Information Document
Capacity Market Load Forecast
ID #[xxxx-xx]

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1 Purpose

This Information Document relates to the following Authoritative Document:

- Section 207.1 of the ISO rules, *Gross Minimum Procurement Volume* ("Section 207.1").

The purpose of this Information Document is to describe the methodology the AESO uses to complete a forecast of Alberta gross load required pursuant to subsection 5 of Section 207.1 which is then used in the Resource Adequacy Model.

2 Input variables

This section describes the input variables used to create the load forecast.

2.1 Load data

The AESO uses Alberta gross load as the measure of load for the load forecast.

2.2 Economic drivers

A weighted average of the Conference Board of Canada's real Alberta gross domestic product at basic prices, population, and employment forecasts, represented as RQTOA, RHA, and RLEMA series' respectively, as the economic driver variable. The AESO indexes each series to a common base year. The weightings of these three series (after individual indexing) used to form the AESO's final economic driver variable is derived by their relative correlation with Alberta gross load over time. The AESO will monitor the relative correlations of these variables with Alberta Gross load on an ongoing basis and update the weighted average when necessary.

The AESO uses the weighted index methodology between these inputs because of the three series' extremely high correlation with Alberta gross load, and the fact that the weighted index of all three based on those weightings minimizes model error more than any individual index. This is shown by the explanation below:

2.2.1 Index justification

Table 1 below shows the Alberta gross load model tested with each variation of economic driver and their respective mean absolute percent error statistics. Table 1 does not show statistics for models without oilsands production as they produced higher errors than *all* models with oilsands production. The following list describes the names of iterations of the model displayed in Table 1:

- ET indicates economic data was used only as a trend;
- ETI indicates the economic trend was interacted with calendar and temperature variables;
- WI indicates the weighted index is the economic trend;
- E indicates employment is the economic trend; and
- GDP indicates gross domestic product is the economic trend.

[1] "Authoritative Documents" is the general name given by the AESO to categories of documents made by the AESO under the authority of the *Electric Utilities Act* and associated regulations, and that contain binding legal requirements for either market participants or the AESO, or both. AESO Authoritative Documents include: the ISO rules, the Alberta reliability standards, and the ISO tariff.

Table 1: In-sample (2011-2017) mean absolute percent errors for all economic driver variables

Model	Hourly	Daily	Monthly	Seasonal	Weighted
ETI - WI	1.21%	1.25%	1.41%	1.23%	1.24%
ETI - E	1.27%	1.30%	1.36%	1.20%	1.24%
ET - WI	1.25%	1.28%	1.36%	1.22%	1.25%
ET - E	1.29%	1.32%	1.36%	1.21%	1.25%
ET - GDP	1.25%	1.29%	1.38%	1.24%	1.26%
ETI - GDP	1.22%	1.26%	1.45%	1.31%	1.30%

Table 1 demonstrates that model error is minimized when the weighted index is interacted with calendar and temperature variables.

2.2.2 Other economic drivers

Other economic drivers that the AESO may use include natural resource extraction data. The AESO considers conventional oil and gas, and oilsands extraction. Historic data for these variables is available from the Government of Alberta economic dashboard. For forecast data, the AESO considers public sources including the Canadian Association of Petroleum Producers forecast reports, or other economic forecasting vendors. The AESO tested its Alberta gross load model with and without oilsands extraction and found that the model performs better with its inclusion in all cases. At this time, conventional oil and gas production did not improve the model.

2.3 Temperature

The AESO obtained temperature data from 1987 to current for Calgary, Edmonton, Fort McMurray, and Lethbridge from Environment Canada and used it as the temperature variables in the load forecast. On a go forward basis, temperature data is populated to AESO databases from the AESO's current weather forecasting provider. The AESO uses an average of the 4 weather locations as the temperature input in the load forecast.

2.4 Calendar variables

The AESO derives many different variables from a standard calendar. The AESO specifically considers variables representing month, weekday, days before and after holidays, standard holidays, hour of day, weighted average sunrise and sunset hours across Alberta, and daylight savings time shifts.

2.5 Other considerations

The AESO actively looks to find variables that minimize forecast error. To the extent that variables are found that minimize forecast error, and can be reasonably forecast, the AESO includes them in the load forecast. For example, the AESO controls for outlier events like the Fort McMurray fires of 2016 and other outlier events if they improve model accuracy.

3 Model specification

The AESO utilizes an iterative process to find the model specification that minimizes error. This section describes that process.

3.1 Diagnose procedure

In order to determine a model that minimizes forecast error, the AESO utilizes an iterative process of training a model, then predicting load outcomes over a period of time with actual outcomes with that model, and testing those predictions against the actual outcomes. This is often referred to as an out-of-sample test, or hold-out testing. The AESO tests multiple model structures and variables during the same out-of-sample test period and picks the model with the lowest overall hourly mean absolute percent error. The AESO has chosen an hourly mean absolute percent error minimization as the objective function due to the fact that is it possible for energy to go unserved in any hour in the resource adequacy simulation. Therefore, the AESO finds it prudent to weight accuracy across all hours, and not a subset of hours, like daily, or monthly, or seasonal peaks. That said, The AESO ran multiple tests and determined that hourly mean absolute percent error minimization produces the best mean absolute percent errors across a weighted average of hourly, daily peak, monthly peak, and seasonal peaks.

The specifications tested included multiple lagged temperature trials, and groupings of holidays and weekdays. The AESO conducts the process as follows: The first model is the naïve model, which predicts hourly load as a function of a variety of seasonality, temperature, and independent variables. Once the base line is established with the naïve model, the second model specification is the recency effect. The recency effect determines the optimal combination of the following lagged temperature effects:

- the simple moving average of the temperatures from the preceding 24 hours;
- the temperatures from preceding hours; and
- the weighted moving average of the temperatures from the preceding 24 hours.

If the holdout mean absolute percent error from any of the lagged temperature models has a smaller mean absolute percent error than the naïve model, the AESO selects the lowest overall recency effect model, and that model moves to the third specification test. The third specification adds the weekend effect. This is done by grouping two adjacent days together and calculating the holdout mean absolute percent error generated by this grouping. For reference, adjacent days are tried in the weekend effect specification test: Monday-Tuesday, Tuesday-Wednesday, Wednesday-Thursday, Thursday-Friday, Friday-Saturday, Saturday-Sunday, and Sunday-Monday. If the holdout mean absolute percent error improves by adding the weekend effect, then the weekend effect model with the lowest mean absolute percent error moves to the last specification test.

Finally the last specification is the holiday effect. The AESO first develops models with the special days (holidays, and the days before and after) modeled as the weekday on which they occur. The AESO then develops models to test the special day considered to be all other day types of the week. If considering a special day as another day of the week improves model accuracy, then the AESO modifies its weekday assignment. If adding the holiday effect decreases the holdout mean absolute percent error, the AESO chooses the optimal holiday effect grouping as the final model structure.

3.2 Further specification

With the winning model selected from the diagnose procedure, the AESO then further tests model specifications. They are as follows:

3.2.1 Temperature function

With the winning structure from the diagnose procedure, the AESO tests whether or not a squared or cubic term on temperature is most appropriate for the model. The default choice is to include temperature with a cubic function to capture diminishing increase in load at extreme temperatures. That is, the amount of heating load required is very similar at -30 degrees and -40 degrees, which the cubic function reflects.

The AESO ensures that the model does not fit a cubic function that predicts a decline in load from -30 to -40 through a sensitivity analysis. If the AESO finds that a decrease in temperature in winter extremes decreases load, or likewise if an increase in temperature during summer extremes decreases load, a squared temperature function is chosen. The squared function makes it impossible for extreme temperatures to decrease predicted loads.

3.2.2 Economic growth interaction

The AESO then further tests whether or not including the economic index as a simple long-term trend variable, or interacting it with the monthly, day of the week, temperature, and hourly indicators improves model accuracy. The AESO has concluded that currently, when the weighted index is interacted with the calendar terms, the holdout mean absolute percent error improves. The following table outlines that the objective of hourly mean absolute percent error minimization, and the economic index interacted with the calendar variables best achieves the AESO's goal of choosing a model that minimizes forecast error.

In the table, HM indicates hourly mean absolute percent error minimization, DM indicates daily peak mean absolute percent error minimization, ET indicates economic data was used only as a trend, and ETI indicates the economic trend was interacted with calendar and temperature variables.

Table 2: In-sample (2011-2017) mean absolute percent errors for different error minimizations and economic interactions

Model	Hourly	Daily	Monthly	Seasonal	Weighted
HM - ETI - WI	1.21%	1.25%	1.41%	1.23%	1.24%
HM - ET - WI	1.25%	1.28%	1.36%	1.22%	1.25%
DM - ETI - WI	1.26%	1.30%	1.47%	1.24%	1.27%
DM - ET - WI	1.29%	1.33%	1.42%	1.26%	1.29%

The AESO will review these results on an ongoing basis to ensure that the interacted term is the forecast error reducing framework.

3.2.3 Model training period

The AESO has determined that currently, a 5 year training period for the one year holdout period yields the optimal amount of historic data to train on. The AESO did not contemplate less than 5 years of data as it is likely too small of a sample to capture the relationship between the economic drivers and load growth. The AESO conducted a reverse anchor walk forward procedure to determine the optimal in and out of sample fit for model testing. The table below describes the results from the different training and holdout periods with the same model:

Table 3: Training period optimization

Holdout Mean Absolute Percent Error	Training Period	# of years	Holdout Period
1.49%	2010-2016	7	2017
1.49%	2011-2016	6	2017
1.48%	2012-2016	5	2017

Once the AESO determines the winning model, it then trains the winning model on the existing training period and the holdout period to ensure that the most recent data is used in the forecast. The AESO will review these results on an ongoing basis to ensure that the interacted term is the forecast error minimizing framework.

4 Quantifying uncertainty

The AESO recognizes that there are two large sources of uncertainty with regard to the load forecast - temperature and economics. The AESO quantifies these uncertainties by running a probabilistic forecast where 30+ historic weather years, and 5 different economic scenarios are used for the forecast horizon.

The combination of the sensitivities produces 150 load profiles for study in the Resource Adequacy Model.

4.1 Temperature

The AESO uses temperature data back to 1987 to test the possible ranges of temperature variation possible in the future. The AESO takes each weather year as it was observed historically, and inserts it into the model to test what load would be at that temperature level in each hour for that weather year.

4.2 Economic

The AESO created 5 economic scenarios, including the reference scenario, to test the impact of economic uncertainty. The AESO created the scenarios by looking at the minimum and maximum growth rates that have been observed on the economic index in the last 20 years. The AESO then takes the reference case economic index (as provided by the Conference Board of Canada) and shocks it by the extreme growth rates in the first forecast year. The AESO then simulates the economic forecast to carry on the same growth trajectory as the reference case thereafter. With the bookend scenarios created by the highest and lowest shocks seen in the last two decades, the AESO selects the midpoints between the reference and high and low scenarios to create the remaining two scenarios.

The goal of these scenarios is to capture a credible suite of scenarios. The highs and lows essentially simulate what the economic index would be if the worst recession (in terms of the economic index) happened in the first forecast year, or conversely what the index would look like if the biggest expansion in the last 20 years happened in the first forecast year. The AESO chose 20 years as a historic range to ensure that the sample is representative of what is possible going forward.

The AESO recognizes that extreme outcomes are less likely than the reference scenario. Because of this, the AESO assigns probabilities to each economic scenario. The probabilities are as follows:

Table 4: Scenario probability distribution

Scenario	Probability
Minimum	10%
Low	20%
Reference	40%
High	20%
Maximum	10%

Revision History

Posting Date	Description of Changes
	Initial release