Executive Summary

The Gross Cost of New Entry and Net Cost of New Entry are significant inputs for a fully functioning capacity market. Accurate estimation ensures that resources can enter and exit the market when appropriate price signals are present. To develop an objective accurate estimation, the AESO will contract with independent financing and engineering services firms to determine appropriate detailed cost estimates for the Gross Cost of New Entry and develop a forecasting approach to the subsequent Net Cost of New Entry calculation. This document explains the approach that the AESO will take in developing the Gross Cost of New Entry and Net Cost of New Entry calculations and exemplifies illustrative results using preliminary data from the 2017 Long Term Outlook. Furthermore, the document identifies the selection and rationale of recommending simple cycle technology as the reference technology.

Approach to Gross CONE Estimation

The AESO intends to contract with independent external subject matter experts, experienced in power plant development, engineering/construction, and finance in Alberta, to determine the appropriate Gross Cost of New Entry (Gross CONE) and Net Cost of New Entry (Net CONE) estimates that will set the demand curve framework for Alberta’s capacity market. The capacity market intends to incent supply additions with sufficient revenue, to ensure resource adequacy. Annual procurement is administered by an auction mechanism, where supply is bid into the market against a price stream dictated by the demand curve. The demand curve is indexed to the Net Cost of New Entry for a specific reference technology.

Using independent and experienced consultants will provide a credible Gross CONE value, which properly reflects the appropriate financing and plant development costs for the generic reference plant. The estimates from Gross & Net CONE set various market parameters, including inflection points on the capacity market demand curve, and as such, accurate estimation is paramount. Due to the in-depth nature of the Gross CONE estimate, the AESO intends to use the study for 3-4 years, indexing the Gross CONE estimates to changes in key drivers of capital costs. The Net CONE estimate can then measure the “missing money”, considering the net revenues that the reference plant can derive from the forecast energy and ancillary service markets. Net CONE calculation should be as accurate a representation as possible, since the metric will set the price level Alberta will pay for capacity, noting however that this accuracy is difficult to achieve given the inherent uncertainty in forecasting. Future studies will adapt if market conditions change, invoking new reference technologies and Net CONE estimates accordingly.

Reference Technology Selection

The reference technology selection for Alberta’s capacity market represents an important benchmark for capacity market participants to consider in investment and retirement decisions. The reference technology selection process is designed to ensure adequate revenue for required generation additions. The reference technology should represent a technology that can be developed to meet the capacity needs, during the timeframe, at a low cost. Philosophically, the reference technology should represent...
the most likely unit to be developed under expected market conditions to meet capacity needs. Factors to consider include historical capacity additions, the lowest Gross CONE option, the lowest net CONE option, or the fastest deployable technology. In all capacity market jurisdictions, the reference technology is based on a natural gas-fired power station. Some capacity markets refer to a combined cycle plant, while other markets prefer a simple cycle reference technology.

**Frequency of Development**

The most frequently installed new generation source in Alberta is natural-gas fired electric capacity. Historical additions provide some insights into likely future developments: Between 2012 and 2016, development of natural-gas generation resulted in 919 MW of new combined cycle capacity, 816 MW of cogeneration capacity, and 176 MW of simple cycle capacity. The combined cycle additions were primarily driven by the development of a single facility, the Shepard Energy Center, indicating that combined cycle plants can be developed in Alberta but are likely to be developed less frequently given their larger size. Cogeneration is not a good reflection of the reference power plant since electricity generation is a secondary economic driver in the development of these facilities. Generally, cogeneration developments in Alberta host steam plants dedicated to steam-assisted-gravitational-drainage (SAGD) oil production. The idiosyncratic resource specific costs and non-electricity economic value of cogeneration facilities means that the Net CONE of cogeneration could vary across a wide range, and that Alberta would not be able to attract an unlimited quantity of that resource type at similar Net CONE, thus making cogeneration unsuitable as a reference technology. Simple cycle developments resulted in more than 10 unique facilities totalling only 176 MW of capacity, which includes plants as small as 5 MW and as large as 63 MW. Plants therefore appear attractive from a frequency of development perspective, except for the fact that these facilities vary across a range of different sizes, heat rates, and technology costs. The variety of different simple cycle technologies introduces an additional challenge for selecting a single Net CONE reference plant. The most frequent development of natural-gas fired electric generation does not provide a strong recommendation in terms of capacity market reference technology.

**Reference Plant Costs**

The Alberta Electric System Operator estimates indicative capital and operating costs in the 2017 Long Term Outlook (LTO) Data File. Overnight capital costs for selected natural-gas fired technologies are presented as a range of installed costs ($/kW of capacity), fixed operating costs ($/kW-yr), variable operating costs ($/MWh), and based on a useful life assumption (years). Until a detailed EPC estimate can be provided by an experienced consultant, to inform the selection decision the AESO will present modeling results based on the inputs from the 2017 LTO. Table 1, below, indicates the capital and operating costs associated with simple cycle and combined cycle natural-gas generation from the 2017 LTO.

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1 For Long Term Outlook Data File, please visit: [http://www.aeso.ca/grid/forecasting](http://www.aeso.ca/grid/forecasting)
Table 1: Capital and Operating Cost for Natural Gas Generating Units

<table>
<thead>
<tr>
<th></th>
<th>Combined Cycle</th>
<th>Simple Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overnight Capital Cost, $/kW</td>
<td>$1,500-$1,950</td>
<td>$1,000-$1,500</td>
</tr>
<tr>
<td>Useful Life, years*</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Heat Rate, GJ/MWh</td>
<td>6.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Fixed O&amp;M, $/kW-yr</td>
<td>27.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Variable O&amp;M, $/MWh</td>
<td>8.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Gross CONE, $/kW-yr</td>
<td>$184.00-$230.00</td>
<td>$144.00-$174.00</td>
</tr>
</tbody>
</table>

*The useful life assumption is based on depreciation of natural-gas generating assets in Alberta, but is not explicitly stated in the 2017 Long-Term Outlook.

**Lowest Gross Cost of New Entry: Lowest unit installed cost ($/kW)**

Based on the 2017 LTO information the lowest unitized Gross CONE among considered generating plants results from the development of simple cycle natural-gas generation. The fixed capital costs associated with simple cycle technology are estimated to be $1,000/kW to $1,500/kW of capacity, which represents a lower capital cost estimate than combined cycle generation ranging between $1,500/kW to $1,950/kW. Simple cycle power plants are expected to have lower fixed operating and maintenance costs ($18/kW-yr) than combined cycle power plants ($27/kW-yr), which suggests that simple cycle power plants will have a fixed capital cost advantage over combined cycle power plants, when depreciated over a similar useful life and financed using the same weighted average cost of capital.

**Lowest Net Cost of New Entry: Lowest net Cost of New Entry ($/kW-yr)**

Applying the energy and ancillary service revenues associated with combined cycle and simple cycle technologies provides insights to the most economic generation source, from a net capacity cost perspective. The market revenues estimated here are derived by dispatching each facility’s variable costs against the forecast future power pool prices to determine the energy market revenues. Variable costs are estimated by adding the cost of natural-gas fuel to the variable operating and maintenance costs of the facility. The simple cycle facility is assumed to have a heat rate of 9.6 GJ/MWh, while the combined cycle facility heat rate is assumed as 6.7 GJ/MWh. The simple cycle and combined cycle facility operating and maintenance costs are estimated at $8/MWh an $4/MWh respectively.

Using EDC Associates Ltd.’s Q3 2017 energy market forecasts as an indicative measurement for energy margins, the lowest Net CONE results from the development of simple cycle natural-gas generation, with an estimated Net CONE of $57/kW-yr to $105/kW-yr in 2021. Using the same price forecasts, combined cycle natural-gas generation resulted in a Net CONE between $81/kW-yr and $124/kW-yr. The Net CONE range for simple cycle and combined cycle generation has some overlap, but the simple cycle plant generally represents the lower Net CONE generation source. This measure alone does not preclude consideration of combined cycle technology as a reference generating plant.

**Generation Source of Last Resort: Fastest time to energization (months)**

Another perspective on the reference technology relates to the concept of adding new capacity quickly. In the event that the electrical system experienced a near term capacity requirement, a simple cycle generation facility could be developed in 2-3 years, whereas a combined cycle facility would require 3-5 years of development time. Therefore, the simple cycle facility represents a generation source of last resort, with a faster construction schedule.
**Selected Reference Technology**

The AESO proposes using simple cycle technology as the reference technology for Alberta’s capacity market, beginning in 2021. The selection of this technology can be rationalized by the frequency of historic generation project developments, the lowest Gross CONE, the lowest or equivalent Net CONE, and the generation source of last resort. The AESO anticipates limits on greenhouse-gas emissions from large facilities will constrain the development of simple cycle facilities larger than 150 MW in the future. Therefore, the reference technology selection will be limited to a plant 150 MW or less. This level also corresponds roughly to the size of the annual average growth of the Alberta Market. As such, most frame turbines would be too large to represent a likely development in the province. Aerodervative turbines including LM6000’s, E-class turbines, reciprocating internal combustion engines, and LMS100 turbines all represent simple cycle technologies with recent developments in the province. Fuel efficiency tends to favor LMS100 turbines and reciprocating internal combustion engines, while availability and maintenance costs may favor LM6000 or E-class power plants. In order to constrain the plant to 150 MW or less the following configurations will be considered:

- Two General Electric LM6000PH aeroderivative gas turbines (110 MW)
- One General Electric LMS100PB aeroderivative gas turbine (118 MW)
- 7 Wartsila 18V50SG reciprocating internal combustion engines (130 MW)
- One General Electric MS7001EA frame gas turbine (91 MW)

These potential configurations could be considered, going forward, as plants for further examination in the Gross CONE report, if they are similar to the recommendations from the expert consultant.

**Financing Costs**

Financing costs for the reference plant will be measured as an after-tax weighted average cost of capital (ATWACC). The ATWACC will be composed of equity and debt rate components, weighted according to a debt/equity split. The underlying debt will represent a typical Alberta power plant investor’s weighted average cost of debt. The AESO will contract with an external consultant to determine the appropriate financing assumptions for the reference plant used in the Gross CONE calculation.

The ATWACC for individual firms is expected to vary greatly, as different participants and projects will have asymmetric credit ratings, costs of debt, and debt/equity ratios. The AESO will work with the external consultant to provide realistic financing assumptions in the Gross CONE calculation, based on observable cost and leverage data applicable to Alberta based power projects.

The WACC and tax rates will be used to calculate the levelized annual return on and return of capital associated with the reference technology. This levelized annual return will be added to the annual fixed O&M costs for the reference facility to arrive at the annual Gross CONE value. Prior to the completion of the consultant work, the debt/equity ratio used for the purposes of interim analysis is 45% debt and 55% equity. The analysis assumes a cost of debt of 5.6% and a tax rate of 27%. The cost of equity is assumed to be 15.5%, resulting in a 10.4% nominal weighted-average-cost-of-capital, or an 8.2% real weighted-average-cost-of-capital.
Energy & Ancillary Services Net Revenues

There are several methods that can be used to determine the net energy and ancillary service revenues which will determine the Net CONE. Some capacity markets use historical revenue analysis to determine future energy and ancillary services revenues for the reference plant, while other markets prefer to forecast or forward prices using a specific formula. Markets may also approach the net energy and ancillary services revenues using a simulated forecast approach.

Energy revenues in Alberta have been quite volatile historically. The capacity market could reduce the cyclical volatility in total revenues, since new facility development should proactively incent a more consistent reserve margin versus the energy-only market structure. Further changes to the Alberta energy and ancillary services market may cause systematic changes to future energy and ancillary services revenues compared to history. As such, historical revenue analysis at this time is not expected to appropriately reflect changes in the future energy market conditions.

Three-year forward electricity prices in Alberta trade with limited liquidity and are not expected to be suitable for the purposes of estimating the energy and ancillary services revenue offset for the Net CONE Calculation. Forward electricity prices can change quickly, with influence from a limited number of market participants. Selecting a moment at which to capture the forward electricity price presents a further difficulty associated with this approach to estimate the energy and ancillary services revenue offset.

The AESO recommends a forecasting approach to Net CONE determinations. With forecast power and natural-gas prices, the reference plant can be dispatched at times when price exceeds variable production costs. The forecast will dictate the production and the resulting energy and ancillary services revenues for the reference plant. Annual energy and ancillary service net revenues can be subtracted from the Gross CONE to determine Net CONE for the reference plant. The exact approach to energy and ancillary services calculation has yet to be determined.
Figure 2: Gross & Net CONE for Gas Fired Technologies