# Alberta Capacity Market

## Comprehensive Market Design (CMD 1)
## Design Rationale Document

## Section 3: Calculation of Capacity Market Demand Parameters

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# 3. Calculation of Capacity Market Demand Parameters

## 3.1 Alberta System Load Forecasts

**Input from Working Group Members and Industry Stakeholders through SAM 3.0:**

Not all working group members agree with using Alberta Internal Load (AIL) to forecast load, and propose that using Alberta Interconnected Electric System (AIES) or system load would be a simpler and more accurate approach.

The Supply Adequacy working group did not establish a provisional recommendation on the methodology to forecast load; however, the approach was reviewed and comments were provided to the AESO by working group members.

**AESO Rationale**:

Key objectives for the AESO's capacity market load forecast are transparency, accuracy and following industry best practices.

Gross demand (i.e. AIL) is currently the best measure of total provincial demand for which Alberta will need to procure capacity. Gross demand, as opposed to net-to-grid demand, is best suited to capture the overall behaviour between economic activity and load.

Forecasting gross demand aligns with the AESO's current planning and reliability mandate.

Utilizing multiple hourly weather and economic profiles introduces load-related uncertainty to the resource adequacy modelling, which provides a better reflection of the range of potential future conditions through which the reliability performance of differing capacity volumes can be tested.

A key intent of the AESO's load forecast models is to minimize model error.

Additional details of the proposed load forecast methodology and process can be found here: www.aeso.ca/assets/Uploads/Capacity-market-load-forecast-model-description-and-process.pdf.

## 3.2 Establishment of the Resource Adequacy Standard

**Input from Working Group Members and Industry Stakeholders through SAM 3.0:**

Generally, the working group agrees on the following points:

The Government of Alberta should set the physical resource adequacy requirement with target values for expected unserved energy (EUE) and/or loss of load hours (LOLH).

The AESO and/or working group should provide the Government of Alberta with a recommendation on setting the reliability targets and measures.

LOLH or EUE are acceptable resource adequacy criteria, but loss of load expectation (LOLE) is not the optimal resource adequacy criterion because it is an overly conservative measure.

**AESO Rationale:**

- Based on public policy announcements, the Government of Alberta is expected to establish the supply adequacy standard.

Through the working group process, a working assumption on the resource adequacy standard was required to evaluate the demand curve options. An initial working assumption of 100 MWh/yr of expected unserved energy was established. Following additional review of historical data, the AESO is revising this working assumption to 400 MWh/yr. The impact of this revision to the demand curve analysis can be found in Section 3.5. The government is expected to define the resource adequacy standard for Alberta, which will be used in developing the capacity demand curve.

## 3.3 Modelling to Estimate Resource Adequacy Standard

**Input from Working Group Members and Industry Stakeholders through SAM 3.0:**

The working group agrees that target procurement volume should be based on probabilistic resource adequacy requirement modelling, considering supply adequacy impacts of all resources regardless of their capacity market eligibility.

The working group reviewed and approved a set of methodologies and inputs for the resource adequacy modelling. Continued transparency is requested in the ongoing consultation process.

**AESO Rationale:**

- A probabilistic approach is expected to provide greater information on the relationship between capacity and supply adequacy, as well as better capture the correlations between supply and demand variability. This results in a more informed and accurate estimation of the target procurement volume.

Additional material on the model inputs and methodologies were evaluated within the Adequacy and Demand Curve working group and additional material can be found here:

https://www.aeso.ca/assets/Uploads/Best-Practice-Comparison.pdf

https://www.aeso.ca/assets/Uploads/ReliabilityModeling-Final.pdf

https://www.aeso.ca/assets/Uploads/ReliabilityModeling-Materials-Nov8.pdf

https://www.aeso.ca/assets/Uploads/1.2-WIG-Recommendation-Reliability-Modeling.pdf

- The AESO continues to explore other assumptions/inputs as it implements the resource adequacy modelling tool, including modelling operating procedures during emergency energy alerts, modelling regulating reserves, correlating demand and supply at specific sites, and the availability and capability of imports.

- The required generation capacity volume will be reduced by the qualified volume of self-supply and ineligible resources, and take into account unqualified import UCAP to determine the target procurement level for the capacity auction. This ensures all capacity volumes are accounted for, such that the target level of reliability is achieved at lowest cost to consumers and capacity is not over-procured.

## 3.4 Calculation of Gross-Cost and Net-Cost of New Entry

**Input from Working Group Members and Industry Stakeholders through SAM 3.0:**

The working group reached directional alignment on:

Using an independent consultant with Alberta-specific expertise in financing and developing power plants to calculate gross-cost of new entry (gross-CONE).

Selecting the reference technology based on the following criteria: most frequently developed (historically); most economic (lowest net-cost of new entry or net-CONE); lowest capital cost (lowest gross-CONE); and shortest time to energization (development timeframe).

Stakeholders and working group members shared similar comments that the financing inputs are to consider Alberta's market context.

The working group was directionally aligned with the AESO's rationale that simple-cycle technology currently best fits these criteria.

SAM 3.0 industry stakeholder comments supported having independent experts calculate gross-CONE and net-CONE using a simple-cycle gas turbine as the reference technology.

**AESO Rationale:**

**Gross-CONE Calculation**

- The gross-CONE and net-CONE are significant inputs into the capacity market demand curve, and for a functioning capacity market. Accurate estimation ensures that new resources are attracted to enter the market when appropriate price signals are present. Contracts with independent financing and engineering services firms, to determine appropriate detailed cost estimates for the gross-CONE, increase the objectivity and accuracy of estimates. Using an independent and experienced consultant will provide a more accurate gross-CONE value, which properly reflects the appropriate financing and plant development costs for the generic reference plant.

- Due to the in-depth nature of the gross-CONE estimate, the AESO expects that the comprehensive study will be used for three to five years. The gross-CONE estimate will be updated using indices which reflect changing market conditions and capture changes in capital costs between study updates. This approach will ensure efficient, timely and transparent annual gross-CONE studies, while maintaining an updated accurate measure of the cost of new entry.

**Reference Technology**

- The reference technology selection is designed to ensure the capacity market provides adequate revenue for required generation additions.

- As described by the criteria outlined above (i.e. frequency of historic generation project developments, the lowest gross-CONE, the lowest net-CONE, timeline to delivery, and the generation source of last resort), the reference technology should represent a technology that can be developed to meet the capacity needs during the capacity auction timeframe at a low cost and, philosophically, be the unit most likely to be developed under predicted future market conditions.

- Currently, simple-cycle technology best fits all these criteria in Alberta.

- In all capacity market jurisdictions, the reference technology is based on a gas-fired power station. Some capacity markets refer to a combined-cycle plant, while other markets prefer a simple-cycle reference technology.

- The AESO anticipates that limits on greenhouse gas emissions from large facilities will constrain the development of simple-cycle facilities larger than 150 MW in the future. Based on this, the AESO is expecting that the default size of the reference technology selection will be 150 MW or less. This level also corresponds roughly to the size of the annual average growth of the Alberta mAeroderivative 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 favour LM6000 or E-class power plants.

- Further analysis to support this recommendation can be found here:

www.aeso.ca/assets/Uploads/2.2-Cost-of-New-Entry-Document-for-Adequacy-Demand-Curve-Working-Group-Final-2017Nov22.pdf

**Financing Costs**

- Using an approach that considers Alberta-specific conditions for financing generation projects will most accurately characterize on-the-ground conditions for developing supply to meet adequacy needs. 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 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.

**Energy and Ancillary Services Net Revenues**

There are several methods that can be used to determine the net energy and ancillary services 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. An additional option is to approach the net energy and ancillary services revenues using a simulated forecast approach.

- The methodology will dictate the production and the resulting energy and ancillary services revenues for the reference plant. Annual energy and ancillary services net revenues can be subtracted from the gross-CONE to determine net-CONE for the reference plant.

- The AESO selected a forward-looking approach to energy and ancillary services revenues because, based on Alberta's circumstances, historical revenue anlaysis and forward electricity pricing are not adequate for developing an energy price outlook. First, historical prices reflect volatility that may be dampened in the future with a capacity market and potential market power mitigation in the energy market. Second, Alberta's energy market is undergoing a significant change based on fleet make-up and broader policy impacts, thus a forward-looking approach is needed to reflect market conditions faced by participants. Further, incorporating the forward power price curve is challenging in the Alberta context given that forward curve liquidity significantly decreases beyond a two-year time horizon, and average on-peak prices do not provide sufficient pricing granularity to inform the level of revenues that can be captured by gas peaking plants that will be considered as reference technologies.

## 3.5 Capacity Market Demand Curve

**Input from Working Group Members and Industry Stakeholders through SAM 3.0:**

The working group developed a set of demand curve principles, which provide guidance on balancing resource adequacy, cost and volatility in the demand curve:

Supply adequacy: demand curve parameters should be set to ensure procurement of a sufficient amount of capacity for reliable operation of the electricity grid and to achieve the resource adequacy target, while avoiding significant over-procurement or under-procurement.

Efficient price formation: demand curve parameters should be set to send an efficient price signal in the capacity market, avoid excessive capacity price volatility and reduce the opportunity for the exercise of market power.

Demand curve parameters should be set to balance between achieving resource adequacy and lowest possible long-term cost to consumers, and to sustain resource adequacy over time through a market-based outcome.

- Demand curve parameters and the dependence on net-CONE should be set to ensure that Alberta's market attracts investment in new capacity and maintains existing capacity in order to achieve the resource adequacy target.
- Demand curve parameters should be compatible with, and robust to, reasonably foreseeable changes in supply, demand, energy prices and other factors in the electricity market.
- To the extent applicable to the Alberta context, the demand curve analysis should incorporate experience and lessons learned from other jurisdictions.
- Unique aspects of Alberta's electricity system (e.g. small size of the market, market transition) should be considered.

- Three demand curves were developed as candidates to continue to be tested. Each curve is downward-sloping, convex, and has price caps ranging between 1.6 and 1.9 x net-CONE (or 0.5 gross-CONE, whichever is greater).
  - Brattle simulations revealed that the three curves were a workable range of well-performing curves, noting that across the three curves there were trade-offs surrounding robustness to market conditions, price volatility, reliability outcomes and market power exposure.
  - While these curves met the desired outcomes of ensuring resource adequacy, provided a price signal of net-CONE on average, and mitigated against net-CONE error, participants raised concern that the curves would lead to consistent over-procurement.
- The AESO believes that further discussion is required on demand curve design with the working group on the trade-offs between a steeper demand curve (resulting in increased volatility), versus a more gradual demand curve (resulting in greater risk of over-procurement).
- Industry stakeholders and working group members raised concerns of the right-shifted nature of all the candidate curves and their risk of over-procuring or overpaying for capacity and limiting dynamic pricing in the energy market. It was also noted that the effectiveness of the demand curve through the capacity market implementation and supply mix transition should be considered.
- Independence, stakeholder engagement, and appropriate governance were all noted by the working group to be important considerations for the design of and ongoing management of the capacity market and the establishment of the demand curve.

**AESO Rationale:**

- The AESO's development of the demand curve was guided by principles developed by the working group, as described above.
- The AESO re-evaluated the working assumption being used for the resource adequacy standard and adjusted to a 400 MWh expected unserved energy target; the demand curve analysis was reassessed with this value to develop three new candidate curves. The results of that analysis are displayed below in Figure 1.
- With the revised resource adequacy target assumption, the width of the candidate demand curve narrows and becomes steeper overall. Also, the volume between the target volume and the volume at 1 x net-CONE is reduced, thereby reducing the risk of over-procurement.
- The middle of the three curves was evaluated in the revenue sufficiency analysis and chosen for the CMD proposal, as this curve is thought to best meet the design curve criteria stated above.
- Based on the defined principles, a downward-sloping, convex curve was selected (the slope on the minimum-to-target segment of the curve is steeper than the slope of the target-to-foot segment).
  - The downward-sloping section from minimum quantity to target inflection point reflects increased demand under scarcity conditions, compared with the kink-to-foot portion, where demand has more elasticity (less marginal value at high levels of reliability).
- The Y-axis points for the demand curve will be set in reference to a multiple of net-CONE parameters.
  - The price cap (zero quantity-to-minimum segment) is set based on the maximum value of either a 1.75 net-CONE multiple or a 0.5 gross-CONE multiple.

The price cap is a tool that helps mitigate the exercise of market power, beyond a known limit.

Higher price caps can allow for steeper curves, with associated pros and cons.

A minimum price cap is proposed as curves with a minimum price cap, set at the maximum of net-CONE or a proportion of Gross-CONE, and is resilient to reliability erosion in cases of low net-CONE or underestimation of net-CONE. Without a minimum on the price cap, reliability can erode in instances of low net-CONE or underestimation of net-CONE as the market will clear at a low volumetric level.

The inflection point is set between 0.8 to 1.0 x net-CONE.

The justification for the inflection point being at or slightly below the 1.0 x net-CONE multiple relates to the asymmetry of possible quantitative reliability outcomes. From a reliability perspective, it is generally less concerning to be over-supplied than under-supplied, given an equivalent volume. Although being over-supplied will dampen energy market price signals, being under-supplied could lead to supply shortfalls or increased unserved energy. Further resource adequacy modelling indicates that the risk of supply shortfall grows exponentially as capacity volume tightens below a certain threshold. Therefore the “kink” in the demand curve can be offset slightly to the right of the target level, and at a lower multiple of net-CONE.

The foot is set at zero.

Negative pricing would not incentivize capacity additions.

An above zero price floor is not desirable because it would have the potential to attract and retain excess quantities of capacity resources, particularly if the cost of incremental supply is low. This was the experience in the early years after implementation of ISO-NE’s capacity market with a price floor that attracted incremental low-cost supply into the already long market. By allowing capacity prices to drop to zero at higher quantities, the demand curve will ensure that customer costs are more aligned with reliability value and mitigate the potential for sustained periods with excess supply.

The X-axis points for the demand curve will be set in reference to quantity of megawatts of capacity.

The X-axis points will be set in reference to resource adequacy metrics, and demand curve performance simulations.

The minimum point will be set at a value of capacity commensurate with 800 MWh of expected unserved energy, based on the outcome of a resource adequacy study.

This minimum value is guided by current ISO Rule 202.6 *Resource Adequacy Level,* in which the AESO would take action to ensure supply adequacy stays above a certain threshold.

The inflection point will be set at a level slightly higher than the level associated with 400 MWh of EUE (revised working assumption), based on the reasoning for the inflection point described above.

The foot of the demand curve will be set at a level such that the resource adequacy target is expected to be met, on average. Price outcomes can be expected to average at net-CONE levels while also balancing capacity price volatility and maintaining the desired convexity of the curve. This combination is expected to best achieve the demand curve principles.

Considerations or trade-offs considered in evaluating the width of the demand curve include:

Steeper curves are more robust to a wide range of market conditions, have less reliability risk from underestimated net-CONE, and less risk of excess capacity above the reliability requirement.

Flatter curves have lower price volatility and less exposure to exercise of market power and need for strict mitigation; however, there is a risk of procuring more capacity than required to meet the resource adequacy target.

Assessments of Alberta' s system indicate that a curve based on the marginal reliability value is too steep to achieve reliability.

Through the working group, Brattle completed simulation of various demand curves to evaluate their performance under a broad range of plausible capacity market outcomes; those simulations provided quantitative outcomes against which to evaluate the demand curve principles.

In the final working group meeting, three candidate curves were reviewed and considered. Brattle and the AESO identified these curves as a workable range of well-performing curves, noting that across the three curves there were trade-offs surrounding robustness to market conditions, price volatility, reliability outcomes and market power exposure.

Further material on these candidate curves, along with the rationale for their selection, can be found here: [www.aeso.ca/assets/Uploads/2.1-2017-11-29-Candidate-Demand-Curves-ForPosting.pdf](www.aeso.ca/assets/Uploads/2.1-2017-11-29-Candidate-Demand-Curves-ForPosting.pdf)

Figure 1
Revised Candidate Curves

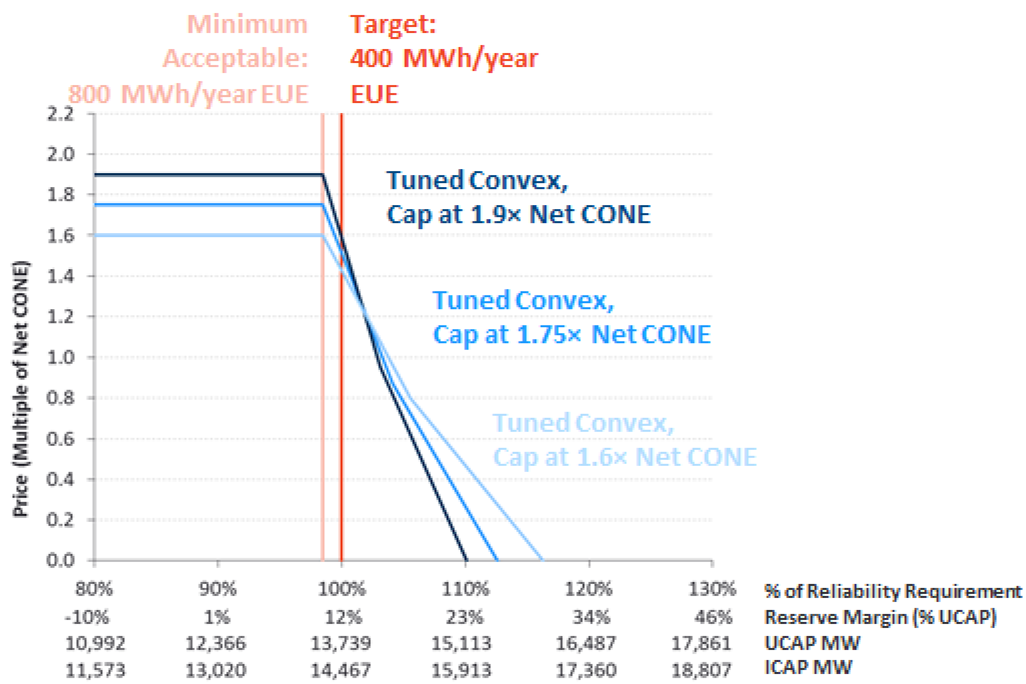


Table 1: Candidate Curve Results with 400 MWh/year EUE Target

| | Price | | | Reliability | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average | Standard Deviation | Frequency at Cap | Average EUE | Average LOLH | Average Reserve Margin | Average Quantity as % of Rel. Req. | Average Excess (Deficit) Above Rel. Req. | Average Uncleared Supply | Frequency Below Rel. Req. |
| Demand Curve | *($/kW-year)* | *($/kW-year)* | *(%)* | *(MWh)* | *(Hours)* | *(%)* | *(%)* | *(MW)* | *(MW)* | *(%)* |
| Cap at 1.6x Net CONE | $139 | $51 | 10% | 400 | 3.2 | 15% | 104% | 514 | 299 | 18% |
| Cap at 1.75x Net CONE | $139 | $61 | 10% | 401 | 3.2 | 15% | 103% | 458 | 332 | 18% |
| Cap at 1.9x Net CONE | $139 | $70 | 10% | 403 | 3.2 | 14% | 103% | 409 | 367 | 18% |

The shape and parameters of the demand curve will be reviewed once the outputs of the detailed resource adequacy modelling are available, and again when the resource adequacy standard is defined.

## 3.6 Calculation of Capacity Market Demand Parameters Assessment Against the Capacity Market Design Criteria

- The government-mandated resource adequacy standard along with a forward-looking probabilistic resource adequacy model will ensure the capacity market contributes to the reliable operation of the electricity grid. This approach and implementation will be consistent with, and complementary to, other measures aimed at ensuring reliability that already exist within the energy market.
- Consistent with the design criteria, the procurement of capacity to meet load will employ market-based mechanisms by developing a convex, downward-sloping demand curve that considers the cost of new entrants to Alberta's capacity market, while at the same time promoting an effective balance between capacity cost and supply adequacy.
- Publication of all demand curves prior to each auction ensures that capacity market mechanisms, outcomes and information are transparent.
- A demand curve approach is used in almost all other capacity markets. In the development of the demand curve, the AESO has adopted best practices and lessons learned from other capacity market implementations, while still considering the unique aspects of Alberta.