Québec's Cost-Effective Electrical Efficiency Potential: Results of a Utility-Stakeholders Working Group Process

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ABSTRACT

This paper describes the results of a working group, launched in 2004 by Hydro-Québec, on the province's cost-effective electric DSM potential. The group, comprised of representatives of a variety of regulator-approved stakeholder groups, a joint stakeholder expert, Hydro-Québec, and Hydro-Québec's consultant (the latter three are co-authors of this paper), was tasked with reviewing a series of sectoral cost-effective potential studies the utility had previously commissioned.

This paper presents both the quantitative and qualitative results, comparing the former to similar potential studies. Quantitatively, the working group had a relatively minor impact in terms of the overall potential results, with the ten-year potential increasing by some 3% to just under 20 TWh/year, or some 17.5% of demand. On the other hand, the process had a more significant impact with regard to specific end-uses and measures. Indeed, some end-use potentials changed dramatically, while new measure opportunities identified through the process have already been integrated into Hydro-Québec's portfolio of programs. Qualitatively, the process was generally deemed a positive, relationship-building experience that enabled both stakeholders and Hydro-Québec to embark on an improved path of transparency and openness.

In the final analysis, consensus was not achieved, with key differences relating to methodological issues that are described in this paper. Nonetheless, Hydro-Québec intends to repeat the experience through the creation of a standing committee of stakeholders.

Introduction

As is the case for many utilities in North America, Hydro-Quebec – a publicly-owned electric utility in the province of Quebec, Canada – relies on technical and economic potential studies of energy efficiency in order to quantify the extent of potential savings and to identify the major cost-effective opportunities. These studies are highly valued by Hydro-Québec, as well as

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by stakeholders, since they represent a key milestone in laying the foundation for developing DSM programs and energy reduction targets.

In 2004, Hydro-Quebec and seven stakeholders, comprised of environmental, consumer and business representatives, agreed to establish a working group tasked with reviewing a set of draft economic potential studies developed for the residential, commercial, small and medium industrial[4] (SMI) and large industrial sectors**.** The assessments for the first three sectors – the sole focus of this paper [5]– were developed for Hydro-Québec by the firm *Technosim* and are updates of earlier 2001 studies. Several stakeholders retained the services of a regulator-accredited expert consultant (Philippe Dunsky) to assist them throughout the process. While Hydro-Québec has been conducting economic potential studies since 1992, this was the first time that it opened the process to direct stakeholder involvement.

In this paper, we first present the draft methodology and economic potential results for the 2005-2014 period, as they were established prior to the establishment of the working group. We then present the working group process, and discuss the degree of consensus as well as areas of disagreement or unresolved differences, including on methodological issues.

In the remainder of this paper, we present the final results and compare them both (i) to the results obtained prior to the working group, and (ii) to the results of recent Canadian and American potential studies. We also discuss the lessons learned and insights gained though this successful working group process. In our closing remarks, we describe a new process that Hydro-Quebec seeks to implement by Fall 2006 in order to ensure continuous updates of the economic potential studies.

Initial (pre-Working Group) Results

Methodology

The basic methodology used in assessing the economic potential is presented hereafter for each of the three major sectors covered. In all instances, a micro-analytical approach was used although some variations in methodology applied to each sector.

It is noteworthy that, at Hydro-Québec's request, fuel switching and certain early replacement measures were explicitly excluded from this assessment.

Commercial sector. In this bottom-up technique, the market was broken down into a number of representative segments based on their vocation and other significant energy use characteristics (e.g. number of meals per day served in restaurants). For each segment, a typical building was defined based on the data available for the segment, such as building size, insulation levels and operating schedules. This information was then used to define a standard building type that could be integrated into an hourly simulation model, allowing for an assessment of the typical impact of various energy efficiency measures. The cost of the measures was also evaluated as well as the market penetration in each given segment. Combining the simulated, forecast efficiency savings and the estimated measure cost, each measure's cost-effectiveness was assessed based on a set of predetermined avoided costs. The market segment size and expected measure penetration

[4]The small and medium-sized industries are defined as those having a minimum demand inferior to 5 MW.
[5]This paper does not cover the large industrial sector, whose original economic potential study was conducted by a different team using a different methodology.

were then used to obtain the total potential for every measure in each market segment. Combining all this information for the entire sector led to the overall economic potential.

In the commercial sector, Hydro-Québec used 29 segments based on building vocations. These were further broken down into some 70 typical buildings. For each building, between 20 and 30 energy efficiency measures were assessed for the various end-uses and for three different climate zones. The vast majority of measures were evaluated using a DOE2.1e modeling tool. Using this detailed simulation tool allowed for consideration of interactive effects between measures and between end-uses.[6]

Residential sector. The micro-analytical method was also used in the residential sector. In this case, however, the market was broken down not uniquely based on building types but, in many instances, based on equipment types or applications (e.g. lighting measures were assessed based on typical light bulb wattage and operating hours). As with the commercial sector, each residential segment was characterized in term of its energy related parameters (e.g. size of refrigerator, lighting hours, wall and roof insulation levels). Furthermore, each segment's market size was assessed based on each measure's existing and forecast baseline saturation level (e.g. the fraction of 60w-equivalent / 500 h/yr loads in a given segment that are already serviced by compact fluorescents).

The energy savings attributable to each measure for each segment was evaluated using a number of tools, namely: i) monitored results for a given measure in a specific segment, when available; ii) detailed simulation of the measure; and, iii) analytical evaluation. The choice of tool was determined further to an initial literature review. Measure savings were also obtained for three different climate zones.

Small and medium industries (SMI). In this case, the market was broken down into a number of representative processes. Most of these were generic processes covering pumps, ventilation, compressed air, mechanical drives, refrigeration and conveyors. Measures were accepted only to the extent they would have limited impact on the buildings housing the process. Separately, non-process measures were evaluated using a limited number of building types. In this instance, DOE2.1e was used to evaluate the energy savings of each measure as well as the impact of processes on HVAC systems. Almost all process related measures were evaluated using analytical methods.

Context – Unique Québec Attributes

Prior to presenting the results of the original economic potential study, it is worth noting some distinctive characteristics of the Québec market that may considerably influence the cost-effective savings potential.

The first such characteristic is the high market share of electrically heated homes and buildings in Quebec. Indeed, some 68% of all homes in Québec are electrically heated, as is nearly 50% of the total commercial building floor area. Furthermore, in new residential constructions, electric heating has up to 90% market share. The impact of having so many

[6]Interactive-effects occur when the impact of a measure on a given end-use has a direct impact on another end-use. The most obvious cross-effect is when a measure altering a building's internal gains increases the building's heating load and/or reduces its cooling load.

electrically heated buildings is twofold. First, the importance of envelope and heating-related measures is considerably higher in Quebec than in most other North-American electricity markets, and second, interactive effects play a much more significant role in reducing the net electricity savings of most non-shell measures.

The second important characteristic is the fairly cold climate in Quebec. The typical household energy use profile is about 55% heating, 20% domestic hot water, 15% domestic appliances and 5% lighting. When cooling is used in the residential sector, it represents at most about 5% of load and often only 2%. The combination of this energy use profile and a high electric heating ratio increases the relative importance of heating measures compared to appliances, lighting and cooling. Specifically, these characteristics tend to further increase the interactive effects, thereby reducing the savings attributable to better appliances and lighting measures. Even in the commercial sector, most buildings are strongly heating-dominated, even though cooling and, more importantly, lighting play significant roles as well.

Finally, there are two other elements distinguishing this market. First, not only is the typical cooling load fairly low, the fraction of mechanically-cooled buildings is limited compared to many other markets. Indeed, in the residential sector, just 1 in 4 households has air-conditioning. In the commercial sector, approximately 40% of the total floor area is mechanically cooled. The second element concerns the residential sector. Indeed, the market share of exterior pools in Québec is among the highest in North-America (some 20% of all households, including those in multi-unit residential buildings). In fact, pools are a more significant load in the residential sector than cooling.

On the other hand, no significant Québec-specific attributes seem to affect the industrial sector.

Initial Results

Table 1 presents the economic potential that was determined *prior* to the working group. The potential was based on a set of avoided costs that, on the whole, average out to roughly 7.7 U.S. cents/kWh.[7] As discussed earlier, large industrial is not covered in this paper.

Table 1. Draft 10-year Economic Potential PRIOR to the Working Group Process

	Potential (GWh/yr.)		
Source	*Residential*	*Commercial /Institutional*	*Small/Medium Industrial*
Heating	5,516	3,499	199
Domestic Hot Water	401	232	12
Cooling	50	250	19
Appliances/Motors	787	1,258	1,048
Pools/Process	509	156	195
Lighting	1,408	3,198	452
Total	**8,671**	**8,593**	**1,925**
Fraction of sectoral demand	**13.7%**	**22.9%**	**15.6%**

[7]Assuming an exchange rate of US$0.89 per $C.

Table 1 clearly portrays the Québec-specific attributes discussed previously. Specifically, in the residential sector, the bulk of the potential is linked to reducing heating loads. Insulation measures for roofs, walls and basements are the primary set of measures in this sector. Behavioural measures related to reducing the heating set point on thermostats are also very significant. It should, however, be underlined that Hydro-Quebec's surveys generally indicate that 50% of households consider that they are already reducing the set point at one time or another during a typical day (the potential estimates accounted for this baseline behaviour). Measures that are more important in other regions, such as Energy Star appliances, are much more marginal in Quebec due to the importance of interactive effects for almost every type of appliance.

In the commercial sector, unlike most other markets where lighting and cooling are the dominant opportunities, the most important measures in Québec are heating-related (although lighting does represent a significant opportunity). Many heating-related measures are focused on optimal operation of HVAC systems. However, unlike the residential sector, most of these are not considered behavioural but implemented through Energy Management Systems (EMS). Behavioural measures were not considered in most cases for commercial buildings given the level of commitment that would be required to systematically implement these measures. Also, a greater fraction of the heating potential in the commercial sector is linked with the installation of new heating equipment, namely heat recovery ventilators and ground-source heat pumps. The greater potential in the commercial sector associated with ground-source systems is essentially due to the higher cost of the baseline systems in this sector, which always incorporate mechanical ventilation and cooling, and economies of scale for larger geothermal systems.

Finally, the bulk of the small-medium industrial sector's potential is in motor-related measures. This is very much in line with most industrial markets. Process-related motors are responsible for nearly 50% of this sector's total energy use.

Working Group Process

Process Description

In spring 2004, the Quebec Energy Board (Québec's utilities commission), key stakeholders and Hydro-Québec agreed that the regulatory process was not conducive to enriching the economic potential analyses due to its very formal and conflict-based structure. All agreed that the assessments would benefit from closer scrutiny and the opportunity to obtain more information from a greater variety of sources.

For this reason, a working group was established. Participants included representatives of environmental, consumer and business stakeholder groups, a "joint expert" working on behalf of several of these groups and accredited by the Board, representatives of Hydro-Quebec and a representative from Technosim. The latter three are the co-authors of this paper. It is in a spirit of collaboration that a series of technical meetings was planned outside the Board's legal framework. In total, eight full-day meetings were held between September 2004 and May 2005 to review the three sectors.

Prior to the meetings, participants received detailed information on the methodology and the results described above, as well as on specific measures. Given the limited time available, the group was unable to perform a detailed review of every measure for every building-type or market segment defined in the micro-analytical aproach. Furthermore, the agricultural sector – a subsector of the residential market – was not discussed, while the small/medium industrial (SMI) sector received relatively limited attention when compared with residential and commercial/institutional.

What Changed and What Didn't

The meetings themselves revealed three orders of concerns:

- *Assumptions:* Stakeholders sought to review the assumptions used in assessing the savings potential and cost-effectiveness of measures;
- *Measures:* Stakeholders sought to ensure that all relevant measures had been considered; and,
- *Methodology:* Stakeholders sought to ensure the methodology itself was sound and reflective of the appropriate perspectives and concerns.

Assumptions

The bulk of meeting time was spent on reviewing the minutiae of thousands of individual measure assumptions. These ranged, for most measures, from useful lives to interactive effects, baseline consumption, unit costs, free ridership and the host of other analytical inputs. This review resulted in a substantial number of mostly minor changes to the initial assumptions. It is noteworthy that the extent of revision was both significantly greater for the residential sector and smaller for the SMI sector than it was for C&I.

Measures

Some time was also given to constructive suggestions for the addition of new measures. After discussion, a number of new measures were indeed retained, the most significant of which were:

- Super/premium T8 lights (commercial/institutional and SMI sectors);
- Cold-climate heat pumps (residential sector);
- Grey water heat recovery systems (all sectors); and,
- High-efficiency computer power supplies (all sectors).

Methodology

In hindsight, relatively little time was given to examining fundamental methodological issues. Some methodological issues were addressed, however, leading to two specific changes:

- Sensitivity analyses were added in order to account for alternative avoided cost scenarios; and
- The method for treating competing/overlapping measures was changed so that theoretically competing options could coexist in submarkets (in lieu of the previous *all or nothing* assumption).

However, other methodological issues and concerns were not addressed, leading to a series of differences that would remain unresolved. In particular, a number of stakeholder groups as well as the joint expert believed that further refinements were required, as follows:[8]

- *Non-Energy Benefits (NEBs)* need to be accounted for, whenever possible, in the total resource cost (TRC) calculation. Despite the difficulty in valuing NEBs, not accounting for them may skew the TRC results and lead to both the exclusion of cost-effective measures as well as suboptimal real-life programs. Hydro-Québec, however, preferred to retain the TRC methodology used for assessing its DSM programs that it had previously proposed to the Québec Energy Board and that had been approved.
- *Environmental Externalities* also need to be accounted for to determine the societal value and therefore societal cost-effectiveness of measures. Again, Hydro-Québec preferred to retain the methodology that it had previously proposed and that had been approved in the past.
- *Early Replacement Opportunities* should not have been *de facto* excluded from the list of potential measures. Doing so, it was argued, would exclude a number of cost-effective measures (including several that were already a part of the utility's own programs), thereby understating the true cost-effective potential. Hydro-Québec, however, elected to exclude these measures because its DSM programs focus mostly on retrofit and natural replacement opportunities.

Finally, these groups and the joint expert believed that two additional sets of information should have been provided. First, they proposed that capacity – not only energy – savings be assessed. Second, while not opposed to the economic ranking approach used by Hydro-Québec and Technosim to eliminate overlapping measures, the aforementioned groups and the joint expert proposed that an alternate set of results present the impact of an energy-based ranking.[9] The utility did not respond favourably to these proposals for the following reasons: i) assessing capacity savings were not a priority at that time, and ii) the expected costs of preparing the alternative set of impacts was deemed to outweigh expected benefits.

Ultimately, because this was a consultative and not a collaborative or negotiated process, Hydro-Québec retained its own preferences, while stakeholder groups' and the joint expert's disagreements were noted in the final report.

[8] Additionally, one stakeholder group believed that measure costs should be assessed net of government subsidies for the purposes of the TRC. However, no other party shared this position.

[9] We refer here to the process of choosing among two or more measures that could be applied individually but that could not be applied simultaneously to the same end use. While many potential studies choose the least expensive measure or the measure with the maximum net *economic* benefit, these stakeholders and the joint expert felt that it would be equally relevant to choose the measure that provided the greatest level of *energy* savings, in order to correctly assess the full, cost-effective *energy* – not merely economic – savings potential.

Final (post-Working Group) Results

Economic Potential Results

Table 2 presents the final, post-Working Group economic potential. The reader will note that differences, as compared to the original version, are not very large. However, some individual components of the potential in each sector have changed more significantly. It is noteworthy too that the adjustments presented previously did not always increase the potential; rather, in a significant number of cases, information brought forward during the technical meetings resulted in a reduction of the energy savings potential for some measures based on new or more up-to-date data.

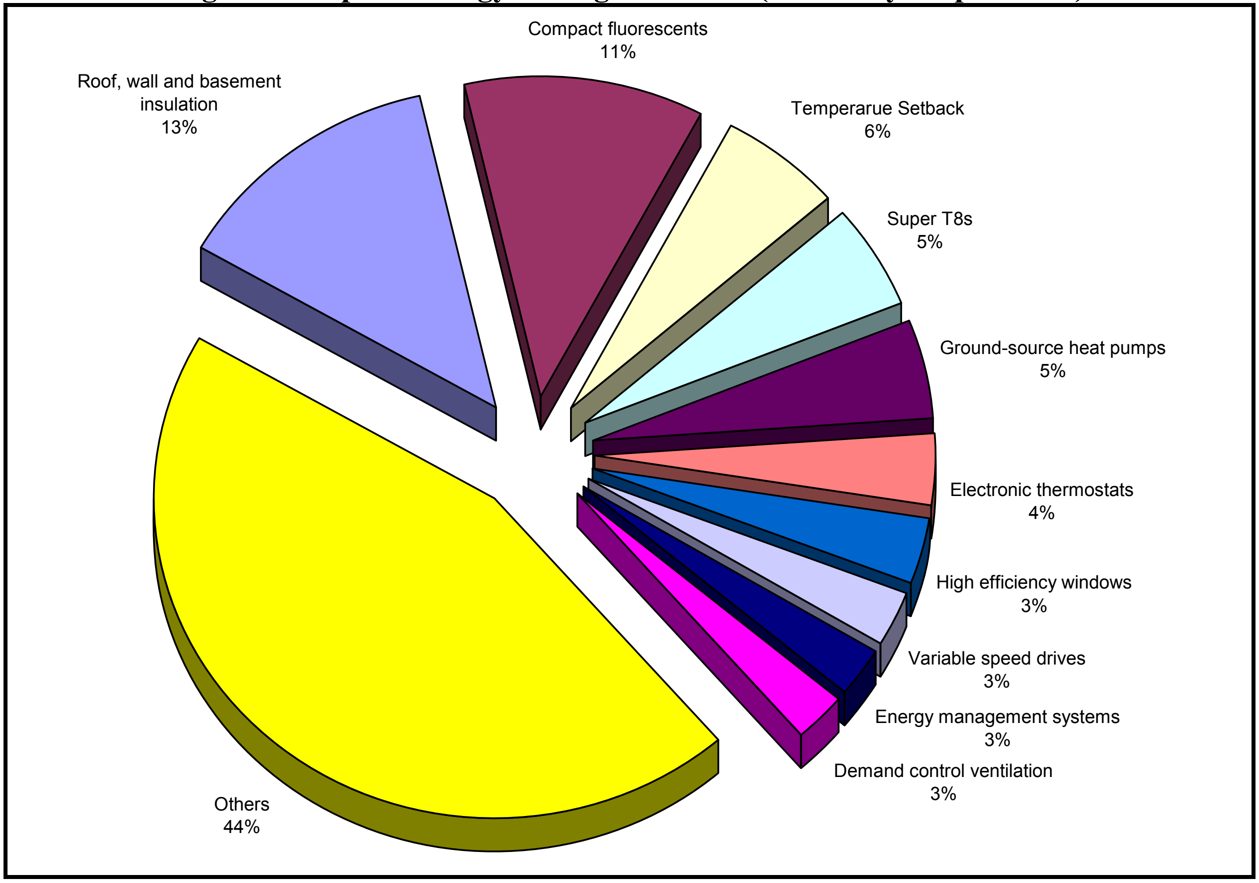
Table 2. 10-year Economic Potential AFTER the Working Group Process (GWh/yr.)

	Heating	Hot Water	Cooling	Appliances	Pools/ Process/ Motors	Lighting	Total	% of Deman d
Residential								
before	5,516	401	50	787	509	1,408	**8,671**	
after	5,125	690	50	978	417	1,665	**8,925**	**14.2%**
change	***-7.1%***	***72.1%***	***0%***	***24.3%***	***-18.1%***	***18.3%***	***2.9%***	
Comm./Inst.								
before	3,499	232	250	1,258	156	3,198	**8,593**	
after	3,865	205	227	1,440	156	3,146	**9,039**	**24.1%**
change	***10.5%***	***-11.6%***	***-9.2%***	***14.5%***	***0%***	***-1.6%***	***5.2%***	
Small/Medium Industrial								
before	199	12	19	1,048	195	452	**1,925**	
after	239	33	20	847	230	406	**1,775**	**14.4%**
change	***20.1%***	***175%***	***5.3%***	***-19.2%***	***17.9%***	***-10.2%***	***-7.8%***	
TOTAL ***(excl. large industrial)***								
before	9,214	645	319	3,093	860	5,058	**19,189**	
after	9,229	928	297	3,265	803	5,217	**19,739**	**17.5%**
change	***0.2%***	***43.9%***	***-6.9%***	***5.6%***	***-6.6%***	***3.1%***	***2.9%***	

As can be seen, heating opportunities continued to dominate with nearly 50% of the overall economic potential. However, the revision led to significant increases in potential hot water savings, notably due to the addition of grey water heat recovery systems, one of a number of measures brought forth by the stakeholders.

Figure 1 presents the ten most significant energy saving measures, all markets considered.

Figure 1. Top-10 Energy Saving Measures (from 10-year potential)



Comparison with Other Assessments

Comparing the economic potential within different regions is always risky It is often tempting to make direct comparisons, for example, based on the potential's share of total energy use. However, some markets have attributes that set them apart from others, as mentioned earlier. These comparisons must also account for the varying avoided costs of energy, consideration of non-energy benefits, as well as for differences in key assumptions such as the baselines, regulatory changes, inclusion of fuel switching measures, timeframe and discount rates, not to mention the industrial structure of the host region's economy.

Despite these limitations, comparisons can be useful and interesting. A study published by ACEEE (Nadel et al. 2004) provides a solid basis for comparing our results with U.S. potential studies. We have gone beyond this, however, and added a series of recent Canadian to the list, as seen in Figure 2.

Figure 2. Comparison of Economic Potential Study Results (% Energy Savings)

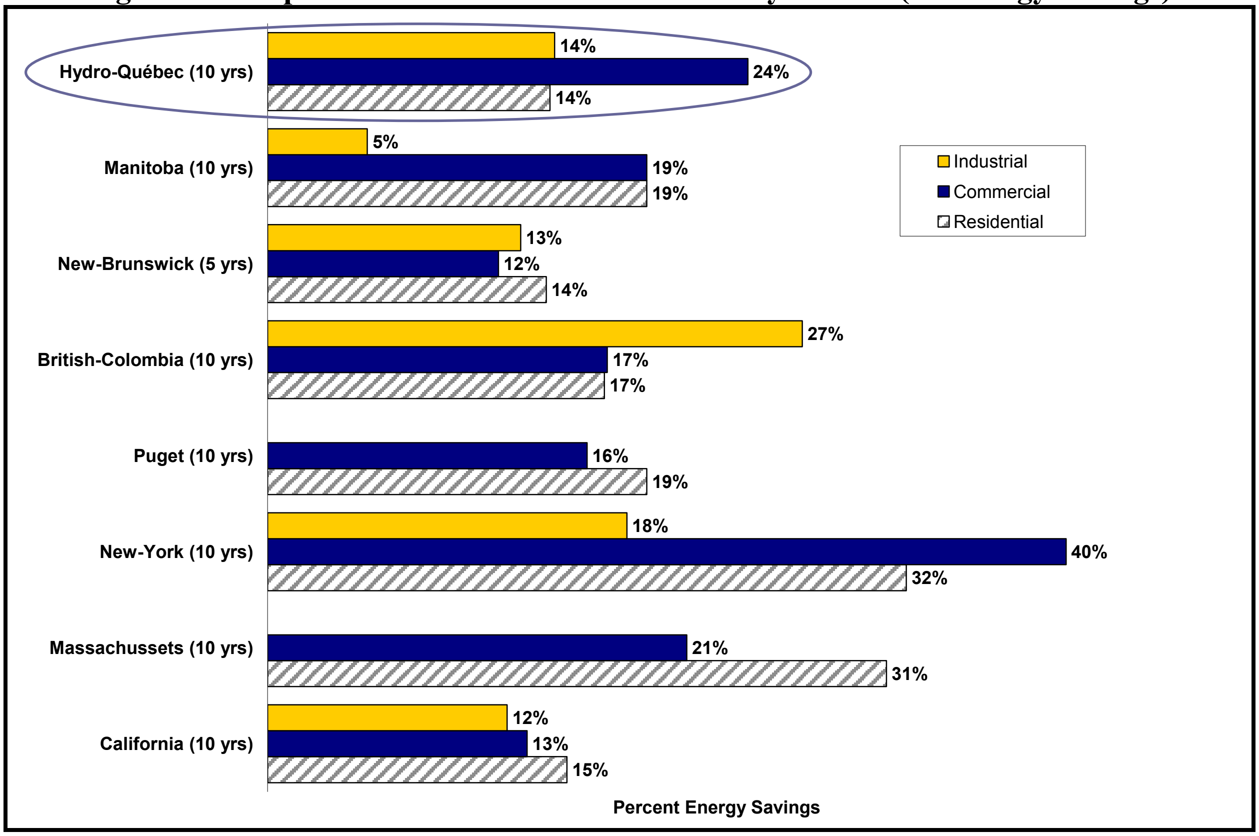


Figure 2 shows that the potential identified for Hydro-Quebec is not significantly different from that in most other utilities, even though it is in the lower range in the residential sector.

Lessons Learned from the Working Group Approach

Perhaps the most valuable benefit from the Working Group experience is the increase in trust and improved working relationship between Hydro-Quebec and stakeholders with respect to energy efficiency. Prior to the establishment of the working group, both groups were strongly entrenched in their respective positions: on one side, stakeholders argued that Hydro-Québec was deliberately underestimating the economic potential while on the other side, the utility believed that stakeholders' potential estimates were ill-founded.

These diametrically opposed views could be explained by a wellhead of distrust that had built up over previous years and, furthermore, by the fact that initial discussions on the topic took place in the context of the conflict-driven regulatory process which left little room for exchanging views and finding common ground on complex topics such as this.

These conflicting attitudes prevailed during the initial meetings, hampering the progress and making a difficult start to the working group process. Over time, however, respectful dialogue and open-mindness on both sides enabled the working group to overcome its initial stumbling blocks. As the meetings progressed, members solidified their working relationship and, as a result, ironed out many differences.

As explained in the previous section, the economic potential increased or decreased by sector as a direct result of the working group process. The authors believe that changes cannot alone indicate the process' success or failure. Rather, all working group members were of the view that the process was a successful experience because, in the final analysis, the economic potential estimates for each sector were more robust. This stems from the review of the methodology and key assumptions (e.g. incremental and total costs, energy savings, markets), as well as from the addition of new measures.

The working group reached this conclusion even though it faced outstanding issues at its last meeting, notably regarding the methodology. The stakeholders indicated that openness and transparency on the part of both Hydro-Québec's and Technosim's representatives played a significant role in achieving this positive outcome.

As a final task, the working group looked at ways to improve future collaborative processes. Even though they relate to basic project management planning, the following two key findings were found to be critical to success:

- Objectives and participants' expectations should be shared and clearly defined at the outset in order to avoid potential frustrations along the way and minimize the risks of the process being derailed.
- Topics to be reviewed should be prioritized at the outset and revised on an on-going basis, ensuring that the focus is spent on issues that matter the most, such as methodology.

On a final note, the working group had a positive, tangible impact on Hydro-Québec's DSM programs shortly after having completed its tasks. For example, the utility introduced new incentives for high-efficiency T-8 lighting in the commercial sector and revised its energy saving targets for several of its residential programs.

Conclusions and Next Steps

The establishment of a stakeholder working group had three primary impacts: First, it arguably improved the study's accuracy, both through attention to assumptions and the addition of several new measures. Second, it set the parties on a path of improved cooperation. And third, it left all parties with a greater comfort level with regard to the potential study's results.

The estimate of the economic potential relies on a wealth of constantly evolving information, such as the energy savings and costs of technologies. The economic potential is set to play a key role in identifying major cost-effective opportunities. Building upon the success of the initial working group, Hydro-Quebec intends to establish a standing committee by Fall 2006 that would be mandated to: i) ensure that the measure set is kept up to date and ii) review methodological issues. The standing committee would report on an annual basis to the Québec Energy Board.

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