Stakeholder Engagement Pre-Reading

Reference Levels and Reference Quantities

April, 2021

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Powering Tomorrow.

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Disclaimer

This document describes the methodologies that the IESO will use to determine reference levels and reference quantities.

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1. Overview of Reference Levels and Reference Quantities

Reference levels for financial dispatch data parameters and reference quantities are IESO-approved estimates for what prices (reference levels) and quantities (reference quantities) market participants might have offered for a resource in the energy and operating reserve markets had they been subject to unrestricted competition. Examples of financial dispatch data parameters are energy offers and operating reserve offers.

Reference levels for non-financial dispatch data parameters are IESO-approved estimates for a resource's operational capabilities. Examples of non-financial dispatch data parameters are energy ramp rate and lead time.

The IESO will determine reference levels for financial and non-financial dispatch data parameters of each resource.

The reference quantity for energy is based on the available capability of the resource to supply energy under current operating conditions. The reference quantity for suppliers of operating reserve is based on the operational capability of the resource.

The IESO has developed methodologies to calculate reference quantities for the energy and operating reserve market.

For financial reference levels, non-financial reference levels and reference quantities, where inputs vary according to season the reference level or quantity can also vary according to season.

Market participants are not obligated to submit offers that are consistent with reference levels or reference quantities. Reference levels and quantities are an input into the IESO processes related to market power mitigation.

2. Process for Establishing Reference Levels for Financial Dispatch Data Parameters

The IESO uses a cost-based approach to determine financial reference levels for eligible resources before they can participate in the IESO-administered markets.

2.1. Reference Level Workbooks

Reference level workbooks have been created for the following technology types and may be populated by market participants to determine reference levels:

- nuclear;
- thermal;
- wind;
- solar;
- hydroelectric;
- energy storage; and
- dispatchable loads.

2.2. Use of Historical or Forecast Cost Data

Section 2.5 outlines each relevant historical study period over which relevant data should be collected when determining reference levels.

Where available, market participants should use the historical information spanning the suggested historical study period from Section 2.5 when determining the contribution of a cost to a reference level.

Where the information for the suggested historical study period is not available, but at least one year of data is available, market participants should use the available data when determining the contribution to a reference level.

Market participants may request that the IESO approve a modification to a relevant historical study period for a particular resource where there is a material difference between the past operation during the historical study period and the projected future operation of the resource. In order for the IESO to approve such a modification, the market participant will demonstrate the difference and submit that information to the IESO for consideration.

Where the information is not available for at least one year, market participants may adopt one of three approaches instead to determine the contribution to a reference level until at least one year of historical information becomes available. Market participants may choose one or a combination of the following approaches to apply:

- forecasted costs based on costs associated with eligible maintenance activities in accordance with the original equipment manufacturer (OEM) recommended maintenance intervals or accepted industry practices;
- independent third-party average cost information applicable for the technology type of the resource;
- certified documentation for the OEM or vendor; or
- Another approach that produces a reasonable forecast for the required input value.

Unless otherwise specified in Section 2.5, in order to determine the contribution of an eligible cost to a reference level, market participants perform the following steps:

1. Calculate the total annual eligible costs for each year in the historical study period.
2. Calculate the number of relevant events[1] that occurred during each year of the historical study period.
3. Calculate the annual contribution per eligible cost by dividing the total annual eligible costs per year by the number of relevant events in a given year in the historical study period.
4. Calculate the number that should be entered into the applicable form per eligible cost by calculating the average of the annual contributions across the historical study period.

2.3. Supporting Documentation

All market participants are required to provide supporting documentation from verifiable sources[2] to substantiate the values entered for that resource.

Where a market participant is requesting a financial reference level of $0/MWh, no supporting documentation is required for that reference level.

Acceptable forms of documentation include:

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[1] The relevant event for an energy reference level is the MWh injected in a year, the relevant event for the start-up-reference level is the number of starts in a year and the relevant event for the speed no-load reference level is the number of hours where the resource was operating during the year.

[2] For example, documents created by independent third parties, such as invoices. These sources are discussed in more detail below.

- meter data from previous electricity billing periods;
- historical electricity bills where prices had been escalated based on any electricity pricing increases imposed by the IESO;
- materials from vendors regarding operations, including, but not limited to, information on the following:
  - resource efficiency and performance at beginning and end of life; and
  - details on the auxiliary power demands during operation.
- Any data that is supplied as vendor reference data should be on the vendor letterhead and datasheets. If details are insufficient, the IESO may request additional information to be supplied by the vendor;
- paid invoices from contractors or vendors for relevant services or products that relate to eligible costs. Amounts in historical invoices may be adjusted for inflation if appropriate from when the cost was paid to what it could cost in the current market based on an appropriate third-party index, including the Consumer Price Index;
- relevant contracts for equipment supply or service provision. Where only a portion of the total costs in a contract is eligible to be included into the reference level, market participants must report that portion of costs attributed to the eligible cost. The determination of eligible costs embedded in a contract must come from either a cost breakdown provided in the contract or in a communication from the service provider;
- vendor quotation for a firm commitment that provides details on the scope of services or parts being supplied. These details must provide sufficient information for the IESO to ascertain whether the quoted costs are eligible for inclusion in the determination of the reference level; and
- any other documentation that is required to support the participant's input in the reference level worksheet.

Where documentation from the above list is not available, ~~Documentation~~ documentation developed by the relevant market participant can be provided. This internal documentation will be~~, ~~ evaluated on a case by case basis by the IESO. When determining the eligibility of documentation developed by the relevant market participant, the IESO may compare the documentation to information for similar types of equipment (e.g. independent 3rd party research reports or recommendations).

Market participants must include clear explanations of how each piece of documentation supports the relevant input. The IESO reserves the right to deem any documentation unacceptable if it does not sufficiently support the input values. Reasons for deeming documentation unacceptable include, but are not limited to:

- documentation being illegible;
- not from a reliable source;
- costs are not eligible to be included into reference levels;
- incomplete information; and
- vague or unclear information to support the values entered into the calculation sheets.

Market participants may be asked to provide additional information upon IESO's request. The IESO will not review incomplete reference level workbooks and may ask a market participant to resubmit a reference level workbook that the IESO has deemed incomplete. The IESO may review any other information it deems relevant for completeness, eligibility and correctness.

After evaluating the reference level workbook submission, the IESO can approve or reject it.

If:

- the submission is rejected, the IESO will inform the market participant of the rationale. The market participant will be required to resubmit their reference level workbook with updated cost components and provide additional supporting information as indicated by the IESO; or
- the submission is approved, the relevant reference levels will be approved by the IESO and provided to the market participant. These reference levels will also be used by the IESO to determine reference level values for the relevant resource on an ongoing basis.

2.4. Eligible Cost Components for Financial Reference Levels

Eligible cost components for financial reference level calculations are the costs that are incurred as a result of providing incremental supply of energy or operating reserve. The IESO has designed the financial reference levels to include all short-run marginal costs (SRMCs).

This section lists and describes the various cost components that are eligible to be included in the reference level cost calculation formulas. However, all of the cost components defined in this section might not be applicable for all technology types. Section 2.5 provides technology-specific guidelines regarding applicable cost-components, formulas and supporting documentation relevant for different technology types of the resource.

2.4.1. Fuel-Related Costs

Fuel-related costs, as applicable to a technology, represent the cost of materials used for the operation required to release energy for the purpose of electricity production.

Fuel commodity costs are adjusted, as applicable, with efficiency or performance metrics to determine fuel-related costs.

2.4.2. Emission Costs

Fossil fuel resources are allowed to include the costs associated with emissions based on the relevant emissions policy, such as the Federal Carbon Pricing Backstop, and the emission rate. This rate indicates the quantity of emissions by the resource for each MWh of power produced.

2.4.3. Performance Factor

The performance factor is a means to account for uncertainties across resources and changes to resource efficiency without having to adjust the heat rate for the resource. Changes to resource efficiency are measured by the fuel consumption per MWh of production or per start. For example, performance factors per resource can be impacted by seasonal factors such as ambient conditions. Where provided, performance factors can result in financial reference levels that differ according to the season. For example, a resource could have a higher energy reference level in the season in which the resource is less efficient.

2.4.4. Operating and Maintenance Costs

Operating costs are the costs incurred while operating the resource. Maintenance costs are the costs incurred in the upkeep associated with maintaining the resource's systems and equipment in the condition required to perform their intended function. These costs are collectively referred to as Operating and Maintenance (O&M) costs. O&M costs incurred are approved by the IESO based on information provided by market participants, and allocated, as applicable, to:

- energy offer reference level ($/MWh);
- start-up ~~cost~~ reference level ($/start); and
- speed no-load ~~cost~~ reference level ($/hour).

For energy offers, the incremental O&M costs needed to produce energy is divided across the total MWh generated for that period to arrive at a $/MWh figure. For start-up offers, the incremental O&M costs incurred as a result of starting up the unit, is defined per a typical start. For speed no-load offers, the incremental O&M costs represent the upkeep and expenses incurred for each hour of operation by the resource, regardless of how much energy is supplied in a given hour.

Only the portion of O&M costs incurred as a result of providing incremental supply of energy or operating reserve is eligible to be included in reference levels. O&M costs that do not vary as a result of incremental supply of energy or operating reserve, referred to as fixed O&M costs, are not eligible costs and cannot be accounted for when determining a reference level.

Examples of fixed O&M costs that are not eligible costs include, but are not limited to:

- preventive or routine maintenance that is not directly attributable to incremental supply from the resource;
- building maintenance;
- road construction or maintenance;
- landscaping; and
- perimeter security.

The portion of labour costs that is incremental and attributable to eligible maintenance activities can be included in reference levels. Eligible labour costs are limited to only staff overtime or contractor labour required for eligible maintenance activities. Staffing costs that do not vary with supply of energy and operating reserve cannot be included into the resource's reference level.

For resources that are not continuously staffed and can demonstrate that an incremental labour cost is incurred to start or operate the resource, the additional costs can be included within the reference levels. Incremental costs will be based on actual historic costs or contracts in place for the labour to start or operate the resource.

Maintenance costs associated with the incremental supply of energy or operating reserve are divided into three categories: major maintenance costs, scheduled maintenance costs and unscheduled maintenance costs. The allocation of eligible operating and maintenance costs between incremental energy, speed no-load, and start-up reference levels may vary by resource type based on the OEM recommendations for maintenance activities, and by the type of maintenance (major, scheduled or unscheduled maintenance).

2.4.4.1 Major Maintenance Costs

Major maintenance costs are costs related to major component replacements, maintenance activities or inspection of the resource that occur during the resource's design life. They are necessary to maintain the resource's operational ability for electricity production for its design life and are required as a direct result of incremental electricity production.

The design life of the resource is the number of years that the resource was expected to operate for at the time that it came into service. Design life is established with the market participant as part of determining reference levels. The initial determination of design life considers any modifications or past improvements undertaken by the market participant that may have extended the resource's original design life from when it first entered into commercial operation.

Design life is typically established in the design basis for a facility. The design basis for a generation facility will have a specific design life mentioned in design documentation and it is not fluid. The design life is used to make key decisions for allowances and material selection in a generation facility. (e.g. tube thickness allowances in boilers when the boiler is designed and manufactured).

Market participants are required to provide relevant supporting documentation that identifies the remaining expected design life of the resource. Relevant documentation can be in the form of design documentation for the resource or reputable studies and assessments of generation facility life.

Any costs associated with performance improvements of a resource or any life extension activities beyond the design life established during the initial process to determine reference levels are ineligible costs and may not be included in reference levels.

Performance improvements are expenditures to improve any of the following characteristics of the resource beyond their values established during the initial process to determine reference levels:

- efficiency in the amount of fuel used to produce a fixed MWh quantity of energy;
- maximum production capability; or
- availability to supply energy or operating reserve, including modifications to enable alternate operating modes at the resource.

If performance improvement projects are undertaken in lieu of major maintenance, the estimated cost for the major maintenance will be an eligible cost. However, the incremental cost to undertake the performance improving project will be an ineligible cost.

Major maintenance conducted on resources can vary significantly between different technology types. Section 2.5 describes the eligible major maintenance components and required supporting documentation per technology type.

2.4.4.2 Scheduled Maintenance Costs

Scheduled maintenance costs are costs associated with routine maintenance tasks on electrical and mechanical equipment. Market participants should review these costs, and update if necessary, on an as-needed basis.

Scheduled maintenance costs will only be approved for activities that result from incremental supply of energy or operating reserve. Examples of eligible costs include cost of consumable materials and overtime labour specifically required to perform these maintenance activities (above base labour required for fixed O&M).

2.4.4.3 Unscheduled Maintenance Costs

Unscheduled maintenance costs include costs associated with all non-scheduled maintenance activity needed for equipment required for incremental electricity production. Such equipment includes mechanical, electrical and/or instrumentation and controls systems required to return the site to full operation in the event of an equipment failure. Examples of eligible costs include overtime labour or third-party labour contracted to repair the components and materials cost associated with any such repairs.

Eligible costs are limited to unscheduled maintenance for turbine, generator, transformer, or Balance of Plant (BOP) components that result from incremental supply of energy or operating reserve.

If the system or equipment is needed to remain in-service when the resource is not in operation, expenses related to such system or equipment cannot be included.

2.4.5. Incremental Third Party Payments

Eligible incremental third-party payments for solar resources include payments that are paid on the basis of incremental generation due to third parties per agreements in effect for the resource and required for the operation of the resource. These include royalties, such as for crown land use, payments to Indigenous communities, and terms of land lease agreements.

Market participants must delineate whether the costs are incurred based on measurements at the resource revenue meter, or via SCADA measurements, and adjust accordingly so that the resource operational meter is used as the reference for determining the reference level cost.

2.4.6. Opportunity Costs

Dispatchable resources with intertemporal production limitations, such as hydroelectric and storage resources, may face an opportunity cost when they offer to inject energy. These resources may sacrifice the opportunity to produce energy in a future interval by producing it in the current one given operational limitations. For example, a hydroelectric generating station with pondage that is able to shift production to a time when electricity prices are higher may incur opportunity costs. Such intertemporal opportunity costs can be included in the energy reference level for relevant resources. Opportunity costs for these resources represent the expected future revenues that market participants give up when these resources produce a MWh of energy in the current time period.

The storage horizon opportunity cost is applicable for resources that are energy limited across a multi-day period or a "storage horizon".

The storage horizon is measured in days and is determined by the formula:

$$\text{Storage Horizon} = \frac{\left(\dfrac{\text{Maximum Possible Water in Storage } (\text{m}^3)}{\text{Power Flow } \left(\dfrac{\text{m}^3}{\text{s}}\right)}\right)}{\left(\text{Minimum Monthly Plant Capacity Factor} * 86400 \left(\dfrac{\text{s}}{\text{d}}\right)\right)}$$

Where:

- Maximum Possible Water in Storage m^3 = the volume between Max. Allowed (Lake Compliance Max) and Min. Allowed (Lake Compliance Min);
- Power flow (m^3/s) = Maximum turbine flow (m^3/s); and
- Minimum Monthly Plant Capacity Factor = The minimum of the average monthly capacity factor of the resource calculated for each calendar month.

Average monthly capacity factors are calculated for the past 5 year's monthly capacity factor of that particular calendar month. The following steps outline the calculation of Minimum Monthly Plant Capacity Factor:

1. Year-0 is defined as the current calendar year. Commencing at Year-6 and ending at Year-1, calculate the monthly capacity factor of every month in the respective years. For clarity, the capacity factor in the current calendar year is not required. The monthly capacity factor is calculated as:

   $$\text{Capacity Factor} = \frac{\text{Total Energy Produced (MWh)}}{\text{Maximum Generation Rating (MW)} * \text{Number of hours in a month}}$$

   The outcome of Step 1 is 60 monthly capacity factors.

2. Average the monthly capacity factors from Step 1 for each calendar month in the past 5 years. Complete this for all calendar months in a year.

   For example:

   January Capacity Factor =
   (Jan 2019 CapFactor + Jan 2018 CapFactor + Jan 2017 CapFactor + Jan 2016 CapFactor + Jan 2015 CapFactor)/5

   The outcome of Step 2 is one average monthly capacity factor value for each calendar month.

3. The Minimum Monthly Plant Capacity Factor is equal to the lowest average monthly capacity factor from January to December determined in Step 2.

An intraday opportunity cost is applicable for resources are energy-limited within a 24-hour period and submits a max daily energy limit for the dispatch day that is less than the maximum capacity of the resource across the dispatch day. Resources that meet both of these criteria can apply both of these opportunity costs to their reference levels. Dispatchable hydroelectric resources are eligible for both the storage horizon and intraday opportunity cost adders. Dispatchable energy storage resources are eligible to have the intraday opportunity cost adder. Any other dispatchable resource may demonstrate, with relevant supporting documentation, to the IESO that it is energy-limited and the IESO will review and/or approve of applicable opportunity cost adders.

Where the opportunity costs provided do not address all relevant aspects of opportunity cost for a particular resource, market participants may request that the IESO add an additional resource-specific opportunity cost for that resource.

In order to do so, market participants must submit the proposed methodology for any additional opportunity cost, along with supporting materials. The submitted materials must explain:

- why the provided opportunity cost does not address a material opportunity cost that the resource faces when making energy production decisions;
- what additional opportunity cost would address the material opportunity cost identified above; and
- how to calculate the additional opportunity cost.

The IESO may deny the request for an additional opportunity cost if it is determined that:

- the identified additional opportunity cost does not address a material opportunity cost;
- the proposed methodology would not address any additional opportunity costs; or
- the calculation of the additional opportunity cost would prove excessively burdensome.

The following sub-section describes the methodology the IESO uses to calculate the opportunity cost for relevant resources.

2.4.6.1 Opportunity Cost

The opportunity cost to be included into energy reference level is calculated as follows:

$$\text{Opportunity Cost}\left(\frac{\$}{\text{MWh}}\right) = \text{Storage Horizon Opportunity Cost}\left(\frac{\$}{\text{MWh}}\right) + \text{Intraday Opportunity Cost}\left(\frac{\$}{\text{MWh}}\right)$$

2.4.6.2 The Storage Horizon Opportunity Cost

The storage horizon opportunity cost calculates the opportunity cost of producing a MWh of energy in the current dispatch day compared to storing the fuel for use in a time horizon of greater than 24-hours. A resource that has a storage horizon of less than 24 hours is not eligible to use storage horizon opportunity cost and thus has a storage horizon opportunity cost value of $0/MWh.

The storage horizon opportunity cost is a resource-specific calculation updated on a daily basis by the IESO.

To calculate the storage horizon opportunity cost, the IESO will carry out the following steps:

1. Establish a historical study period of the 28 days prior to the dispatch day.
2. Calculate the average LMP per day of the week per hour. For example, the average LMPs for HE1 of Monday are determined by averaging the resource's LMPs during HE1 for all of the Monday's in the historical study period. An example of this calculation is shown in the table below.

Table 2-1: Average LMP Per Day of the Week Per Hour

Monday HE	Week 1, Monday LMP ($/MWh)	Week 2, Monday LMP ($/MWh)	Week 3, Monday LMP ($/MWh)	Week 4, Monday LMP ($/MWh)	Average LMP ($/MWh)
1	10	15	12	15	13
2	12	17	14	17	15
...	...	...	...	...	...
24	6	6	4	4	5

3. Calculate this average value per resource for each hour for each day of the week.
4. Create an on-peak multiplier and an off-peak multiplier based on price movements in NY Zone A day-ahead prices.
    a. The off-peak multiplier is calculated by dividing the forward[3] off-peak ~~price~~ NY Zone A day-ahead price by the average off-peak NY Zone A day-ahead settled price for the historical study period.

[3] The term forward refers to the publicly traded futures contract related to NY Zone A and Michigan Hub~~.~~

$$\text{NY Off Peak Multiplier} = \frac{\text{Forward OffPeak NYZA DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OffPeak NYZA Price } (\frac{\$}{\text{MWh}})}$$

b. The on-peak multiplier is calculated by dividing the forward on-peak price NY Zone A day-ahead price by the average on-peak NY Zone A day-ahead settled price for the historical study period.

$$\text{NY On Peak Multiplier} = \frac{\text{Forward OnPeak NYZA DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OnPeak NYZA Price } (\frac{\$}{\text{MWh}})}$$

5. Create an on-peak multiplier and an off-peak multiplier based on price movements in MISO Michigan Hub day-ahead prices.
   a. The off-peak multiplier is calculated by dividing the forward off-peak Michigan Hub day-ahead price by the average off-peak Michigan Hub day-ahead settled price for the historical study period.

$$\text{Mich Off Peak Multiplier} = \frac{\text{Forward OffPeak MichHub DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OffPeak MichHub Price } (\frac{\$}{\text{MWh}})}$$

   b. The on-peak multiplier is calculated by dividing the forward on-peak Michigan Hub day-ahead price by the average on-peak Michigan Hub day-ahead settled price for the historical study period.

$$\text{Mich On Peak Multiplier} = \frac{\text{Forward OnPeak MichHub DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OnPeak MichHub Price } (\frac{\$}{\text{MWh}})}$$

6. Create a simple average between the NY Off Peak Multiplier and the Mich Off Peak Multiplier.

$$\text{Off Peak Multiplier} = \frac{\text{NY Off Peak Multiplier} + \text{Mich Off Peak Multiplier}}{2}$$

Create a simple average between the NY On Peak Multiplier and the Mich On Peak Multiplier.

$$\text{On Peak Multiplier} = \frac{\text{NY On Peak Multiplier} + \text{Mich On Peak Multiplier}}{2}$$

7. For each day in the storage horizon for the resource, multiply the relevant LMP from step 3 by the relevant on-peak or off-peak multiplier from step 46. This creates the forecast LMPs for the resource.

5.8. The storage horizon opportunity cost is the maximum of:

   a. The highest forecast LMP for the resource across the storage horizon; and
   b. $0/MWh.

The example below presents the storage horizon opportunity cost calculation of a dispatchable hydroelectric resource with a 2-day storage horizon. The calculation takes place before the opening of the Wednesday DAM mandatory window for the Thursday dispatch day:.

Table 2-2: Example of Storage Horizon Opportunity Cost Calculation for Thursday

Thursday HE	Week 1, Thursday LMP ($/MWh)	Week 2, Thursday LMP ($/MWh)	Week 3, Thursday LMP ($/MWh)	Week 4, Thursday LMP ($/MWh)	Average LMP ($/MWh)
1	9	17	13	13	13
2	19	8	16	25	17
…	…	…	…	…	…
24	6	12	13	20	12.75

Table 2-3: Example of Storage Horizon Opportunity Cost Calculation for Friday

Friday HE	Week 1, Friday LMP ($/MWh)	Week 2, Friday LMP ($/MWh)	Week 3, Friday LMP ($/MWh)	Week 4, Friday LMP ($/MWh)	Average LMP ($/MWh)
1	20	18	10	14	15.5
2	12	11	12	19	13.5

Friday HE	Week 1, Friday LMP ($/MWh)	Week 2, Friday LMP ($/MWh)	Week 3, Friday LMP ($/MWh)	Week 4, Friday LMP ($/MWh)	Average LMP ($/MWh)
...	...	...	...	...	...
24	5	9	5	9	7

The forward off-peak New York Zone A day-ahead price is equal to $13-/MWh for the storage horizon and the average settled price of the historical study period is $10/MWh.

$$\text{NY Off Peak Multipler} = \frac{\text{Forward OffPeak NYZA DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OffPeak NYZA Price } (\frac{\$}{\text{MWh}})}$$

NY Off-Peak Multiplier = 13/10

=1.3

The forward on-peak New York Zone A day-ahead price is equal to $20 /MWh for the storage horizon and the average settled price of the historical study period is $19/MWh.

$$\text{NY On Peak Multiplier} = \frac{\text{Forward OnPeak NYZA DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OnPeak NYZA Price } (\frac{\$}{\text{MWh}})}$$

NY On-Peak Multiplier = 20/19

=1.05

The forward off-peak Michigan Hub day-ahead price is equal to $20/MWh for the storage horizon and the average settled price of the historical study period is $11/MWh.

$$\text{Mich Off Peak Multiplier} = \frac{\text{Forward OffPeak Mich DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OffPeak Mich Price } (\frac{\$}{\text{MWh}})}$$

Michigan Off-Peak Multiplier = 20/11

=1.82

The forward on-peak Michigan Zone A day-ahead price is equal to $19/MWh for the storage horizon and the average settled price of the historical study period is $18/MWh.

$$\text{Mich On Peak Multiplier} = \frac{\text{Forward OnPeak Mich DA Price } (\frac{\$}{\text{MWh}})}{\text{Average Settled OnPeak Mich Price } (\frac{\$}{\text{MWh}})}$$

Michigan On-Peak Multiplier = 19/18

=1.06

Off-Peak Multiplier = (1.3+1.82)/2 = 1.56

On-Peak Multiplier = (1.05+1.06)/2 = 1.06

Table 2-4: Example of Forecast LMP Calculation for Thursday

Thursday HE	Average LMP ($/MWh)	Applicable Multiplier	Forecast LMP ($/MWh)
1	13	1.56	20.28
...	...	...	...
13	35	1.06	37.10
...	...	...	...
24	12.75	1.56	19.89

Table 2-5: Example of Forecast LMP Calculation for Thursday

Friday HE	Average LMP ($/MWh)	Applicable Multiplier	Forecast LMP ($/MWh)
1	15.5	1.56	24.18
...	...	...	...
13	18	1.06	19.08
...	...	...	...
24	7	1.56	10.92

The maximum forecast LMP in ($/MWh) for the storage horizon is $37.10/MWh. This value becomes the storage horizon opportunity cost adder for the dispatch day.

2.4.6.3 The Intraday Opportunity Cost

The intraday opportunity cost calculates an opportunity cost of producing a MWh of energy in the current dispatch day based on the prices for the dispatch day determined in the day-ahead market. The intraday opportunity cost is eligible for use for resources that are energy-limited below their maximum available capacity for each hour in the day within a 24-hour period. This is demonstrated through its submission of a max daily energy limit for the dispatch day that is less than the maximum capacity of the resource across the dispatch day. A wind and solar resource may not include an intraday opportunity cost adder into its energy reference levels.

The intraday opportunity cost will be equal to the maximum of $0/MWh and the highest DAM LMP. This value will be published after day-ahead schedules are produced and will be applied to reference levels for the resource for the dispatch day.

> Example: This example shows DAM LMPs in ($/MWh) for a resource which are created for 24 hours of a dispatch day. The highest positive value of DAM LMP is $31/MWh and is equal to the intraday opportunity cost adder.

Table 2-6: Example of DAM LMPs Calculation for HE 1 to HE 12

HE	1	2	3	4	5	6	7	8	9	10	11	12
DAM LMP	$10	$8	$9	$11	$3	$14	$10	$15	$13	$18	$20	$19

Table 2-7: Example of DAM LMPs Calculation for HE 13 to HE 24

HE	13	14	15	16	17	18	19	20	21	22	23	24
DAM LMP	$26	$31	$19	$17	$25	$26	$21	$15	$12	$10	$11	$9

2.4.7. Start-Up Costs

Start-up fuel volume is the amount of fuel needed to start a thermal resource. This value may vary depending on how long the resource has been offline. Thermal resources are allowed to submit different start-up fuel volumes for starting up from a cold, intermediate and hot state. Different start-up fuel volume reference levels will be established for each starting state of the resource.

For non-thermal resources that have start-up costs but do not submit start-up offers, these costs are reflected in energy offer reference levels. Section 2.5 further identifies relevant costs for different technologies.

2.4.8. Speed No-Load Costs

Speed no-load costs can include fuel costs and operating and maintenance costs.

The fuel cost component is the fuel burn that would be hypothetically consumed if the resource were to back down to a zero power output while staying synchronized to the IESO-controlled grid.

Depending on the resource, heat rate curves may show that there is some level of fuel consumption that is not attributable to incremental production.

For example, if a resource had the following heat rate curve and incremental heat rate curve, some fuel cost is fixed and not attributable to incremental production:

Heat rate curve:

$$HR(MWh) = 5MWh^2 + 2MWh + 5$$

For this resource, the speed-no-load cost of fuel is 5.

Another way of explaining the fuel cost component of speed-no-load cost is that it is the y-intercept of the heat rate curve.

The presence of speed-no-load costs in reference levels does not signify that the IESO that will model resources in this operating state (synchronized but not injecting). Rather, it is a method to allow reference levels to more accurately match the shape of cost curves, where appropriate.

This reference level methodology uses the approach of separating the fixed hourly costs of synchronized operation from costs associated with incremental production.

For resources that have speed no-load costs but do not submit speed no-load offers, these costs are reflected in energy offer reference levels. Speed no-load offers are used by the IESO to determine the commitment and scheduling of non-quick start resources that are eligible for the generator offer guarantee make-whole payment.

2.4.9. Operating Reserve Costs

Operating reserve is the generation capability that can be converted fully into energy or the participant load that can be not be consumed from the system as dispatched by the IESO. The IESO has both synchronized and non-synchronized reserve requirements.

Operating reserve reference levels for 10-minute synchronized, 10-minute non-synchronized and 30-minute non-synchronized reserve are based on incremental costs associated with posturing a resource to be able to provide additional energy. These reference levels are not based on the costs associated with the injection of additional energy.

Market participants requesting operating reserve reference levels greater than $0.10/MW are required to provide supporting materials to the IESO.

2.5. Financial Reference Level by Technology Type of the Resource

This section identifies cost-components related to energy offers, start-up offers, speed no-load, offers and operating reserve offers, as applicable.

These cost-components include incremental operating and maintenance costs, speed no-load costs, labour costs, opportunity costs, emission adders, electricity consumption/charging costs, fuel costs and operating reserve costs. If applicable, the formulas may employ additional performance factors to represent the efficiency of the technology in its determination of SRMCs.

For an energy offer, the IESO will establish an energy offer reference level curve for each set of dispatch data values. This will include up to 20 non-decreasing values of the energy reference level to form a monotonically increasing cost curve.

For energy offer reference levels, when cost curve is not monotonically increasing, the energy offer reference level will be set based on the highest cost for a given MW range.

2.5.1. Thermal

This section describes how the inputs for the applicable form should be completed to request each relevant reference level.

Thermal resources will have the following reference levels, as applicable:

- energy offer reference level;
- start-up ~~cost~~ reference level;
- speed no-load ~~cost~~ reference level; and
- operating reserve offer reference level.

Thermal resources include those resources that are primarily fueled by natural gas, biomass and oil. Resources that use two types of fuel to generate electricity and can decide which type of fuel to use when generating electricity will be required to register reference levels for each fuel type.

This section covers the following thermal resources:

- combined cycle;

- fossil or biomass steam (biomass); and
- combustion turbine.

To determine reference levels that are affected by thermal states, market participants determine the ambient conditions associated with hot, warm and cold thermal state reference levels. These ambient conditions will be used to determine all thermal state-affected reference levels.

2.5.1.1 Combined Cycle

A combined cycle resource uses an electric generating technology in which electricity is generated by both a combustion turbine (the Brayton Cycle) and a steam turbine generator (the Rankine Cycle). The gas turbine exhaust heat flows to a conventional boiler or to a heat recovery steam generator (HRSG) to produce steam for use by a steam turbine generator in the production of electricity.

For combined-cycle resources, the IESO will define reference levels for the simple-cycle mode and for all possible configurations of the combined-cycle mode, if applicable.

In the Ontario market, combined-cycle resources have the option to participate as pseudo--units. Using the cost-based reference level methodology, the IESO will establish multiple sets of reference levels for all combined-cycle resources as follows:

For the simple-cycle mode:

- Physical unit reference levels.

For a combined-cycle mode:

- Pseudo-unit reference levels for all possible configurations as relevant to a given resource such as running one combustion turbine with the steam turbine (1x1), running two combustion turbines with the steam turbine (2x1), etc.; and
- Physical unit reference levels.

2.5.1.1.1 Deriving Pseudo-Unit Reference Levels for a Combined Cycle Resource

Reference levels for pseudo--units are to be calculated based on physical unit parameters ~~and~~ in a manner consistent with the translation between physical units and pseudo--units in the IESO systems.

For example, financial reference levels for a pseudo--unit in 1x1 configuration will be determined based on aggregating the reference levels for the relevant combustion turbine with the reference levels for the steam turbine. Reference levels for a pseudo-unit in 2x1 configuration are determined based on aggregating the reference levels for the relevant combustion turbines with the reference levels for the contribution from the steam turbine. ~~physical units with the translation approach of the relationship~~

~~between physical units and pseudo-units that will be used in the renewed market for modelling purposes.~~

~~The IESO first determines the reference levels for the physical units at the combined-cycle resource, and then derives the pseudo-unit reference levels from those values. This will be done using the same ratio to allocate costs that is used to allocate MWs from physical units to pseudo-units.~~

2.5.1.1.2 Determining the Appropriate Configuration to use for the Relevant Calculation Engine for a Combined Cycle Resource

For financial reference levels, the IESO will determine the appropriate reference level (i.e., 2x1, 1x1) to apply for a combined-cycle resource based on the configuration that the resource was scheduled in As-Offered Scheduling of the DAM calculation engine or PD-Scheduling of the PD engine.

2.5.1.2 Cogeneration Resources

Market participants will work with the IESO to develop resource-specific reference levels for each cogeneration resource. In addition, separate reference levels will be established for different operating states of cogeneration facilities with or without steam turbine operations.

2.5.1.3 Financial Reference Level Equations

This section includes financial reference level equations for thermal resources. Equations are provided for thermal resources that are eligible for generator offer guarantees and those that are not eligible for generator offer guarantees.

These equations show the categories of eligible costs for each financial reference level.

2.5.1.3.1 For Thermal Resources that are Eligible for Generator Offer Guarantees

For thermal resources that are eligible for the Real-Time Generator Offer Guarantee (RT_GOG) and the Day-Ahead Generator Offer Guarantee (DAM_GOG), the following equations for reference levels will be applied. The descriptions of the components are provided below.

$$\textbf{Energy } \boldsymbol{Reference\ Level}\left(\frac{\$}{\boldsymbol{MWh}}\right) = \left(Incremental\ Heat\ Rate\left(\frac{GJ}{MWh}\right) * Total\ Fuel\ Related\ Costs\left(\frac{\$}{GJ}\right) * Performance\ Factor\right) + Emission\ Costs\left(\frac{\$}{MWh}\right) + Operating\ and\ Maintenance\ Costs\left(\frac{\$}{MWh}\right)$$

$$\textbf{Speed } \boldsymbol{No\ Load\ Reference\ Level}(\$/\boldsymbol{hr}) = (Speed\ No\ Load\ Heat\ Consumption\left(\frac{GJ}{hr}\right) * Total\ Fuel\ Related\ Costs\left(\frac{\$}{GJ}\right) * Performance\ Factor) + Emission\ Costs\left(\frac{\$}{hr}\right) + Operating\ and\ Maintenance\ Costs\left(\frac{\$}{hr}\right)$$

$$\boldsymbol{Start - up\ Reference\ Level}\left(\frac{\$}{\boldsymbol{Start}}\right) = \left(Start\ Fuel\ Consumed\left(\frac{GJ}{start}\right) * Total\ Fuel\ Related\ Cost\left(\frac{\$}{GJ}\right) * Performance\ Factor\right) + \left(Start - up\ Station\ Service\ Quantity\left(\frac{MWh}{start}\right) * Station\ Service\ Price\left(\frac{\$}{MWh}\right)\right) + Start - Up\ Emissions\ Costs\left(\frac{\$}{start}\right) + Operating\ and\ Maintenance\ Costs\left(\frac{\$}{start}\right)$$

2.5.1.3.2 For Resources Not Eligible for Generator Offer Guarantees

For thermal resources that are not eligible for the RT_GOG and the DAM_GOG, the IESO will use the primary reference level (described below) within the relevant scheduling engine to assess ex-ante mitigation for a price impact.

To assess settlement mitigation, the IESO will apply the primary reference level for the first X hours in the schedule of the resource, where X is equal to the MRT of the resource. Following the first X hours in the schedule of the resource, the IESO will apply the secondary reference level to assess settlement mitigation.

This approach ensures that settlement mitigation allows these resources to amortize their startup costs appropriately over their MRT, while at the same time assessing the appropriate costs to use for settlement mitigation for subsequent hours.

The IESO will apply following equation for reference levels for these types of thermal resources:

Primary Energy Reference Level:

$$\textbf{Energy } \boldsymbol{Reference\ Level} \left(\frac{\$}{\boldsymbol{MWh}}\right) = \left(Incremental\ Heat\ Rate \left(\frac{GJ}{MWh}\right) * Total\ Fuel\ Related\ Costs \left(\frac{\$}{GJ}\right) * Performance\ Factor + Emission\ Costs \left(\frac{\$}{MWh}\right) + \ Operating\ and\ Maintenance\ Costs \left(\frac{\$}{MWh}\right) + \frac{Start - up\ cost \left(\frac{\$}{start}\right)}{Hours\ per\ Start\ \left(\frac{h}{start}\right) x\ MLP(MW)}\right.$$

The Hours per Start (from the formula above) for each thermal state will be used to amortize start costs. The IESO will also use Minimum Loading Point (MLP) in MW and the minimum run-time of the resource. Market participants can request that the Hours per Start vary from the minimum run-time where operating characteristics of a specific resource warrant such treatment.

Secondary Energy Reference Level:

$$\textbf{Energy } \boldsymbol{Reference\ Level} \left(\frac{\$}{\boldsymbol{MWh}}\right) = \left(Incremental\ Heat\ Rate \left(\frac{GJ}{MWh}\right) * Total\ Fuel\ Related\ Costs \left(\frac{\$}{GJ}\right) * Performance\ Factor\right) + Emission\ Costs \left(\frac{\$}{MWh}\right) + \ Operating\ and\ Maintenance\ Costs \left(\frac{\$}{MWh}\right)$$

2.5.1.4 Incremental Heat Rates

Market participants must provide Heat Rate curves to determine the incremental heat rate and should be provided on a Higher Heating Value (HHV) basis. These curves show heat rate in GJ/MWh needed per MW of net electrical output.

Heat rate (HR) equals the GJ heat input (HHV basis) divided by the MWh of energy output.

$$\text{Heat } Rate = HR = \frac{Heat\ Input\ (GJ)}{Net\ MW}$$

Incremental heat rate describes the heat input necessary to produce an additional MW of output. Mathematically, the incremental heat rate is the first derivative of the heat rate curve.

$$\text{Incremental } Heat\ Rate = \Delta HR = \frac{Change\ in\ Fuel\ In}{Change\ in\ Energy\ Out} = \left(\frac{d_y}{d_x}\right)\ Heat\ Rate$$

Market participants are required to provide heat rates and incremental heat rates for their physical units and pseudo--unit reference levels for all possible configurations as relevant for the configuration at the resourcegeneration facility.

If the resource is also capable of burning more than one type of fuel, the market participant must also provide the incremental heat rate for operation of the resource for each fuel type. For example, if a resource is capable of burning natural gas and diesel, the market participant must provide the incremental heat rate for operation of the resource on both fuel types along with the incremental heat rate curves for their physical units and pseudo-unit reference levels for all possible configurations.

The following are the requirements for the supporting documentation to develop the incremental heat rate:

- heat rate and incremental heat rate curves will be provided based on HHV for each fuel type and for each operating mode. They will be based on design or comparable resource data modified by actual resource test data;
- reference conditions for the heat rate curves provided they are listed in OEM and Performance Tests;
- heat rate and incremental heat rate curves need to show the corresponding heat rate and incremental heat rate from minimum loading point (MLP) up to the maximum capacity of the resource; and
- correction curves provided by the OEM for the equipment performance under different ambient conditions.

HHV is defined as the amount of heat released by a specific quantity (initially at 25^{o}C) once it is combusted and the products have returned to a temperature of 25 ^{o} C.

The HHV heat content of the fuel also needs to be provided by the market participant.

Acceptable supporting documentation is as follows:

- seller’s quote or invoice;
- contract or nominal value based on industry standards; and
- as burned test, in stock test, as received test, as shipped test.

2.5.1.5 Total Fuel Related Costs

Eligible total fuel-related costs for thermal resources are expressed by the following equation:

$$\text{Total } Fuel\ Related\ Costs\ (\$/GJ) = (Fuel\ Commodity\ Index\ (\$/GJ) + Service\ Price\ Adder(\$/GJ)) * (1 + Compressor\ Fuel\ Volume\ Adder(\%))$$

When calculating the eligible total fuel-related costs, fixed charges for transportation equipment (e.g., pipelines, train cars, and barges) are ineligible and shall be excluded.

Fuel costs need to be converted to $/GJ for consistency.

2.5.1.5.1 Fuel Commodity Index

A fuel price index is used to determine the commodity price charged by the relevant supplier for the fuel purchased.

The following sub-sections describe the relevant index that the IESO uses to determine reference levels where reasonably possible. The way that these indices are used is based on the timing of their publication or availability. Timing of publication and integration into the reference levels will be determined as part of the consultation process to determine resource-specific reference levels.

Natural Gas

For natural gas, the applicable NGX Union Dawn Day-Ahead Index price for the gas day in $US/MMBtu is the acceptable fuel commodity index and the IESO will use the values published daily by Intercontinental Exchange where reasonably possible.

Market participants may request use of either a different fuel index, or a modification to use of the Dawn hub price to account for distance from the Dawn hub. These modifications will be evaluated on a case-by-case basis.

Where a methodology is supported by relevant documentation and appropriately reflects the relationship between the Dawn (or other) trading hub and the resource, it will be eligible for use.

Residual Fuel Oil

For residual fuel oil, the fuel commodity price is the relevant Platts indices for spot oil and the IESO will use the values published daily by Platts where reasonably possible. The supporting documentation required is a report showing the Platts indices for the relevant mix of types of sulfur spot oil (New York Harbour) in $US/bbl.

Ignition Oil

For ignition oil, the fuel commodity price is the weekly average wholesale (Rack) price for Furnace Oil in $CAD/litre and the IESO will use the most recent values as published by Natural Resource Canada (NRCan) where reasonably possible. The supporting documentation required is a report listing the weekly average wholesale (rack) price for furnace oil (rack) in cents per litre ($CAD) as published by NRCan for the applicable week of consumption.

Biomass

For biomass fuel, the fuel commodity price is the contract price with the biomass supplier in $CAD/tonne. This value will be provided by the participant. This contract price will be updated on an as-needed basis (annual updates will be conducted where reasonably possible) and the generator will provide the price to the IESO. The supporting documentation required will be copies of the contracts showing the prices with the suppliers.

2.5.1.5.2 Compressor Fuel Volume Adder

Compressor Fuel Volume Adder is the percentage of fuel consumed by the compressor including volumes for injecting or removing gas from storage. This cost is only eligible for natural gas-fired resources.

The following supporting documentation is required:

- copies of transportation, storage and load balancing contracts outlining the requirement to provide fuel to acquire the services should be provided; and
- copies of current regulatory approved rate schedules showing the percentage fuel requirements as applicable.

2.5.1.5.3 Service Price Adder

Natural Gas

The service price adder for natural gas-fired thermal resources ($CAD/GJ) is added to the fuel price for the additional services related to the commodity charge for transporting, balancing and storing of natural gas plus the marketer risk premium as described below:

- Pipelines, storage providers, and gas utilities provide various services to deal with imbalances between the quantity of gas purchased and the quantity of gas consumed;
- Imbalances created from the difference between the quantity of gas purchased and the quantity of gas consumed can be managed by injecting the excess gas into storage or withdrawing the shortfall in gas from storage. Storage services are provided by service providers to meet this need. The same rationale outlining the need for balancing services applies to the need for storage services; and
- A marketer risk premium may be incurred by end-users purchasing smaller volumes relative to large volume buyers.

Participants would provide the IESO with the amount of the service price adder applicable to their facility. The value would be set out as $CAD/GJ.

The following supporting documentation is required:

- copies of the transportation, storage and load balancing contracts outlining the requirement to provide fuel to acquire the services;

- copies of current regulatory approved rated schedules showing the variable commodity charges as applicable; and
- copies of contracts with gas suppliers showing the marketer premium.

Residual Fuel Oil (RFO)

For RFO, the eligible costs include an adder paid to the fuel supplier plus the cost of transportation from the point of purchase to the generation facility, which would be price in $US/bbl, converted to $CAD/bbl at the applicable foreign exchange rate on the day of synchronization (See section 2.6 for more details).

The following supporting documentation is required:

- copies of the contracts showing the price adder paid to the fuel supplier; and
- the cost of transportation from the point of purchase to the generation facility.

Biomass

For biomass, the value includes the sum of a transportation adder plus the heat adjustment factor priced in $CAD/tonne.

Transportation is required to move the biomass supply from the point of purchase to the generation facility.

A heat adjustment factor is calculated and applied to the price to account for differences between the heating value specified in the contract and the heating value of the biomass actually delivered.

The following supporting documentation is required:

- copies of the contracts showing the prices paid for the transportation adder; and
- independent reports showing the heating values that are used to determine the heat adjustment factor.

Co-firing

Resources that co-fire more than one fuel shall take a weighted average of the cost of the fuel ($), with weights determined on a per GJ basis.

When calculating the total fuel-related costs, fixed charges for transportation equipment, such as pipelines, train cars and barges, are excluded.

Conversion Factors

Documentation that describes the formulas for the conversion factors used to convert from $/MMBtu, $/bbl, $/litre or $/tonne to $/GJ is required.

2.5.1.5.4 Performance Factors

Performance factors are the calculated ratio of actual fuel burn to either theoretical fuel use (design heat input) or the most recent heat rate performance test and can be represented by the following formula:

$$\text{Performance } Factor = \frac{Total\ Actual\ Fuel\ Consumed\ (GJ)}{Total\ Theoretical\ Fuel\ Consumed (GJ)}$$

Market participants must provide the calculated performance factors for the resources on a seasonal basis (winter and summer). Thermal resources may experience some decline in performance during certain seasons or weather conditions, or due to resource age or declining efficiency. The IESO will update performance factors, similar to other components of reference levels, on an as-needed basis.

Acceptable supporting documentation include the following:

- actual fuel consumed: measured fuel quantities over one three (13)five years and heat content of fuel in 5-minute intervals; or monthly spot check test basis;
- theoretical fuel consumedconsumption based on design information:
  - heat rate and correction curves for each 5-minute interval and MWh of production during the same time period for the actual fuel consumed data;
  - reference site conditions for theoretical fuel consumption;
  - MWh of production during the time period; and
  - manufacturer-defined new and clean period (first x hours of operation).

2.5.1.5.5 Emissions Costs

Emissions costs are eligible costs and can be accounted for in the manner described in the following subsections.

Resources that a part of a Generation Facility that have annual emissions that exceed 50,000 tCO2e per year or have opted in to the Greenhouse Gas Emission Performance Standards[4]:

For thermal resources that must register their facility as required in accordance with the Greenhouse Gas Emission Performance Standards (O. Reg. 241/19), eligible

[4] tCO_2e is tonnes of carbon dioxide equivalent.

incremental emissions costs are based on the efficiency difference for the dispatch load and the allowance permitted under the legislation for thermal generation.

The contributions of emissions cost for energy reference levels is to be reviewed and updated on an as-needed basis based on the applicable Emission Performance Standard (EPS) for and carbon price for each year.

The contribution of eligible emissions costs are calculated using the following formula:

$$\text{Emissions } Charge\left(\frac{\$}{MWh}\right) = \left(Incremental\ HR\ \left(\frac{MJ}{MWh}\right) \times Performance\ Factor \times\ Emission\ Factor\ \left(\frac{tCO_2e}{GJ}\right) \times \frac{1\ GJ}{1000\ MJ} - Emission\ Performance\ Standard\left(\frac{tCO_2e}{GWh}\right) \times \left(\frac{1\ GWh}{1000\ MWh}\right) \times Carbon\ Price\ \left(\frac{\$}{tCO_2e}\right)$$

where, tCO_2e = tonnes of carbon dioxide equivalent
Emission Factor shall be in accordance with the applicable value in Tables 20-1a, 20-2, 20-3, 20-5, or 20-7 or other methodology as allowed in the Guide: Greenhouse Gas Emissions Reporting.
Emission Performance Standard shall be in accordance with the applicable value for fossil electricity generation in accordance with the Greenhouse Gas Emission Performance Standards (O. Reg. 241/19)

Other Resources

For other resources that do not qualify for the OBPS, eligible emissions costs are based solely on fuel consumption, as reflected by the following formula:

$$\text{Emissions } Charge\left(\frac{\$}{MWh}\right) = Incremental\ HR \times Performance\ Factor \times Emission\ Factor\ \left(\frac{tCO_2e}{GJ}\right) \times \frac{1}{1000} \times Carbon\ Price\ \left(\frac{\$}{tCO_2e}\right)$$

Supporting Documentation

Supporting documentation regarding eligible emissions costs (required in addition to the supporting documentation provided for total fuel related costs) is as follows.

For resources that part of a generation facility that have annual emissions that exceed 50,000 tCO2e per year or have opted in to the Greenhouse Gas Emission Performance Standards resources:

- Emission Factor, as defined Guide: Greenhouse Gas Emissions Reporting (https://www.ontario.ca/page/guide-greenhouse-gas-emissions-reporting). If a resource specific Emission Factor is proposed by the market participant for the reference level as applicable, supporting documentation must be provided to substantiate the calculation of an average Emission Factor based on quality of fuel received at the generation facility for the last 5 years.

For other resources:

- Invoices including their emissions charge as justification for emissions charges on a $/GJ basis.

2.5.1.6 Operating and Maintenance Costs

For thermal resources, eligible operating and maintenance costs are calculated according to the following formula:

$$
\begin{aligned}
O\&M\ Costs \left(\frac{\$}{MWh}, \frac{\$}{start}, \frac{\$}{hr}\right) &= Major\ Maintenance \left(\frac{\$}{MWh}, \frac{\$}{start}, \frac{\$}{hr}\right) \\
&+ Scheduled\ Maintenance\ Costs \left(\frac{\$}{MWh}, \frac{\$}{start}, \frac{\$}{hr}\right) \\
&+ Unscheduled\ Maintenance\ Costs \left(\frac{\$}{MWh}, \frac{\$}{start}, \frac{\$}{hr}\right) \\
&+ Operating\ Consumables\ Adder \left(\frac{\$}{MWh}, \frac{\$}{Start}, \frac{\$}{hour}\right)
\end{aligned}
$$

The allocation of eligible operating and maintenance costs between energy, speed no-load, and start-up reference levels may vary by resource type based on the OEM recommendations for maintenance activities, and by the type of maintenance (major maintenance or unplanned maintenance).

For resources that are capable of burning multiple fuels, market participants must submit operating and maintenance costs inputs into the reference levels for each fuel type that the resources are capable of burning.

2.5.1.6.1 Major Maintenance Costs

Eligible major maintenance costs for thermal resources include maintenance related to the gas turbine, steam turbine, heat recovery steam generator, or steam generator, where applicable.

Costs reimbursed by insurance and/or warranty under construction or equipment supply contracts are ineligible.

Eligible costs are determined on the basis of timing that covers one major maintenance inspection cycle. The duration of these inspection cycles varies according to the component or service. These durations take the place of the historical study period described above. The contribution of each major maintenance cost to the relevant reference level is determined according to the formula for pro-rating these costs as provided in the following sections (either on an equivalent operating hour (EOH)-basis or on a per-start basis).

If such historical information is not available, market participants may submit forecasted major maintenance expenditures based on costs associated with eligible maintenance activities in accordance with the OEM recommended maintenance intervals or prudent industry practices.

Market participants must provide sufficient supporting documentation for the forecasts in accordance with Section 2.3.

OEM-Recommended Interval on EOH or Operating Hour (h) Basis

For all major maintenance with maintenance intervals on an hours (h) or EOH-basis (i.e. 25,000-hour gas turbine inspection interval), the default cost allocation by offer type is as follows:

$$\text{Major } Maintenace\left(\frac{\$}{MWh}\right) = \sum\nolimits_i \frac{Maintenance\ Cost_i\ (\$)}{Output\ _i(MW) * Maintenance\ Interval_i\ (h, EOH)}$$

$$Major\ Maintenace\left(\frac{\$}{start}\right) = \sum\nolimits_i Maintenance\ Cost_i\ (\$) \cdot \frac{Hours\ Per\ Start_i\left(\frac{h}{start}\right)\ or\ Equivalent\ Operating\ Hours\ Per\ Start\ \left(\frac{EOH}{Start}\right)}{Maintenance\ Interval_i\ (h, EOH)}$$

$$Major\ Maintenace\left(\frac{\$}{h}\right) = \sum\nolimits_i \frac{Maintenance\ Cost_i\ (\$)}{Maintenance\ Interval_i\ (h, EOH)}$$

The EOH basis can only be used where the OEM provides a recommendation that includes additional weight for each start to calculate an equivalent life to factor in the impact of operating hours and starts on the equipment.

OEM-Recommended Interval on Per-Start Basis

For all eligible major maintenance costs with maintenance intervals on a start basis (e.g. every 2,400 starts), the default cost allocation can be proposed by the market participant as follows:

$$\text{Major } Maintenace\left(\frac{\$}{MWh}\right) = \sum_i \frac{Maintenance\ Cost_i\ (\$) * (Applicable\ portion\ of\ the\ start\ cost)}{Output(MW) \cdot Hours\ Per\ Start\left(\frac{h}{Start}\right) \cdot Maintenance\ Interval_i(start)}$$

$$Major\ Maintenace\left(\frac{\$}{start}\right) = \sum_i \frac{Maintenance\ Cost_i\ (\$) \cdot (1\ start\ or\ applicable\ portion\ of\ the\ start\ cost)}{\cdot\ Maintenance\ Interval_i(starts)}$$

$$Major\ Maintenace\left(\frac{\$}{h}\right) = Not\ applicable$$

Gas Turbines

For combustion turbines, either as standalone resource or as part of a combined cycle installation, eligible major maintenance costs include costs for inspections in accordance with the planned maintenance recommendations provided by the OEM including:

- combustion inspection;
- hot gas path inspection;
- major inspection; and
- rotor inspection.

Eligible costs for the above include:

- incremental payments made under a long-term service agreement or contractual service agreement. All or a portion of the incremental amounts may be eligible based on the terms of the relevant contracts based on eligible activities;
- replacement or refurbishment of capital parts for the gas turbine or gas turbine generator consistent with OEM recommendations and prudent industry practice;
- miscellaneous hardware or parts that are normally replaced during a gas turbine inspection;
- generator inspections;
- consumables required for the outage;
- technical advisors required;
- temporary incremental labour required;
- crane rentals required; and
- temporary infrastructure required (scaffolding, temporary office trailers, washrooms, etc.)

The supporting documentation required from market participants is described in Section 2.3.

Combined Cycle Steam Resources and Fossil or Biomass Steam Resources

For steam resources in a combined cycle facility and fossil biomass steam resources, the inspections on the heat recovery steam generator and steam turbine attributed to incremental electricity production are eligible costs where they are consistent with recommendations from the OEMs, which include:

- minor inspection; and
- major inspection.

Eligible costs for the above include:

- turbine blade repair or replacement;
- turbine diaphragm repair;
- casing repair or replacement;
- bearing repair or refurbishment;
- generator inspection;
- boiler repairs;
- primary air fan repairs;
- stop valve inspection and repairs;
- throttle valve inspection and repairs;
- nozzle block inspection and repairs;
- intercept valve inspection and repairs;
- PA/ID/FD Fan repairs;
- consumables required for the outage;
- technical advisors required;
- temporary incremental labour required;
- crane rentals required; and
- temporary infrastructure required (scaffolding, temporary office trailers, washrooms, etc.)

The supporting documentation required from market participants is described in Section 2.3.

Scheduled Maintenance Costs

Eligible scheduled maintenance costs for thermal resources include routine maintenance tasks on BOP equipment for combined cycle generation facilities and fossil or biomass steam resources.

Eligible costs include routine inspections as per the following, where applicable:

- inspection and rebuild of fan motors for the air-cooled condenser;
- heat transfer unit cleaning (air cooler, air heaters, economizers);
- selective catalytic reduction and CO reduction catalyst replacement;
- precipitator repairs;
- membrane replacements;
- reverse osmosis cartridges replacement;
- condensate extraction pumps overhauls;
- boiler feedwater pumps overhauls;
- bypass systems and/or sky vents inspections and parts replacements;
- condenser cooling water pumps overhaul;
- gas compressor inspection and overhaul;
- auxiliary boilers inspection;
- bucket elevator plant repairs;
- cooling tower fan motor and gearbox inspection;
- cooling tower fill and drift eliminators replacement; and
- biomass material handling systems including pulverizer maintenance

The supporting documentation required from market participants is described in Section 2.3. The historical study period for scheduled maintenance costs for thermal resources is 5 years to determine the applicable contribution to the determination of the energy, start-up cost, or speed no-load reference level.

Unscheduled Maintenance Costs

The supporting documentation required from market participants is described in Section 2.3. The historical study period for unscheduled maintenance costs for thermal resources is 5 years to determine the applicable contribution to the determination of the energy, start-up cost, or speed no-load reference level.

Operating Consumables Cost Adder

Eligible operating consumable costs for thermal resources are non-labour cost components which account for material, and consumable costs and fees incurred as a result of electrical power production. Costs must be incremental and avoidable to be eligible to contribute to the relevant reference level.

Eligible costs include:

- make-up water for the steam cycle (combined cycle steam resources and fossil or biomass steam resources only);
- steam cycle chemicals (combined cycle steam resources and fossil or biomass steam resources only);
- lubrication oil; and
- reagents for emission abatement equipment (e.g. ammonia or urea), if applicable.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for the operating consumable cost adder for thermal resources is 5 years to determine the applicable contribution to the determination of the energy or start-up cost reference level.

Eligible operating consumables can be calculated by either of the following methods depending on whether the market participant allocates these costs to the energy reference level or the start-up reference level:

Allocating Operating Consumables Cost Adder to Energy Reference Level

The eligible costs per year in the historical study period shall be divided by the generation per year for each year of the historical study period. The average across all years in the historical study period is the eligible operating consumables cost adder to the energy reference level. Where market participants allocate operating consumables costs on the basis of starts, these costs are not eligible to be considered in the energy reference level.

$$\text{Operating } Consumables\ Cost\ Adder\ \left(\frac{\$}{MWh}\right) = \frac{Historical\ Operating\ Consumables\ Cost\ (\$)}{Historical\ Electricity\ Generation\ (MWh)}$$

Allocating Operating Consumables Cost Adder to Start-up Reference Level

Market participants may elect to allocate a portion of their operating consumable cost based on the ratio that they typically incur operating consumables during operations. If they typically incur 10% of their operating consumables costs during starts, then 10% of their operating consumables costs are eligible to be allocated on the basis of starts within the historical study period.

$$\text{Operating } Consumables\ Cost\ Adder\ \left(\frac{\$}{Start}\right) = \frac{Historical\ Operating\ Consumables\ Cost\ Related\ to\ Starts\ (\$)}{Historical\ Number\ of\ Starts\ (Starts)}$$

2.5.1.7 Start-Up Costs

Eligible start-up costs for thermal resources are all costs associated with start-up. These include costs required to bring the boiler, turbine, and generator from shutdown conditions to the MLP of the resource.

Start-up costs for thermal resources will vary according to the thermal state of the resource where appropriate, resulting in reference level contributions that vary according to thermal state.

$$\begin{aligned}\text{Start } Cost\ (\frac{\$}{Start}) &= (Start\ Fuel\ Consumed(\frac{GJ}{start}) * Total\ Fuel\ Related\ Cost(\frac{\$}{GJ}) \\ &* Performance\ Factor) + (Station\ Service\ Quantity\left(\frac{MWh}{start}\right) \\ &* \ Station\ Service\ rate\left(\frac{\$}{MWh}\right)) + StartUp\ Emissions\ Costs\left(\frac{\$}{start}\right) \\ &+ \ Start\ Maintenance\ Adder\left(\frac{\$}{start}\right) \\ &+ Start\ Operating\ Consumables\ Adder\ (\frac{\$}{start})\end{aligned}$$

2.5.1.7.1 Start Fuel Consumed

Start fuel consumed for thermal resources is the quantity of start fuel consumed from the first firing up of the resource until its MLP. This value can vary depending on how long the resource has been offline or the thermal state of the resource. Thermal resources must submit start-up fuel quantities for starting up from a cold, warm and hot state. The IESO will set reference levels for each thermal state. If multiple types of fuel are required for a resource to start up, the market participant must identify the required quantities for each type of fuel required for the start per thermal state.

2.5.1.7.2 Station Service

Station service is the incremental quantity of electricity withdrawals from the delivery point included from the initiation of the start sequence of the resource until the resource reaches MLP. Incremental quantity of electricity withdrawals will be multiplied by the station service rate. For resources with electric auxiliary boilers, the incremental station service cost associated with operating the auxiliary boiler may be included with the station service.

Incremental station service cost is determined based on the incremental electricity withdrawals above an average baseline consumption of the resource when it is not generating electricity.

2.5.1.7.3 Start-Up Emissions Costs

Eligible start-up emissions costs for thermal resources are the costs based on relevant emissions policy such as the Federal Carbon Pricing Backstop.

$$\text{Emissions } Charge\left(\frac{\$}{Start}\right) = \left(Start\ Fuel\ Consumed\ \left(\frac{GJ}{Start}\right) \times Fuel\ Carbon\ Content\ \left(\frac{tCO_2e}{GJ}\right) - Output\ Based\ Standard\left(\frac{tCO_2e}{GWh}\right) \times Electricity\ Generated\ During\ Start\left(\frac{GWh}{Start}\right)\right) \times Carbon\ Price\left(\frac{\$}{tCO2e}\right)$$

For the IESO to calculate the incremental emission charge obligation for each type of start (hot, warm and cold), market participants are required to provide supporting materials that demonstrate the electricity generated from the initiation of the start up until the resource reaches its MLP.

When thermal resources burn biomass fuels during start-up, there are no resultant eligible start-up emissions costs.

2.5.1.7.4 Start-Up Maintenance Adder

Market participants can include a start maintenance adder in the start-up costs using the methodology prescribed in Section 2.5.1.6.1.

2.5.1.7.5 Start-Up Operating Consumables Adder

A start-up operating consumables adder is eligible to be included in the start-up costs using the methodology prescribed in Operating Consumables Adder sub-section of Section 2.5.1.6.1.

2.5.1.8 Speed No-Load Fuel Cost

The eligible speed no-load fuel cost is the hourly cost required to hypothetically maintain the thermal resource in a speed no-load state. This type of hypothetical operation is not actually carried out by these resources. This reference level methodology uses the approach of separating the fixed hourly costs of synchronized operation from costs associated with incremental production. It is calculated as follows:

$$\text{Speed } No\ Load\ Fuel\ Costs \left(\frac{\$}{hr}\right) = Fuel\ Price \left(\frac{\$}{GJ}\right) * Speed\ No\ \sout{Leaod}Load\ Heat\ Consumption \left(\frac{GJ}{hr}\right) \times Performance\ Factor + Speed\ No\ Load\ Emission\ Costs \left(\frac{\$}{hr}\right)$$

2.5.1.9 Speed No-Load Heat Consumption

Speed no-load heat consumption is the minimum fuel burn that would be hypothetically consumed if the resource were to back down to a zero-power output while staying synchronized with the IESO-controlled grid.

This quantity should be determined by market participants based on a regression analysis of the heat input as a function of net power output of the resource. The data for the regression analysis can be derived from test data or design information of the resource.

2.5.1.9.1 Speed No-Load Emission Costs

Eligible speed no-load emission costs are the costs associated with emissions based on the relevant emissions policy such as the Federal Carbon Pricing Backstop.

$$\text{Emissions } Charge \left(\frac{\$}{hr}\right) = No\ load\ heat\ consumption\ (GJ/hr) \times Fuel\ Carbon\ Content \left(\frac{tCO_2e}{GJ}\right) \times Carbon\ Price \left(\frac{\$}{tCO2e}\right)$$

Speed no-load emissions costs do not apply when resources are firing biomass fuel.

2.5.1.10 Operating Reserve Reference Levels

Operating reserve reference levels are approved based on incremental costs incurred by the resource to make the operating reserve capability available. These are the costs incurred by a resource at the time it is supplying operating reserve. These costs are not incurred when the resource is not providing operating reserve. If applicable, market participants are required to demonstrate the costs associated with the provision of operating reserve on a resource-specific basis with relevant supporting documentation. No incremental costs are associated with providing operating reserve for operating and maintenance of the equipment.

2.5.2. Hydroelectric

Hydroelectric resources produce electricity by using the power of flowing water. Hydroelectric resources will have both an energy reference level and an operating reserve reference level.

This section describes how market participants should provide the inputs for the applicable form to facilitate the calculation of each relevant reference level.

As reflected in the equation below, the energy reference level for hydroelectric resources with storage is the greater of either the incremental costs for operating and maintenance of the hydroelectric resource or the opportunity cost.

For hydroelectric resources, the IESO applies the following equation for the energy reference level and the components are described in subsequent sections.

$$\text{Energy } Reference\ Level = MAX(Total\ Fuel\ Related\ Costs + (Major\ Maintenance + Scheduled\ Maintenance + Unscheduled\ Maintenance) * EOH\ Factor, Opportunity\ Costs)$$

2.5.2.1 Total Fuel-Related Costs

The total fuel-related costs for hydroelectric resources includes the gross revenue charges and the pumped hydro fuel costs.

2.5.2.1.1 Gross Revenue Charges

Hydroelectric resource owners pay taxes and charges based on gross revenue on a $/MWh basis. These taxes and charges are known as the gross revenue charge (GRC). GRC is an eligible fuel-related cost for hydroelectric resources.

Examples of GRC components include:

- property taxes payable to the Minister of Finance;
- property taxes payable to the Ontario Electricity Financial Corporation;
- water rental charges payable to the Minister of Finance;
- charges from the Niagara Parks Commission; and
- charges from the Province of Quebec.

Supporting documentation for the GRC include invoices issued by the relevant authority.

The contribution of GRC to the energy reference level is expressed by the following equation:

$$Marginal\ Gross\ Revenue\ Charge = \frac{Property\ Tax\ Charge\ (\$) + Water\ Rental\ Charge\ (\$)}{Long\ Term\ Average\ Energy\ (MWh)}$$

Where, the property tax charge is calculated based on the marginal tax rate, the water rental charge and the long term average energy.
Long Term Average Energy is the annual energy which is expected to be produced during the average hydrological year, also known as the P50 Energy generation.

The Long Term Average Energy should be calculated using at least 10 years of actual generation records, or calculated via an hourly simulation model with at least 10 years of hydrological records.

2.5.2.1.2 Pumped Hydro Fuel Cost

Pumped-storage hydropower is a type of hydroelectric energy storage. It is configured with two reservoirs at different elevations that can generate power as water moves past a turbine. The water from the lower reservoir is pumped up into the higher reservoir to refill it for power generation later.

For hydroelectric resources that are configured in this way, the cost of energy necessary to pump water from the lower reservoir and move it up to the upper reservoir is an eligible cost for the energy reference level.

The IESO calculates the pumping power cost on a seven-day rolling average basis by multiplying the costs to withdraw power by the power consumed during each hour, divided by the total power consumed over the seven-day period (168 hours) to determine the average cost, as described below:

$$\text{Pumping}\ Power\ Cost\ \left(\frac{\$}{MWh}\right) = \frac{\sum_{168}^{1}\left(Pumping\ Withdrawal\ Costs_h\ \left(\frac{\$}{MWh}\right) * Pumping\ Power_h\ (MWh)\right)}{\sum_{168}^{1} Pumping\ Power_h\ (MWh)}$$

The Pumping Withdrawal Costs include the energy price paid for pumping withdrawals plus a fixed $/MWh adder for related energy regulatory charges incurred during withdrawal operations.

If no water has been pumped during the previous seven-day period, the IESO uses the last pumping power cost that was calculated for the resource using a non-zero value for pumping power ~~cost~~ quantity~~calculated for the hydroelectric resource~~.

The pumped storage fuel cost is calculated by dividing the pumping power cost by the pumping efficiency, as described below:

$$\text{Pumped } Storage\ Fuel\ Cost \left(\frac{\$}{MWh}\right) = \frac{Pumping\ Power\ Cost\ (\frac{\$}{MWh})}{Pumping\ Efficiency\ (\%)}$$

Pumping efficiency is measured using the ratio of generation produced to the amount of generation used as fuel. It is calculated as the generation produced in MWh over the energy consumed to pump that MWh of generation produced. This component is applicable to pumped storage hydroelectric generation resources only.

$$\text{Pumping } Efficiency = \frac{Generation\ Produced\ (MWh)}{Pumping\ Energy\ Consumed\ (MWh)}$$

Supporting documentation for this cost is the calculation of pumping efficiency by the market participant, using the resource's revenue meter data to determine the generation produced in MWh. Market participants can also calculate and submit the seasonal pumping efficiencies, if applicable for the resource, to the IESO.

2.5.2.2 Operating and Maintenance Costs

Eligible maintenance costs included in the reference levels must be related to expenses incurred as a result of energy production and considered variable costs that are directly attributable to the production of energy. Costs must be incremental and avoidable to be considered eligible for the reference level determination for the resource.

Costs that do not vary due to increased electricity production are considered ineligible. Examples of ineligible costs include, but are not limited to, building maintenance, roads, dams and dam safety, hydro-mechanical equipment, penstocks and water conveyance systems, HVAC systems, service air and water systems, water treatment, drainage and dewatering.

2.5.2.2.1 Major Maintenance Costs

Eligible major maintenance costs for hydroelectric resources include:

- turbine refurbishment;
- runner blade repair;
- turbine/generator bearing refurbishment or replacement;
- wear ring replacement;
- generator rewinds;
- stator core refurbishment/replacement;

- rotor pole rewinding;
- governor/HPU refurbishment;
- transformer oil filtration/replacement; and
- transformer replacement.

Costs reimbursed by insurance and/or not directly incurred by the market participant due to warranty of the resource or any sub-component under construction or equipment supply contracts are excluded.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for major maintenance costs for hydroelectric resources is 40 years.

2.5.2.2.2 Scheduled Maintenance Costs

Eligible scheduled maintenance costs for hydroelectric resources include:

- oil and lubricant replacement;
- filter replacements;
- feedwater piping repair;
- water treatment plant service
- mechanical seal replacement; and
- consumable materials for the maintenance of turbine/generator components.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for scheduled maintenance costs for hydroelectric resources is 5 years.

2.5.2.2.3 Unscheduled Maintenance Costs

Section 2.2.4 describes the eligible unscheduled maintenance costs that can be included in the reference level calculations. The supporting documentation required from market participants is described in Section 2.3. The historical study period for unscheduled maintenance costs for hydroelectric resources is five years.

2.5.2.3 Modifying Historical Eligible Maintenance Costs to Account for Changing Operational Profiles

The contributions of the eligible maintenance costs described above (major maintenance, scheduled maintenance, unscheduled maintenance) to the energy reference level are derived based on the historical operation of the unit.

There might be changes in how a resource was dispatched in the most recent year of operation, which is referred to as the current operating period, compared to how a resource was dispatched in the historical study period. To account for these changes, market participants may elect to apply a correction factor to eligible historical maintenance costs based on the equivalent operating hours (EOHs) methodology. This correction factor is applied to improve how accurately the energy reference level reflects historical eligible costs under the current operating period of a hydroelectric resource.

The EOH should be calculated for the relevant historical study period according to the type of maintenance cost as discussed above. If fundamental attributes of the resource have significantly changed due to upgrades or modifications, the baseline EOH will be determined on a resource-specific basis so that only those years in the historical study period when the fundamental attributes of the resource are consistent with the current attributes of the resource are used. The EOH should also be calculated for the last year of operation (the current operating period).

The ratio of the EOH from the historical study period to the EOH from the current operating period is the correction factor. The correction factor is used to index eligible maintenance costs from all maintenance cost categories (major maintenance, scheduled maintenance and unscheduled maintenance).

The value of EOH for a given year is calculated using the following equation:

$$\text{Equivalent } Operating\ Hours\ (EOH) = Hours\ of\ Operation\ (h) + (\#\ of\ starts/stops * start/stop\ equivalent\ hours)$$

Where:

- Hours of Operation are the total number of hours the unit is used for generating electricity;
- # of start/stops are the total number of start/stop cycles of the unit; and
- start/stop equivalent hours are the number of hours of operation associated with each start/stop. Market participants should state their assumptions and provide supporting materials for this value, which may include research studies in determining EOH start/stop hours.

The following case study illustrates example calculations for the EOH multiplier:

Table 2-8: ~~Table 2-1:~~ EOH Methodology Illustrative Example

Parameter	Historical Annual Operation (last 5 years)	Current Operating Period (last year)
Hours of operation	5000 h	5000 h
# of start/stops	100	300

Parameter	Historical Annual Operation (last 5 years)	Current Operating Period (last year)
Start/stop equivalent hours	5 hrs per start/stop	5 hrs per start/stop

Historical EOH is calculated as:

$$\text{Equivalent } Operating\ Hours\ (EOH) = 5000h + (100 * 5h) = 5{,}500\text{h}$$

And current operating regime EOH is calculated as:

$$\text{Equivalent } Operating\ Hours\ (EOH) = 5000h + (300 * 5h) = 6{,}500\text{h}$$

Therefore, the appropriate correction factor is calculated as:

6,500/5,500 = 1.18

2.5.2.4 Opportunity Costs

Section 2.4.6 describes the method that the IESO uses to determine eligible opportunity costs.

Eligible opportunity costs for hydroelectric resources may include the intraday opportunity cost and the storage horizon opportunity cost. The dispatchable hydroelectric resource shall provide to the IESO the value, measured in a unit of time, of the maximum storage capability of its resource operating under normal conditions along with relevant supporting documentation. Supporting documentation of the storage capacity may include water management plans specific to the resource.

2.5.2.5 Operating Reserve Reference Levels:

Operating reserve reference levels are approved based on incremental costs incurred by the resource to make the operating reserve capability available. If applicable, costs associated with provision of operating reserve are required to be demonstrated by the market participant on a resource-specific basis with relevant supporting documentation.

No incremental costs are associated with providing operating reserve for operating and maintenance of the equipment.

2.5.3. Solar

Solar resources use photovoltaic cells to convert solar radiation to electricity.

This section describes the inputs that market participants need to provide in the applicable form to request an energy reference level.

For solar resources, the following equation for energy reference level will be applied and the components are described in subsequent sub-sections:

$$\text{Energy } Reference\ Level = Operating\ and\ Maintenance\ Costs$$

2.5.3.1 Operating and Maintenance Costs

This section describes the eligible maintenance costs for solar resources that can be included into the reference levels.

2.5.3.1.1 Major Maintenance Costs

Eligible major maintenance costs for solar resources include costs to replace inverter units. Costs reimbursed by insurance and/or warranty are excluded.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for major maintenance costs for solar resources is 10 years.

For new solar installations, the statistical energy output given in a P50 resource assessment can be used when historical injection data is not available.

2.5.3.1.2 Scheduled Maintenance Costs - Electrical and Mechanical

Eligible scheduled maintenance costs for solar resources include:

- inverter annual maintenance;
- combiner box inspections;
- standard cleaning of electronics; and
- racking bolt torque checking.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for scheduled maintenance costs for solar resources is 5 years.

2.5.3.1.3 Unscheduled Maintenance Costs - Electrical

Eligible unscheduled maintenance costs for solar resources include overtime labour or third-party labour contracted to repair the components and materials costs associated with any such repairs in the event of equipment failure.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for unscheduled maintenance costs for solar resources is 5 years.

2.5.3.2 Incremental Third Party Payments

Section 2.4.5 describes eligible incremental third-party payments that need to be included in the calculation of the reference levels for solar resources.

2.5.4. Wind

This section describes the inputs that market participants with wind resources should provide in the applicable form to request an energy reference level.

Wind power generation refers to the technology of converting the kinetic energy of the wind into electric power through a wind turbine. The wind turbine produces electricity by collecting and transforming wind power into rotational mechanical energy to drive a generating unit.

For wind resources, the IESO will apply the following equation for the energy reference level and the components are described in subsequent sub-sections.

$$\text{Energy } Reference\ Level = Operating\ and\ Maintenance\ Costs$$

2.5.4.1 Operating and Maintenance Costs

The following sub-sections list the eligible major, scheduled and unscheduled maintenance costs that can be included in the reference level calculations for wind resources.

2.5.4.1.1 Major Maintenance Costs

Eligible major maintenance costs for wind resources include:

- blade (blade structure, complete blade, lightning protection system, LEP coating);
- pitch system (bearing change, hydraulics);
- drive train (main shaft / bearing changeout);
- gearbox (bearing change, complete gearbox change); and
- generator (bearing change, complete generator changeout).

Costs reimbursed by insurance or warranty under construction or equipment supply contracts are excluded.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for major maintenance costs for wind resources is 10 years.

For new wind installations, the statistical energy output given in a P50 resource assessment can be used when historical injection data is not available.

2.5.4.1.2 Scheduled Maintenance Costs

Eligible scheduled maintenance costs for wind resources include:

- converter and main cabinets checks;
- power cables – stator and rotor check;
- bus bar and power cables inspection;
- generator and gearbox inspections and monitoring program;
- yaw and pitch system inspection;
- lubrication and oil changes;
- bearing inspection and lubrication;
- bearing sealing inspection and insulation test;
- stator winding inspection;
- cooling circuit and heat exchanger inspection;
- blade heating inspection;
- standard cleaning;
- vibration check (generator frame, bearing housing);
- bolt torque tightening;
- shaft alignment check; and
- blade inspection and minor repair.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for scheduled maintenance costs for wind resources is 5 years.

2.5.4.1.3 Unscheduled Maintenance Costs

Eligible unscheduled maintenance costs for solar resources include overtime labour or third party labour contracted to repair the components and materials costs associated with any such repairs in the event of equipment failure.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for unscheduled maintenance costs for wind resources is 5 years.

2.5.4.2 Incremental Third-Party Payments

Section 2.4.5 describes the eligible incremental third-party payments that can be included in the reference level calculations for wind resources.

2.5.4.3 Operational Costs Related to Start-Up

Eligible operational costs related to start-up include costs to consume energy to warm up the resource to enable it to respond to dispatch instructions. Examples of wind resources that are expected to incur these costs include those with cold climate packages or blade heating.

The cost of power is eligible to be included in the energy offer reference level on a $/MWh basis based on the total cost of starting the unit divided by energy production across the historical study period.

Unit SCADA data must be provided as supporting materials to show warm-up stage consumption, and hence cost. The supporting documentation required from market participants is described in Section 2.3.

The historical study period for operational costs related to start-up for wind resources is 1 year.

2.5.5. Nuclear

A nuclear resource is licensed to produce commercial power from controlled nuclear reactions to heat water to produce steam that drives steam turbines generators.

Nuclear resources will have an energy reference level. This section describes the inputs for the applicable form that market participants should complete to request an energy reference level.

For nuclear resources, the IESO applies the following equation for the energy reference level and the components are described in subsequent sub-sections.

$$\text{Energy } Offer\ Reference\ level\left(\frac{\$}{MWh}\right)$$
$$= Incremental\ Fuel\ Consumption\left(\frac{kg\ (U)}{MWh}\right)$$
$$* \left(Total\ Fuel\ Related\ Costs\left(\frac{\$}{kg\ (U)}\right) * Performance\ Factor\right)$$
$$+ Maintenance\ Costs\left(\frac{\$}{MWh}\right) + Operating\ Costs\left(\frac{\$}{MWh}\right)$$
$$+ Incremental\ Third\ Party\ Payments\ (\frac{\$}{MWh})$$
$$+ ProratedStartupCosts\left(\frac{\$}{MWh}\right)$$

2.5.5.1 Fuel-Related Costs

Eligible fuel-related costs for nuclear resources can be grouped into resource generation capacity data and total fuel-related costs.

2.5.5.1.1 Resource Generation Capacity Data

The following sections define the resources power production capacities and efficiencies.

Net Power

Net power is equal to the power (MW) delivered to the grid. This is the gross generator output minus the house loads (the auxiliary power consumption of the resources) required to operate the resource for power production

$$\text{Net } Power(MW) = Gross\ Output(MW) - \ House\ Loads\ (MW)$$

Maximum Licensed Reactor Power (RP)

This is the current maximum thermal power, MW(th) at which the nuclear resource is approved to operate according to their Canadian Nuclear Safety Commission (CNSC) Operation License.

Heat Rate

Heat rate is the resource's heat input, MW(th) divided by its net electrical power output, MWh.

$$\text{Heat } Rate = \ Max\ Licenced\ RP\big(MW(th)\big)\ /\ Net\ Electrical\ Production\ (MWh)$$

Incremental Fuel Consumption

Incremental fuel consumption (kg(U)/MWh) is the relationship between an additional MWh of output and the additional uranium fuel input in kg necessary to produce it. This is determined from the ratio of the change in fuel input to the change in Resource MWh output.

$$\text{Incremental } Fuel\ Consumption\ \left(\frac{kg\ (U)}{MWh}\right) = Fuel\ Burn\ Rate\ (\frac{kg(U)}{MW(th)}) * Heat\ Rate\ (\frac{MW(th)}{MWh})$$

Fuel Burn Rate, kg(U)/MW(th) is the actual burn rate of the uranium fuel as reported in the station Annual Fuel Performance Report or the Station Safety Report.

Capacity Factor

Capacity factor is the ratio of actual electrical energy output for the resource over a given period of time to the maximum possible electrical energy output over that period. Capacity factor indicates the extent of the use of the resource. If the resource is always running at its rated capacity, then the capacity factor is 100% or 1.

Performance Factors

The performance factor is the calculated ratio of actual fuel burn to the theoretical fuel burn (design heat input) to achieve a required generator output.

In the nuclear industry, this is known as the Thermal Performance Indicator (TPI) as defined by World Association of Nuclear Operators (WANO). The WANO specifications dictate the data collection and analysis requirements.

The TPI is the ratio of overall actual cycle efficiency to the design cycle efficiency. In this regard, the TPI encompasses the entire reactor-boiler-turbine-condenser cycle. This indicator is an integrated measure that includes unnecessary heat loads, turbine cycle and condenser performance. PF is expressed as a percentage, 100% indicates perfect thermal performance.

2.5.5.1.2 Total Fuel-Related Costs

Eligible total fuel related cost is the sum of eligible basic fuel costs and eligible fuel disposal costs. All of these costs shall be expressed in $/kg(U).

$$TotalFuelRelatedCost\left(\frac{\$}{kg(U)}\right) = BasicFuelCost\left(\frac{\$}{kg\ (U)}\right) + FuelDisposalCost\left(\frac{\$}{kg\ (U)}\right)$$

Basic Fuel Costs

Eligible basic fuel costs are the total costs of fuel, including natural uranium cost, conversion to UO2 and fabrication. These costs are supplied by the fuel vendor and are expressed in $/kg.

Fuel Disposal Costs

Eligible fuel disposal costs are the costs associated with transportation of spent fuel and spent fuel disposal and shall be expressed in $/kg (U).

Fuel disposal costs shall be added directly to the basic fuel costs to determine eligible total fuel-related costs. These costs shall be confirmed with invoicing for the long term storage costs of spent fuels.

On-site storage costs for spent fuel is not an eligible cost as this is considered part of the fixed operating costs of the resource.

2.5.5.2 Operating and Maintenance Costs

Eligible operating costs are those costs directly attributed to consumable materials and services required for operation of the reactor and energy production. These are non-labour cost components accounting for materials, and consumable costs incurred as a result of electrical power production and safe operation of the nuclear reactor.

They include the cost of:

- lubricants;
- chemicals;
- gases;

- demineralized water;
- acids;
- caustics and heavy water (deuterium oxide);
- tritium removal;
- ion exchange resins procurement and disposal; and
- filters.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for operating costs for nuclear resources is 5 years.

Major Maintenance Costs

Eligible major maintenance costs for nuclear resources include:

- turbine and generator refurbishment and rebuilds;
- turbine and generator control and power systems refurbishment and rebuilds;
- all major pump and motor repairs, boiler feed, condenser cooling water, primary heat transport, or moderator cooling;
- all systems heat exchanger tube plugging and tube bundle replacements;
- all critical system valves and valve operators repair / replacement;
- trash rack breakdown / equipment failure repair;
- repair or replacement of reactivity control units;
- feeder and pressure tube inspection, assessment and replacement;
- main output and unit transformer inspection, repair and replacement;
- isolated phase bus inspection and repair;
- all critical electrical systems, transformers, switchgear, bus duct, breakers, protective relays, motor control equipment, surge protection, rectifiers, inverters and batteries; and
- maintenance or replacement of emergency power systems.

Costs reimbursed by insurance and/or covered by warranty under construction or equipment supply contracts are excluded.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for major maintenance costs for nuclear resources is 10 years.

Scheduled Maintenance

Eligible scheduled maintenance costs for nuclear resource include maintenance tasks during major outages and or during operating periods including inspections and work such as:

- turbine blade inspection;
- turbine diaphragm repair; casing inspection;
- turbine and generator seal inspections repair/replacement;
- heat exchanger cleaning;
- turbine emergency stop and control valves, reheat stop and intercept valve inspections and repairs;
- turbine and generator control and power systems inspections;
- all major pump and motor inspection and repairs, boiler feed, condenser cooling water, primary heat transport, or moderator cooling;
- all systems heat exchanger tube bundle inspections;
- all critical system valves and valve operator inspections;
- scheduled maintenance of reactivity control units;
- heavy water purification, ion exchange equipment, filters and strainers;
- containment systems inspection and maintenance;
- feeder and pressure tube inspection, assessment and replacement;
- main output and unit transformer inspection, repair and replacement;
- isolated phase bus inspection and repair;
- fueling machine service and maintenance;
- primary and secondary spent fuel bay systems inspection and repair;
- repairs to any safety related systems where its current condition is resulting in an impairment and forcing unit de-rate or shutdown;
- all electrical systems, transformers, switchgear, bus duct, breakers, protective relays, motor control equipment, surge protection, rectifiers, inverters and batteries; and
- scheduled maintenance of emergency power systems.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for scheduled maintenance costs for nuclear resources is 5 years.

Unscheduled Maintenance Costs

Eligible unscheduled maintenance costs for nuclear resources are expenses incurred as a result of electrical production resulting from run-to-equipment-failure maintenance strategies and unplanned equipment failures.

Eligible costs include only maintenance costs related to:

- electrical production;
- reactor safety margin management;
- environmental qualification maintenance;
- radiation safety management;
- conventional safety;
- environmental safety; and
- regulator code compliance requirements [CNSC RD/GD-201, RD/GD-98].

Eligible costs incurred for corrective action and root-cause investigations include:

- temporary repair;[5]
- repair,
- overhaul;
- refurbishment;
- replacement; or
- modification costs.

In addition, costs incurred as a result of corrective action and root cause investigations (inspection and equipment failure diagnosis) are also eligible.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for unscheduled maintenance costs for nuclear resources is 5 years.

2.5.5.3 Incremental Third Party Payments

Section 2.4.5 describes the eligible incremental third-party payments that can be included in the reference level calculations for nuclear resources.

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[5] Repairs can be considered temporary to allow equipment to last until the next outage due to limitations of downtime or inability to adequately conduct the repair outside of an outage.

2.5.5.4 Operational Costs Related to Start-Up

Eligible operational costs related to start-up are costs incurred as a result of a cold start of a nuclear resource, where nuclear fuel, consumables, and power from the grid are consumed during the course of the startup phase.

In cases where a resource is dispatched, but needs to consume power and fuel to start up, market participants can include this cost into the incremental energy for the resource on a $/MWh basis based on the total cost per start divided by energy production across the historical study period.

Market participants must provide the unit SCADA data as supporting documentation to show warm-up stage consumption, and hence the cost.

Total per start costs shall be expressed according to the following formula:

$$\text{Total } per\ Start\ Cost\left(\frac{\$}{Start}\right) = StartFuel\frac{kg\ (U)}{Start} * TFRC\frac{\$}{kg\ (U)} * \ PerformanceFactor + StationserviceQuantity\ (MWh) * StationServiceRate\ \$/MWh + StartMaintenanceAdder\ \$/start$$

Where:

- Startup fuel is the fuel consumed from cold to licensed full power operation.
- Station service quantity is the grid power consumed during the startup phase to the point of the nuclear resource powering its own house loads.
- Start maintenance adder ($/start) is eligible maintenance costs required specifically and only for the resource startup.

Pro-Rated Start Costs are start-up costs distributed across one operating cycle, between planned and scheduled outages (IESO informed).

Pro-Rated Start-up Cost ($/MWh) = Total per Start Cost ($/Start) / (Days Between Outages * 24 (hrs/day) * Net Electrical Output (MWh) * Capacity Factor)

The supporting documentation required from market participants is described in Section 2.3. The historical study period for operational costs related to start-up for nuclear resources is 1 year.

2.5.6. Energy Storage

Energy storage resources will have an energy reference level and an operating reserve reference level. This section describes the inputs that market participants must provide in the applicable form to request the relevant reference level.

Energy storage refers to the capture of energy produced at one time for use at a later time. There are various energy storage technologies including technologies that rely on mechanical, electromechanical and chemical reactions. Energy storage resources store energy in the form of compressed air, flywheel, flow battery, rechargeable battery and hydrogen storage.

For energy storage resources, the IESO applies the following equation for the energy reference level and the components are described in the subsequent sections.

The energy reference level is equal to the greater of either the incremental costs for discharging the energy storage resource or the opportunity cost.

$$\text{Energy } Reference\ Level\left(\frac{\$}{MWh}\right) = Charging\ Cost\left(\frac{\$}{MWh}\right) + Station\ Service\ Cost\left(\frac{\$}{MWh}\right) + Major\ Maintenance\left(\frac{\$}{MWh}\right) + Scheduled\ Maintenance\ Electricial\ and\ Mechanical\left(\frac{\$}{MWh}\right) + Unscheduled\ Maintenance\ Costs\left(\frac{\$}{MWh}\right)$$

2.5.6.1 Fuel-Related Costs

This section describes the fuel-related costs associated with charging costs and station service costs in energy storage.

2.5.6.1.1 Charging Costs

The SRMC of an energy storage resource includes the recharging costs for the resource.

The IESO calculates the eligible charging costs by using the following equation:

$$Charging\ Cost\ (\frac{\$}{MWh}) = \frac{Average\ Electricity\ Purchase\ Price\ from\ previous\ year\left(\frac{\$}{MWh}\right) x\ IESO\ annual\ escalation}{Round\ Trip\ Efficiency}$$

Average Electricity Purchase Price

The average electricity purchase pricing for the resource is based on the average price the resource paid in the same calendar month of the previous year. If the resource has been operating for less than one year, it is assumed the resource is charging overnight. The average overnight electricity pricing for the resource from the same month of the previous year is used to calculate the charging costs.

Round-Trip Efficiency

The round-trip efficiency of an energy storage resource is analogous to the heat rate of a thermal resource.

The round-trip efficiency of the energy storage resource is the amount of energy that can be discharged compared to the amount of energy that was required to recharge the resource.

The efficiency of an energy storage resource is calculated using the following equation:

$$\text{Efficiency} = \frac{\sum Annual\ MWh\ Discharged}{\sum Annual\ MWh\ Charged}$$

The MWh charged is to be calculated using meter data based on the electricity purchased by the market participant to recharge the resource after discharging. This will also include energy used to recharge the resource as a result of the resource's natural self-discharge.

Round-trip efficiency can be updated on an as-needed basis.

There are two options for the historical study period for round-trip efficiency for energy storage resources:

1) where a market participant indicates a year-round round-trip efficiency factor is desired for a particular energy storage resource, the relevant historical study period is one year; or
2) a seasonal round-trip efficiency factor may be used for a particular energy storage resource at the request of a market participant. In this case, the relevant historical study period is six months for the summer round-trip efficiency and six months for the winter round-trip efficiency.

IESO Annual Price Escalation

The electricity consumption price is escalated by the calendar year-over-year electricity price increase, if any, that is imposed by the IESO and is relevant for the resource. This escalation factor is determined by taking the maximum of zero and the change in hourly electricity price simple average from the current calendar year from the hourly electricity price simple average previous calendar year.

2.5.6.2 Station Service Costs

There are two potential configurations for station services supply for energy storage assets:

- station services are supplied behind the meter, with a tap off the low voltage side of the step-up transformer. In this case, the station services are functionally supplied by the energy storage system during discharging. Effect of station services in this case is captured in the round-trip efficiency calculation; or

- station services are supplied using a separate feed with a revenue meter for electricity consumed to serve station services and auxiliary loads.

Most energy storage resources have auxiliary services and station services. In some cases, these services are supplied by a separate metered connection.

The station service costs adder is only eligible for resources in the second configuration; where auxiliary loads are supplied by a separate metered connection or where the auxiliary loads have been removed from the efficiency using a meter on the auxiliary feed. Eligible station service costs are incurred by energy storage resources due to higher auxiliary consumption during discharging (i.e. cooling or heating of batteries). It does not include normal auxiliary or station services loads required regardless of operating status: protection and controls, controls, lighting, monitoring, security, communications, etc.

The historical study period for station service costs for energy storage resources is the corresponding calendar month from the previous calendar year.

$$\text{Station } Service\ Cost\ \left(\frac{\$}{MWh}\right) = \frac{Auxiliary\ power\ consumed\ during\ operation\ (MWh)}{Energy\ Discharged\ during\ operation\ (MWh)}\ x$$
$$Average\ Electricity\ Purchase\ Price\ from\ previous\ year\ \left(\frac{\$}{MWh}\right) x\ IESO\ annual\ escalation$$

Eligible station services costs will be calculated on a monthly average based on the same calendar month from the previous year.

Supporting documentation for auxiliary power consumed during operation and energy discharged during operation must be consistent with one of the following two methods:

1. Historical Billing: Auxiliary power consumed during operation: Consumption at the meter will be compared during periods of discharging and periods of idling for the same month from the previous year. Energy discharged during operation: Discharged energy sold to the grid based on historical meter data from the same month from the previous year. This approach is preferred by the IESO where data is available.

2. Energy Storage Vendor Data: Market participants can provide datasheets or performance documentation from the vendor outlining the increased auxiliary demands during discharging.

$$\frac{Auxiliary\ power\ consumed\ during\ operation\ (MWh)}{Energy\ Discharged\ during\ operation\ (MWh)} = \frac{Auxiliary\ Load\ (MW)\ x\ duration\ for\ total\ discharge\ (hr)}{Discharge\ energy\ capacity\ of\ asset\ (MWh)}$$

2.5.6.3 Operating and Maintenance Costs

Section 2.4 describes the eligible maintenance costs included into the reference level calculations for energy storage resources.

2.5.6.3.1 Major Maintenance Costs

Eligible major maintenance costs for energy storage resources include:

- costs to replace or maintain inverter units;
- major maintenance to maintain good state of repair and performance for the major storage or generation components. Some examples include:
    - compressed air energy storage – maintenance inspections associated with incremental operation of the compressor, expander, turbine, storage cavern;
    - hydrogen storage – maintenance of the electrolyzer, fuel cell, storage vessel;
    - flywheels - vacuum system maintenance or maintenance of the rotating body/housing;
    - lithium ion battery[6] - battery cell replacement for cycle-related degradation; and
    - flow batteries - battery electrolyte rebalancing or replacement for flow batteries.

The IESO uses the vendor estimates for these costs based on the current pricing at the time of determining or updating reference levels as the indicator of the appropriate cost of the relevant product or service.

Costs reimbursed by insurance and/or covered by warranty of the resource or sub-components of resources provided under a construction or equipment supply contracts are excluded.

The historical study period for major maintenance costs for energy storage resources is 10 years.

2.5.6.3.2 Scheduled Maintenance Costs

Eligible scheduled maintenance costs for energy storage resources include costs incurred for routine inspections and work such as:

- annual (or bi-annual) vendor maintenance program;

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[6] For batteries, cell or electrolyte replacement must be like-for-like. The *energy* and power capacity of the *energy* storage resource should be equal to or less than the beginning of life capacity of the resource.

- inverter annual maintenance;
- standard cleaning of electronics; and
- SCADA inspections.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for scheduled maintenance costs for energy storage resources is five years.

2.5.6.3.3 Unscheduled Maintenance Costs

Eligible unscheduled maintenance costs for energy storage resources include overtime labour or third-party labour contracted to repair the components and materials costs associated with any such repairs in the event of equipment failure. The supporting documentation required from market participants is described in Section 2.3. The historical study period for unscheduled maintenance costs for energy storage resources is five years.

2.5.6.4 Operating Reserve Reference Levels

Energy storage resources with a discharge duration of longer than one hour have the ability to provide operating reserve to the grid. For these energy storage resources, the IESO applies the following equation for the operating reserve reference level and subsequent sub-sections provide descriptions of the components.

$$\text{Operating } Reserve\ Incremental\ Cost\left(\frac{\$}{MW}\right) = Auxiliary\ Energy\ Consumption\left(\frac{\$}{MW}\right)$$

Auxiliary energy consumption is energy consumed by auxiliary services necessary for the energy storage resource to respond to dispatch and the following equation shows how it is intended to be calculated:

$$\text{Auxiliary } Energy\ Consumption\left(\frac{\$}{MW}\right) = \frac{Auxiliary\ power\ consumed\ during\ operation\ (MWh)}{MW\ offered\ on\ Operating\ Reserve\ (MW)}\ x$$
$$Average\ Electricity\ Purchase\ Price\ from\ previous\ year\left(\frac{\$}{MWh}\right) x\ IESO\ annual\ escalation$$

Eligible costs that can be included in this calculation are the costs of auxiliary services necessary for the energy storage resource to respond when dispatched (e.g. heating/cooling of batteries, keeping the expander/turbine available for compressed air energy storage, etc.). Eligible costs do not include costs related to components that are not directly related to energy generation (lighting, security etc.) or costs required to keep the energy storage resource operating safely (protection and controls, controls, communications, etc.).

Submissions regarding consumption of auxiliary power for reference levels should be supported by electricity consumption meter data showing, periods of idling (no operating reserve provided), periods when operating reserve is provided to IESO and periods when the resource is charging and discharging. This data will be used to demonstrate the incremental increase in auxiliary load compared to idling when providing operating reserve, and the incremental decrease in auxiliary load when providing operating reserve compared to operating mode.

Average electricity price can be calculated based on the prices paid from the same month in the previous year, escalated by the IESO annual escalation rate.

The historical study period for auxiliary energy consumption for energy storage resources is one.

2.5.7. Dispatchable Loads

Dispatchable loads have an operating reserve reference level.

This section describes how the inputs for the applicable form should be completed to request operating reserve reference level.

For dispatchable loads, the IESO applies the following equation for the operating reserve reference level and the components are described in subsequent sub-sections.

$$\begin{aligned}\text{Total } OR\ Cost \left(\frac{\$}{MW}\right) &= Incremental\ O\&M\ Costs \left(\frac{\$}{MW}\right) + Standby\ Costs\ for\ BTM\ Generation \left(\frac{\$}{MW}\right) \\ &+ Standby\ Costs\ for\ BTM\ Storage \left(\frac{\$}{MW}\right) \\ &+ Cost\ of\ Production\ Flexibility \left(\frac{\$}{MW}\right)\end{aligned}$$

The following sub-sections provide details to cost-components relevant to positioning a dispatchable load resource to provide operating reserve and its applicable calculation methodology.

2.5.7.1 Operating and Maintenance Costs

2.5.7.1.1 General Eligibility of Operating and Maintenance Costs

Eligible costs for reference level calculations for dispatchable loads include:

- operating and maintenance costs related to the provision of operating reserve and regular operation of the dispatchable load;
- incremental operating and maintenance costs; and
- incremental labour costs required to support eligible maintenance activities.

The following costs are not eligible for reference level calculations for dispatchable loads:

- operating and maintenance costs of equipment related to the requirement to vary the resource's load in response to dispatch instructions. These costs are expected to be included within the resource's energy bid, and hence are excluded for the purposes of operating reserve;
- preventative maintenance, routine maintenance and other operating costs that are not directly attributable to the provision of incremental operating reserve;
- fixed or non-avoidable costs such as maintenance costs for metering, control or communications equipment or the general routine maintenance of behind the meter (BTM) generation or storage; and
- staffing costs (including staff overtime) required for operations of the resource.

2.5.7.1.2 Cost Components

The operating and maintenance costs can be broken down into common categories of accounting that market participants must submit to the IESO to verify and validate the operating reserve reference level curve for the resource.

The appropriate period for analysis of historical records may vary depending on the nature of the resources due to changes in the operations or production of the dispatchable load facility. An average of costs over three years is recommended as many costs are not expended on an annual basis. An alternative appropriate timeframe may be proposed by the market participant with a justification of why this period was selected.

2.5.7.1.3 Incremental Operating or Maintenance Costs

This cost component is related to any operating or maintenance costs associated with providing the incremental operating reserve services in accordance with the IESO's requirements that are in addition to the costs associated with acting as a dispatchable load. For example, incremental O&M costs would include costs incurred to operate a dispatchable load in a way that it is available to reduce load more rapidly in response to operating reserve activation than it would normally require for a dispatchable load.

Incremental Operating or Maintenance Costs can be calculated as follows:

$$\text{Incremental } O\&M\ Costs\left(\frac{\$}{MW}\right) = \frac{Annualized\ Incremental\ O\&M\ Cost\ (\frac{\$}{Year})}{Incremental\ OR\ Provided\ (MW) \times Annual\ Hours\ of\ OR\ Provided\ (\frac{hours}{Year})}$$

The supporting documentation required from market participants is described in Section 2.3. The historical study period for incremental operating or maintenance costs for dispatchable loads is three years. The appropriate historical study period may vary depending on the nature of the dispatchable load due to changes in the operations or production of the dispatchable load. Market participants can propose an alternative appropriate historical study period with an explanation of why this proposed period results in a more accurate estimate of current costs than the default three-year historical study period.

2.5.7.2 Standby Costs for BTM Generation or Storage

2.5.7.2.1 General Eligibility of Standby Costs for BTM Generation or Storage

If a dispatchable load employs BTM generation or energy storage in order to vary its net load in response to dispatch signals, a component of the facility's costs is reflected in the standby and operating costs of the BTM resource.

Costs included into the reference levels for operating reserve must be related to expenses incurred as a result of the provision of operating reserve and be incremental to the regular operation of the dispatchable load resource to provide operating reserve capabilities.

Variable costs of operating a BTM resource to reduce the facility's load in response to dispatch instructions are expected to be included within the resource's energy bid. Therefore, they are excluded for the purposes of operating reserve.

Standby costs incurred to enable the dispatchable load to provide incremental operating reserve quantities such as costs associated with incremental maintenance or standby losses are eligible costs if they are:

- incremental to those costs incurred under normal operation as a dispatchable load; and
- avoidable.

Ineligible O&M expenses include capital costs of BTM equipment and costs associated with routine maintenance of equipment. In general, any O&M costs that would be incurred, regardless of whether the resource is providing operating reserve, is ineligible.

To determine eligible costs for resources with BTM generation or storage, market participants should refer to the relevant subsection of Section 2.5 of this document and the relevant reference level workbook.

The following sections list eligible standby costs associated with BTM resources used to enable dispatchable loads to provide operating reserve.

2.5.7.2.2 Standby Costs for BTM Generation

In cases where a BTM generation resource must operate in a standby mode exclusively to enable the facility to provide operating reserve, only the fuel, operating and maintenance costs associated with standby mode operation of the BTM resource are eligible costs.

For example, a dispatchable load that cannot achieve the minimum ramp rates required to provide operating reserve without having the BTM resource on standby. In this case, the costs to have the BTM resource on standby would be eligible costs.

Fuel, operating and maintenance costs associated with operating the BTM resource to respond to dispatch instructions are not eligible because they are reflected in the energy bid.

Unit SCADA data can be used as supporting documentation of hours of standby operation and fuel consumption, and hence cost.

Standby Costs for BTM Generation can be calculated as follows:

$$\text{Standby } Costs\ for\ BTM\ Generation \left(\frac{\$}{MW}\right) = \frac{Annualized\ Generation\ Standby\ Costs\ (\frac{\$}{Year})}{Incremental\ OR\ Provided\ (MW) \times Annual\ Hours\ of\ OR\ Provided\ (\frac{hours}{Year})}$$

Participants should refer to the applicable reference level workbooks and guidance documents relevant to the generation technology employed, and provide information in accordance with these documents, as applicable.

The supporting documentation required from market participants is described in Section 2.3. The historical study period for standby BTM generation costs for dispatchable loads is one year.

2.5.7.2.3 Standby Costs for BTM Storage

Eligible costs for dispatchable loads that use BTM energy storage resources to respond to dispatch instructions for the dispatchable load include the costs of self-discharge or standby power requirements (e.g. for controls, or heaters), provided the BTM energy storage resource is being utilized exclusively for the purposes of providing incremental operating reserve capability.

Losses and costs associated with operating the BTM energy storage resource in response to dispatch instructions, such as charging costs, are expected to be included in the energy bid of the resource.

SCADA and/or submetering data can be used to provide auditable proof of standby power requirements for energy storage and the hours of operation.

Standby costs for BTM Storage can be calculated as follows:

$$\text{Standby } Costs\ for\ BTM\ Storage\ \left(\frac{\$}{MW}\right) = \frac{Annualized\ Storage\ Standby\ Costs\ (\frac{\$}{Year})}{Incremental\ OR\ Provided\ (MW) \times Annual\ Hours\ of\ OR\ Provided\ (\frac{hours}{Year})}$$

The supporting documentation required from market participants is described in Section 2.3. The historical study period for standby BTM energy storage costs for dispatchable loads is one year.

2.5.7.2.4 Cost of Production Flexibility

Eligible costs of production flexibility include incremental costs of performance guarantees or of supply and/or delivery contracts for production inputs as a result of the provision of operating reserve capacity (such as premiums for flexibility in supply volumes).

Eligible costs of production flexibility are only those costs that would have been avoided had the dispatchable load not provided operating reserve.

Costs which are required as part of the normal operations as a dispatchable load are ineligible.

Cost of Production Flexibility can be calculated as follows:

$$\text{Cost } of\ Production\ Flexibility\ \left(\frac{\$}{MW}\right) = \frac{Annualized\ Incremental\ Cost\ of\ Flexibility\ (\frac{\$}{Year})}{Incremental\ OR\ Provided\ (MW) \times Annual\ Hours\ of\ OR\ Provided\ (\frac{hours}{Year})}$$

The supporting documentation required from market participants is described in Section 2.3. The historical study period for costs of production flexibility for dispatchable loads is three years. The appropriate historical study period may vary depending on the nature of the dispatchable load due to changes in the operations or production of the dispatchable load.

Market participants can propose an alternative appropriate historical study period with an explanation of why this proposed period results in a more accurate estimate of current costs than the default three-year historical study period.

2.6. Accounting for Currency Exchange

Market participants must indicate the portion of costs that are incurred in a foreign currency in their reference level submissions to help calculate the reference level values on a daily basis. These include, but are not limited to, operating and maintenance and fuel costs that are denominated in USD or other foreign currencies.

Conversion to CAD from another currency to calculate reference level values for a particular dispatch day will be based upon the applicable end of day foreign exchange rate as posted by the Bank of Canada.

3. Process for Establishing Reference Levels for Non-Financial Dispatch Data Parameters

The IESO will establish reference levels for the following non-financial dispatch data parameters:

- minimum generation block run-time;
- minimum generation block down time;
- lead time;
- maximum number of starts per day;
- MLP;
- energy ramp rate; and
- operating reserve ramp rate.

During the Facility Registration process, market participants submit data and supporting documentation to the IESO to establish registered values and reference levels for non-financial dispatch data parameters.

Typically, a resource's registered values reflect its operational capabilities. The IESO compares the market participants' offered values for dispatch data against the registered to validate the offers.

A resource's non-financial reference levels represent the IESO's determination of the resource 's operating characteristics in a competitive environment rather than an operational limit or other validation criteria.

The IESO determines non-financial dispatch data reference levels for the mitigation process based on the criteria of competitive performance across a resource's starts, time or range of production. The IESO-approved reference levels for non-financial dispatch parameters might be equal to the registered values if the registered values are relatively static and are not expected to change all year.

If the registered values are not static, the reference level values for non-financial dispatch data parameters are approved, where applicable by season (summer and winter).

The summer period will be from May 1st to October 31st and the winter period will span from November 1st to April 30th of the following year. Table 3-1 lists the resources for which non-financial dispatch data reference levels are approved.

Table 3-1: Reference Levels for Non-Financial Dispatch Data Parameters

Registered Reference Level Name	Target Non-Financial ~~Offer Parameter~~Dispatch Data Parameter	~~Reference Level Registered For~~Resources Required to Register Reference Level
Energy ramp rate reference level	Energy ramp rate	• All dispatchable generation ~~facilities~~resources • All dispatchable energy storage resources
Operating reserve ramp rate reference level	Operating reserve ramp rate	• All dispatchable ~~generation facilities~~generation ~~facilities~~ resources eligible to submit operating reserve ramp rates • All dispatchable loads • All dispatchable energy storage resources
Lead time reference level (hot, warm and cold)	Lead time (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
Minimum loading point reference level	Minimum loading point	All NQS resources eligible for the generator offer guarantee programs
Minimum generation block run-time reference level	Minimum generation block run-time	All NQS resources eligible for the generator offer guarantee programs
Minimum generation block down time reference level (hot, warm and cold)	Minimum generation block down time (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
Maximum number of starts per day reference level	Maximum number of starts per day	• All NQS resources eligible for the generator offer guarantee programs

Registered Reference Level Name	Target Non-Financial ~~Offer Parameter~~Dispatch Data Parameter	~~Reference Level Registered For~~Resources Required to Register Reference Level
		• All dispatchable hydroelectric generation ~~facilities~~resources
Ramp up energy to MLP reference level (hot, warm and cold)	Ramp up energy to MLP (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
Ramp hours to MLP reference level (hot, warm and cold)	Ramp hours to MLP (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs

The IESO provides market participants the ability to register different values for specific non-financial dispatch data parameters for different seasons. However, values of a non-financial parameters that do not vary across these across seasons should remain the same.

Each time a market participant submits dispatch data for non-financial dispatch data parameters, the IESO verifies those inputs against the resource’s reference levels.

Non-financial dispatch parameters are mitigated based only on a conduct test rather than both the conduct and impact tests. Dispatch data submissions for that set of parameters are tested to determine if the submitted value of the relevant parameter is greater than the reference level plus the conduct threshold. Any submissions of these dispatch data parameters above the allowable values will be rejected by data validation and the market participants will be required to resubmit their offers.

3.1. Non-Financial Dispatch Data Parameters

This section provides guidelines that market participants should follow to register reference levels for non-financial dispatch data parameters during the Facility Registration process, including the supporting documentation required by the IESO for verification. The reference levels described in the following sub-sections are fixed for the entire dispatch day and market participants can request the IESO to establish seasonal reference levels, if applicable.

3.1.1. Energy Ramp Rate Reference Level

The energy ramp rate reference level is approved for dispatchable generation and energy storage resources. It contains up to five quantity-ramp rate couplets that describe the rates, in megawatts per minute (MW/min), during normal operation across the entire dispatchable range, at which a resource can increase or decrease its output.

The IESO estimates an energy ramp rate reference level as the ramp rates of the resource across the entire dispatchable range under a competitive environment. This differs from the registered maximum bid/offer ramp rate value (a single value), which is the maximum ramp rate capability of the resource.

3.1.2. Operating Reserve Ramp Rate Reference Level

The operating reserve ramp rate reference level is approved for dispatchable generation and load ~~facilities~~resources. It is the rate, in megawatts per minute (MW/min), during normal operation, at which a resource can increase or decrease its output upon the activation of operating reserve.

3.1.3. Lead Time Reference Level

The lead time reference level is approved for dispatchable non-quick start thermal resources. It is the amount of time, in hours, needed for a ~~generation unit~~resource to start-up and reach its MLP from an offline state. The length of the lead time depends on the thermal operating state of the ~~generation unit~~resource as either hot, warm or cold.

3.1.4. Minimum Loading Point Reference Level

The minimum loading point reference level is approved for dispatchable non-quick start thermal resources and is the minimum MW output that a ~~generation unit~~resource must maintain to remain stable without the support of ignition.

3.1.5. Minimum Generation Block Run Time Reference Level

The minimum generation block run-time reference level is approved for dispatchable non-quick start thermal resources and presents the minimum number of consecutive hours a ~~generation unit~~ resource must be scheduled to its MLP, in accordance with the technical requirements of the resource.

3.1.6. Minimum Generation Block Down Time Reference Level

The minimum generation block down time reference level is approved for dispatchable non-quick start thermal resources. It is the time between when a ~~generation unit~~resource was last at its MLP before de-synchronization and the time the ~~generation unit~~resource can be scheduled back to its MLP after re-synchronizing.

3.1.7. Maximum Number of Starts per Day Reference Level

The maximum number of starts per day reference level is approved for dispatchable hydroelectric resources and all dispatchable non-quick start thermal resources except nuclear resources. This reference level is the maximum number of times a ~~generation unit~~resource can be physically started within a dispatch day.

3.1.8. Ramp-up Energy to Minimum Loading Point (Upper Bound) Reference Level

Ramp up energy to the MLP (upper bound) reference level is approved for dispatchable non-quick start thermal resources. It is the ~~average~~ maximum quantity of energy, in MWh, a resource is expected to produce from the time of synchronization to the time it reaches its MLP during normal operation. Ramp up energy to MLP is required for the hot, warm and cold thermal operating states of the resource.

3.1.9. Ramp-up Energy to Minimum Loading Point (Lower Bound) Reference Level

Ramp up energy to the MLP (lower bound) reference level is approved for dispatchable non-quick start thermal resources. It is the minimum quantity of energy, in MWh, a resource is expected to produce from the time of synchronization to the time it reaches its MLP during normal operation. Ramp up energy to MLP is required for the hot, warm and cold thermal operating states of the resource.

~~3.1.9.~~3.1.10. Ramp Hours to Minimum Loading Point Reference Level

Ramp hours to MLP reference level is approved for dispatchable non-quick start thermal resources. It is the number of hours required for the resource to ramp from synchronization to its MLP during normal operation. Ramp hours to MLP is required for the hot, warm and cold thermal operating states of the resource.

3.2. Ongoing Updates to Non-Financial Reference Levels

Market participants can make changes to a resource that might impact the operational characteristics represented by a non-financial reference level. In such cases, the market participant must initiate the process to update the relevant non-financial reference level no later than five business days following the change that has occurred.

If market participants believe that any component of the established non-financial reference levels no longer reflects their operational capabilities for the current period, they may request the IESO to revise their non-financial reference levels through the Online IESO/Registration processes. Market participants can use a future date while submitting this request to reflect the expected date by when the operational characteristics are likely to change. To limit the frequency of updates, non-financial reference levels will be set for seasonally variability. Market participants will not be able to submit requests for changes to their non-financial reference levels for a dispatch day after the closure of the DAM submission window.

If the IESO reviews and approves the change request, the IESO notifies the market participant and establishes the new reference levels as of a forward-facing effective date. If the request is not approved, the previously established reference level will continue to be used.

At its own volition, the IESO may initiate the process to request a change to reference levels if the IESO is of the view that the registered non-financial reference level is no longer representative of the operational characteristics of the resource.

3.3. Supporting Documentation for Non-Financial Reference Levels

All market participants are required to provide supporting documentation from verifiable sources to substantiate the values entered for that resource, unless otherwise noted.

~~For example, if a market participant requests a ramp rate reference level that is equal to or greater than 1/5 of the resource's capacity, then no supporting materials are required. In this case, the requested reference level would allow the resource to ramp the entire capacity of the resource in one 5-minute interval. A ramp rate reference level this high could not be used to withhold the resource and so it is unnecessary to submit supporting documentation for ramp rate reference levels that meet this requirement.~~ Supporting documentation is not required to establish energy ramp rate reference levels where the requested value does not limit the resource to producing energy below its maximum generating capability for an interval. If the submitted energy ramp rate reference level value is greater than or equal to 1/5th of the hourly capacity, then supporting documents are not needed.

Supporting documentation is not required to establish operating reserve ramp rate reference levels where the requested value does not limit the resource to producing operating reserve below its maximum generating capability for an interval.

For a resource that is registered as being able to supply 10-minute operating reserve, if the submitted operating reserve ramp rate reference level value is greater than or equal to 1/10th of the maximum operating reserve that the resource can provide, then supporting documents are not needed.

For a resource that is registered as being able to supply 30-minute operating reserve, but not 10-minute operating reserve, if the submitted operating reserve ramp rate reference level value is greater than or equal to 1/30th of the maximum operating reserve that the resource can provide, then supporting documents are not needed.

Supporting documentation is not required to establish MGBRT or MLP reference levels where the submitted reference level is equal to the value currently registered for the resource and where the summer and winter reference level will be the same value.

Acceptable forms of documentation include:

- materials from vendors regarding operations, including, but not limited to, information on the following:
    - resource efficiency and performance data;
    - equipment test data; and
    - relevant sections from operating and maintenance manuals;
- ~~Any~~ any data that is supplied as vendor reference data should be on the vendor letterhead and datasheets. If details are insufficient, the IESO may request additional information to be supplied by the vendor;
- relevant contracts for equipment supply or service provision; and
- any other documentation that is required to support the participant's input in the reference level worksheet.

Market participants must include clear explanations of how each piece of documentation supports the relevant input. The IESO reserves the right to deem any documentation unacceptable if it does not sufficiently support the input values. Reasons for deeming documentation unacceptable include, but are not limited to:

- documentation being illegible;
- not from a reliable source;
- costs are not eligible to be included into reference levels;
- incomplete information; and
- vague or unclear information to support the values entered into the workbook.

3.4. Non-Financial Reference Levels by Technology Type

3.4.1. Thermal

~~For combined cycle facilities, non-financial reference levels will be based on the most restrictive configuration at that facility.~~

~~For example, if the MLP of the facility in 1x1 configuration is the highest, the 1x1 MLP will be the MLP reference level registered for use when the resource is in combined cycle mode of operation.~~

~~This approach of using the most restrictive configuration to set the non-financial reference level will be used any non-financial reference level that varies according to configuration.~~ To determine reference levels that are affected by thermal states, market participants determine the ambient conditions associated with hot, warm and cold thermal state reference levels. These ambient conditions will be used to determine all thermal state-affected reference levels. ~~Where a resource's thermal state is considered to establish a non-financial reference level, then the market participant shall use similar conditions of a relevant thermal state to establish any other thermal state-affected non-financial reference level.~~

3.4.1.1 Energy Ramp Rates

Market participants must provide ramp rate and supporting documentation from manufacturers data with relevant sections from operating and maintenance manuals for the resource or performance tests. The energy ramp rate reference level for a PSU is a single MW/min value that is the slowest energy ramp rate over the entire dispatchable range of the PSU for any configuration.

3.4.1.2 Operating Reserve Ramp Rate

Market participants must provide ramp rate and supporting documentation from manufacturers data with relevant sections from operating and maintenance manuals for the resource or performance tests. The operating reserve ramp rate reference level for a PSU is a single MW/min value that is the slowest operating reserve ramp rate for the PSU for any configuration.

3.4.1.3 Lead Time- Hot, Warm and Cold

Market participants must provide lead times and supporting documentation from manufacturers data from contract or performance tests.

Market participants may choose points on their lead time curve to establish their hot, warm and cold lead time reference levels.

The choice of the cold lead time reference value is limited to ensure that the resource is able to be scheduled in a 24-hour look-ahead period.

The limitation on the cold reference level is expressed via the following equation:

$$24 \geq MGBRT_{ref} + Cold\ Lead\ Time_{ref} + 6$$

This relationship can be re-stated as:

$$Cold\ Lead\ Time_{ref} \leq 18 - MGBRT_{ref}$$

The value 6 above is derived from the aggregate of conduct thresholds for lead time (3 hours) and MGBRT (3 hours).

This limit is necessary as a cold lead time reference level higher than this value would make it possible for a market participant to withhold the resource through use of submitting a lead time parameter.

Market participants should manage occasions when a resource has a lead time that is longer than this limit through use of outage slips as the resource is unavailable.

3.4.1.4 Minimum Loading Point

Market participants must provide MLP and supporting documentation from manufacturers data, contract or performance tests.

Where a participant already has a registered MLP and is satisfied with the same MLP reference value for winter and summer, no additional supporting materials need to be submitted. The IESO will use the currently-registered value of MLP as the summer and winter MLP reference level.

3.4.1.5 Minimum Generation Block Run Time

Market participants must provide documentation that is a recommendation from the OEM on a value for MGBRT based on good operating practices for the equipment at the resource. This documentation would form the basis for approval of seasonal MGBRT reference levels.

Where a participant already has a registered MGBRT and is satisfied with the same MGBRT reference value for winter and summer, no additional supporting materials need to be submitted. The IESO will use the currently-registered value of MGBRT as the summer and winter MGBRT reference level.

3.4.1.6 Minimum Generation Block Down Time

Market participants must provide minimum generation block down time and supporting documentation with recommendations from the OEM on minimum time required for the resource. This documentation that shall include the resource shutdown curve and relevant limitations on the equipment recommended by the OEM before the resource can be restarted after a shutdown.

3.4.1.7 Maximum Number of Starts per day

The maximum number of starts per day is determined based on non-financial reference levels for ~~lead time,~~ minimum generation block run-time~~,~~ and minimum generation block down time (hot), rounded down to the nearest whole number, as follows:

$$\text{Maximum } Number\ of\ Starts\ Per\ Day$$
$$= \frac{24}{Lead\ Time\ (hot) + MGBRT + MGBDT\ (hot) - Lead\ Time\ (hot)}$$
$$= \frac{24}{MGBRT + MGBDT\ (hot)}$$

$$3.4.1.8 \quad \text{Maximum } Number\ of\ Starts\ Per\ Day = \frac{24}{Lead\ Time\ (hot) + MGBRT + MGBDT}$$

3.4.1.93.4.1.8 Ramp Up Energy to MLP (Upper Bound and Lower Bound)

The supporting documentation for the following non-financial dispatch parameters includes start-up curves from the OEM or designer of the generation facilityresource or operational data demonstrating a representative sample to establish the quantities below.

- Ramp hours to MLP – Hot
  - The number of hours required for the resource to ramp from synchronization to its MLP during normal operation when the resource is in a hot thermal state.
- Energy per ramp hour (upper bound) – Hot
  - The average maximum quantity of energy in MWh that the resource is expected to produce in each ramp hour during normal operation when the resource is in a hot thermal state.
- Energy per ramp hour (lower bound) – Hot
  - The minimum quantity of energy in MWh that the resource is expected to produce in each ramp hour during normal operation when the resource is in a hot thermal state.
- Ramp hours to MLP – Warm
  - The number of hours required for the resource to ramp from synchronization to its MLP during normal operation when the resource is in a warm thermal state.
- Energy per ramp hour (upper bound) – Warm
  - The average maximum quantity of energy in MWh that the resource is expected to produce in each ramp hour during normal operation when the resource is in a warm thermal state.
- Energy per ramp hour (lower bound) – Warm
  - The minimum quantity of energy in MWh that the resource is expected to produce in each ramp hour during normal operation when the resource is in a warm thermal state.
- Ramp hours to MLP – Cold
  - The number of hours required for the resource to ramp from synchronization to its MLP during normal operation when the resource is in a cold thermal state.
- Energy per ramp hour (upper bound) – Cold

    - The ~~average~~ maximum quantity of energy in MWh that the resource is expected to produce in each ramp hour during normal operation when the resource is in a cold thermal state.
- Energy per ramp hour (lower bound) – Cold
    - The minimum quantity of energy in MWh that the resource is expected to produce in each ramp hour during normal operation when the resource is in a cold thermal state.

3.4.2. Hydroelectric

3.4.2.1 Energy Ramp Rates

Market participants must provide ramp rate and supporting documentation from manufacturers data with relevant sections from operating and maintenance manuals for the resource or performance tests.

For hydroelectric resources, environmental or social restrictions may limit the rate of change of flow through any of the units or the resource. Supporting documentation includes:

- water management plans, highlighting change of flow limitations;
- operating agreements which may limit the ramp rate, highlighting limitations;
- environmental approval documentation related to flow restrictions, if applicable; and
- supporting calculations converting rate of change of flow, to MW/min.

3.4.2.2 Operating Reserve Ramp Rate

Market participant must provide ramp rate and supporting documentation from manufacturers' data with relevant sections from operating and maintenance manuals for the resource or performance tests.

3.4.2.3 Maximum Number of Starts per day

Market participants must provide the maximum number of starts and supporting documentation that are in the form of either:

- Recommendations from manufacturers data with relevant sections from operating and maintenance manuals for the resource;
- Equipment specification from procurement of equipment;
- Design basis for the resource;
- Historical assessment of actual start and stops; or

- Opinion or condition assessment document from a reputable and qualified 3rd party that is applicable for the resource

3.4.2.4 Other Parameters

Market participants may submit other non-financial parameters in the assessment of reference levels as is necessary. These parameters may include but are not limited to:

- Start Time: The start time refers to time required to reach synchronization from standby. Supporting documentation includes OEM Manuals, recent test data, or equivalent.
- Rated Power: The maximum rated power for each resource, including any restrictions based on seasonality. Supporting documentation includes nameplate data, OEM data, recent test data or equivalent.

3.4.3. Solar

3.4.3.1 Energy Ramp Rate

Market participants must provide ramp rates and supporting documentation such as resource specifications, that show the ramp rates (MW/min) for the resource across its dispatchable range.

3.4.4. Wind

3.4.4.1 Energy Ramp Rate

Market participant must provide ramp rates and supporting documentation with relevant sections from operating and maintenance manuals for the resource that show the ramp rates (MW/min) for the resource across its dispatchable range.

3.4.5. Nuclear

3.4.5.1 Energy Ramp Rate

Market participant must provide ramp rates and supporting documentation with relevant sections from operating and maintenance manuals for the resource that show the ramp rates (MW/min) for the resource across its dispatchable range.

If nuclear ramp rate capabilities can be very different for the same range of production depending on reactor conditions, the energy ramp rate reference level for nuclear resources will be set based on the least flexible profile of the resource.

3.4.6. Energy Storage

3.4.6.1 Energy Ramp Rates

Market participant should provide the ramp rates and supporting documentation with relevant sections from operating and maintenance manuals for the resource that show the ramp rates (MW/min) for the resource across its dispatchable range.

3.4.6.2 Operating Reserve Ramp Rate

Market participants must provide their ramp rate and supporting documentation, which can be the same documentation as they submit for the energy ramp rate if the rates are the same.

Market participants must provide supporting documentation from the operating manual to justify a slower operating reserve ramp rate than the energy ramp rate. These include delays due to startup, particularly for energy storage technologies with rotating generation or which need to be heated prior to starting.

3.4.7. Dispatchable Loads for Operating Reserve

3.4.7.1 Operating Reserve Ramp Rate

Market participant must provide ramp rate and supporting documentation from the operating and maintenance manuals for the resource.

4. Process for Establishing Reference Quantities

The IESO will determine estimates for what market participants might offer for their resources in the energy and operating reserve markets if they are subject to unrestricted competition. These estimates are known as reference quantities. Reference quantities are used in the assessment of physical withholding by the IESO. Physical withholding will be assessed ex-post.

Sections 4.1 to 4.7 describe the methodology that the IESO uses to determine reference quantities for resources of different generation technologies. The applicable supporting documentation that are required from market participants to inform the determination of reference quantities are also listed.

The reference quantity for energy is based on the available capability of the resource to supply energy under current operating conditions.

The reference quantity for suppliers of operating reserve is based on the operational capability of the resource. The operating reserve capacity of a resource is the power capacity that can be delivered within the time period required: 10-minute reserve (synchronized), 10-minute reserve (non-synchronized), and 30-minute reserve (synchronized or non-synchronized). Operational restrictions that prevent a supplier of operating reserve from providing incremental energy can be reflected in the reference quantity.

Inputs required for the calculation of reference quantities may vary seasonally. Market participants shall provide summer and winter values for parameters and inputs used in the determination of reference quantities where applicable. If the default approaches described in this section do not account for the specific operational characteristics of a resource in a reasonably complete manner, market participants may submit requests for modifications to this methodology to be applied on a resource-specific basis. Any such requests must be accompanied by supporting documentation to the IESO during the Facility Registration process. The IESO will review and consider use of these modifications where appropriate to establish the reference quantity for each resource.

Reference quantities will be calculated for resources according to their eligibility to provide operating reserve. If a resource can only provide 30-minute reserve, then the IESO will only determine an operating reserve reference quantity for that resource for 30-minute reserve.

4.1. Thermal

This section describes the methodology the IESO uses to determine reference quantities for resources offering operating reserve and energy.

4.1.1. Energy

To establish the reference quantity for available capacity of thermal resources, the IESO uses the uses the same approach as the methodology to determine resource capability of the Generator Output and Capability Report as published by the IESO on the public IESO report site, http://reports.ieso.ca/.

In the report, capability is measured as the maximum potential output of the resource under current conditions, which includes maximum unit de-rates and outages for that hour.

4.1.2. Operating Reserve

The IESO applies the following formulas for calculating the reference quantities for operating reserve. The supporting documentation required from market participants is described in Section 3.3.

For resources that are not NQS resources, MLP is assumed to be 0 MW for the purpose of determining operating reserve reference quantities.

4.1.2.1 10-minute reserve (synchronized)

The reference quantity for 10-minute operating reserve for thermal resources is calculated as follows:

Ramp Capability_10S (MW) = operating reserve ramp rate reference level (MW/min) x (10 minutes)

Operating Reserve Reference Quantity_10S (MW) is the Ramp Capability_10S (MW), but shall not exceed nameplate capacity minus MLP (MW) and planned de-rate/outage (MW) of the resource.

4.1.2.2 10-minute reserve (non-synchronized)

For non-synchronized 10-minute operating reserve, the reference quantity for thermal resources is calculated as follows:

Ramp Capability_10N (MW) = operating reserve ramp rate reference level (MW/min) x (10 minutes)

Operating Reserve Reference Quantity_10N (MW) is the Ramp Capability_10N (MW), but shall not exceed nameplate capacity minus MLP (MW) and planned de-rate/outage (MW) of the resource.

4.1.2.3 30-minute reserve (non-synchronized)

For non-synchronized 30-minute reserve, the reference quantity for thermal resources is calculated as follows:

Ramp Capability_30R (non-synchronized) (MW) = operating reserve ramp rate reference level (MW/min) x (30 minutes)

Operating Reserve Reference Quantity_30R (MW) is the Ramp Capability_30R (MW), but shall not exceed nameplate capacity minus MLP (MW) and planned de-rate/outage (MW) of the resource.

4.2. Hydroelectric

4.2.1. Energy

Hydroelectric resources use the following methodologies to determine energy reference quantities:

- For each resource, the market participant ~~Each generation resource~~ indicates, and provides documentation that shows, the minimum head-based capability for each generation unit in that resource. This documentation is used by the IESO to verify the indicated numerical value of the maximum production for each generation unit in each resource when the head is at its minimum level;
- The reference quantity for each hydroelectric resource is the sum of the minimum head-based capability across all generation units at that resource; and
- The MW amount that each generation unit contributes to the reference quantity can be no lower than 0 MW. This amount is reduced to account for outages and de-rates on that ~~generation unit~~resource.

4.2.2. Operating Reserve

Hydroelectric resources use the following methodologies to determine operating reference quantities:

- For each resource, the market participant indicates, and provides documentation that shows, the minimum head-based capability for each generation unit in that resource. This documentation is used by the IESO to verify the indicated numerical value of the maximum production for each generation unit in each resource when the head is at its minimum level;
- The reference quantity for each hydroelectric resource is the sum of the minimum head-based capability across all generation units at that resource; and

- The MW amount that each generation unit contributes to the reference quantity can be no lower than 0 MW. This amount is reduced to account for outages and de-rates on that resource.

For hydroelectric resources, tHydroelectric resources use the following two different methodologies to determine operating reserve reference quantities. The IESO uses the first methodology where maximum DEL data exists for use, and otherwise uses the second methodology.

The two methodologies are:

- for hydroelectric resources that submitted a maximum daily energy limit (DEL) for the prior dispatch day's run of the DAM, the operating reserve reference quantity is calculated by estimating the minimum available energy in the system, which should be available to provide operating reserve; and
- for hydroelectric resources that did not submit a maximum DEL, the operating reserve reference quantity is calculated based on the operational characteristics of each resource.

4.2.3. Methodology for Dispatchable Hydroelectric Resources that have Submitted a Maximum DEL

The following sections describe the methodology to establish reference quantities for hydro resources that have submitted a maximum DEL.

If multiple hydroelectric resources share a common forebay, and submit a common DEL that applies to multiple hydroelectric resources, then the IESO will determine a single operating reserve reference quantity per dispatch day that will apply jointly to those hydroelectric resources.

One daily operating reserve reference quantity is created for each dispatch day. The daily operating reserve reference quantity can never exceed the sum of the rated power of the resource for all 24 hours of the dispatch day (accounting for outages).

OR Reference Quantity $(MWh)_N$ = Maximum Daily Energy Limit $(MWh)_{N-1}$ – Day Ahead Energy Market Commitment $(MWh)_{N-1}$ – Minimum Daily Energy Production $(MWh)_N$

The IESO publishes reference quantities for the dispatch day prior to the opening of the DAM submission window. Therefore, market participants must submit the minimum daily energy production to the IESO in advance of the publishing.

If the IESO does not receive the minimum daily energy production for the current dispatch day prior to the determination of the reference quantities, then the IESO will use a value of 0 MW for the sum of the minimum daily energy production for the current dispatch day.

4.2.3.1 Maximum DEL

The maximum DEL represents the maximum amount of energy, in MWh, that a generation unit can be scheduled to supply within a dispatch day. This represents the maximum available energy in storage that can be used for generation. The previous day's maximum DEL submitted by the market participant for use in DAM scheduling is used as a variable in the determination of reference quantity for the dispatch day.

4.2.3.2 DAM Energy Schedule

This is the energy scheduled in the day-ahead market. The DAM schedule for the resource from the previous day is used as a variable in the determination of reference quantity for the dispatch day.

4.2.3.3 Minimum Daily Energy Production

The minimum daily energy production minimum daily energy production of a resource is the sum across all hours of a dispatch day of the hourly must-run energy. This accounts for minimum hourly output and hourly must run water for the resource for the dispatch day.

4.2.4. Methodology for Dispatchable Hydroelectric Resources that have not Submitted a Maximum DEL

The IESO applies the formulas found in the following subsections for calculating the reference level quantities for operating reserve.

These operating reserve reference quantities are determined on an hourly basis for each resource based on the capability of each resource to respond to dispatch instructions during a contingency event.

The IESO will use the same approach to determine operating reserve reference quantities as energy reference quantities. The operating reserve reference quantity is equal to the minimum head-based capability.

minimum head-based capability for each dispatchable hydroelectric resource as the reference quantity for operating reserve for hydro resources. The minimum head-based capability will be determined in the reference quantity registration process. The value of head-based capability will impact the registered reference quantity, rather than being used directly by the calculation engines.

4.2.4.1 10-minute reserve (synchronized)

The reference quantity for 10-minute operating reserve for hydroelectric resources is calculated as follows:

Ramp Capability_10S (MW) = operating reserve ramp rate reference level (MW/min) x (10 minutes)

~~Operating Reserve Reference Quantity_10S (MW) is the Ramp Capability_10S (MW), but shall not exceed nameplate capacity minus planned de-rate/outage (MW) of the resource.~~

~~4.2.4.2 10-minute reserve (non-synchronized)~~

~~For non-synchronized 10-minute operating reserve, the reference quantity for hydroelectric resources is calculated as follows:~~

~~Ramp Capability_10N (MW) = operating reserve ramp rate reference level (MW/min) x (10 minutes)~~

~~Operating Reserve Reference Quantity_10N (MW) is the Ramp Capability_10N (MW), but shall not exceed nameplate capacity minus and planned de-rate/outage (MW) of the resource.~~

~~4.2.4.3 30-minute reserve (non-synchronized)~~

~~For non-synchronized 30-minute reserve, the reference quantity for hydroelectric resources is calculated as follows:~~

~~Ramp Capability_30R (non-synchronized) (MW) = operating reserve ramp rate reference level (MW/min) x (30 minutes)~~

~~Operating Reserve Reference Quantity_30R (MW) is the Ramp Capability_30R (MW), but shall not exceed nameplate capacity minus planned de-rate/outage (MW) of the resource.~~

~~The supporting documentation required from market participants is described in Section 3.3.~~

4.3. Solar

4.3.1. Energy

A solar resource's energy reference quantity for each dispatch hour is equal to the IESO's centralized day-ahead forecast for the resource. In the day-ahead scheduling process, market participants have the option to submit their self-determined hourly variable generation forecast to the IESO. Where submitted, the market participant-submitted value becomes the reference quantity.

4.4. Wind

4.4.1. Energy

A wind resource's energy reference quantity for each dispatch hour is equal to the IESO's centralized day-ahead forecast for the resource. In the day-ahead scheduling process, market participants have the option to submit their self-determined hourly variable generation forecast to the IESO. Where submitted, this market participant-submitted value becomes the reference quantity.

4.5. Nuclear

4.5.1. Energy

The available capacity of nuclear resources is based on the methodology to determine the resource capability of the Generator Output and Capability Report as published by the IESO on the public IESO report site, http://reports.ieso.ca/.

In the report, capability is measured as the maximum potential output of the resource under current conditions, which includes maximum unit de-rates and outages for that hour.

4.6. Energy Storage

Energy storage resource reference quantity guidance is applicable to all energy storage resources with a discharge duration of over one hour at the rated power, including:

- battery energy storage (lithium, flow, lead acid, etc.);
- compressed air energy storage;
- hydrogen energy storage; and
- gravimetric energy storage technologies (e.g. smart cranes, advanced rail, etc.).

Energy storage resources that have a discharge duration under 1 hour at their rated power are exempt because the minimum duration of operating reserve is 1 hour. Therefore, the operating reserve reference quantity for these storage resources are zero, including:

- flywheels;
- supercapacitors/ultracapacitors; and
- power batteries.

As energy storage resources' participation evolves in the IESO market, the methodology to determine reference quantities will be updated to appropriately account for such changes.

This methodology was formulated based on the assumption that energy storage resources complete a charge-discharge cycle at least once each dispatch day.

4.6.1. Energy

The energy reference quantity for energy storage resources is the resource's nameplate capacity less planned outage or de-rates for 1 hour of each dispatch day.

4.6.2. Operating Reserve

Due to the unique nature of energy storage assets, market participants have the ability to offer operating reserve in both generation and load mode.

As a result, the operating reference quantity for energy storage resources is the resource's nameplate capacity less planned outage or de-rates 2 hours of each dispatch day.

4.7. Dispatchable Loads

Dispatchable loads can offer up to 100% of their dispatchable energy demand as operating reserve, subject to the minimum requirements for operating reserve service. As a dispatchable load, the resource~~facility~~ is capable of adjusting its demand in response to the IESO's dispatch schedule for participation in the energy market.

However, there may be considerations that prevent a resource ~~facility~~ from offering the full capability of its dispatchable load for operating reserve and the market participant shall identify any such conditions to the IESO along with the supporting documentation listed in the following section.

4.7.1. Operating Reserve

As dispatchable loads operate based on a combination of operational needs as well as the energy market, their capacity will vary according to their operating schedule.

Operating profile information describing expected operation of the resource may be obtained from market participants as part of the registration process to provide a reference quantity envelope for operating reserve capacity on an hourly basis.

The operating reserve reference quantity is the maximum amount of dispatchable load expected to be bid within each hour, as defined by the operating profile. Where the market participant has not provided information about the operating profile, the operating reserve reference quantity is the nameplate capacity of the resource.

Market participants who are not able to provide their full dispatchable load capacity shall provide the IESO with an explanation of the limitations for the provision of operating reserve and the relevant supporting documentation that can be used to calculate a resource-specific reference quantity, based on the methodology described below.

To assess resource-specific quantities, market participants shall provide following supporting documentation regarding their capacity to provide operating reserve, if other than the amount of their energy bids:

- operating schedule and hourly dispatchable load forecast;
- details of intra-hour load variability and characteristics including equipment descriptions and historical load profile examples;

- details of ramp-rate limitations at various load levels;
- expected response time; and
- other resource-specific considerations impacting ability to provide operating reserve.

The calculation methodology to develop a resource-specific reference quantity for operating reserves for dispatchable loads involves the following three steps.

1. The first step is to determine dispatchable energy range.

   Dispatchable Energy Range = Highest Forecast Hourly Load x (1 – Intra-hour load variability) – Non-dispatchable Load

2. The next step is to determine maximum 10 or 30 min ramp rate.

   a. If providing 10-minute reserve:

   Maximum 10-Min Ramp Rate = operating reserve ramp rate reference level (MW/min) x (10 min – Response Time (min))

   b. If providing 30-minute reserve:

   Maximum 30-Min Ramp Rate = operating reserve ramp rate reference level (MW/min) x (30 min – Response Time (min))

   10-minute and 30-minute ramp rate are bounded by the rated capacity of the resource.

3. The final step is to determine the maximum hourly operating reserve capacity.

   a. If Dispatchable Energy Range > Maximum 10 or 30-Min Ramp Rate

   Maximum Hourly OR Capacity = Maximum 10 or 30-Min Ramp Rate

   b. If Dispatchable Energy Range < Maximum 10 or 30-Min Ramp Rate

   Maximum Hourly OR Capacity = Dispatchable Energy Range

The supporting documentation required from market participants is described in Section 3.3.

4.7.1.1 Resource Operating Schedule

Each resource has a unique operating schedule, which affects the amount of load it will be able to reduce in order to provide operating reserve. A resource that operates at five days a week will only be able to offer full capacity during the days and hours that it is expected to be at its highest level of load. Dispatchable loads will provide information regarding operating schedules to the IESO, along with their forecasted amount of dispatchable load.

4.7.1.2 Highest Forecast Hourly Load

The highest hourly load bid, in MWh, during period of hourly energy bid.

4.7.1.3 Non-Dispatchable Portion of Load

A resource that has designated a portion of its load, in MWh, as non-dispatchable may not be able to reduce its load beyond the difference between its dispatchable energy bid and the non-dispatchable portion of its load.

4.7.1.4 Response Time Capability

A resource will have a finite response time, in minutes, after being dispatched before it will begin ramping its load. This response time needs to be accounted for in its offer in combination with ramp rate. E.g. If response time for a resource in the above example is 2 minutes, then the total capacity that could be offered as 10-minute operating reserve would be 8MW, and the amount that could be offered as 30-minute reserve would be 28MW.

4.7.1.5 Intra-Hour Variability of Load:

When a load varies by percentage within the hour, given a specific level of dispatch, the quantity of operating reserve that can be offered should correspond to the minimum load within that hour. For example, if a resource that is dispatched as a 30 MW load has a load that may vary by 10% during the hour, the quantity of operating reserve that can be offered should be 30 x (100 - 10%) = 27 MW. Details to support intra-hour variability of load include characteristics including equipment descriptions and historical load profile data.

4.7.1.6 Other Considerations

In addition, there may be other discretionary reasons for not offering full dispatchable load capacity as operating reserve, including non-performance costs. If there is some uncertainty in the ability of a resource to reduce its full load within the required time frame, a more conservative offer may be provided to reduce the risk of any potential penalties for non-performance.

If the dispatchable load is utilizing BTM energy storage or thermal generation, additional limitations and reference quantity calculations may described in from Section 4.1 to 4.6.

The relationship between dispatchable load and operating reserve will depend on the nature of the dispatchable load resource, which is resource-specific. Therefore, historical bid information will be used as the basis for estimating reference quantities for dispatchable loads offering operating reserve in Ontario.

The calculation methodology for establishing the reference quantity assumes the operating reserve capacity is not limited by specific factors associated with BTM generation or storage. The methodology for determining reference quantities for operating reserve for dispatchable loads will be adapted to resource-specific methodology, where substantiated requests are approved for specific resources.

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