



Stakeholder Engagement Pre-Reading

Reference Levels and Reference Quantities

November, 2020

Stakeholder Engagement Pre-Reading Reference Levels and Reference Quantities—August 27, 2020

The external stakeholder engagement sessions in November, 2020 will cover the methodologies that the *IESO* will use to approve reference levels and reference quantities.

The purpose of this document is to provide stakeholders with information on the detailed design for the above topics and set expectations for these sessions. These materials are required reading for the session.

Table of Contents

Stakeholder Engagement Pre-Reading	1
Table of Contents.....	2
1. Overview of Reference Levels and Reference Quantities	4
2. Process for Establishing Reference Levels for Financial Dispatch Data Parameters....	5
2.1. Reference Level Workbooks	5
2.2. Use of Historical or Forecast Cost Data.....	5
2.3. Supporting Documentation.....	6
2.4. Eligible Cost Components for Financial Reference Levels.....	8
2.5. Financial Reference Level by Technology Type of the Resource	16
3. Process for Establishing Reference Levels for Non-Financial Dispatch Data Parameters	61
3.1. Non-Financial Dispatch Data Parameters	63
3.2. Ongoing Updates to Non-Financial Reference Levels.....	65
3.3. Supporting Documentation for Non-Financial Reference Levels.....	65
3.4. Non-Financial Reference Levels by Technology Type	66
4. Process for Establishing Reference Quantities	72
4.1. Thermal.....	72
4.2. Hydroelectric.....	74
4.3. Solar	76
4.4. Wind	77
4.5. Nuclear.....	77
4.6. Energy Storage	77
4.7. Dispatchable Loads.....	78

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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 approve 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 approve 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 approve 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 events¹ 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 sources² 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:

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.
- documentation developed by the relevant *market participant*, evaluated on a case by case basis by the *IESO*. When determining the eligibility of documentation developed by the relevant *market participant*, the *IESO* will consider the reasonableness of the content of the documentation and 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 approve 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 approve 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 approve 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". An intraday opportunity cost is applicable for resources are *energy*-limited within a 24-hour period. Resources that meet both of these criteria can apply both of these opportunity costs to their reference levels.

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:

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

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 locational marginal price (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.

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

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 forward³ 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.

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.

4.5. 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 4. This creates the forecast LMPs for the resource.

6. 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.

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

³ The term forward refers to the publicly traded futures contract related to NY Zone A.

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.*

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.*

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* 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.

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.

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.

Deriving Pseudo-Unit Reference Levels for a Combined Cycle Resource

The *IESO* will align its process of calculating reference levels for *pseudo-units* and physical units with the translation approach of the relationship between physical units and *pseudo-units* that will be used in the renewed market.

The *IESO* first approves 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*.

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

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.

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.

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

Speed No Load Reference Level(\$/hr)

$$\begin{aligned} &= (\text{Speed No Load Heat Consumption} \left(\frac{GJ}{hr} \right) \\ & * \text{Total Fuel Related Costs} \left(\frac{\$}{GJ} \right) * \text{Performance Factor}) \\ & + \text{Emission Costs} \left(\frac{\$}{hr} \right) + \text{Operating and Maintenance Costs} \left(\frac{\$}{hr} \right) \end{aligned}$$

$$\begin{aligned}
& \textbf{Start – up Reference Level} \left(\frac{\$}{\text{Start}} \right) \\
& = \left(\text{Start Fuel Consumed} \left(\frac{\text{GJ}}{\text{start}} \right) * \text{Total Fuel Related Cost} \left(\frac{\$}{\text{GJ}} \right) \right. \\
& \quad \left. * \text{Performance Factor} \right) \\
& + \left(\text{Start – up Station Service Quantity} \left(\frac{\text{MWh}}{\text{start}} \right) \right. \\
& \quad \left. * \text{Station Service Price} \left(\frac{\$}{\text{MWh}} \right) \right) + \text{Start – Up Emissions Costs} \left(\frac{\$}{\text{start}} \right) \\
& + \text{Operating and Maintenance Costs} \left(\frac{\$}{\text{start}} \right)
\end{aligned}$$

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:

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

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 *facility*. *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*:

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

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.

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

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.

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

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 *generation 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°C) once it is combusted and the products have returned to a temperature of 25 °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:

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

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.

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 approve 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 approve 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.

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.

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.

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.

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:

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

Market participants must provide 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 (1) year and heat content of fuel in 5- intervals; or monthly spot check test basis;

- theoretical fuel consumed: heat rate and correction curves for each 5-minute interval and MWh of production during the time period;
- 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).

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 Standards⁴

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

$$\begin{aligned}
 & \text{Emissions Charge} \left(\frac{\$}{\text{MWh}} \right) \\
 &= \left(\text{Incremental HR} \left(\frac{\text{MJ}}{\text{MWh}} \right) \times \text{Performance Factor} \right. \\
 & \times \text{Emission Factor} \left(\frac{\text{tCO}_2\text{e}}{\text{GJ}} \right) \times \frac{1 \text{ GJ}}{1000 \text{ MJ}} \\
 & \left. - \text{Emission Performance Standard} \left(\frac{\text{tCO}_2\text{e}}{\text{GWh}} \right) \times \left(\frac{1 \text{ GWh}}{1000 \text{ MWh}} \right) \right) \\
 & \times \text{Carbon Price} \left(\frac{\$}{\text{tCO}_2\text{e}} \right)
 \end{aligned}$$

where, tCO₂e = 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 (<https://www.ontario.ca/page/guide-greenhouse-gas-emissions-reporting>)

Emission Performance Standard shall be in accordance with the applicable value for

⁴ tCO₂e is tonnes of carbon dioxide equivalent.

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:

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

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 in 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.

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 approved 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 approved 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:

$$\text{Major Maintenance} \left(\frac{\$}{MWh} \right) = \sum_i \frac{\text{Maintenance Cost}_i (\$)}{\text{Output}_i (MW) * \text{Maintenance Interval}_i (h, EOH)}$$

$$\text{Major Maintenance} \left(\frac{\$}{\text{start}} \right) = \sum_i \text{Maintenance Cost}_i (\$)$$

$$\frac{\text{Hours Per Start}_i \left(\frac{h}{\text{start}} \right) \text{ or Equivalent Operating Hours Per Start} \left(\frac{EOH}{\text{Start}} \right)}{\text{Maintenance Interval}_i (h, EOH)}$$

$$\text{Major Maintenance} \left(\frac{\$}{h} \right) = \sum_i \frac{\text{Maintenance Cost}_i (\$)}{\text{Maintenance Interval}_i (h, EOH)}$$

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:

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

$$\text{Major Maintenance} \left(\frac{\$}{\text{start}} \right) = \sum_i \frac{\text{Maintenance Cost}_i (\$) \cdot (1 \text{ start or applicable portion of the start cost})}{\text{Maintenance Interval}_i (\text{starts})}$$

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

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.

$$1. \text{ Operating Consumables Cost Adder } \left(\frac{\$}{MWh} \right) = \frac{\text{Historical Operating Consumables Cost } (\$)}{\text{Historical Electricity Generation } (MWh)}$$

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.

$$2. \text{ Operating Consumables Cost Adder } \left(\frac{\$}{\text{Start}} \right) = \frac{\text{Historical Operating Consumables Cost Related to Starts } (\$)}{\text{Historical Number of Starts } (\text{Starts})}$$

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.

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

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.

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.

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.

$$\begin{aligned} & \text{Emissions Charge} \left(\frac{\$}{\text{Start}} \right) \\ &= \left(\text{Start Fuel Consumed} \left(\frac{\text{GJ}}{\text{Start}} \right) \times \text{Fuel Carbon Content} \left(\frac{\text{tCO}_2\text{e}}{\text{GJ}} \right) \right. \\ & \quad \left. - \text{Output Based Standard} \left(\frac{\text{tCO}_2\text{e}}{\text{GWh}} \right) \right) \\ & \quad \times \text{Electricity Generated During Start} \left(\frac{\text{GWh}}{\text{Start}} \right) \times \text{Carbon Price} \left(\frac{\$}{\text{tCO}_2\text{e}} \right) \end{aligned}$$

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.

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.

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 Cost

The eligible speed no-load 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:

$$\begin{aligned} \text{Speed No Load Costs} \left(\frac{\$}{\text{hr}} \right) &= \text{Fuel Price} \left(\frac{\$}{\text{GJ}} \right) * \text{Speed No Load Heat Consumption} \left(\frac{\text{GJ}}{\text{hr}} \right) \\ &+ \text{Speed No Load Emission Costs} \left(\frac{\$}{\text{hr}} \right) \end{aligned}$$

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.

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.

$$\begin{aligned} \text{Emissions Charge} \left(\frac{\$}{\text{hr}} \right) &= \text{No load heat consumption} (\text{GJ/hr}) \times \text{Fuel Carbon Content} \left(\frac{\text{tCO}_2\text{e}}{\text{GJ}} \right) \\ &\times \text{Carbon Price} \left(\frac{\$}{\text{tCO}_2\text{e}} \right) \end{aligned}$$

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.

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

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.

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:

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

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.

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:

$$\begin{aligned} & \text{Pumping Power Cost} \left(\frac{\$}{\text{MWh}} \right) \\ &= \frac{\sum_{168}^1 \left(\text{Pumping Withdrawal Costs}_h \left(\frac{\$}{\text{MWh}} \right) * \text{Pumping Power}_h (\text{MWh}) \right)}{\sum_{168}^1 \text{Pumping Power}_h (\text{MWh})} \end{aligned}$$

If no water has been pumped during the previous seven-day period, the *IESO* uses the last non-zero value for pumping power cost 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:

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

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.

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

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.

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.

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.

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:

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

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 2-1: EOH Methodology Illustrative Example

Parameter	Historical Annual Operation (last 5 years)	Current Operating Period (last year)
Hours of operation	5000 h	5000 h

Parameter	Historical Annual Operation (last 5 years)	Current Operating Period (last year)
# of start/stops	100	300
Start/stop equivalent hours	5 hrs per start/stop	5 hrs per start/stop

Historical EOH is calculated as:

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

And current operating regime EOH is calculated as:

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

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 approve 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:

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.

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.

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.

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.

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

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.

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.

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.

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.

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

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.

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

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

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.

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

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.

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

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.

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).

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

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.

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:

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.

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

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.

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.

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

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.

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:

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

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:

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

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.

$$\text{Station Service Cost} \left(\frac{\$}{\text{MWh}} \right) = \frac{\text{Auxiliary power consumed during operation (MWh)}}{\text{Energy Discharged during operation (MWh)}} \times x$$

Average Electricity Purchase Price from previous year $\left(\frac{\$}{MWh}\right) \times$ *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.

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

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.

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 battery⁶ - 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.

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;
- 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.

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

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.

IESO applies the following equation for the *operating reserve* reference level and subsequent sub-sections provide descriptions of the components.

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

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:

$$\text{Auxiliary Energy Consumption} \left(\frac{\$}{\text{MWh}} \right) = \frac{\text{Auxiliary power consumed during operation (MWh)}}{\text{MW offered on Operating Reserve (MW)}} \times$$

$$\text{Average Electricity Purchase Price from previous year} \left(\frac{\$}{\text{MWh}} \right) \times \text{IESO annual escalation}$$

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.

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

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

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.

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.

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:

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

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

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*.

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:

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

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.

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:

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

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.

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:

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

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.

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* approves 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 data* 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 3-2: Reference Levels for Non-Financial Offer Parameters

Registered Reference Level Name	Target Non-Financial Offer Parameter	Reference Level Registered For
<i>Energy ramp rate reference level</i>	<i>Energy ramp rate</i>	<ul style="list-style-type: none"> • All dispatchable <i>generation facilities</i> • All dispatchable <i>energy storage resources</i>
<i>Operating reserve ramp rate reference level</i>	<i>Operating reserve ramp rate</i>	<ul style="list-style-type: none"> • All dispatchable generation facilities • All <i>dispatchable loads</i> • All dispatchable <i>energy storage resources</i>
Lead time reference level (hot, warm and cold)	Lead time (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
<i>Minimum loading point reference level</i>	<i>Minimum loading point</i>	All NQS resources eligible for the generator offer guarantee programs
<i>Minimum generation block run-time reference level</i>	Minimum generation block run-time	All NQS resources eligible for the generator offer guarantee programs
<i>Minimum generation block down time reference level (hot, warm and cold)</i>	Minimum generation block down time (<i>hot, warm and cold</i>)	All NQS resources eligible for the generator offer guarantee programs
<i>Maximum number of starts per day reference level</i>	Maximum number of starts per day	<ul style="list-style-type: none"> • All NQS resources eligible for the generator offer guarantee programs • All dispatchable hydroelectric <i>generation facilities</i>
Ramp up <i>energy</i> 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

Registered Reference Level Name	Target Non-Financial Offer Parameter	Reference Level Registered For
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 data* 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.

3.1.1.1 Operating Reserve Ramp Rate Reference Level

The *operating reserve* ramp rate reference level is [approved](#) for dispatchable generation and load facilities. 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*.

3.1.1.2 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 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* as either hot, warm or cold.

3.1.1.3 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* must maintain to remain stable without the support of ignition.

3.1.1.4 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* must be scheduled to its MLP, in accordance with the technical requirements of the resource.

3.1.1.5 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* was last at its MLP before de-synchronization and the time the *generation unit* can be scheduled back to its MLP after re-synchronizing.

3.1.1.6 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* can be physically started within a *dispatch day*.

3.1.1.7 Ramp-up Energy to Minimum Loading Point Reference Level

Ramp up *energy* to the MLP reference level is [approved](#) for dispatchable non-quick start thermal resources. It is the average 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.

3.1.1.8 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.

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;
- 3. 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.

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.

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.

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

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 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 approved based on non-financial reference levels for lead time, *minimum generation block run-time*, and *minimum generation block down time*, rounded down to the nearest whole number, as follows:

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

3.4.1.8 Ramp Up Energy to MLP

The supporting documentation for the following non-financial dispatch parameters includes start-up curves from the OEM or designer of the *generation facility* 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 – Hot
 - The average 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 – Warm

- The average 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 – Cold
 - The average 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* determines will approve 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*.

Sections 4.1 to 4.7 describe the methodology that the *IESO* uses to approve 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 approve an *operating reserve* reference quantity for that resource for 30-minute reserve.

4.1. Thermal

This section describes the methodology the *IESO* uses to approve 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 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](#).

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 [approve energy](#) reference quantities:

- 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*.

4.2.2. Operating Reserve

Hydroelectric resources use the following two different methodologies to approve [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 days* 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.

4.2.1.4.2.3. 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 approve 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*.

~~4.2.1.14~~.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*.

~~4.2.1.24~~.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*.

~~4.2.1.34~~.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*.

~~4.2.2.4~~.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 approved on an hourly basis for each resource based on the capability of each resource to respond to *dispatch instructions* during a *contingency event*.

4.2.2.14.2.4.1 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.

4.2.2.24.2.4.2 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.

4.2.2.34.2.4.3 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 approve the resource capability of the Generator Output and Capability Report as published by the *IESO* on the public [IESO report site](#).

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 approve 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 *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 *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. For example, if the 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 $30 \times (100 - 10\%) = 27$ 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 be 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.