DESIGN

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Renewable Integration Initiative

Variable Generation Dispatch Detailed Design Summary

This document describes the detailed design decisions of the Dispatch Technical Working Group (DTWG) and the Floor Prices Focus Group (FPFG)

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Table of Contents

Table of Changes

Reference (Section and Paragraph)	Description of Change

1. Introduction

1.1 Purpose

The purpose of this document is to describe the design decisions adopted by the IESO as stakeholdered by the Dispatch Technical Working Group (DTWG) and the Floor Prices Focus Group (FPFG). This document is expected to represent a complete statement of the design status at the time of issue.

For more detailed information on the stakeholdering of this design, particularly its development and rationale for the decisions described in this document, please visit the SE-91 webpages:

- Dispatch Technical Working Group – http://www.ieso.ca/imoweb/consult/consult_se91-DTWG.asp
- Floor Prices Focus Group – http://www.ieso.ca/imoweb/consult/consult_se91.asp

1.2 Scope

This document describes the detailed design relating to the integration of grid-connected solar and wind resources into the IESO *dispatch* process and the coordination of this *dispatch* with *flexible nuclear generation*, as stakeholdered with the DTWG and FPFG.

This document provides a functional overview of the DTWG and FPFG decisions, which will be described and will include market facing impacts to the extent that they are known.

1.3 Who Should Use This Document

This document is prepared for the following groups to use in order to help them understand the changes this design introduces to the *IESO-administered market*:

- *Market participants*, in order to assess the potential impact of the design on their businesses and operations;
- Members of Stakeholder Engagement 91 (SE-91); and
- The general public, in order to support discussions describing the DTWG and FPFG detailed design.

1.4 Assumptions and Limitations

While this document makes references to specific parameters that might be used in various processes, it does not convey any assumptions on the value of those parameters. These parameters will be set according to *IESO* policy and will be determined at a later date under the amended authority of the *market rules*.

This design summary assumes the use of current *market participant* interfaces to the greatest extent that is practical. However, current limitations of system capabilities and implementation of necessary system changes may alter this design.

This design summary is based on known *IESO* and *market participant* business requirements at the time of issue. As market manuals that reflect this design are developed and stakeholdered, they will become the primary documentation that will be used to communicate any design changes to *market participants*.

1.5 Conventions

Throughout this detailed design document, "we", "our", "us" refers to the *IESO* and unless otherwise stated, "you", "your" and "yours" refers to participants in the *IESO-administered markets*.

The following standard conventions are used in this document:

- Time in this design document is Eastern Standard Time (EST).
- We use the 24-hour clock and the 'hour-ending' (HE) convention to specify a particular hour. For example, HE19 or hour ending 19:00 is the hour that starts at 18:00 and ends at 19:00.
- The meanings of the italicized terms and acronyms used in this document are defined in Chapter 11 of the market rules.
- Double quotation marks are used to indicate titles of legislation, publications, forms and other documents.
- All prices (e.g. $/MWh) are in Canadian dollars.
- The term 'cost' used in subsequent sections refers to as-offered amounts, as submitted by *market participants*, to consume and produce *energy* in the *IESO-administered markets* (IAM). It does not represent the actual expenditures by a *market participant* to maintain or generate an electricity-related product.
- The term 'DTWG' refers to the Dispatch Technical Working Group. This group is responsible for enabling collaboration between the *IESO* and stakeholders to create a *variable generation dispatch* design.
- The term 'FPFG' refers to the Floor Prices Focus Group. This group is responsible for enabling collaborating between the *IESO* and stakeholders to create a *dispatch* order for baseload generation.
- The term 'RII' refers to the Renewables Integration Initiative. This project is responsible for sustaining reliable operation of the *IESO-controlled grid* (ICG) and promoting market efficiency of the *IESO-administered Markets* as renewable resources are integrated into the ICG.

1.6 How This Document Is Organized

This document is organized as follows:

- Section 2 of this document provides overviews and background for the DTWG and FPFG in the context of their terms of reference and objectives.
- Section 3 of this document describes the technical limitations and technical operating preferences of *variable generation facilities*.
- Section 4 of this document defines the *dispatch* data requirements for *variable generation facilities* and how *dispatch instructions* will be sent to these *facilities*.

- Section 5 of this document describes how the *IESO* will more accurately predict generation output from *variable generation facilities*.
- Section 6 of this document describes how the operating characteristics of *variable generation facilities* fit into the *IESO* scheduling processes.
- Section 7 of this document describes how congestion management settlement credits will be calculated for *variable generation facilities*.
- Section 8 of this document describes how floor prices and loss penalty factors will affect the *dispatch* of *variable generation facilities*.

– End of Section –

2. Dispatch Technical Working Group (DTWG) Overview

The DTWG was created to enable the *IESO* and stakeholders to collaborate on defining and describing the details surrounding *variable generation dispatch* design. The RII design principles related to *dispatch* provide the framework for the DTWG scope and objectives. As outlined in the DTWG Terms of Reference, the objectives of the working group are the following:

- To define the technical limitations for wind and solar generation *facilities* that must be respected by the *dispatch algorithm*;
- To define the *dispatch data* requirements (price/quantity pairs and ramp rates) for *variable generation facilities* and how *dispatch instructions* will be sent to these *facilities*;
- To define the appropriate *dispatch* compliance rules for *variable generation facilities*; and
- To define the conditions under which *variable generation facilities* are eligible to receive Congestion Management Settlement Credits (CMSC).

More information on the DTWG Terms of Reference is located here:
http://www.ieso.ca/imoweb/pubs/consult/se91/SE91-DTWG-Terms_of_Reference.pdf

The DTWG was also tasked with determining the impacts of *dispatch* tie-breaking for *variable generation facilities* and common floor prices following consultations with the Floor Prices Focus Group (FPFG). These impacts are included in Section 6, IESO Scheduling Processes.

2.1 Background

As part of the Renewables Integration Stakeholder Engagement (SE-91) process, 11 principles were derived to form the basis for the integration of renewable resources with the *IESO-administered markets* and the *IESO-controlled grid*. These principles can be grouped into three areas related to renewable generation:

- Forecasting;
- Visibility; and
- Dispatch.

From the 11 principles, the following principles relate directly to the *dispatch* of *variable generation* resources and one to both variable generation and flexible nuclear generation:

- "**Principle 7:** All variable resources connected to the *IESO-controlled grid*, and embedded variable resources that are registered *market participants*, will be actively dispatched on a five-minute economic basis."
- "**Principle 8:** *Variable generators* will operate within a compliance deadband when ambient conditions offer sufficient fuel."
- "**Principle 9:** *Variable generators* will be entitled to Congestion Management Settlement Credit (CMSC) payments."
- **"Principle 10:** The *IESO* may establish various floor prices for offers from baseload generators, i.e. wind, must-run hydro and nuclear, to ensure efficient *dispatches* during periods of local and/or global surplus baseload generation (SBG) events."

In support of these design principles, a discussion paper[1] for SE-91 discusses the technical, regulatory and public safety restrictions on dispatching baseload generation resources and proposes a *dispatch* order for these resources. This discussion paper formed the basis for consultation at the Floor Price Focus Group (FPFG) on the mechanism used to achieve the desired *dispatch* order.

– End of Section –

[1] http://www.ieso.ca/imoweb/pubs/consult/se91/se91-20111121-Dispatch_Order_Discussion_Paper.pdf

3. Variable Generation Technical Limitations

The DTWG design discussions began with consulting working group members regarding the technical limitations of *variable generation facilities*. DTWG group members were asked to provide information relating to the technical limitations on wind and solar generators that the *dispatch algorithm* must respect.

3.1 Technical Operation

Wind Facilities

Wind *facilities* prefer to operate only when ambient weather conditions allow them to generate above approximately 5-10% of the available capacity of their *facility*. Wind *facilities* cannot operate below this range without shutting down individual turbines, a process which, under certain conditions, can result in a longer return to service for these turbines.

Operation within the 5-10% range will be managed through the *offer* submission of *dispatch data* (see section 4, Dispatch Data Requirements). To better understand how *offer* submissions will determine the daily *dispatch* order, please see section 8, Floor Prices and Tie Breaking.

Solar Facilities

There are no technical characteristics or operating preferences that limit the ability to *dispatch* solar resources within their operating range.

– End of Section –

4. Dispatch Data Requirements

The *dispatch data* for a dispatchable resource includes three main elements:

- Price/quantity pairs;
- Ramp rates; and
- The *facility* to which this data relates.

Dispatch data allows the *market participant* (MP) to communicate how they wish their *facility* to operate and provides the scheduling algorithms with boundaries on how to *dispatch* the resource. As direct inputs to the *dispatch* algorithms, the *dispatch data* must accurately reflect the operational capabilities and technical limitations of the *variable generation* equipment.

Although there may be specific requirements relating to *dispatch data* parameters, variable *generators* will not be required to submit new types of *dispatch data* beyond what is already in place for other *dispatchable generators*.

4.1 Price-Quantity Pair Laminations

Dispatchable generators submit *offers* to supply *energy* to the *IESO-administered markets*. *Offers* consist of the quantities of *energy* that a *generation facility* is able to supply, as well as the prices at which the *generator* is willing to produce the offered quantities of *energy*. These combinations of price and quantity are referred to as *price-quantity pairs*.

The *dispatch data* quantity value will be submitted by the MP and shall reflect the maximum mechanical capability (i.e. assuming maximum wind potential) of the *facility* at the time of submission and updated as required by the *market rules*. The *dispatch data* price value will also be submitted by the MP and will reflect their economic considerations. However, the *dispatch data* price will be bound by the established floor prices described in section 8, Floor Prices and Tie Breaking.

The same number of *price-quantity pairs* available for other *dispatchable* resources will be available to *variable generation* resources. *Market participants* may include up to 20 *price-quantity pairs* within a single *offer*. The quantity parameters will reflect the capability of the facilities while the price value will be left to the discretion of the *market participant*. However, the price value will be limited by *MMCP* and established floor prices.

4.2 Ramp Rates

Ramp rates are a measure of the rate at which a *generator* can reduce or increase its MW output, expressed in terms of MW/minute. Along with being a component of the *dispatch data* submission, ramp rates are inputs to the DSO and Day-Ahead Optimization System (DAOS) algorithms. Ramp rates are submitted using megawatt breakpoints representing the level at which there is a change in the ramping capability of the *facility*. Each *offer* can include up to five sets of ramp rates. Submitting multiple ramp rate sets allow *dispatchable facilities* to ensure that their *dispatch instructions* reflect their actual ramp capability.

Wind Facilities

Ramp rates for control purposes are not necessarily the same rates that occur during wind change. This is similar to the characteristics of other generation technologies and is managed through the *dispatch data* submission. Typical ramp rates for wind resources are dependent on the *facility*.

Solar Facilities

A *facility*'s ramp rates are dependent on the equipment and size of the *facility* and also the direction of ramping.

There are five ramp rates (up and down) and breakpoints available to all *dispatchable* resources and these will be applicable to *variable generation resources* as well.

– End of Section –

5. Forecasting Variable Generation Output

From the time that *variable generation facilities* first started connecting to the *IESO-controlled grid*, their expected *energy* output has been derived from information provided to the *IESO* by the *variable generators* themselves. The *IESO* has implemented a new centralized forecasting service that will more accurately predict the generation output from wind and solar *facilities* in Ontario. Forecasts will be produced for all existing and future transmission-connected wind and solar *facilities*, and for distribution-connected wind and solar *facilities* with an installed capacity equal to or greater than 5 MW.

Centralized Forecasting will provide the *IESO* with two forecasts:

- 48-hour rolling forecast
- 5-minute forecast

The hourly forecasts for each *dispatchable variable generation facility* will be integrated into the day-ahead and pre-dispatch scheduling functions:

- Day-Ahead Commitment Process (DACP)
- Predispatch Constrained (PDC)
- Predispatch Unconstrained (PDU)

The 5-minute centralized forecast for *variable generation facilities* being provided to the *IESO* are to be integrated into the following Market Interface System (MIS) dispatching functions:

- Multi-Interval Optimization (MIO)
- Real-Time Unconstrained (RTU)

5.1 48-hour Energy Forecast

The 48-hour rolling forecast is utilized as an input to the DACP and both pre-dispatch sequences. This forecast is revised on an hourly basis at 20 minutes prior to the *dispatch* hour. The 48-hour forecast covers the period beginning at the top of the coming hour to 48 hours into the future. This time horizon was chosen to ensure the forecast encompasses both the Day-Ahead and Pre-dispatch timeframes regardless of when the forecast is received. Values provided in this forecast are hourly average values and have a 60-minute resolution. These hourly forecasts are specific to each *variable generation facility*.

5.2 5-minute Energy Forecast

The 5-minute forecast will be utilized as an input to the RTU and MIO sequences. This forecast will be available for each *dispatchable generator* and will be updated every 5 minutes. Values provided in this forecast are instantaneous values for each discreet 5-minute interval within the hour. The values provided for each resource are end-of-interval quantities (i.e. not 5-minute averages). The time horizon will span a rolling 24 intervals to ensure all possible MIO advisory intervals are encompassed by this forecast.

– End of Section –

6. IESO Scheduling Processes

The optimized solution that the *IESO* uses to satisfy the electricity demand and calculate the *market schedules* and clearing prices occurs in three separate scheduling processes:

- The Day-Ahead Commitment Process (DACP)[2];
- Pre-dispatch, both constrained and unconstrained sequences; and
- Real-time *dispatch*, both constrained and unconstrained sequences.

Scheduling *variable generation* resources within each process requires special consideration to account for the operating characteristics of these *facilities*.

Each *dispatch* period will create constrained schedules and shadow prices and for all timeframes using a variety of inputs, as described by the *market rules*. The *dispatch* solution, represented by the constrained schedule, for a *variable generation facility* will not exceed the minimum of the following:

- Amount of *energy* that the *variable generation facility* is expected to be capable of producing, based on the most recent *IESO* 5-minute forecast;
- *Dispatch data* submitted by the *variable generator*;
- Manual constraints that have been applied to the *facility*; and
- *Outages* or derates to the *facility* that have been submitted through the *IESO* outage reporting process.

However, a *variable generation facility* may be sent a *dispatch instruction* that is less than what the *facility* would have otherwise been able to produce based on its available fuel. Such dispatch instructions are a result of the security constrained economic solution for the *variable generation facility* and indicate that the *facility* is either uneconomic or that a transmission, security, or technical limitation is restricting its ability to produce *energy*.

6.1 Dispatch Obligation

The real-time *dispatch algorithm* will determine the need for the *variable generation facilities* to respond to *dispatch instructions*. A *variable generation facility* will only receive *dispatch instructions* when it is required to take action determined by the real-time *dispatch algorithm*.

Unless limited by the security-constrained economic solution, *variable generation facilities* will be given the flexibility to generate according to the ambient weather conditions. The *facility* will only be required to follow a specific MW quantity when *dispatch instructions* are sent from the *IESO*. All *dispatch instructions* sent by the *IESO* will indicate the action that the *variable generation facility* is required to take. This information is called the Obligation Indicator and has two possible values:

- **Mandatory**
- **Release**

[2] The Day-Ahead Commitment Process (DACP) does not calculate market schedules or market clearing prices, only constrained schedules and shadow prices.

Mandatory

This Obligation Indicator notifies the *variable generation facility* that it must adjust its *energy* output to the MW quantity specified in the *dispatch instructions* in order to be compliant with the security constrained economic needs of the system. These *dispatch instructions* must be actively acknowledged by confirming receipt and the intent to follow. This communication requirement is identical to the communication required from other *dispatchable* resources. Compliance is enforced within the compliance deadband unless, as with all *dispatchable* resources, such compliance would endanger the safety of any person, damage equipment, or violate any *applicable law*. If the *variable generation facility* is unable to comply with the *dispatch instructions* for these reasons, it has the option to reject them. Upon rejecting the *dispatch instructions*, a *variable generator* must follow up with a phone call to the *IESO* control room so alternate action can be taken.

When *dispatch instructions* are determined for any *dispatchable* resource, including *variable generation* resources, a filtering process is applied to minimize the number of *dispatch instructions* issued. This filtering process applies when the change from one set of *dispatch instructions* to subsequent *dispatch instructions* is not deemed material. *Dispatch instructions* will be automatically filtered and not sent to a *generation facility* if the change is smaller than the lesser of:

- 2% of the unit capability; or
- 10 MW.

Release

This Obligation Indicator notifies the *variable generator* that the *facility* is released from following specified *dispatch instructions* and that *energy* may be supplied from the *variable generation facility* to the *IESO-controlled grid* as ambient fuel conditions allow. The target MW output for these *dispatch instructions* is the 5-minute forecast value of the *facility*. The *market participant* is not required to generate to the target MW but to generate at whatever the fuel conditions allow. If the MP cannot achieve this target for reasons other than ambient weather conditions the MP is required to update the *dispatch data* to reflect the actual capability of the *facility*. This set of *dispatch instructions* must be actively acknowledged by confirming receipt and intent to follow.

If no acknowledgement of the Mandatory instruction or Release notification is received, the *IESO* Control Room receives an alarm. The *IESO* will contact the *variable generator* to determine the reason for the unacknowledged *dispatch instructions* and the *variable generator* may be considered non-compliant.

If, in the intervals that follow the release notification, the *variable generation facility* continues to be free to generate per available fuel, based on the security constrained economic solution, it will not receive *dispatch instructions* until such time as the *dispatch algorithm* produces *dispatch instructions* with a Mandatory Obligation Indicator.

6.1.2 Market Schedules

During intervals in which a *variable generation facility* is subject to a mandatory *dispatch instruction*, the *market schedule* for that *facility* will be bounded between 0 MW and the lesser of:

- the MP offered capacity of the resource;
- any *outage* or derate affecting the resource; and
- the *IESO* 5-minute centralized forecast quantity for that interval.

In all other intervals, the market schedule will be determined by a telemetry snapshot of the *facility's* output taken at the end of the interval.

6.1.3 Compliance Deadbands

"*Variable generators* will operate within a compliance deadband when ambient conditions offer sufficient fuel" (**Design Principle #8**).

Currently, all *dispatchable* resources are required to follow each set of *dispatch instructions* they receive within the margin of the compliance deadband. All *dispatchable* resources must generate within the *dispatch* compliance deadband unless such compliance would endanger the safety of any person, damage equipment, or violate any *applicable law*. In such cases, the *IESO* must be notified so that alternate action can be taken.

Given the technical limitations and unique operating characteristics of *variable generation facilities*, the existing definition of compliance deadband is sufficient to ensure compliance. Existing compliance deadband criteria are as follows:

- For *facilities* >= 30 MW, deadband is the greater of ± 15 MW or ± 2% of the *dispatch instructions*; and
- For *facilities* < 30 MW, deadband is ± 10 MW of the *dispatch instructions*.

The following are exceptions when applying compliance deadbands to *variable generation facilities*:

- Existing compliance deadbands for *dispatchable* resources will apply to *variable generation facilities* only while they are subject to mandatory *dispatch instructions*.
- Compliance deadbands will only be enforced when sufficient fuel (e.g. wind, irradiance) exists to achieve the *dispatch* target. In other words, if a *variable generation facility* were required to raise its output to generate within the compliance deadband, compliance would only be enforced if the weather conditions were such that the *generator* could actually achieve the target MW.

More information on compliance deadbands can be found at the *Market Rule* Interpretation Bulletin, located here:

http://www.ieso.ca/imoweb/pubs/interpretBulletins/ib_IMO_MKRI_0001.pdf

– End of Section –

7. Congestion Management Settlement Credits (CMSC)

"*Variable generators* will be entitled to Congestion Management Settlement Credit (CMSC) payments" (**Design Principle #9**).

A constraint is considered to have occurred when the real-time market schedule differs from the real-time constrained schedule. CMSC ensures that *market participants* who have been constrained on or off receive the total operating profit they would have received in the absence of the constraint.

Like other *dispatchable generators*, *variable generation facilities* who respond to *dispatch instructions* may be eligible for CMSC payments and the calculation of these CMSC amounts will be the same as for other *dispatchable generators*.

The CMSC calculation for *variable generation facilities* will have the following additional characteristics:

- Enabled in every interval subject to a mandatory *dispatch instruction*; and
- Disabled for the *dispatch* intervals that are not subject to mandatory *dispatch instructions*, including intervals for which a release notification was issued.

– End of Section –

8. Floor Prices and Tie Breaking

8.1 Floor Prices

"The *IESO* may establish various floor prices for *offers* from baseload *generators*, i.e. wind, must-run hydro and nuclear, to ensure efficient *dispatches* during periods of local and/or global surplus baseload generation (SBG) events" (**Design Principle #10**).

Table 8-1 lists the proposed *dispatch* order for various baseload *generation* resources:

Table 8-1: Proposed Dispatch Order for Baseload Generation Resources

Baseload Generation Resource
Flexible nuclear
Solar/Wind
Wind (last 10% of a facility's available capacity)
Baseload hydroelectric and nuclear

Due to the increased operational complexity when wind *facilities* are dispatched to low output levels (See Section 3, Variable Generation Technical Limitations), a separate floor price for the last 10% of a wind *facility's* available capacity was established. This distinct price will allow for the majority of a wind *facility* to be dispatched prior to full shutdown.

The final prices will be published in the appropriate market manual. The *IESO* will review these floor prices within six months of coming into force and periodically thereafter.

8.2 Loss Penalty Factors & Daily Dispatch Order

Upon designating floor prices to *variable generation facilities*, it is understood that for some constraints, such as SBG, certain *generators* will always be dispatched in their entirety while others will not. This *dispatch* order is based on the penalty loss factors associated with the injection point on the ICG.

If the *IESO* were simply to set all *variable generation facility* loss penalty factors to the same value, this would drive all *variable generation facilities* to be dispatched in proportion to their size, assuming that they are all priced equally. If all *variable generation facilities* are proportionally dispatched and the magnitude of the *dispatch instructions* are such that all are within the dispatched *facilities*' compliance deadbands, the required response may not be achieved, leading to real-time operational concerns.

To counteract this undesirable outcome, the *IESO* set the loss penalty factor for all *variable generation facilities* and will randomly select a daily *dispatch* order for these *facilities*. This daily *dispatch* order will drive the scheduling algorithm to fully *dispatch* each *variable generation facility* in sequence, rather than apportioning a share of the required *dispatch* across the entire fleet.

The daily *dispatch* order will be considered in the DACP, pre-dispatch and real-time scheduling processes. In order to avoid large changes in the *variable generation facilities* being dispatched at a time when surplus baseload generation is likely to occur, the *dispatch* order will change at HE16 each day.

This random daily *dispatch* order will span a 3-month horizon and will be updated on a schedule that coincides with *IESO* network model builds, which typically happens monthly. As daily *dispatch* orders are developed for months within the 3-month horizon, these new months will be appended to the existing list. As new *variable generation facilities* complete commissioning, they will be at the bottom of the order until a new month is published. The randomly-generated *dispatch* order will be published on the *IESO* website.

– End of Section –

References

Document Name	Document ID

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