Stakeholder Engagement Pre-Reading

Reference Levels and Reference Quantities– August 27, 2020

The external stakeholder engagement session on August 27, 2020 will cover the methodologies that the *IESO* will use to determine 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 the session. These materials are required reading for the session.

Contents

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1 Overview of Reference Levels and Reference Quantities

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

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

The reference quantity for *energy* is based on the available capability of the resource to supply *energy* under current operating conditions. The reference quantity for suppliers of *operating reserve* is based on the operational capability of the resource.
The *IESO* has developed methodologies to calculate reference quantities for the *energy* and *operating reserve* market.

2 Process for Establishing Reference Levels for Financial Dispatch Data Parameters

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

2.1 Reference Level Workbooks

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

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

2.2 Use of Historical or Forecast Cost Data

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

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

Where the cost 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 cost data when determining the contribution of a cost to a reference level.

Where the cost information is not available for at least one year, *market participants* may adopt one of three approaches instead to determine the contribution of a cost to a reference level until at least one year of historical cost 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; or
- certified documentation for the OEM or vendor.

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

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

2.3 Supporting Documentation

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

Acceptable forms of documentation include:

- 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

[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.

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.

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 determined by the *IESO* and provided to the *market participant*. These reference levels will also be used by the *IESO* to determine reference level values for the relevant resource on an ongoing basis.

2.4 Eligible Cost Components for Financial Reference Levels

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

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

2.4.1 Fuel-Related Costs

Fuel-related costs, as applicable to a technology, represent the cost of materials used for the operation required to release *energy* for the purpose of electricity production. Fuel commodity costs are adjusted, as applicable, with efficiency or performance metrics to determine fuel-related costs.

2.4.2 Emission Costs

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

2.4.3 Performance Factor

The performance factor is a means to account for uncertainties across resources and changes to resource efficiency without having to adjust the heat rate for the resource. Changes to resource efficiency are measured by the fuel consumption per MWh of production or per start. For example, performance factors per resource can be impacted by seasonal factors such as ambient conditions.

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 determined 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.

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.

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

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

- efficiency in the amount of fuel used to produce a fixed MWh quantity of *energy*;
- maximum production capability; or

- availability to supply *energy* or *operating reserve*, including modifications to enable alternate operating modes at the resource.

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

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

2.4.4.2 Scheduled Maintenance Costs

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

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

2.4.4.3 Unscheduled Maintenance Costs

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

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

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

2.4.5 Incremental Third Party Payments

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

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

2.4.6 Opportunity Costs

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

The opportunity cost adder is applicable for resources that can store fuel across a multi-day period or a "storage horizon". Where the opportunity cost adder does not address all relevant aspects of opportunity cost for a particular resource, *market participants* may request that the *IESO* add a resource-specific additional opportunity cost adder.

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

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

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

- the identified additional opportunity cost adder 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 adder would prove excessively burdensome.

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

2.4.6.1 Opportunity Cost Adder

The opportunity cost adder calculates the opportunity cost of producing a MWh of *energy* in the current *dispatch day*.

The opportunity cost adder is a resource-specific calculation updated on a daily basis by the *IESO*. It has a minimum value of $0/MWh and is applied to the relevant resource for all hours in the *dispatch day*. The opportunity cost adder is based on historical prices[3] at the resource indexed based on the NGX Union Dawn Day-Ahead Index[4] and the storage horizon of the

[3] Historical prices will be LMPs when they are available or shadow prices at the resource bounded by the –MMCP and the MMCP.

[4] If the resource is less than 1-year old, the *IESO* will use the shadow prices of a proxy resource that is located in close electrical proximity to the relevant resource.

resource. The NGX Union Dawn Day-Ahead Index is used as an instrument to index historical prices according to current market conditions.

The *IESO* will use this historical price data and the NGX Union Dawn Day-Ahead Index to form a value for the opportunity cost adder for each relevant resource. The historical price data is used to create a historical price distribution across the storage horizon of the resource. To calculate the opportunity cost adder, the *IESO* applies the following process:

1. A dataset that contains hourly average historical prices is created. This dataset begins at HE1 of the same calendar day as the *dispatch day* from the previous year. The dataset ends at HE24 of the first day of the dataset plus the number of days equal to the storage horizon of the resource.
2. Each hourly average historical price in the dataset is divided by the historical NGX Union Dawn Day-Ahead price for that same date.
   For example, if the maximum storage horizon of a resource is 7 days and today's date is June 1, 2020, then 168 hourly ratios are created from June 1, 2020 to June 7, 2020 using historical data from June 1, 2019 to June 7, 2019 respectively.
   $$Hourly\ Ratio_{y,m,d,h} = \frac{Hourly\ Average\ Historic\ Price_{y-1,m,d,h}}{NGXUnionDawnDayAheadIndex_{y-1,m,d}}$$
   Example of one hourly ratio:
   $$June\ 1, 2020\ Hourly\ Ratio\ _{HE1} = \frac{Hourly\ Average\ Historic\ Price_{2019/06/01,HE1}}{NGXUnionDawnDayAheadIndex_{2019/06/01}}$$
3. Each of these hourly rations is multiplied by the NGX Union Dawn Day-Ahead Index for the current *dispatch day* to index the historical prices to current conditions. The opportunity cost adder is the 95th percentile value from the dataset.

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. Therefore, 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

This 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.* This type of hypothetical operation is not carried out in the *IESO-administered market*. This reference level methodology uses the approach of separating the fixed hourly costs of synchronized operation from costs associated with incremental production.

For non-thermal resources that have speed no-load costs but do not submit speed no-load offers, these costs are reflected in *energy* offer reference levels.

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 Form X.X 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.

2.5.1.1.1 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 is currently used for modelling purposes.

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

2.5.1.1.2 Determining the Appropriate Configuration to use 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 the As-Offered run of the DAM calculation engine or the PD-Scheduling run of the PD engine.

If the resource is scheduled in a different configuration than the configuration that was used in the As-Offered run of the DAM calculation engine or the PD-Scheduling run of the PD engine and the resource is mitigated to a lower reference level than ought to have been applied, the *market participant* can apply for cost recovery using the ex-post cost recovery process. For example, the *IESO* might use the 2×1 reference level for a resource even though the resource was committed in 1×1 configuration. In such cases, the only cost recovery that is eligible is the difference between the reference levels of the two configurations.

2.5.1.2 Cogeneration Resources

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

2.5.1.3 Financial Reference Level Equations

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

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

2.5.1.3.1 For Thermal Resources that are Eligible for Generator Offer Guarantees

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

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

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

$$\textbf{Start} - \textbf{up Reference Level}\left(\frac{\$}{\textbf{Start}}\right)$$

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

2.5.1.3.2 For Resources Not Eligible for Generator Offer Guarantees

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

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

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

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

Primary Energy Reference Level:

$$\textbf{Energy Reference Level}\left(\frac{\$}{\textbf{MWh}}\right)$$

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

The Hours per Start (from the formula above) for each thermal state will be used to amortize start costs as well as average operating output in MW will default to 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:

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

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.

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

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

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

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

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

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

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

2.5.1.5.1 Fuel Commodity Index

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

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

Natural Gas

For natural gas, the applicable NGX Union Dawn Day-Ahead Index price for the gas day in $US/MMBtu is the acceptable fuel commodity index and the *IESO* will use the values published daily by Intercontinental Exchange where reasonably possible. Other fuel indices may be proposed. The *IESO* will ask participants to provide information explaining why the NGX Union Dawn Day-ahead Index price is not applicable for their *facility*.

Residual Fuel Oil

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

Ignition Oil

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

Biomass

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

2.5.1.5.2 Compressor Fuel Volume Adder

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

The following supporting documentation is required:

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

2.5.1.5.3 Service Price Adder

Natural Gas

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

- Pipelines, storage providers, and gas utilities provide various services to deal with imbalances between the quantity of gas purchased and the quantity of gas consumed;
- Imbalances created from the difference between the quantity of gas purchased and the quantity of gas consumed can be managed by injecting the excess gas into storage or withdrawing the shortfall in gas from storage. Storage services are provided by service providers to meet this need. The same rationale outlining the need for balancing services applies to the need for storage services; and

- A marketer risk premium may be incurred by end-users purchasing smaller volumes relative to large volume buyers.

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

The following supporting documentation is required:

- copies of the transportation, storage and load balancing contracts outlining the requirement to provide fuel to acquire the services;
- copies of current regulatory approved rated schedules showing the variable commodity charges as applicable; and
- copies of contracts with gas suppliers showing the marketer premium.

Residual Fuel Oil (RFO)

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

The following supporting documentation is required:

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

Biomass

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

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

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

The following supporting documentation is required:

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

Co-firing

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

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

Conversion Factors

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

2.5.1.5.4 Performance Factors

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

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

M*arket 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).

2.5.1.5.5 Emissions Costs

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

Output-Based Performance Standard Resources

For thermal resources that qualify for the output-based performance standards (OBPS), eligible incremental emissions costs are based on the efficiency difference for the *dispatch* load and the allowance permitted under the OBPS for natural gas-fired or fuel oil-fired generation.

The contributions of emissions costs for *energy* reference levels are reviewed and updated on an as-needed basis based on the applicable allowance and carbon price for each year (the OBPS is expected to be updated each year).

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

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

where, tCO_2e = tonnes of carbon dioxide equivalent

The following supporting documentation regarding eligible emissions costs are required for OBPS resources in addition to the supporting documentation provided for total fuel related costs:

- Fuel Emission Factor, as defined in Output-Based Pricing System Regulations (OBPSR): SOR/2019-266; and
- Output-Based Pricing Standards applicable to the resource, as defined in Output-Based Pricing System Regulations: SOR/2019-266. Applies to facilities covered by OBPSR only.

Non-OBPS Resources

For resources that do not qualify for the Output-Based Pricing System (OBPS), eligible emissions costs are based solely on fuel consumption, as reflected by the following formula:

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

The following supporting documentation regarding eligible emissions costs are required for non-OBPS resources in addition to the supporting documentation provided for total fuel related costs:

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

2.5.1.6 Operating and Maintenance Costs

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

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

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

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

2.5.1.6.1 Major Maintenance Costs

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

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

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

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

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

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

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

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

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

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

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

OEM-Recommended Interval on Per-Start Basis

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

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

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

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

Gas Turbines

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

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

Eligible costs for the above include:

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

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

Combined Cycle Steam Resources and Fossil or Biomass Steam Resources

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

- minor inspection; and
- major inspection.

Eligible costs for the above include:

- turbine blade repair or replacement;
- turbine diaphragm repair;
- casing repair or replacement;
- bearing repair or refurbishment;
- generator inspection;
- boiler repairs;
- primary air fan repairs;
- stop valve inspection and repairs;
- throttle valve inspection and repairs;

- nozzle block inspection and repairs;
- intercept valve inspection and repairs;
- PA/ID/FD Fan repairs;
- consumables required for the outage;
- technical advisors required;
- temporary incremental labour required;
- crane rentals required; and
- temporary infrastructure required (scaffolding, temporary office trailers, washrooms, etc.)

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

Scheduled Maintenance Costs

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

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

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

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.

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

Allocating Operating Consumables Cost Adder to Start-up Reference Level

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

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

2.5.1.7 Start-Up Costs

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

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

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

2.5.1.7.1 Start Fuel Consumed

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

2.5.1.7.2 Station Service

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

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

2.5.1.7.3 Start-Up Emissions Costs

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

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

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

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

2.5.1.7.4 Start-Up Maintenance Adder

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

2.5.1.7.5 Start-Up Operating Consumables Adder

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

2.5.1.8 Speed No-Load 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:

$$Speed\ No\ Load\ Costs\left(\frac{\$}{hr}\right)$$
$$= Fuel\ Price\left(\frac{\$}{GJ}\right) * Speed\ No\ Lead\ Heat\ Consumption\left(\frac{GJ}{hr}\right)$$
$$+ Speed\ No\ Load\ Emission\ Costs\left(\frac{\$}{hr}\right)$$

2.5.1.9 Speed No-Load Heat Consumption

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

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

2.5.1.9.1 Speed No-Load Emission Costs

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

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

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

2.5.1.9.2 Operating Reserve Reference Levels

Operating reserve reference levels are determined 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 Form X.X 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.

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

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.

2.5.2.1.1 Gross Revenue Charges

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

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

Supporting documentation for the GRC include invoices issued by the relevant authority.
The contribution of GRC to the *energy* reference level is expressed by the following equation:

$$GRC\left(\frac{\$}{MWh}\right) = \frac{Annual\ GRC\ (\$)}{Annual\ Energy\ Production\ (MWh)}$$

Annual GRC is the total GRC paid for a hydroelectric resource during one year of the historical study period.

Average *energy* production is the total *energy* produced by the hydroelectric resource during one year of the historical study period.

Contribution of the GRC to the *energy* reference level for a hydroelectric resource is the average of the annual GRC divided by annual *energy* production for all years in the historical study period.

The historical study period for the GRC for hydroelectric resources is 10 years.

2.5.2.1.2 Pumped Hydro Fuel Cost

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

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

The *IESO* calculates the pumping power cost on a seven-day rolling average basis by multiplying the real time locational marginal price (LMP) 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:

$$Pumping\ Power\ Cost\ \left(\frac{\$}{MWh}\right) = \frac{\sum_{168}^{1}\left(Real\ Time\ LMP_h\ \left(\frac{\$}{MWh}\right) * Pumping\ Power_h\ (MWh)\right)}{\sum_{168}^{1} Pumping\ Power_h\ (MWh)}$$

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:

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

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

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

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

2.5.2.2 Operating and Maintenance Costs

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

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

2.5.2.2.1 Major Maintenance Costs

Eligible major maintenance costs for hydroelectric resources include:

- turbine refurbishment;
- runner blade repair;
- turbine/generator bearing refurbishment or replacement;
- wear ring replacement;
- generator rewinds;
- stator core refurbishment/replacement;
- rotor pole rewinding;
- governor/HPU refurbishment;
- transformer oil filtration/replacement; and
- transformer replacement.

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

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

2.5.2.2.2 Scheduled Maintenance Costs

Eligible scheduled maintenance costs for hydroelectric resources include:

- oil and lubricant replacement;
- filter replacements;
- mechanical seal replacement; and
- consumable materials for the maintenance of turbine/generator components.

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

2.5.2.2.3 Unscheduled Maintenance Costs

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

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

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

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

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

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

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

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

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
# of start/stops	100	300
Start/stop equivalent hours	5 hrs per start/stop	5 hrs per start/stop

Historical EOH is calculated as:

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

And current operating regime EOH is calculated as:

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

Therefore, the appropriate correction factor is calculated as:

6,500/5,500 = 1.18

2.5.2.4 Opportunity Costs

Section 2.4.5 describes the method that the *IESO* uses to determine eligible opportunity costs. Eligible opportunity costs for hydroelectric resources include the opportunity cost adder. 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 determined 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 form X.X 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.

2.5.3.1.1 Major Maintenance Costs

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

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

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

2.5.3.1.2 Scheduled Maintenance Costs - Electrical and Mechanical

Eligible scheduled maintenance costs for solar resources include:

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

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

2.5.3.1.3 Unscheduled Maintenance Costs - Electrical

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

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

2.5.3.2 Incremental Third Party Payments

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

2.5.4 Wind

This section describes the inputs that *market participants* with wind resources should provide in Form X.X 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.

$$Energy\ Reference\ Level = Operating\ and\ Maintenance\ Costs$$

2.5.4.1 Operating and Maintenance Costs

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

2.5.4.1.1 Major Maintenance Costs

Eligible major maintenance costs for wind resources include:

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

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

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

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

2.5.4.1.2 Scheduled Maintenance Costs

Eligible scheduled maintenance costs for wind resources include:

- converter and main cabinets checks;
- power cables – stator and rotor check;
- bus bar and power cables inspection;
- generator and gearbox inspections and monitoring program;
- yaw and pitch system inspection;
- lubrication and oil changes;
- bearing inspection and lubrication;
- bearing sealing inspection and insulation test;
- stator winding inspection;
- cooling circuit and heat exchanger inspection;
- blade heating inspection;

- standard cleaning;
- vibration check (generator frame, bearing housing);
- bolt torque tightening;
- shaft alignment check; and
- blade inspection and minor repair.

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

2.5.4.1.3 Unscheduled Maintenance Costs

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

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

2.5.4.2 Incremental Third-Party Payments

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

2.5.4.3 Operational Costs Related to Start-Up

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

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

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

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

2.5.5 Nuclear

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

Nuclear resources will have an *energy* reference level. This section describes the inputs for Form X.X that *market participant*s should complete to request an *energy* reference level.

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

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

2.5.5.1 Fuel-Related Costs

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

2.5.5.1.1 Resource Generation Capacity Data

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

Net Power

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

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

Maximum Licensed Reactor Power (RP)

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

Heat Rate

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

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

Incremental Fuel Consumption

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

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

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

Capacity Factor

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

Performance Factors

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

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

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

2.5.5.1.2 Total Fuel-Related Costs

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

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

Basic Fuel Costs

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

Fuel Disposal Costs

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

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

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

2.5.5.2 Operating and Maintenance Costs

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

They include the cost of:

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

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

Major Maintenance Costs

Eligible major maintenance costs for nuclear resources include:

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

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

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

Scheduled Maintenance

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

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

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

Unscheduled Maintenance Costs

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

Eligible costs include only maintenance costs related to:

- electrical production;
- reactor safety margin management;
- environmental qualification maintenance;

- radiation safety management;
- conventional safety;
- environmental safety; and
- regulator code compliance requirements [CNSC RD/GD-201, RD/GD-98].

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

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

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

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

2.5.5.3 Incremental Third Party Payments

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

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:

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

[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.

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 Form X.X 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.

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

2.5.6.1 Fuel-Related Costs

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

2.5.6.1.1 Charging Costs

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

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

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

Average Electricity Purchase Price

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

Round-Trip Efficiency

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

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

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

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

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

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

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

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

IESO Annual Price Escalation

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

2.5.6.2 Station Service Costs

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

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

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

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

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

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

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

2.5.6.3 Operating and Maintenance Costs

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

2.5.6.3.1 Major Maintenance Costs

Eligible major maintenance costs for *energy* storage resources include:

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

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

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

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

2.5.6.3.2 Scheduled Maintenance Costs

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

- annual (or bi-annual) vendor maintenance program;
- inverter annual maintenance;
- standard cleaning of electronics; and
- SCADA inspections.

[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.

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

2.5.6.3.3 Unscheduled Maintenance Costs

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

2.5.6.4 Operating Reserve Reference Levels

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

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

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

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

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

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

Average electricity price can be calculated based on the prices paid from the same month in the previous year, escalated by the *IESO* annual escalation rate. The historical study period for auxiliary *energy* consumption for *energy* storage resources is one.

2.5.7 Dispatchable Loads

Dispatchable loads have an *operating reserve* reference level.

This section describes how the inputs for Form X.X 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.

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

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

2.5.7.1 Operating and Maintenance Costs

2.5.7.1.1 General Eligibility of Operating and Maintenance Costs

Eligible costs for reference level calculations for *dispatchable loads* include:

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

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

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

2.5.7.1.2 Cost Components

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

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

2.5.7.1.3 Incremental Operating or Maintenance Costs

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

Incremental Operating or Maintenance Costs can be calculated as follows:

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

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

2.5.7.2 Standby Costs for BTM Generation or Storage

2.5.7.2.1 General Eligibility of Standby Costs for BTM Generation or Storage

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

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

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

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

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

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

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

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

2.5.7.2.2 Standby Costs for BTM Generation

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

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

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

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

Standby Costs for BTM Generation can be calculated as follows:

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

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

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

2.5.7.2.3 Standby Costs for BTM Storage

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

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

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

Standby costs for BTM Storage can be calculated as follows:

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

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

2.5.7.2.4 Cost of Production Flexibility

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

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

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

Cost of Production Flexibility can be calculated as follows:

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

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

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

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

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

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

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

Typically, a resource's registered values reflect its operational capabilities. The *IESO* compares the *market participants*' offered values for *dispatch data* against the registered to validate the *offers*. A resource's non-financial reference levels represent the *IESO*'s determination of the resource 's operating characteristics in a competitive environment rather than an operational limit or other validation criteria. The *IESO* determines non-financial *dispatch data* reference levels for the mitigation process based on the criteria of competitive performance across a resource's starts, time or range of production. The *IESO*-determined reference levels for non-financial dispatch parameters might be equal to the registered values if the registered values are relatively static and are not expected to change all year. If the registered values are not static, the reference level values for non-financial *dispatch data* parameters are determined, 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 determined.

Table 3-1: Reference Levels for Non-Financial Offer Parameters

Registered Reference Level Name	Target Non-Financial *Offer* Parameter	Reference Level Registered For
Energy ramp rate reference level	*Energy* ramp rate	• All dispatchable *generation facilities* • All dispatchable *energy* storage resources

Registered Reference Level Name	Target Non-Financial *Offer* Parameter	Reference Level Registered For
Operating reserve ramp rate reference level	*Operating reserve* ramp rate	• All dispatchable generation facilities • All *dispatchable loads* • All dispatchable *energy* storage resources
Lead time reference level (hot, warm and cold)	Lead time (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
Minimum loading point reference level	*Minimum loading point*	All NQS resources eligible for the generator offer guarantee programs
Minimum generation block run-time reference level	*Minimum generation block run-time*	All NQS resources eligible for the generator offer guarantee programs
Minimum generation block down time reference level (hot, warm and cold)	*Minimum generation block down time* (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
Maximum number of starts per day reference level	*Maximum number of starts per day*	• All NQS resources eligible for the generator offer guarantee programs • All dispatchable hydroelectric *generation facilities*
Ramp up *energy* to MLP reference level (hot, warm and cold)	Ramp up *energy* to MLP (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs
Ramp hours to MLP reference level (hot, warm and cold)	Ramp hours to MLP (hot, warm and cold)	All NQS resources eligible for the generator offer guarantee programs

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

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

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

3.1 Non-Financial Dispatch Data Parameters

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

3.1.1 Energy Ramp Rate Reference Level

The *energy* ramp rate reference level is determined 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 determined 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 determined 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 determined 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 determined 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 determined 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 determined 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 determined 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 determined 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.

Acceptable forms of documentation include:

- materials from vendors regarding operations, including, but not limited to, information on the following:
    - resource efficiency and performance data;
    - equipment test data; and
    - relevant sections from operating and maintenance manuals;

  Any 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

3.4.1.1 Energy Ramp Rates

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.

3.4.1.2 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.

3.4.1.3 Lead Time- Hot, Warm and Cold

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

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 participant must provide *minimum generation block run-time* and supporting documentation with recommendations from the OEM on minimum time required for the resource.

3.4.1.6 Minimum Generation Block Down Time

Market participant must provide *minimum generation block down time* and supporting documentation from the operating and maintenance manual for their resource that state the minimum number of hours after being dispatched below MLP after which the resource can reach MLP again.

3.4.1.7 Maximum Number of Starts per day

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

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

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 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.

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 estimates for what *market participant*s 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 determine reference quantities for resources of different generation technologies and lists the applicable supporting documentation that are required from *market participants* to inform the determination of reference quantities.

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

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

4.1 Thermal

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

4.1.1 Energy

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

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

4.1.2 Operating Reserve

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

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

4.1.2.1 10-minute reserve (synchronized)

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

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

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

4.1.2.2 10-minute reserve (non-synchronized)

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

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

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

4.1.2.3 30-minute reserve (non-synchronized)

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

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

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

4.2 Hydroelectric

Hydroelectric resources use the following two different methodologies to determine reference quantities. The *IESO* uses the first methodology where maximum DEL data exists for use, and otherwise uses the second methodology.

The two methodologies are:

- for hydroelectric resources that submitted a maximum daily *energy* limit (DEL) for the prior *dispatch day*'s run of the DAM, the *energy* and *operating reserve* reference quantity is calculated by estimating the minimum available *energy* in the system, which should be available to provide *energy* and *operating reserve*; and
- for hydroelectric resources that did not submit a maximum DEL, the *energy* reference quantity is calculated from actual historical *energy* production profiles of prior years.

4.2.1 Methodology for Dispatchable Hydroelectric Resources that have Submitted a Maximum DEL

The following sections describe the methodology to establish reference quantities for hydro resources that have submitted a maximum DEL.
If multiple hydroelectric resources share a common forebay, and submit a common DEL that applies to multiple hydroelectric resources, then the *IESO* will determine a single *operating reserve* and *energy* reference quantity per *dispatch day* that will apply jointly to those hydroelectric resources.

4.2.1.1 Energy

One daily *energy* reference quantity is created for each *dispatch day*. The daily *energy* 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).

$$\text{Energy Reference Quantity (MWh)}_{N} = \text{Maximum Daily Energy Limit (MWh)}_{N-1} - \text{Day Ahead Energy Market Commitment (MWh)}_{N-1}$$

4.2.1.2 Operating Reserve

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).

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

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*.

4.2.1.2.1 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*.

4.2.1.2.2 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*.

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

4.2.2.1 Energy

The methodology to determine hourly *energy* reference quantities for hydroelectric resources that have not submitted a maximum DEL for a particular study date is based on the historical *energy* production of that resource and comprises the following steps:

1. Data for the same calendar date from the previous 7-years of *energy* production of the resource is collected for each hour in a *dispatch day*. For example, to determine the reference quantity for January 20, 2019, the historical data collected will include the hourly production at the resource from January 20, 2012 – 2018 for each of HE1 - 24.
2. If an outage or de-rate has occurred in any hour of the past seven historical years, the quantity of that outage or de-rate is added back to the hourly production identified. This creates an outage-adjusted hourly production MW value for each *dispatch hour* in the historical study period.
3. The value for each hour is divided by the nameplate capacity of the resource at the time of production to determine an hourly capacity factor for each *dispatch hour* in the historical study period.
4. These hourly capacity factors are grouped into two datasets; one for dates in the historical study period that were *business days*; one for dates in the historical study period that were not *business days*.
5. The average capacity factors for each hour in the *dispatch day* is determined for each dataset. For example, the average historical capacity factor for HE1, January 20, 2019 is the total of all capacity factors from HE1 January 20, 2012 – 2018 divided by the number of dates in the dataset.

a. The output consists of two datasets:
    i. A dataset that contains average historical capacity factor for each of HE 1-24 from the dates in the historical study period that were *business days*; and
    ii. A dataset that contains average historical capacity factor for each of HE 1-24 from the dates in the historical study period that were not *business days*.

6. The *IESO* determines if the study date (January 20, 2019 in our example) is a *business day*.
7. If the study date is a *business day*, the *energy* reference quantity for each hour of the *dispatch day* is the average historical capacity factor in the *business day* dataset multiplied by the installed capacity less planned outages of the resource for the corresponding hour. If the study date is not a *business day*, the corresponding non-*business day* average capacity factor is used instead in the same manner.

   $$\text{Energy Reference Quantity (MWh)} = \text{Average Historical Capacity Factor}_h \times (\text{Nameplate Capacity (MW)} - \text{Planned Outage (MW)}_h)$$

4.2.2.2 Operating Reserve

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

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

4.2.2.2.1 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.

4.2.2.2.2 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 and planned de-rate/outage (MW) of the resource.

4.2.2.2.3 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 planned de-rate/outage (MW) of the resource.

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

4.3 Solar

4.3.1 Energy

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

4.4 Wind

4.4.1 Energy

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

4.5 Nuclear

4.5.1 Energy

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

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

4.6 Energy Storage

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

- battery *energy* storage (lithium, flow, lead acid, etc.);
- compressed air *energy* storage;

- hydrogen *energy* storage; and
- gravimetric *energy* storage technologies (e.g. smart cranes, advanced rail, etc.).

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

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

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

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

4.6.1 Energy

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

4.6.2 Operating Reserve

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

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

4.7 Dispatchable Loads

Dispatchable loads can offer up to 100% of their dispatchable *energy* demand as *operating reserve*, subject to the minimum requirements for *operating reserve* service. As a *dispatchable load*, the *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 reserve*s for *dispatchable loads* involves the following three steps.

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

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

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

   a. If providing 10-minute reserve:

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

   b. If providing 30-minute reserve:

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

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

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

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

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

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

      Maximum Hourly OR Capacity = Dispatchable Energy Range

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

4.7.1.1 Resource Operating Schedule

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

4.7.1.2 Highest Forecast Hourly Load

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

4.7.1.3 Non-Dispatchable Portion of Load

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

4.7.1.4 Response Time Capability

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

4.7.1.5 Intra-Hour Variability of Load:

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

4.7.1.6 Other Considerations

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

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

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

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