TECHNICAL/ECONOMIC POTENTIAL OF POWER DEMAND MANAGEMENT

INTEGRATED SYSTEM

Hydro Quebec
Distribution

Technical/economic potential of power demand management

Integrated system

31 October 2012

Table of contents

1. Introduction

In paragraph 159 of decision D-2011-162 on the 2011–2020 Supply Plan, “the Régie asks the Distributor to specifically review the technical/economic potential of consumption management, for all the sectors, and to file a report on this subject in the 2012 Progress Report on the Plan. In said report, the impact of each measure studied, whether or not it is retained in the technical/economic potential assessment,[143] shall be distinguished and quantified.” Note 143 specifies, “In particular, the greywater heat recovery device, the behavioural impact of the Distributor’s energy conservation tips for winter peak, and the new remote-read meters.”

In this document, the Distributor presents the results of the technical/economic potential assessment of power demand management measures in the residential, commercial, institutional, and industrial sectors. In addition, the Distributor provides clarification on the specific measures mentioned by the Régie in the note relating to the above-cited passage of the decision.

2 Background to power demand management

2.1 Definition

The Distributor has noted various interpretations of the term consumption management in its recent regulatory cases (e.g., in files R-3776-2011, R-3770-2011, and R-3748-2010). To provide for a more uniform understanding of the terminology used, the Distributor proposes to use the term “power demand management” instead of “consumption management” from now on to cover all of the Distributor’s customer interventions designed to reduce the Distributor’s power requirements.

2.2 General principles

The technical/economic potential of the power demand management measures represents the reduction in demand associated with the implementation of such measures where this is technically possible and where the unit cost is less than or equal to the Distributor’s avoided power cost, without considering consumer acceptance of such measures. That is, barriers of a commercial or financial nature are not yet included in the assessment. More particularly, for the commercial and institutional (CI) sectors, the application of the measures may increase the customer’s maximum monthly power demand, thus increasing its electricity bill. For this reason, it is important to remember that only a portion of the technical/economic potential identified in this assessment will be able to be commercially exploited.

2.2.1 Power gain delivered by a measure

Power is, by its nature, an instantaneous quantity that varies over time. Unlike a kWh saved, the power gain due to a measure varies according to the period and the moment when the load reduction takes place. To decrease the Distributor's power requirements, a measure has to provide a gain coinciding with the Distributor's peak. For this reason, for the purposes of the technical/economic potential assessment, the analysis is limited to the winter months and to two periods of the day, 6 to 9 a.m. and 4 to 7 p.m.

2.2.2 Power curve, load recovery, and non-additivity of potentials

The technical/economic potential of power demand management measures is limited by the Distributor's power curve. To wit, a large number of measures could provide for a reduction in power requirements at certain times of the day, but there would be a concomitant increase at other times of the day. This phenomenon, called "load recovery" or "payback," limits the technical/economic potential of power demand management. If there were no limits on the potential targeted by such measures, load recovery would create a new peak at another time of the day. Figure 1 presents the annual peak day curve of the Distributor's power requirements before and after application of a measure.

This characteristic is typical of the residential and CI sectors, in which, for the majority of measures, load recovery cannot be postponed by more than two hours after the end of a peak period. Thus, in these sectors, the technical/economic potential of power demand management measures is limited more by load recovery problems than by avoided costs. Furthermore, the peculiarities of each measure in terms of its impact on the hourly curve, as well as the load recovery problems, mean that the potentials of the measures are not necessarily additive. These measures differ in this respect from energy conservation measures, whose combined technical/economic potential is calculated as the sum of the potentials of the measures taken individually.

Moreover, while load reduction measures (e.g., dual energy heating) are not subject to the phenomenon of load recovery, they do alter the Distributor's power curve and could therefore affect the potential of the other measures.

Figure 1 – Power curves for system annual peak day

[Legend:]
Hour
Curve without measure
Curve with measure

For industrial customers, consumption curves are more stable and the load recovery effect is less marked. The potentials of the different measures for industrial customers are thus more readily combined.

Therefore, the overall impact of power demand management measures can only be determined for a scenario involving a given set of measures where the commercially achievable potential is determined, the purpose being to ensure that the quantities, combination, and hour-by-hour deployment of the measures does not create a new peak on the curve shown in Figure 1.

2.2.3 Selection criteria for measures

The choice of power demand management measures is determined by the following selection criteria:

- measures available on the market;
- measures technologically proven;
- maintenance of acceptable minimum service.

The relatively simple measures involving load shedding without provision of acceptable minimum service are not considered. For example, interruption of water heaters in the residential sector must not lead to situations where customers lack hot water.

For industrial customers, power demand management measures entail the possibility of momentarily interrupting certain plant functions and letting them resume later, at off-peak hours. These interruptions may be of variable duration, but complete plant shutdowns were not included in the technical/economic potential assessment.

3 Technical/economic potential assessment: residential, commercial, and institutional sectors

3.1 Methodology

The methodology chosen to perform the technical/economic potential assessment for the residential and CI sectors is microanalytical in nature. The approach consists in defining a certain number of typical buildings for each sector and market segment and applying the power demand management measures to them. The full potential of the measures is then calculated by extending the impacts on the reduction of power requirements to the full set buildings of which this building is representative. The advantage of this approach is that it makes the cost-effectiveness of each measure easily quantifiable in terms of technical/economic potential.

3.2 Choice of measures

The list of measures selected for the residential sector is presented in Table 1, while the ones chosen for the CI sectors are presented in Table 2. These lists include measures that can be applied on a large scale. The purpose of the measures selected is specifically to reduce the Distributor's power requirements. In addition, the impacts of the behaviour-based measures that consumers may adopt further to awareness-raising efforts or specific guidelines from the Distributor during the winter peak period were assessed.

Energy conservation measures are excluded from this assessment; their impact on power was previously assessed as part of the technical/economic potential assessment for the energy conservation measures. Thus, for example, "greywater heat recovery device" was not selected as a measure since it is primarily an energy conservation measure. The technical/economic potential assessment of the energy savings deriving from this measure, as well as its impact on power, were filed with the Régie as follow-up to file R-3740-2010.[1] As to next-generation meters, they are not considered to be a specific power demand management measure. Equipped with a forward-compatible technological platform, they will offer the possibility of rolling out power demand management measures or programs at a later date.

[1] http://www.regie-energie.qc.ca/audiences/Suivis/Suivi_HQD_D-2011-028_PTE_ReseauIntegre.html

Table 1 – Measures selected for the residential sector

Heating-related measures	**Description**
Heat storage with control	Installation of heat storage with limited recharge at peak hours and restoration programmed according to Distributor's requirements
Heat pump with gas backup	Addition of gas backup for residential heat pumps
Additional dual energy	Conversion of all-electric appliances with central heating system to dual energy
Setpoint management	Automatic lowering of temperature setpoints at Distributor's peak hours with prior increase before peak hours
Manual setpoint management – behavioural	Temporary manual lowering of temperature by the customer at system peak hours without prior increase
Hot water-related measures	
High-storage water heater	Addition of extra storage to a standard water heater
High-storage water heater with control	Addition of extra storage to a standard water heater and remote water heater interruption at Distributor's peak hours
Water heater - remote control	Remote water heater interruption at Distributor's peak hours and phased load recovery
Water heater - timer control	Water heater interruption at peak hours with on-board timer
Three-element water heater	Replacement of two-element water heater by three-element water heater
Household appliance-related measures	
Dryer – behavioural or with control	Not using dryer at peak hours – behavioural or with possibility of remote management
Dishwasher – behavioural or with control	Not using dishwasher at peak hours – behavioural or with possibility of remote control
Washing machine – behavioural or with control	Not using washing machine at peak hours – behavioural or with possibility of remote control
Spas – behavioural or with control	Not heating spa at peak hours – behavioural or with possibility of remote control
Lighting-related measures	
Lighting management – behavioural or with control	Reducing the use of lighting during peak hours

Table 2 – Measures selected for CI sectors

Heating and ventilation measures	Description
Heat storage with control	Installation of heat storage with limited recharge at peak and restoration programmed according to Distributor's requirements
Heat pump with fuel backup	Addition of fuel-powered backup to all heat pumps
Dual energy heating	Conversion of all-electric central heating appliances to dual energy (oil, gas, propane)
Management of temperature setpoints	Lowering of temperature setpoints at Distributor's peak, with room preheating before peak
Reduction of fresh air flow	Temporary closing of outside air dampers during Distributor's peak
Reduction of ventilation rate	Temporary reduction of ventilation rate for variable air volume systems during Distributor's peak
Adjustment of heat pump flow rate	Temporary reduction of heat pump flow rate associated with increased supply temperature for buildings that are not all-electric
Interruption of humidifiers	Temporary interruption of humidifiers
Optimization of start times	Optimization of ventilation system start times to avoid coinciding with Distributor's morning peak
Hot water-related measures	
High-storage water heater with or without control	Replacement of existing water heater by a high-storage water heater, with or without interruption of water heater at Distributor's peak
Control of water heater	Interruption of water heater at Distributor's peak and phased recovery of load
Dual energy (gas) water heater	Replacement of electric water heater by a dual energy water heater
Lighting-related measures	
Ballast with modulation (dimming)	Temporary reduction of general building lighting at Distributor's peak
Partial shutoff of lighting	Partial shutoff of lighting in non-essential areas of buildings
Lighting control	Temporary lighting reduction at Distributor's peak
Other measures	
Anti-sweat heater shutoff	Temporary shutoff of anti-sweat heaters in supermarket refrigerator cases, by customer or remote controlled
Backup genset	Use of backup gensets at peak

3.3 Results

3.3.1 Residential sector

Table 3 presents the potential of power demand management measures for the residential sector. The main measures contained in the technical/economic potential of the residential sector at the 2016–2017 horizon are as follows:

- Management of temperature setpoints, whether manual or remote (by the Distributor), has a technical/economic potential on the order of 800 MW. When managed by the Distributor, this measure includes additional costs related to the remote control infrastructure and allows for the possibility of optimizing the recovery of the load.

- Behavioural measures associated with peak use of household appliances, whose cost of deployment is considered nil. The highest potential is 540 MW and would be reached if all consumers using their dryers at peak switched to off-peak use of the appliance.

- Timer- or remote-controlled water heater management has a technical/economic potential on the order of 500 MW. The potential of remote water heater management is greater than that of timer-based management since it allows for optimization of load recovery.

- Measures involving the installation of appliances, such as dual energy boilers (for buildings of 40 dwellings or more), have a technical/economic potential of approximately 120 MW, while three-element water heaters or heat storage have a potential on the order of 100 MW.

As discussed in section 2.2.2, the potentials of the residential sector measures are not necessarily additive. Thus, the measure offering the highest potential is setpoint management, with a technical/economic potential on the order of 800 MW.

Table 3 – Potential of power demand management measures for the residential sector

Measures included in potential assessment	**Unit cost ($/kW-winter)**	**Potential (MW)**
Lighting management – behavioural Manual setpoint management – behavioural Washing machine – behavioural Dishwasher – behavioural Dryer – behavioural Spas – behavioural		
Three-element water heater Heat storage with control - 40 dwellings Additional dual energy - 40 dwellings Water heater - timer control Setpoint management - central systems Water heating - remote controlled (medium and high curves)		
Measures excluded from potential assessment	**Unit cost ($/kW-winter)**	**Potential (MW)**
Water heater - remote control (low curves) Additional dual energy - Plex, Uni. Heat pump with gas backup Setpoint management - baseboard heaters High-storage water heater – control Heat storage with control - Plex, Uni. Home appliances – control High-storage water heater Lighting management – control		

3.3.2 Commercial and institutional sectors

Table 4 shows the potential of power demand management measures in the commercial and institutional sectors. The highlights of the potential assessment at the 2016–2017 horizon are as follows:

- The measures offering the highest potential are those necessitating the installation of heating appliances, whether heat storage or dual energy, with a technical/economic potential of approximately 1,300 MW. These measures are applied in buildings equipped with central systems. Control of heat storage according to Distributor's peak can be local or remote.

- Heating and ventilation control measures offer a potential of 500–600 MW. The reduction of the fresh air flow rate is preceded by an increase in fresh air flow before peak, while the optimal management of temperature setpoints includes a temperature increase before peak.

- The use of backup gensets allowing for peak load shedding also offers a technical/economic potential of approximately 600 MW.

- The lowest-cost measures can generally be implemented in buildings already equipped with an energy management system (EMS) that do not necessitate any additional control equipment.

In the CI sectors, the highest technical/economic potential is therefore approximately 1,300 MW. The commercially achievable potential of all the measures remains to be demonstrated, particularly in those CI subsectors where they may have an impact on the power demand billed to the customers.

Table 4 – Potential of power demand management measures in the commercial and institutional sectors

Measures included in technical/economic potential assessment	**Unit cost ($/kW-winter)**	**Potential (MW)**
Anti-sweat heater shutoff – customer		
Lighting control – greenhouses		
Optimization of start times (with EMS)		
Reduction of fresh air flow		
Control of water heater		
Heat storage – local		
Heat storage with control		
Management of temperature setpoints (with EMS)		
High-storage water heater - control (with EMS)		
Interruption of humidifiers		
Optimization of start times (with EMS)		
Management of temperature setpoints		
High-storage water heater – control		
Reduction of fresh air flow rate		
Reduction of ventilation rate (with EMS)		
Heat storage – local		
Control of water heater (without EMS)		
Dual energy heating		
Heat storage with control		
Backup gensets		
Dual energy gas water heater		
Measures excluded from potential assessment	**Unit cost ($/kW-winter)**	**Potential (MW)**
Backup gensets		
Dual energy heating		
Heat storage – local		
High-storage water heater		
Heat storage with control		
Heat pump with propane backup		
High-storage water heater – control		
Anti-sweat heater shutoff – control		
Interruption of humidifiers		
Reduction of fresh air flow		
Reduction of ventilation rate		
Control of water heater		
Management of temperature setpoints		
Ballast with modulation (dimming)		
Optimization of start times		
Adjustment of heat pump flow rate		
Dual energy (gas) water heater		
Lighting control – public		

4 Technical/economic potential assessment: industrial sectors

4.1 Methodology

The approach taken for the industrial customers (large, medium-sized, and small) is macroanalytic in nature. It is based on a definition of typical consumption curves and operating conditions for different industrial subsectors. The measures and the costs of the power demand management methods are also determined for each industrial subsector.

4.2 Choice of measures

The technical/economic potential assessment for the industrial sectors comprises two classes of measures:

1) Measures necessitating capital investment and, in certain cases, involving annual operating costs. The costs of these measures are generally not very sensitive to the number of winter hours during which loads are reduced.

2) Measures strictly linked to operations, whose costs depend on the number of winter hours in which loads are reduced. With large industrial customers, it is generally possible to shift production in time; productivity losses may be negligible where the number, frequency, and duration of events are small.

The detailed list of power demand management measures for the industrial sectors is given in the appendix.

4.3 Results

4.3.1 Large industrial customers

In Table 4, the technical/economic potential assessment for the large industrial customers (GI) is presented separately for operational measures and for measures requiring capital investments. For a duration of 100 hours of interruption per winter, the technical/economic potential varies from 1,240 to 1,460 MW depending on the horizon over which the analysis is performed. The Distributor's interruptible electricity is already exploiting nearly all of this potential.

Table 4[2] – GI tariff technical/economic potential by number of hours of interruption

	Winter 2012-2013			Winter 2016-2017		
Total duration (h)/winter						
Operational measures (MW)						
Measures requiring investment (MW)						
Total (MW)						

Note: Values rounded.

Figure 2 provides detailed information on the operational measures included in technical/economic potential, by amount of notice and duration of interruption (100 and 120 hours). The majority of the operational measures for the large industrial customers require prior notice of at least two hours.

Figure 2 – Prior notice for GI operational measures

[Legend:]
Power gains by amount of prior notice
(Winter 2016-2017) - Tariff L industries
Power gain (MW)
100 hours
120 hours

[2] Translator's note: In the original, this and the last table are both labeled "Table 4."

4.3.2 Small and medium-sized customers

Table 5 presents the technical/economic potential for small and medium-sized customers. For a duration of 100 hours of interruption per winter, the technical/economic potential for this class varies from 50 to 60 MW depending on the horizon over which the analysis is performed.

Table 5 – Technical/economic potential for small and medium-sized customers by number of hours of interruption

	Winter 2012-2013			Winter 2016-2017		
Total duration (h)/winter						
Operational measures (MW)						
Measures requiring investment (MW)						
Total (MW)						

Note: Values rounded.

Figure 3 shows that most of the measures for small and medium-sized customers require approximately 24 hours notice.

Figure 3 – Prior notice – Small and medium-sized customers

[Legend:]
Power gains by amount of prior notice
(Winter 2016–2017) - M and G tariff industries
Power gain (MW)
100 hours
120 hours

5. Conclusion

The Distributor has assessed the technical/economic potential for power demand management measures for each class of consumer.

For the residential and CI sectors, the highest technical/economic potential is approximately 1,300 MW at the 2016–2017 horizon and derives from measures involving the installation of heating appliances that allow for shifting of load to off-peak times. This potential takes account of the recovery phenomenon and its impact on the Distributor’s power requirements curve. The commercially achievable potential, however, remains to be demonstrated.

For the industrial customers, the technical/economic potential for power demand management essentially derives from operational measures designed to reduce or interrupt plant operations for variable periods during the winter. For small and medium-sized customers, technical/economic potential remains marginal, while for large industrial customers, the Distributor’s interruptible electricity is already exploiting nearly all of this sector’s potential.

Appendix – List of industrial measures

Operational measures

Interruption of raw material crushers and conveyors
Interruption of coal crushers and conveyors
Interruption of clinker crushers and conveyors
Shutoff of ore concentrators
Interruption of crushers, grinders, breakers, screens, and conveyors
Underground storage of mined ore, allowing for interruption of winch
Concentration of tunnel operations in order to decrease the ventilation of unoccupied areas
Shifting of dynamiting periods to reduce ventilation
Interruption of conveyor load in ports
Shifting of production to weekends
Shifting of quick freezing periods
Interruption of barkers
Shifting of sawing and/or planing operations to weekends
Interruption of chippers
Interruption of TMP refiners
Interruption of barkers and conveyors
Partial interruption of wastewater treatment blowers
Interruption of one paper machine line
Interruption of Kraft refiners
Interruption of mechanical pulp defibrators
Interruption of one paper or cardboard machine line
Modulation of power to electrolytic cells for production of bleach and soda
Interruption of all non-essential equipment
Interruption and/or modulation of gas compressors
Interruption of extruders
Interruption of rubber mixers
Shifting of production to night hours
Modulation of cell amperage
Interruption of electric furnaces
Modulation of power to electrolytic cells for production of zinc and copper
Interruption of furnaces and treatment baths
Interruption of wire drawers, extruders
Shifting of production to nights and weekends
Voluntary load interruption at outlets (elevators, freight elevators, pumps, batteries, etc.)
Measures requiring investment
Remote control of non-essential interior and exterior lighting
Automated control of power demand for peak clipping: heating, hot water
Use of gensets
Interruption of engine block heaters in parking lots (northern plants)
Storage of compressed air for at-peak use
Storage of thermal oil for at-peak use
Establishment of pumped storage for at-peak use
Remote equipment load shedding
Use of lead-acid batteries
Use of flow batteries (new technology)
Temporary switching of electric boilers to fuel power
Remote control of individual or central heating thermostats to reduce temperature
Dimmers in offices and warehouses
Use of heat storage unit in forced-air electric furnaces
Use of heat storage unit in electric baseboard heaters