Alberta's Capacity Market Demand Curve

RESPONSE TO ADDITIONAL APPLICATION REQUIREMENT #29: ANALYSIS OF A DEMAND CURVE BASED ON MARGINAL RELIABILITY IMPACT

PREPARED FOR

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I. Introduction

The Alberta Electric System Operator (AESO) commissioned The Brattle Group (Brattle) to provide analytical support for its development of a demand curve for Alberta's capacity market.[1] Within this role, we have been asked to respond to a request from the Alberta Utilities Commission (AUC) to evaluate the performance of a demand curve based on the marginal reliability value of capacity relative to that of the AESO's Proposed Demand Curve:[2]

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"The CMD rationale mentions, as one of the trade-offs in its evaluation, that 'a demand curve based on the marginal reliability value is too steep to achieve reliability.' Please provide a comparison between the proposed demand curve and a demand curve based on the marginal reliability value with respect to reliability, price volatility and overall cost metrics."

A demand curve based on the Marginal Reliability Impact (MRI) of capacity reflects the expected improvement in reliability associated with adding incremental capacity. It is made up of points for which the price at each capacity level is proportional to its MRI value. Under such a demand curve, prices increase at an increasing rate as reserve margins decline, in order to provide an increasingly strong price signal to avoid very low reliability outcomes. In a similar manner, prices decrease slowly as reserve margins increase at high levels of reliability. This same concept underlies the convex shape of the AESO's Proposed Demand Curve, although the exact price and quantity points are not derived from a reliability calculation. The primary conceptual advantage of an MRI-based curve is that at all quantities it expresses the exact same willingness to pay to avoid outage events (starting with dollars per avoided MWh of expected unserved energy (EUE), and translated into a willingness to pay for capacity in $/kW-year).

Most capacity markets have not chosen to use an MRI-based approach for their demand curves. However ISO New England (ISO-NE) does use such a demand curve. ISO-NE's MRI-based demand curve was first implemented in the 2017 Forward Capacity Auction (for delivery year 2021/22). ISO-NE selected this curve in order to ensure that capacity payments increased or decreased in direct proportion to incremental capacity's marginal contribution to improving

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1 See accompanying Demand Curve Report. Spees, Oates, Wang & Imon Pedtke, *Alberta's Capacity Market Demand Curve*, Prepared for the AESO, Forthcoming.

2 The CMD in the request refers to the AESO's stakeholder process, the Comprehensive Market Design. See AESO, *Calculation of Demand Curve Parameters, Rationale*, June 2018, p. 7.

system reliability.[3] The shape of the ISO-NE curve is calculated based on an analysis of avoided EUE across reserve margins. The price levels of the curve are set such that the price is Net CONE at the reliability requirement, with prices increasing or decreasing in proportion to the MRI curve.

We note that a curve based on marginal expected *reliability* value is not the same as a curve that could be developed based on expected *economic* value or *customer* value. A curve intended to represent marginal economic value could consider the value of avoiding outages, avoiding scarcity events, and avoiding other economic costs associated with supply shortage events. This sort of demand curve would not necessarily align with a defined reliability standard, such as the Government's stated minimum in Alberta. The calculated economic impact of a supply shortage might not yield a large enough economic signal for the demand curve to ensure a particular reliability level. Thus, it is not a demand curve specification that we would recommend considering in Alberta.[4]

In this document, we discuss the conceptual design of an MRI-based demand curve for Alberta and evaluate the performance of two MRI-based demand curves with respect to reliability, price volatility, and cost metrics.

II. Design of the MRI-Based Demand Curves

We developed the MRI-based demand curves using the approach illustrated in Figure 1. The first step is to estimate the marginal reliability improvement with each incremental unit of capacity (decrease in MWh of EUE per UCAP MW increase in capacity). This is calculated as the slope of the total EUE curve estimated by the AESO.[5] We then multiplied the MRI curve value at each capacity level by a reliability value multiplier (in $/MWh) to translate the reliability units into capacity pricing units (in $/kW-year). For each demand curve, we chose the particular value of the reliability value multiplier to meet the intended parameters, with higher values resulting in further right-shifted demand curves. Note that the units of the reliability value multiplier are the

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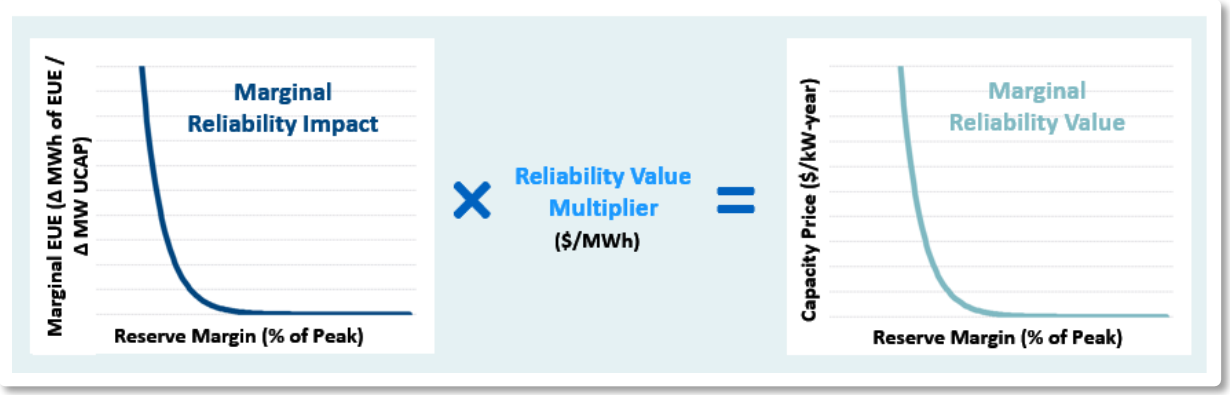
3 See Geissler-White Testimony (starting on PDF p. 661) in ISO-NE and NEPOOL (2016), *Demand Curve Design Improvements*, FERC Docket No. ER16-1434, April 2016.

4 In March 2018, the Alberta government directed the AESO to move forward with a minimum resource adequacy standard of 0.0011% EUE. In the development of the demand curve, the AESO and Brattle are evaluating the ability of any curve to enable the capacity market to procure at least the minimum standard in 95% simulation outcomes. See Alberta Energy, *Policy Direction for Alberta's Capacity Market*, March 2018.

5 In order to calculate a smoothed function of EUE versus capacity, we fitted an exponential function to the individual EUE data points provided by AESO staff. We then calculated the MRI curve as the negative slope of the EUE curve.

same as the units of a traditional value of lost load (VOLL) metric, but the magnitude of the multiplier exceeds the VOLL of a typical customer in order to align with the Alberta's reliability standard.[6] The product of these terms is the MRI-based demand curve's price at each capacity level, as shown to the right of Figure 1. The final curve on the right features prices that decline in proportion to the reliability value of capacity.[7]

Figure 1
Approach to Developing an MRI Curve for Alberta



To test the performance of an MRI-based demand curve in Alberta, we developed two variations of the demand curve as illustrated in Figure 2. Each curve is derived from and proportional to the same underlying MRI curve, but each has been multiplied by a different "reliability value multiplier" so that the final curve has a different price value for each quantity. For both the curves, we impose the same price cap as the AESO's Proposed Demand Curve at 1.75 × Net CONE. The two MRI-based curves we compare are:

- **Minimum at Price Cap MRI** serves as a point of comparison to the AESO's Proposed Demand Curve, since it shares the same definition of price and quantity at the cap. It is scaled using a reliability value multiplier such that the curve crosses the minimum acceptable quantity at the price cap.
- **Reliability-Achieving MRI** is the most analogous comparison to the demand curves presented in the accompanying Demand Curve Report. It is scaled using a reliability value multiplier that is high enough to achieve the same reliability standard as AESO's Proposed Demand Curve, by clearing below the minimum standard in no more than 5% of years.[8]

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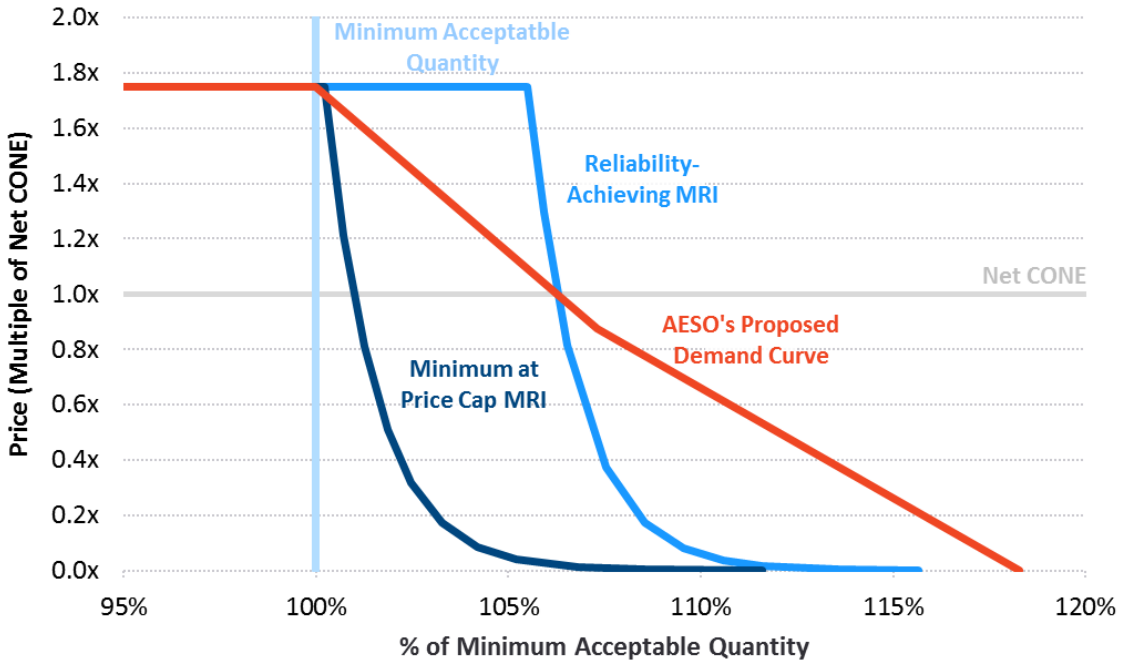
6 The reliability value multiplier is $35,000/MWh for the Minimum at Price Cap MRI curve and is $2,000,000/MWh for the Reliability-Achieving MRI curve.

7 See a discussion of how an economic value-based capacity demand curve could be developed in Pfeifenberger, Spees, Carden, & Wintermantel, *Resource Adequacy Requirements: Reliability and Economic Implications*, Prepared for the Federal Energy Regulatory Commission, September 2013.

8 Note that there are other variations of a reliability-achieving MRI that could have been developed. We have developed one with a price cap at 1.75 × Net CONE, the same as in the AESO's Proposed Demand

Figure 2 shows the two MRI-based demand curves in comparison to the AESO's Proposed Demand Curve. The most prominent difference between the two curves is the horizontal placement, with a higher reliability value multiplier producing a more right-shifted curve. The more right-shifted curve will naturally support more capacity, higher reliability, and incur higher associated customer costs. Both curves have a similar shape and slope (as expected, given that they are all derived from the same underlying MRI curve). Thus, they should produce similar price volatility. However, both MRI curves are much steeper than the AESO's Proposed Demand Curve, and would therefore be expected to produce more price volatility.

Figure 2
Comparison of the MRI-Based Demand Curves with the AESO's Proposed Demand Curve



Sources and Notes:
MRI-based curves are calculated as the slope of the EUE curve provided by the AESO.

III. Performance of the MRI-Based Curves

Using our simulation model, we evaluated the expected price, cost, and reliability outcomes achieved under each demand curve.[9] Table 1 compares the performance of the AESO's Proposed

Curve. However, we could have developed a curve that is relatively more left-shifted and with a higher price cap that could also achieve the Alberta Reliability Standard.

[9] See our accompanying Demand Curve Report for a full description of how our Monte Carlo simulation model evaluates the performance of each curve and a description of the model outputs.

Demand Curve to that of the two MRI-based demand curves. Both MRI-based demand curves produce higher price volatility than the AESO's Proposed Demand curve, as expected given the MRI curves' steeper shape. Prices under the MRI-based demand curves are about 57% more volatile than those expected under the AESO's Proposed Demand Curve.

Between the two MRI-based demand curves, the most important performance differences relate to the horizontal placement. The Minimum at Price Cap MRI curve is left-shifted compared to both the AESO's Proposed Demand Curve and the Reliability Achieving MRI curve. Thus the more left-shifted fails to procure enough supply to meet the minimum acceptable reliability standard 28% of the time (compared to the 5% target that is aligned with Alberta's reliability standard). A lower procured quantity means lower procurement costs; however shortfalls such as these could require frequent out-of-market interventions in many years, rendering the demand curve ineffective in meeting the core design objective. This means that the Minimum at Price Cap MRI curve would not be a suitable choice for Alberta's capacity market given its inconsistency with the minimum reliability standard.

In contrast, the Reliability-Achieving MRI curve is more right-shifted, procures relatively more reliability, and is associated with higher costs. By definition, it is designed to achieve the reliability adequacy objective, so it performs as well as the AESO's Proposed Demand Curve in terms of reliability metrics. The procurement costs under this curve are also similar to those under the AESO's Proposed Demand Curve (as well as the costs under other curves tuned to the same reliability standard). However, as discussed above, the Reliability-Achieving MRI curve produces significantly higher price volatility than the Proposed Demand Curve.

Table 1
Simulated Performance of the MRI-Based Curves and the the AESO's Proposed Demand Curve

	Price and Cost					Reliability			
Demand Curve	Average Price *($/kW-yr)*	Standard Deviation of Price *($/kW-yr)*	Frequency at Cap (%)	Frequency Below Min. Quantity (%)	Average Cost *($mil/yr)*	Average EUE (Before Intervention) *(MWh)*	Average EUE (After Intervention) *(MWh)*	Average Cleared Quantity *(MW)*	Average Uncleared Supply *(MW)*
Simulated Performance									
AESO's Proposed Curve	$139	$53	5%	5%	$1,665	266	118	12,042	247
Min at Price Cap MRI	$139	$82	29%	28%	$1,574	2,114	545	11,353	349
Reliability-Achieving MRI	$139	$83	29%	5%	$1,661	253	109	11,945	350
Percent Difference from the Proposed Curve									
Min at Price Cap MRI	0%	57%	480%	458%	-5%	695%	362%	-6%	41%
Reliability-Achieving MRI	0%	57%	484%	0%	0%	-5%	-7%	-1%	42%

IV. Conclusions

We view consideration of an MRI-based demand curve as a useful exercise because such a curve has various theoretical merits. The MRI curve can be tuned to achieve any given reliability standard (as with the Reliability-Achieving MRI curve we examined here), and conceptually aligns with the design principle of making prices more proportional to the reliability value of capacity. However, we view this conceptual advantage as only one consideration of many that should be incorporated into a robust demand curve design, and not necessarily the most important one. Considering the demand curve's performance at a holistic level, we expect the AESO's Proposed Demand Curve to perform better than an MRI-based curve in the specific context of Alberta.

The primary shortcoming of the MRI-based demand curve is that the curve happens to be particularly steep in Alberta.[10] This curve may be too narrow and steep to offer the most meaningful price formation, leading to higher-than-necessary price volatility and susceptibility to the exercise of market power. An MRI-based Alberta demand curve would have a width of roughly 4% of total capacity or 450 MW, meaning that the entry or exit of one large plant could push the market from a surplus condition to the price cap.[11] In comparison, the AESO's Proposed Demand Curve has a width of 18% or approximately 2,000 MW, which will offer significantly improved performance in mitigating price volatility and the potential exercise of market power.

In terms of reliability, the Reliability-Achieving MRI curve performs equally well to the AESO's Proposed Demand Curve (by design), and both have very similar costs in the long run. The Minimum at Price Cap MRI curve would not be a suitable option for Alberta, because it does not align with Alberta's reliability objective.

In our view, the AESO's Proposed Demand Curve outperforms the MRI-based demand curves, primarily due to the relatively steep shape of the EUE curve in Alberta. It is able to at least partly capture the conceptual benefit of the MRI-based demand curves with its convex shape, while avoiding the shortcomings associated with being strictly proportional to the MRI.

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[10] This same shortcoming would not necessarily apply in all other markets. The New England MRI-based demand curve has a relatively flatter shape and so can be expected to support more graduated price responses, however in an analysis of PJM's system we found that the MRI-based curve was relatively too steep to meaningfully mitigate price volatility. See Pfeifenberger J., Newell, S., Spees, K., Murray, A., Karkatsouli, I., *Third Triennial Review of PJM's Variable Resource Requirement Curve*, May 15, 2014, Prepared for PJM Interconnection.

[11] For the purpose of reporting a "width", we assume 10% of Net CONE to be the "foot" of the curve. This is because technically an MRI-based demand curve never reaches zero even at very high reserve margins.

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