# COMPARAISON DES PRIX DE LA COMBINAISON SÉLECTIONNÉE AVEC LES PRIX DES PRINCIPAUX PRODUITS DISPONIBLES DANS LES MARCHÉS DU NORD-EST DE L'AMÉRIQUE ET LES COÛTS DE TRANSPORT APPLICABLES

# *Benchmark Assessment of the Cost of Peaking Generating Capacity*

## *Final Report*

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# The Competitive Cost of Peaking Generating Capacity in North American Markets

## 1. Introduction

Hydro-Quebec Distribution asked Merrimack Energy Group, Inc. ("Merrimack Energy") to conduct a benchmark analysis of the competitive long-term cost of peaking generating capacity in nearby North American markets. This benchmark study is in conjunction with Hydro-Quebec's requirements for 500 MW of hourly dispatchable capacity with a contract term of twenty (20) years. Hydro-Quebec has identified the needs for a peaking resource that will operate at least 300 hours per year, primarily during the winter months. In addition, Hydro-Quebec estimates that given the expected capacity factor for the units required, units with lower fixed costs and higher variable costs will likely be most economic.

On March 4, 2015 Hydro-Quebec Distribution issued a Call for Tenders (A/O 2015-01) seeking 500 MW of Firm Capacity and Associated Energy for a 20 year delivery term. The electricity may originate from new or existing facilities and must be available on December 1, 2018. Bids were received on May 20, 2015.

This assessment is intended to compare the pricing for capacity-related costs associated with the bids submitted in response to Hydro-Quebec Distribution's Call for Tenders relative to the capacity costs experienced or projected in nearby power markets, primarily in the US. Since Hydro-Quebec Distribution is seeking a 20 year delivery term for the capacity and associated energy, Merrimack Energy has focused on assessing the cost of a new generating unit that operates primarily in peaking mode with limited hours of operation.

Merrimack Energy has conducted several recent benchmark studies for peaking units and has also reviewed a number of proposals for peaking units. We have found that costs for such units vary by region of the country depending on a number of factors including labor costs, tax rates, land availability and costs, permitting requirements, consistency of technology comparisons, land use status (i.e. greenfield or brownfield sites), and the timeliness of available information. In addition, costs vary by technology based on the required application of the generating unit. For example, there are generally trade-offs associated with the required operating parameters and applications for these units which include such factors as heat rates, operating flexibility, quick start capability, ramp rates, etc. Generating units such as the newer GE LMS100 units have a higher capital cost than the traditional Frame units but have lower heat rates, more flexible operating parameters, and quicker start capability.

One of the issues with regard to peaking units is that there are a number of options available on the market including combustion turbine technologies, various technologies using aero-derivative engines, and reciprocating engines. In jurisdictions where a utility has a significant amount of intermittent renewable generation or is seeking generation resources that can ramp up and down quickly to meet changes in the availability of intermittent generation and offer operating flexibility the resource of choice may be a higher capital cost but more flexible and efficient unit. On the other hand, utilities such as Hydro-Quebec which prefers peaking capacity which operates few hours, the technology of choice may be a unit with a lower capital cost without the operating flexibility given the expected low capacity factor and the need for the unit to primarily provide generating capacity.

For this study, Merrimack Energy will attempt to utilize capital and operating cost information for projects expected to be built and operated in New England, New York, and PJM markets in the Northeast US.[1] In some areas of this region costs are likely to vary based on some of the factors identified above. For example, the costs to construct and operate a peaking capacity unit in the New York City area or Long Island will be much higher than in upstate New York markets. In addition, Merrimack Energy has a significant base of cost and operational information on a number of combustion turbine technology options in other regions of the country where costs are generally lower than in the Northeast. We will identify the differences in costs and attempt to apply cost differences to derive representative costs for Quebec.

For this study, Hydro-Quebec requires information on the capital cost, operations and maintenance costs, operating parameters, and annualized costs for the technologies presented. [2]

## 2. Background

For undertaking this assessment, Merrimack Energy will utilize publicly available information supplemented by project specific cost and operational information. Since Hydro-Quebec is seeking approximately 500 MW of generating capacity, we are not including cost information for some combustion turbine options (i.e. aeroderivative options such as the GE LM2500) and reciprocating engine options that are commonly used for peaking applications but have size limitations and may be more applicable for smaller utility systems or in industrial applications. Instead Merrimack Energy will focus more on utility-scale combustion turbines.

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[1] Much of the data used for this analysis is based on 2014 cost information. Merrimack Energy could only find limited information for 2015 power project costs. However, based on our involvement in the power market it is our experience that capital costs of peaking units and combined cycle units have been relatively stable over the past few years.

[2] All three ISOs in the Northeast US have forward capacity markets and commission Cost of New Entrant ("CONE") studies as the basis for establishing benchmark capacity prices for several years. CONE refers to the price at which a power plant can recover its fixed costs in the marketplace. The price is set as a benchmark based on the cost of building a peaking or other unit. These studies are designed to estimate the reference cost of a new generating unit (the reference unit is usually a gas-fired combined cycle unit or peaking unit). The studies have become more detailed and sophisticated over time and have received significant stakeholder scrutiny. In Merrimack Energy's view these studies provide a reasonable benchmark for capital and operating costs for the resources studied and are much more accurate than general market studies, Integrated Resource Plans submitted by utilities, or cost of generation studies.

There are still a wide range of options available in the simple cycle gas turbine or combustion turbine electric generation technology class. For example, the GE LMS 100 unit, which merges two proven technologies: frame industrial gas turbines and aeroderivative gas turbines, has become the technology of choice of larger scale utilities around the US for simple cycle peaking operations. The LMS 100 combines the technology of heavy-duty frame engines and aeroderivative turbines to provide cycling capability without the maintenance impact experienced by frame machines; higher simple-cycle efficiency than current aeroderivative machines; fast starts (10 minutes); and high availability and reliability. The LMS 100 unit is a flexible and efficient unit with an attractive heat rate. This unit is capable of following load quickly and has been touted as a very effective compliment to support the utility system in lieu of the increase in the availability of energy from intermittent resources, such as wind or solar generation. The unit size exceeds 80 MW per turbine.

Another option is the Siemens SGT6-5000F class gas turbine. This gas turbine has been sold in the past 20 years, with more than 5.3 million hours of fleet operation. The SGT6-5000F combustion turbine, with a nominal rating of 220 MW, has consistently had reliability of 99%. A SGT6-5000F can reach full load within 10-12 minutes. Comparable to this turbine is the GE Frame 7FA type of turbine which is used in both combined cycle operations and as a stand-alone peaking unit.

Another option is the GE or similar aeroderivative technology which is derived from aviation applications. For example, GE options in this category are based on the GE CF6 aircraft engine. Aeroderivative options range in size from 18 MW to 100 MW. Recent innovations and advances in gas turbine material and cooling technology have raised firing temperatures without affecting maintenance intervals or component life. Two primary examples of aeroderivative turbines include the GE LM2500 and GE LM6000 units.

According to GE, GE's LM2500 has been one of the top selling aeroderivative gas turbines in its class for more than 40 years. This turbine offers 18-35 MW of power generation with up to 36% efficiency. The unit has proven reliability and availability, dual fuel capability, low emissions (as low as 15 ppm NOx) and fast load response. With steam or water injection and single fuel natural gas, the LM 2500 can guarantee NOx emissions as low as 15 ppm. For applications requiring even lower NOx levels, other means, such as selective catalytic reduction (SCR) must be used.

For utility-scale operations, the LM6000 unit has been a common technology for combined heat and power (CHP) applications as well as for stand-alone electric generation. The LM6000 was introduced in early 1990's. Since its inception, the LM6000 gas turbine has established itself with more than 1000 units ordered and more than 22 million operational hours at reliability greater than 99.8%. The LM6000 targets power generation needs between 35 MW and 60 MW. The unit is capable of 15 to 25 ppm NOx emissions.

The LM6000 provides the buyer with 10 minute start time. The GE LM 6000 Sprint has the best simple-cycle heat rate of any industrial gas turbine in its class. In addition, the LM6000 equipment allows for flexible dispatching with no start penalty for maintenance.

## 3. Current Market Costs and Pricing

One of the most comprehensive sources of data on combustion turbine unit costs are the studies completed for ISO-NE, PJM, and the New York ISO ("NYISO") on the Net Cost for New Entry (Net CONE). For example, PJM's capacity market features a three year forward auction and subsequent incremental auctions in which Variable Resource Requirements (VRR curves) set the "demand". The VRR curves are determined administratively based on the design objective to procure sufficient capacity for maintaining resource adequacy in all locations while also mitigating price volatility and susceptibility to market power abuse. To procure sufficient capacity, the VRR curves price-quantity combinations are established to be consistent with the assumption that, in a long-term economic equilibrium, new entrants will set average capacity market prices at the Net Cost of New Entry (Net CONE). Net CONE is the first year capacity revenue a new generation resource would need (in combination with expected energy and ancillary services margin) to recover its capital and fixed costs, given reasonable expectations about future cost recovery under continued equilibrium conditions. Thus, the sloped demand curve is assigned a price equal to Net CONE at approximately the point where quantity equals the desired average reserve margin. PJM calculates Net CONE for a defined "reference resource" by subtracting its estimates one-year energy and ancillary services net revenue from its estimated Cost of New Entry (CONE). CONE values are determined through triennial CONE studies. PJM has traditionally estimated CONE and Net CONE based on a gas-fired simple-cycle combustion turbine (CT) as the reference technology.[3]

The market structures in ISO-NE and NYISO are similar to PJM with regard to the forward capacity market and ISOs have commissioned similar CONE studies to support that market structure. The interesting aspect of the studies is that different technologies have been selected as representative of the reference resource used for establishing the cost of new entry. In addition, the costs for the same technology may also be different among regions.

**New England Cost of New Entry**

With regard to benchmark costs in New England, the Brattle Group provided a presentation to the ISO NE stakeholders on the results of its study on the net CONE costs for the ISO New England market entitled "Net CONE for the ISO-NE Demand Curve 3rd Response to Stakeholders Comments and Draft Proposal – February 27, 2014". The Brattle Group provided its assessment on the cost estimates for four specific technologies (i.e. LMS100, LM6000, combined cycle, and Frame unit) to establish the Net CONE

[3] Within the CT category, studies have generally assessed multiple CT resource options.

prices for ISO-NE. The Brattle Group stated that the objective of this assessment is to estimate the Net CONE that supports prices just high enough to attract sufficient new investment to meet resource adequacy objectives.

As part of its study, the Brattle Group investigated whether a Frame CT with a lower efficiency (and higher CO2 emissions) relative to aero-derivatives would be able to receive an air permit. The Brattle Group found that no F-class frame type CTs had been proposed recently in New England and there was not a record of a Frame CT being approved or refused a permit, although there was some concern about approval for such a unit in Massachusetts. The Brattle Group also questioned the cost estimates since the capital costs were much lower and yet no such units were proposed.

The analysis focused on the cost of an LMS100 unit and an LM6000 unit. The analysis therefore considered the costs of a GE LM6000 and a GE LMS100 unit as the two primary new entrant options. The analysis concluded that the gross CONE[4] cost of an LMS100 unit is $18.40/kW-month compared to the cost of an LM 6000 of $21.10/kW-month. The gross CONE value for the LMS100 is based on a $2018 overnight capital cost of $1,705/kW installed and included a Carrying Cost (i.e. Capacity Cost) of $15.50/kW-month and a Fixed O&M charge of $2.90/kW-month for a total of $18.40/kW-month.[5] From there, the Brattle Group estimated the Net CONE (Gross CONE adjusted for energy and ancillary service margin and other cost adjustments) to be $17.85/kW-month or $214.20/kW-year.[6]

Table 1 below provides a summary of the cost information and other information for each of the two CT technology options for which detailed data was provided. Dual fuel capacity was apparently assumed on all new entrant options in New England. For combined cycle options, the Brattle Group noted that dual fuel capability led to an incremental cost of about $17.5 million in $2013 which added about $.50/kW-month.

**Exhibit 1: Summary Information for the ISO-NE Benchmark Options**

| **Benchmark Option Summary Information** | **GE LMS 100** | **GE LM6000** |
|---|---|---|
| | | |
| ***Summary Info*** | | |
| | | |
| Technology | LMS 100 | LM 6000 |
| Location | New England | New England |
| In-Service Date | 2018 | 2018 |
| Size (MW) | 188 (2 units) | 173 (4 units) |

[4]Gross CONE costs include the capacity and fixed O&M costs only and are most applicable for assessing the fixed costs of constructing and operating such a unit.

[5] The assumptions underlying the cost analysis include: (1) no network upgrade costs required; (2) estimated electric interconnection costs of $7.1 million in $2013; (3) Cost of debt of 7% and cost of equity of 13.8%; (4) Debt/Equity ratio of 60%/40%; (5) Composite tax rate of 40.5%; (6) WACC of 8%.

[6] The Gross CONE cost at $18.40/kW-month results in an annual cost of $220.80/kW-year.

| Fuel | Natural gas | Natural gas |
|---|---|---|
| Emission Control Equipment | SCR and low NOx combustors | SCR and low NOx combustors |
| | | |
| ***Pricing Information ($2018)*** | | |
| Capital Cost ($/kW)[7] | $1,705 | $1,962 |
| Capital Carrying Cost ($/kW-year)[8] | $186 | $214.80 |
| Fixed O&M ($/kW-year) | $34.80 | $39.60 |
| Total Fixed Cost/kW-year | $220.80 | $254.40 |

Merrimack Energy views these cost estimates to be on the high side of what we have seen in other markets, such as California, which can also be classified as a high cost market. Nevertheless, Merrimack Energy has served as Independent Evaluator for two separate contracts executed by a utility with an independent power producer for LMS 100 units and the annualized fixed costs were slightly less than the LMS100 option noted above.

Furthermore, in its presentation, the Brattle Group indicated that stakeholders of ISO-NE requested that the Brattle Group compare its cost estimates to actual costs of turbines. In response, the Brattle Group compared its cost estimates to the actual costs of turbines in Connecticut's peaker solicitation. The results of the review illustrated that a single LMS100 unit bid a cost of $1,449/kW while several LM6000 units were bid at prices ranging from $1,046/kW to $1,292/kW. The Brattle Group concluded that the Connecticut peaking units selected are lower cost because of economies of scale and were built on brownfield sites as opposed to greenfield sites.

In its presentation, the Brattle Group also presented the costs associated with a Frame CT (2 units with an installed capacity of 417 MW). The Brattle Group estimated the 2018 total plant capital cost to be $377 million or $904/kW installed. Fixed O&M costs were estimated to be $1.52/kW-month with a gross CONE cost of $10.12/kW-month or $121.44/kW-year.

**NYISO**

A study prepared for the NYISO by NERA and Sargent & Lundy entitled "Proposed NYISO Installed Capacity Demand Curves For Capability Years 2014/2015, 2015/2016, and 2016/2017" (Draft Report 8/19/2013) presents high level capital cost information for LMS100 units and Siemens STG6-5000(F) units in several zones in NYISO as a point of comparison and as the basis for determining the CONE in New York. According to the

[7] Overnight costs
[8] The implied Capital Cost Recovery Factor based on the estimated Capital Cost and reported annual Capital Carrying Cost equates to approximately 10.91.

study, the capital costs for various units vary significantly between zones in the NYISO. For example, LMS100 capital costs range from a low of $1,332/kW (2013$) in Zone C Syracuse to a high of $1,858/kW (2013$) in New York City. If these capital costs increase annually by the estimated rate of inflation of 2.5%, capital costs would range from $1,500/kW for Zone C (Syracuse) to $2,100/kW for New York City in 2018$, compared to the ISO-NE estimated capital cost for an LMS100 project of $1,705/kW in 2018$.

For this analysis, Merrimack Energy is presenting the capital cost and operating cost information for both the LMS100 units and the Siemens STG6-5000(F) unit as the primary competitive options studied for setting the Cost of a New Entrant in New York. As background, the decision regarding the CONE value was subject to much scrutiny and was ultimately brought before the Federal Energy Regulatory Commission. Ultimately, the Siemens STG6-5000(F) unit was selected as the basis of the CONE value. Nevertheless, the level of detail presented for each option merits review. Exhibit 2 presents the comparative cost information for each option.

**Exhibit 2: Summary Information for the NYISO-NE Benchmark Options**

| **Benchmark Option Summary Information** | **GE LMS 100** | **Siemens STG6-5000(F)** |
|---|---|---|
| | | |
| ***Summary Info*** | | |
| | | |
| Technology | LMS 100 | Siemens STG6-5000(F) |
| Location | New York – Zone C | New York – Zone C |
| In-Service Date | 2018 | 2018 |
| Size (MW) | 186.25 | 174 |
| Average Load Heat Rate | 9,223 | 10,800 |
| Fuel | Natural gas | Natural gas |
| Emission Control Equipment | SCR and low NOx combustors | SCR and low NOx combustors |
| | | |
| ***Pricing Information ($2018)*** | | |
| Capital Cost ($/kW)[9] | $1,507 | $901.73[10] |
| Capital Carrying Cost ($/kW-year)[11] | $195.61 | $117.11 |
| Variable O&M | $5.38 | $.25 |

[9] Overnight costs

[10] The data for Zone C is based on Appendix B capital cost of $797/kW-year escalated by 2.5% annually to derive 2018 costs.

[11] The implied Capital Cost Recovery Factor based on the estimated Capital Cost and reported annual Capital Carrying Cost for the Siemens option equates to approximately 12.98. This factor is applied to the LMS100 option to calculate the Annual Carrying Charge.

| | | |
|---|---|---|
| ($/MWh) | | |

The NYISO study assumes a 50/50 debt/equity ratio, a 6.5% debt rate and a return on equity of 12.5%. The implied Capital Cost Recovery Factor is 12.98. If the same Capital Cost Recovery Factor is applied to the cost of the LMS100 unit, the annual Capital Carrying Cost will be an estimated $219.41/kW-year.

Although the capital cost information for the Siemens STG6-5000 unit appears to be much lower than alternative peaking options the capital cost and annualized capacity charge is similar to the Frame unit estimated by the Brattle Group for ISO-NE. In addition, Merrimack Energy evaluated a proposal recently in a low cost US market in which the project sponsor proposed STG6-5000(F) units, which had a slightly lower capital cost than the option estimated for NYISO.

**PJM**

The Brattle Group and Sargent & Lundy recently completed a study for PJM entitled "Cost of New Entry Estimates for Combustion Turbine and Combined Cycle Plants in PJM with June 1, 2018 Online Date" (May 15, 2014). The Brattle Group and Sargent & Lundy developed CONE estimates for gas-fired simple cycle combustion turbine (CT) and combined cycle (CCGT) power plants in each of the five administrative CONE areas with an assumed online date of June 1, 2018. For both the CT and CC plants, the study specifies two GE 7FA turbines, with the CCGT equipped with a single heat recovery steam generator and steam turbine, cooling towers and duct-firing capacity. All plants have selective catalytic reduction (SCR) for controlling NOx. Most have dual-fuel capability, including the Eastern Mid-Atlantic Area Council (EMAAC), the region we have used as the basis of this assessment.

According to the study, for each plant specified the analysts conducted a comprehensive bottom-up analysis of the capital costs to build the plant: the engineering, procurement, and construction (EPC) costs, including equipment, materials, labor, and EPC contracting; and non-EPC owner's costs, including project development, financing fees, gas and electric interconnection costs and inventories. The analysts separately estimated annual fixed operating and maintenance (O&M) costs, including labor, materials, property taxes and insurance. The analysts then translated the estimated costs into the annualized average net revenues the resource owner would have to earn over an assumed 20-year economic life to earn its required return on and of capital, assuming an after-tax weighted average cost of capital (WACC) of 8% for a merchant investor, which was estimated based on various reference points. An 8% WACC is equivalent to a return on equity of 13.8% at a 7% cost of debt and a 60/40 debt-to-equity capital structure.

The study specifies the GE 7FA.05 gas the turbine model to be used as the reference installed capacity technology. The reference unit is rated at 396 MW with a total of 2 units, net Summer ICAP, with a heat rate of 10,309, and with dual fuel capability. The unit has evaporative cooling and no inlet chillers. For environmental controls the unit has SCR and CO2 Catalyst.

The unit's total capital cost in 2018$ is $400.2 million or an estimated installed cost of $1,061/kW in 2018 dollars, levelized fixed O&M of $15/kW-year,[12] and variable O&M of $4.29/MWh in 2018. Based on an after-tax weighted average cost of capital, the levelized nominal fixed cost of the project (Gross CONE) is estimated to be $150/kW-year.

**Other Analysis and Projects**

Merrimack Energy also researched other sources of information for the cost of peaking units in other regions of the US. Sources included actual bids and projects, utility resource plans, and other general resource cost studies.

With regard to actual project proposals, Merrimack Energy was involved in a solicitation process recently requesting offers for peaking projects, including generation options. Several different technologies were proposed including LMS100 units, Siemens STG6-5000F turbines, and reciprocating engines. Assuming a 2.5% average annual escalation rate in equipment costs, the estimated 2018 capital cost for the LMS100 unit would be $1,165/kW and the capital cost for the Siemens STG6-5000F would be $890.10/kW. The LMS100 has a reported heat rate of 9,047 BTU/kWh, while the Siemens unit has a heat rate of 9,295. While the results demonstrate that the costs of the generating options in this market are lower than in the Northeast US markets, the cost of a Siemens STG6-5000F unit (Frame unit) is still quite a bit lower than the LMS100.

As another example, Entergy completed a resource plan in 2012 that evaluated the cost and operating parameters for three options considered in the ISO studies: LMS100, LM6000, and GE 7FA (.05). The costs were reported in 2011 dollars and in 2022 dollars. Merrimack Energy has converted the 2011 costs into 2018 costs assuming an annual escalation rate of 2.5% per year. The results are presented in Exhibit 3.

**Exhibit 3: Summary Information for the Entergy IRP Benchmark Options**

| **Benchmark Option Summary Information** | **GE LMS 100** | **GE LM6000** | **GE 7FA(.05)** |
|---|---|---|---|
| | | | |
| ***Summary Info*** | | | |
| | | | |
| Technology | LMS 100 | LM6000 | GE 7FA (.05) |
| In-Service Date | 2018 | 2018 | 2018 |
| Size (MW) | 304 | 290 | 219 |
| Average Load Heat Rate | 8,400 | 9,150 | 9,250 |
| Fuel | Natural gas | | Natural gas |
| | | | |

[12] Fixed O&M in 2018 is estimated to be $5.9 million.

| ***Pricing Information ($2018)*** | | | |
|---|---|---|---|
| Capital Cost ($/kW) | $1,485 | $1,426 | $1,069 |
| Fixed O&M ($/kW-year) | $9.50 | $9.50 | $8.92 |
| Variable O&M ($/MWh) | $2.38 | $2.38 | $2.38 |

Finally, Merrimack Energy recently worked for a utility in the Southwest US that conducted a benchmark assessment for purposes of identifying the capacity cost for power purchases based on market prices through 2017 and the addition of a new peaker in 2018. The company used the costs of an LMS100 as the proxy unit. The utility calculated the capital cost of the LMS100 to be $1,185/kW with a levelized cost of $145/kW-year based on a WACC pre-tax of 11.90%.

## 4. Comparison of Benchmark Prices to the Results from the Firm Capacity and Associated Capacity Call for Tenders (A/O 2015-01)

Since Hydro-Quebec is primarily interested in capacity that is expected to operate a limited number of hours and the capacity is not needed to facilitate integration of intermittent renewable energy onto the grid, CT options such as the GE Frame 7FA and the Siemens STG6-5000F units are most applicable for establishing benchmark costs, assuming there are no permitting issues associated with these units. The analysis reviewed illustrated installed capital costs in the range of approximately $900-$1,050/kW in 2018 dollars with annualized fixed costs (i.e. Gross CONE) of $115 - $150/kW-year in US dollars. For comparison purposes, the range of fixed capacity charges in Canadian dollars would range from approximately $142/kW-year to $185/kW year levelized based on 2018 dollars.[13]

To place the fixed capacity charges for U.S. projects on a comparative basis with the Hydro-Quebec costs presented in Exhibit 4 below, the levelized costs presented should be converted to real levelized costs by determining the first year capacity charge which when escalated by inflation provides the same net present value cost stream as the levelized costs presented in the previous paragraph. To put the prices on a comparable basis, Merrimack Energy calculated the real levelized cost of the price range for fixed capacity charges to be between $114.30/kW-year (Cn$) and $148.90/kW-year (Cn$).

Hydro-Quebec selected three bids submitted by Hydro-Quebec Production. The pricing and related information for the bids selected is included in Exhibit 4. The real levelized price is based on a 2015 initial base price but with a 2018 contract start date..

[13] Merrimack Energy used the average monthly exchange rate for US and Canadian dollars for the period March 2015 to May 2015, which coincides closely to the timeframe from issuance of the Call for Tenders to submission of bids.

**Exhibit 4: Evaluation of Contract Pricing**

| Project Name | Contract Capacity (MW) | Real Levelized Capacity Price (Cn $/kW-year) | Annual Escalation |
|---|---|---|---|
| HQP System - 1 | 100 | $60.00 | 2.0% |
| | | | |
| HQP System - 2 | 200 | $105.00 | 2.0% |
| | | | |
| HQP System - 3 | 200 | $126.60 | 2.0% |

As the above results illustrate, the HQP System 1 and HQP System 2 bids have a real levelized cost below the low end of the benchmark cost range of $114.30/kW-year based on the cost of a new peaking unit. HQP System 3 has a real levelized cost that is within the calculated cost range. As a result, it can be concluded that the 20 year contracts executed by Hydro-Quebec Distribution are cost-effective relative to the alternative option of constructing new peaking capacity in the market to meet the 500 MW requirements.

## 5. Summary and Conclusions

Hydro-Quebec Distribution sought bids for 500 MW of firm capacity and associated energy with a contract start date of December 1, 2018. Hydro-Quebec Distribution issued a Call for Tenders on March 4, 2015 seeking to meet the firm capacity requirements. Hydro-Quebec Distribution received seven bids totaling 830 MW. All but one of the bids proposed existing generation options. Hydro-Quebec Distribution selected three bids proposed by Hydro-Quebec Production for 500 MW of system capacity.

Hydro-Quebec Distribution asked Merrimack Energy to conduct a benchmark study of the costs of firm peaking capacity to assess the reasonableness of the costs of the contracts executed. Merrimack Energy conducted an initial benchmark study prior to launch of the Call for Tenders and updated the study after completion. Merrimack Energy relied primarily upon the Cost of New Entrant (CONE) studies commissioned by ISO-New Energy, NYISO and PJM as the basis for establishing capacity pricing in their respective. Merrimack Energy relied upon the cost estimates calculated for the technology most applicable to the generation requirements of Hydro-Quebec Distribution, i.e. a generation technology which is generally low capital cost with limited operating flexibility given that the number of hours of operations is very limited with an expected low capacity factor. Capital cost estimates for Frame units were the most applicable and the lowest cost options. Merrimack Energy calculated a range of benchmark capital costs of $142 to $185/kW-year levelized in Canadian dollars for a 20 year contract or $114.30/kW-year (Cn$) to $148.90/kW-year (Cn$) on a real levelized cost basis. The results of the Call for Tenders illustrates that the three contracts executed by Hydro-Quebec Distribution with Hydro-Quebec Production were either below the range (two contracts) or were well within the range established. As a result, Merrimack

Energy concludes that the contract pricing for the three contracts is lower than the alternative option of constructing new units to meet Call for Tenders requirements.