeray/Montreal), measurements were made on site and then compared to the standards established by Health Canada.

In fact, the RF emissions from 16,000 AMI meters evenly distributed in each of the pilot project sites were measured for six weeks continuously. Average statistics were collected on site. It should be noted that these statistics reflect nominal situations (basic) in which the AMI network (NAN and WAN) transmit consumption data to the enterprise systems and react to normally anticipated daily events. At the same time, measurements were taken on site and in the laboratory.

The analysis of measurements has identified two types of RF emissions from AMI meters: RF emissions linked to the transmission of usage data (representing approximately 1.5 seconds/day of RF emissions) and RF emissions linked to the maintenance of the NAN network.

The analysis was used to compare the average level of emission calculated with that of Health Canada. The resulting level of average emission of RF waves as calculated by Hydro-Québec Distribution is more than 100,000 less than the maximum level of emission accepted by Health Canada.

These revealing results are planned to be included in a communication to the customers, with the effect of disarming their concerns about the health effects of RF waves.

In addition, Hydro-Québec Distribution continues to work on developing a detailed understanding of its AMI solution by pursuing, in particular the completion of technical tests. For example, certain technical tests aim to measure the response time of the AMI network (latency) to ensure the reliability of orders pushed by the AMI network, to understand the interactivity and the dynamics of the AMI mesh network. This more complete understanding of the network improves the expertise of Hydro-Québec Distribution in the domain of AMI and gives it more autonomy in the management of the NAN “GridStream” network.

[2] - Coverage of FUNCTIONALITIES of the initial scope

The functionalities of the initial scope have been tested during pilot projects and in particular:

- Remote reading (automated meter reading) of the meters to the head-end system
- Billing based on the data of the head-end through the transitional report
- Reading and management of events and alerts
- Reading of the billing registries and profiles
- Loading the billing calendar
- The management tools for the AMI solution (management report)

One of the main indicators of the AMI systems is the rate of reading of the meters. For Hydro-Québec Distribution, on the scope of the meters deployed to date, this rate is greater than 99.4%.

The interruption and remote service reset function remains to be tested. Hydro-Québec Distribution plans to test this function and put it in place during phase one of the project.

Hydro-Québec Distribution followed a strategy for availability and data integrity during the first weeks of each pilot project by comparing the data from the AMI network with those obtained from the existing procedures at Hydro-Québec Distribution (manual meter reading). These different data tests essentially aimed to provide reliable inputs for the billing procedure of Hydro-Québec Distribution and covered the following elements:

- Simulation of parallel billing
- Comparison of the data from manual readings and remote reading
- Comparison of the precision of a sample of retired meters compared to AMI meters.
- Certification of Measurement Canada of the precision of measurements

[3] - Procedures of DEPLOYMENT

Whereas the installation of meters in the pilot projects at Boucherville and the Memphrémagog MRC was fully performed by the personnel of Hydro-Québec Distribution over short periods, the installation of meters that took place over nearly one year in the pilot project at Villeray has been assigned to the service provider Capgemini Québec.

We note moreover that the selection of the service provider for installation was pushed forward precisely in order to test its rhythm, efficiency and the quality of the service delivered.

To date, more than 18,000 meters have been installed including nearly 10,000 by the installation service provider. The rate of installation as well as the rhythm of deployment has been respected in general by the installer and the procedures of quality assurance have been set up.

A survey on customer satisfaction of the pilot projects has also been implemented and the results are positive (customers' average overall satisfaction grade nearly 8/10). This survey covers the installation service, the respect of property, the making of appointments and overall satisfaction. The service provider's installers pass interviews not only with Capgemini Québec but also for special cases, with Hydro-Québec Distribution before final selection.

Deployment of the network:

During pilot projects, Hydro-Québec Distribution took charge with its service provider (Landis+Gyr) of the installation of the AMI network, in particular the collectors and the routers. Hydro-Québec Distribution also performed certification of meters and certification of safety and ICT (this work must still be completed). We remind you that Hydro-Québec Distribution had required in its contract with the supplier that an official topology of the AMI network be produced for the pilot projects and the main area of deployment. For each new region targeted by the deployment, the supplier should also commit by producing an official topology of the AMI network. This practice allowed the acceleration of the communication infrastructure deployment during the pilot projects.

[4] - ORGANISATION and Operating PROCEDURES

For deployment:

Prior to starting the first pilot project, Hydro-Québec Distribution developed and documented the deployment process and procedures. During each pilot project, these procedures were validated and refined.

The deployment processes included the following topics: operational planning, training of installers, acquisition of meters, acquisition and preparation of routers and collectors, quality assurance, work load management, logistics and meter inventory control, installation of meters, installation of routers and collectors, management of unusual cases, call processing, complaints and claims.

Let us note, for example, that the procedure for delivery of meters was refined during the pilot projects so as to send to Hydro-Québec Distribution only a sample of lots (for quality assurance purposes) and at the same time to send the complete lots to the installer.

For system operation:

An organisational makeover was launched in order to put in place an operating team for the AMI (CEM - Exploitation Measuring Center) from the start of the project.

A procedure for transitional meter reading was designed and tested during the pilot projects, accompanied by a tool for reconciling data and a procedure for billing customers based on the AMI data.

The operating procedure of the system includes the following topics: management of start-ups, management of withdrawals, management and monitoring of the network, event and alert management, target procedure for AMI meter reading, management of measurement data, remote updating, etc.

The operating procedures and the CEM staffing should still be stabilised for the large-scale deployment. In addition the procedures for transitioning toward the mode of nominal operation (transition of resources Landis+Gyr to the resources of Hydro-Québec Distribution) should be specified. Finally, the complaint management procedures must also be refined.

[5] - Means of external COMMUNICATION

Means of communication were developed in preparation of pilot projects (letters, flyers, information sheets, Website, announcements for weekly newspapers, videos, form letters for municipalities, signs and signage for trucks of external installers and photo nametags for external installers).

Complaint and claim monitoring as well as an analysis of the reasons for telephone calls were conducted. Meetings and/or telephone calls took place with customers who found themselves in unusual circumstances/cases. We note the volume of complaints and claims is relatively comparable to other AMI projects.

Scripts were created for the representatives of the call center and related training was provided.

Finally, additional efforts should be undertaken to be more proactive in direct communication with customers in particular to demonstrate the short-, medium- and long-term gains to be made by the AMI system.

[6] - Parameters of the OPPORTUNITY ANALYSIS

Cost parameters: through fixed-price contracts including an obligation for results, negotiated with various service providers, Hydro-Québec Distribution reduced its risks of cost slippage of its LAD project. In fact, nearly 75% of costs are fixed. This is the case, for example, for the following:

- Costs for meters, routers, collectors, head-end system and MDMS
- Costs for cellular links
- Fixed costs for installation of meters with performance commitment

The other cost parameters were validated during pilot projects (e.g.: time required for terrain reports in order to finalise the topology of the network, installation time for internal installers, installation time for routers and collectors)

Profits parameters: quantitative financial profits are clear since they originate mainly from the elimination of meter reader positions. Consequently, the pilot projects did not intend to confirm this kind of gain from the project.

[7] - Evolutivity of the system: PROOF OF CONCEPT

During its pilot studies, Hydro-Québec Distribution also hoped to validate the opportunity analysis of the advanced function for detecting electricity theft. A proof of concept on the lines of medium voltage was recently set up and the results are very positive to date (the meters dedicated to the detection of theft were placed on medium voltage lines and are actually read by the AMI "GridStream" network). In addition, tests for updating the ZigBee protocol (to version 2.0) were also successfully carried out, as well as reading the medium voltage by the meter (performed every 15 minutes).

Finally, in parallel with the LAD project, a preliminary study on the outage management is underway. This study, conducted in collaboration with the technical teams of the supplier Landis+Gyr, seeks to evaluate the contribution, if any, of the AMI in detecting and locating outages (in particular the "last gasp" function existing within the AMI system).

Consequently, without wishing to demonstrate, through concept proofs, the exhaustive scope of the advanced functions available in the AMI, Hydro-Québec Distribution has selected certain of them and these are being evaluated. It should be noted that, for the time being, little linking has been done with the initiatives (e.g.: CATVAR project) and the related activities (e.g.: operations and use of the distribution network, customer experience) of Hydro-Québec Distribution.

In the light of the pilot projects conducted by Hydro-Québec and the results obtained to date, the launching of the large-scale deployment can take place right now.

5. Conclusions and recommendations

The point of departure and the motivations are of little importance, the choice of Utilities has been AMI technology already for several years.

Currently, the base of residential electricity meters of Utilities are mostly composed either of electromechanical meters or manually read meters, or remotely-read electronic meters that use AMR technology.

AMI technology is progressively imposing itself as an industry standard and it is observed that most Utilities are launching or completing the replacement of their meters by electronic remote-reading meters with AMI technology. We note that AMI systems are first and foremost measuring devices and the functional scope initially covered by AMI projects is by and large still the same.

Depending on their point of departure (type or existing base), their business objectives as well as their regulatory context, business cases of AMI projects vary from one Utility to another.

- For example, Utilities having already deployed AMR meters will need to add advanced functionalities in order to justify their AMI investment because the operational benefits of remote reading are already present in AMR

  Inversely, Utilities who leave one base of electromechanical meters quite often justify their investment solely by the operating gains linked to the authorisation of certain activities (reading, service start-up, service interruption, etc.), and this is the case of Hydro-Québec Distribution

- Another example is that of Utilities that, in special energy use contexts, are obligated (throug regulatory provisions) to replace their base of meters with AMI meters in order, finally, to implement a time of use pricing

The point of departure and the motivations are of little importance, the Utility's choice has been AMI technology already for several years. This choice is explained by the evolutivity and scalability of AMI technology, based primarily on the following:

- The bidirectional nature of the technology
- The performance of the telecommunication network and the analytical capacity of the information systems network that support the technology
- The addition, through AMI, of measurement points along the AMI network

Owing to its evolutivity and scalability, AMI integrates Smart Grid vision and initiatives

The Smart Grid concept is still in its early stages there is not commonly-accepted definition shared by all. On the other hand, it is clear that AMI (or Smart Metering) is not synonymous with Smart Grid, even if AMI initiatives can contribute to making the distribution network more intelligent.

In fact, AMI systems are only one part of a Smart Grid and not an all-enveloping frame. In fact, the Smart Grid is the result of the harmonious integration of different technologies that include AMI. Consequently, in order to take full advantage of investments made, AMI networks should be designed with the objective of contributing the most to the advanced functions of the Smart Grid.

Hydro-Québec Distribution is part of this process since various applications linked to intelligent electricity networks have already been deployed and put to the test, in particular to increase the reliability and the effectiveness of the distribution network. Examples of this are the PARD, CATVAR initiative and the "Interactive network area."

Moreover, through its technological choices for AMI, Hydro-Québec Distribution hoped to keep all options available in order to later develop other advanced functions, and integrate with Smart Grid initiatives. We note, for example, the work already begun on two advanced functions: detection of electricity theft and outage management.

In the light of the pilot projects conducted by Hydro-Québec Distribution and the results obtained to date, the launching of the large-scale deployment can take place right now.

The preparatory work carried out by Hydro-Québec Distribution has affected all facets of an AMI project, in particular through the implementation of representative pilot projects. By carrying out this work, Hydro-Québec Distribution is assured that it understands the challenges linked to the deployment and operation of the AMI.

The requirements were well covered by Hydro-Québec Distribution during its pilot phase and nothing of major importance was left out.

- The system was tested from end to end and the billing chain is operational.
- The integrity of the measurement data from the AMI meters is ensured.
- System performance meets expectations, including the transaction target volume simulation tests.
- Safety measures, verified by an external company, are efficient and robust.
- The strategy and the processes of deployment were validated and refined.
- A team dedicated to the operation of the AMI (CEM - Center for measurement operation) has been set up
- Approval of the meters has been carried out.

To face the increase burden of a large-scale deployment, certain points should be consolidated and continue to be closely monitored.

This evaluation of the LAD project of Hydro-Québec Distribution highlights several challenges linked to the large-scale deployment phase. Here is a list of recommendations that should be used to start this phase more prudently:

Scope

a) Continue to concentrate on the initial scope and study the development of additional functionalities on the basis of business cases

Team

b) Pursue implementation of a dedicated team whose role would be as operator of the solution working jointly on site for operational activities

Technologies & Evolutivity

c) Continue to improve knowledge of the NAN network, in particular the instructiveness and the dynamics of the meshed RF network and the reliability of commands pushed on the AMI network.

d) Pursue studies and proofs of concept in advanced functions (electricity theft, power outage management), and initialise connections with related activities (operation and using the network, customer experience)

e) Supervise the changes in the scope of specific developments of the MDMS system in order to limit operating costs

Operating the AMI

f) Consolidate the strategy staffing of the CEM procedures well as the operating procedures and specify the procedures for transitioning to the procedures of nominal operation.

Communication

g) To provide continuity in the external communication strategy by proactively distributing information on anticipated changes, by focusing on tangible benefits for customers.

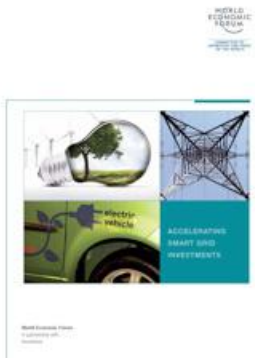
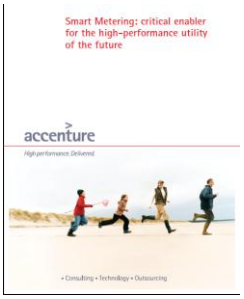
h) Maintain an efficient procedure for complaint management

6. Appendices

6.1. Accenture point of view

You will find below an outline of the Accenture point of view and the articles mentioned:

Point of view:

"Accelerating Smart Grid Investments"	"Achieving High Performance in Smart Grid Data Management"	"Achieving High Performance through Smart Grid Testing"	"Achieving High Performance with Smart Meter Data Management Systems"
			
AMI: Smart Enough? - Metering potential and limitations for smart grid design"	"Delivering Smart Metering in the United Kingdom"	"Smart Metering: critical enabler for the high-performance Utility of the future"	
			

Articles:

energybiz	• The Utility's Smart Grid Journey: An Odyssey of Pervasive Change by Sharon Allan and Susan Christensen
intelligentutility	• Accenture's Sharon Allan: After smart meters, what's next?
	• North American Industry Trends Supporting Intelligent Grids, M. G. Lauby and W. P. Walcom
	• The Challenge Of Powering The Future - An End To End Approach Towards The Next Generation Utility, by J. Azagury, T. Porter and A. Begosso

6.2. Glossary and terminology

AMR	Acronym for *"Automated Meter Reading"* System primarily allowing the reading of remote meters through mobile devices or a fixed communication network.
Business case	French term *"Analyse d'opportunité"* Document making a case for a project, including impacts analyses and technical, organisational and financial feasibility.
ANSI	Acronym for *"American National Standards Institute"* ANSI is a private, not-for-profit organisation which oversees the development of standards for products, services, processes, systems and employees in the United States.
ASGS	Acronym for *"Accenture Smart Grid Services"* Accenture practice dedicated to the field of Smart Grids.
Band-width	Indicates the capacity of a communication route to transmit data over a definite period.
CEM	French acronym for *"Centre d'Exploitation du Mesurage (Exploitation Measuring Center)"* Unit of Hydro-Québec Distribution which deals with the operational activities and monitoring of the components of the **AMI**.
CIS	Acronym for *"Customer Information System"* Customer information system
Collector	Key component of the RF mesh network which ensures the link between the RF mesh network and the Head end system through the **WAN** network. The collector communicates the data between the meters and the **Head End system**.
DLC	Acronym for *"Direct Load Control"* The control of the power demand is a method of management applied by the producer, the Utility and the consumer, while resorting, for example, to load shedding and storage of energy, in order to limit the power demand, for example, in a peak period.

DMS	Acronym for *"Delivery Management System"* Management system for the distribution network
FAN	Acronym for *"Field Area Network"* Local communication network located in a restricted geographical area which connects all the communicating devices belonging to the same organisation, often using the same technology. Term often used to indicate the **LAN** of an **AMI** system.
Head End System	French term *"Frontal d'acquisition"* Technological solution (hardware and software) enabling management and establishment of bi-directional communication between the remote equipment.
GIS	Acronym for *"Geographic Information System"* Information system for the acquisition, storage, analysis, management and retrieval of geographical data.
GridStream	Name given to the **NAN** network of Landis+Gyr, based on **RF** mesh technology.
HAN	Acronym for *"Home Area Network"* Home communication network allowing **IHD** devices to display the total electricity consumption of a customer and being able to offer possibilities of control and management of the principal electricity consumption stations (heating and air-conditioning) according to the electricity price.
IHD	Acronym for *"In Home Display"* Device connected to the **HAN** network which displays the meter data and which makes it possible for domestic customers to monitor their consumption profile.
AMI	Acronym for *" Advanced Metering Infrastructure" (or **IMA** in French for "Infrastructure de Mesurage Avancée")* Infrastructure allowing to interact (e.g.: collect, calculate, analyse consumption data) with an advanced device (such as a water, electricity or gas meter) using bi-directional communication. The architecture includes the hardware/software and telecommunication equipment to interact with these advanced devices.

Interoperability	Ability of a product or a system, whose interfaces are completely known, to function with other existing or future products or systems without access or implementation restrictions. This ability usually rests on the use of standardised interfaces (such as IEC/CIM standards for the electricity industry).
kWh	Acronym for *"kilowatt-hour"* Convenient unit to measure the quantity of power consumption.
LAD	Acronym for *"Lecture à Distance"* Initial French name given to the **AMI** project of Hydro-Québec Distribution.
LAN	Acronym for "Local Area Network" Local communication network located in a restricted geographical area which connects all the communicating devices belonging to the same organisation, often using the same technology.
Last gasp	Or *"dernier souffle"* in French Short transmission made by the meter to notify that it has just lost the power supply.
MDMS	Acronym for *"Meter Data Management System"* System to store and analyse the AMI network data from the **Head end system** and connected systems in order to transmit them to the internal systems of the corporation.
NAN	Acronym for *"Neighbourhood Area Network"* Local communication network with mesh configuration located in a restricted geographical area which connects all the communicating devices belonging to the same organisation, often using the same technology. Term often used to indicate the **LAN** of an **AMI** system with mesh configuration.

NEMA	Acronym for *"National Electrical Manufacturers Association"* American association of electrical manufacturers which provides an international forum for the development of technical standards in the best interests of the industry and the users, takes part in the adjudication of the legislative and regulatory policies and acquires, analyses and disseminates data specific to the electrical industry.
NISTIR	Acronym for *"National Institute of Standards and Technology Interagency Report"* Agency of the Department of Commerce of the United States. The aim of this agency is to promote the economy by developing technologies, metrology and standards, in collaboration with the industry. In co-operation with the Department of Energy, NEMA, IEEE, GWAC, and other stakeholders, the main responsibility of NIST is to coordinate the development of a framework which includes protocols and standards enabling the interoperability of the components and the interactive network systems (Smart Grid). http://www.nist.gov/index.html
OMS	Acronym of *"Outage Management System"* Management Information System to handle power failures.
Distributed Generation	French term *"Production décentralisée"* Electrical energy production by small power stations from installations which allow the distribution under adequate conditions, and this, near the final consumer (e.g.: photovoltaic, wind, cogeneration).
Consumption profile	A consumption profile can be made up of one or more channels. Each channel is a meter reading taken at definite intervals which can vary from 5, 15, 30 or 60 minutes for example. The terms profiles, load profiles or consumption profiles are equivalent.
Register	A synonym also often used is "Index" Saving of continuous data or at a specific time. The data displayed on a meter necessarily come from the registers (e.g.: kWh, Wmax, number of resets).

Reading	Result of the reading and the note taking of the data of a meter. The data can be of varied nature: maintenance data, consumption data (or **registers**), status indicators, technical data and quality data.
Mesh network	French term *"Réseau maillé"* Network topology in which all the devices, each one constituting a "node," are inter-connected without a central hierarchy so as to form a structure in the form of a net or a cobweb. In a telecommunication network, each node can communicate with several other nodes, creating point to multipoint relations, and can also act as a repeater for the other nodes. Thus, more the number of nodes in the telecommunication network with mesh configuration, the more the network is solid. We call it a **NAN** network or **RF** mesh network when an **AMI** system has a mesh type topology.
RF	Acronym for *"Radio frequency"* Frequency of an electromagnetic wave which can vary by convention between 30 hertz (Hz) and 3000 gigahertz (GHz). FM Radio, analogical and mobile telephones, television sets, smart meters (through **AMI**), cell phones, Wi-Fi and microwave ovens are devices which work on radio frequency.
SCADA	Acronym for *"Supervisory Control and Data Acquisition"* System of acquisition and control of data, specially used for monitoring and operating an electrical distribution network.
Smart Grid	Or *"réseau intelligent "*in French All the technological components on an electrical supply network, used so as to optimise the production, transport and distribution, by matching the offer and the demand.
Smart Metering	Or *"mesurage intelligent "* in French See **AMI**
IT	Acronym for *"Information Technology"* All the hardware, software and services used for the collection, the processing and the transmission of information.

Utility	Private or public corporation which provides a public service, such as electricity, gas, and water, and which is managed according to the rules formulated by the State.
VAR	Acronym for *"Volt ampere reactive"* Measuring unit of reactive power in an electrical circuit with alternating current.
WAN	Acronym for *"Wide Area Network"* Extensive communication network which, at long geographical distances, inter-connects several **FAN**, **LAN** or **NAN** often using the same technology. The performance of a WAN results from a trade-off between the extent of the geographical area to be covered and the cost of the connections (which increases with the distance).