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Market Manual 7: System Operations

Part 7.8: Ontario Power System Restoration Plan

Issue 21.0

This document provides the requirements, procedures and guidelines to be followed by those Market Participants that are Restoration Participants and the IESO to support and implement the Ontario Power System Restoration Plan

Disclaimer

The *Ontario power system restoration plan* (*OPSRP*) is the required operating procedure for the *IESO* and *restoration participants* to restore the power system and mitigate the emergency in the event of a partial or complete blackout. Actual *IESO* operations are based upon system conditions and prudent practice. System conditions may warrant deviation from written procedures. The *IESO* Superintendent – Operations will determine the need for such deviation.

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Related Documents

Document ID	Document Title
MDP_PRO_408	Market Manual 1.5: Market Registration Procedures (PRO-408)
MDP_PRO_0040	Market Manual 7.1: IESO-Controlled Grid Operating Procedures
IMO_PLAN_0002	Market Manual 7.10: Ontario Electricity Emergency Plan

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Reference (Paragraph and Section)	Description of Change
Throughout Document	Administrative updates (i.e., updates to personnel listed in document control authorities, department names, typo / grammar corrections, etc.).

1. Executive Summary

1.1 Introduction

Restoration after a blackout is a complex task that requires effective coordination, communication, and decision-making in the face of rarely seen *IESO-controlled grid*[1]configurations and operating conditions. Every disturbance is unique to the conditions of the day and the initiating cause. Exactly how the power system will respond, or the extent of any blackout following a disturbance cannot be predicted.

The *Ontario Power System Restoration Plan* (OPSRP) provides a framework to ensure that the *IESO* and *market participants* can collectively recover Ontario's *integrated power system* and re-establish interconnected operation. It provides the overall strategy, objectives, priorities, as well as restoration paths, and independent actions[2] for participants, while retaining the flexibility to meet the unique circumstances of any blackout.

In addition to providing a response framework, the OPSRP ensures preparedness through such requirements as:

- Individual and integrated equipment tests to meet Northeast Power Coordinating Council (*NPCC*) and Ontario-specific criteria
- Pre-defining communication protocols between the *IESO* and Key Facilities
- A process for *restoration participants* to submit and maintain essential restoration-related information and self-certify their preparedness
- A process for regular review of the OPSRP

1.2 Requirements

NERC/NPCC

The OPSRP meets all restoration-related North American Electric Reliability Corporation (NERC) and Northeast Power Coordinating Council (NPCC) requirements.

Ontario

The *Electricity Act, 1998* describes the obligations of the *IESO* and participants to file emergency plans. These requirements are reflected in *Market Rule* Chapter 5, Section 11, which describe how the *IESO* maintains and implements the OPSRP and how participants support it.

[1] In this market manual, 'grid' means the IESO-controlled grid.

[2] Refer to Section 16: Definitions

Electricity Act, 1998

1) *The Minister shall require the IESO to prepare and file with the Minister such emergency plans as the Minister considers necessary.*
2) *The Minister may require a market participant to prepare and file with the Minister such emergency plans as the Minister considers necessary.*
3) *The IESO shall assist in coordinating the preparation of plans under subsections (1) and (2).*
4) *The Minister may direct the IESO or a market participant to implement an emergency plan filed under subsection (1) or (2), with such changes as the Minister considers necessary.*

1.3 Roles and Responsibilities

In consultation with affected *market participants* the IESO:

- Prepares and reviews the OPSRP
- May establish criteria beyond other standards authority requirements if needed to support grid restoration capability

– End of Section –

2. Restoration Participant Criteria and General Obligations

2.1 Applicability

The following criteria identify facilities that can impact the restoration process. The *IESO* assesses each *market participant*'s facilities against these criteria to determine which participants must be *restoration participants*. Some criteria are specific to a participant class; other criteria apply to all. A *restoration participant* that uses agents to operate any of its facilities is still obligated to meet the *restoration participant* obligations for those facilities.

2.2 Criteria

2.2.1 Transmitters

All *transmitters* are *restoration participants* because they own the facilities that comprise the grid.

2.2.2 IESO

The *IESO* is a *restoration participant* due to its role in restoration.

2.2.3 Generators

Generators that meet any of the following criteria are restoration participants:

- Own Key Facilities[3]
- Have the capability and intent, following a disturbance, to operate separate from the grid in a sizeable electrical island to supply priority customer loads
- Own breakers that are not restoration-related breakers[4], but that the *IESO* deems necessary to accomplish restoration
- Are directly connected to the grid and have the capability to parallel two or more *transmission system* high voltage circuits
- Whose *generation facility* is directly connected to the grid, and
    - Has an aggregate station capacity of:

      ≥ 100 MW if the *facility* is located electrically south of Barrie

      ≥ 50 MW if the *facility* is located electrically north of Barrie
    - Does not meet the capacity thresholds above, but is capable of providing voltage support during a restoration

[3] Refer to Section 16: Definitions

[4] Refer to Section 16: Definitions

- Whose *generation facility* is embedded, and
  - Has an aggregate station capacity of ≥ 100 MW, or
  - Has an aggregate station capacity of ≥ 50 MW and is connected via a dedicated feeder (i.e., one without any load)

2.2.4 Distributors

Distributors that meet any of the following criteria are restoration participants:

- Own Key Facilities
- Have the capability and intent, following a disturbance, to operate separate from the grid in a sizeable electrical island to supply priority customer loads
- Own breakers that are not restoration-related breakers[5], but that the *IESO* deems necessary to accomplish restoration
- Are directly connected to the grid and have the capability to parallel two or more *transmission system* high voltage circuits
- Whose *distribution system* contains or supplies (via another *market participant*) Key Facilities or critical power system loads[6]
- Whose *distribution system* is served by a *facility* that is directly connected to the grid:
  - Where they exercise direct operational control of a restoration-related breaker, and
  - That supplies a peak load of ≥ 20 MW.

  OR

  - Where they do not exercise direct operational control of restoration-related equipment, and
  - That supplies a peak load of ≥ 700 MW.

2.2.5 Connected Wholesale Customers

Connected Wholesale Customers that meet any of the following criteria are *restoration participants*:

- Own Key Facilities
- Have the capability and intent, following a disturbance, to operate separate from the grid in a sizeable electrical island to supply priority customer loads
- Own breakers that are not restoration-related breakers, but that the *IESO* deems necessary to accomplish restoration
- Are directly connected to the grid and have the capability to parallel two or more *transmission system* high voltage circuits
- Whose *facility* is directly connected to the grid, and
- Supplies a peak load of ≥ 20 MW, and
- Where they exercise direct operational control of restoration-related equipment

[5] Refer to Section 16: Definitions

[6] Refer to Section 16: Definitions

2.2.6 Electricity Storage Facilities

Electricity Storage Facilities that meet any of the following criteria are *restoration participants*:

- Own Key Facilities[7]
- Have the capability and intent, following a disturbance, to operate separate from the grid in a sizeable electrical island to supply priority customer loads
- Own breakers that the *IESO* deems necessary to accomplish restoration
- Are directly connected to the grid and have the capability to parallel two or more *transmission system* high voltage circuits
- Whose *electricity storage facility* is directly connected to the grid, and
  - Has a maximum withdrawal capability of ≥ 20 MW, or
  - Has a maximum injection capability of:
    - ≥ 100 MW if the *facility* is located electrically south of Essa TS in Barrie, or
    - ≥ 50 MW if the *facility* is located electrically north of Essa TS in Barrie, or
  - Does not meet the capacity thresholds above, but is capable of providing voltage support during a restoration
- Whose *electricity storage facility* is embedded, and
  - Has an aggregate station injection capacity of ≥ 100 MW, or
  - Has an aggregate station injection capacity of ≥ 50 MW and is connected via a dedicated feeder (i.e. one without any load)

2.3 Restoration Participant General Obligation

Restoration participants are obligated, within the design and safe operation of their facilities, to help restore the grid after a partial or complete system blackout. The *Ontario Power System Restoration Plan* applies to all *restoration participants* and specifies the requirements to successfully meet this obligation.

2.4 Planning Role

Restoration Participants must have a Restoration Plan Planning Coordinator, who is responsible for coordinating the restoration planning requirements of their *facilities* with the IESO. This function includes the responsibility to:

- Prepare and submit their restoration participant attachment (refer to Section 13 for details)
- Work with the IESO and other market participants to plan and participate in drills and exercises
- As applicable:
  - Coordinate with the *IESO* and their *transmitter* to plan and participate in integrated tests (black start and line energization)

[7] Refer to Section 16: Definitions

    - Report on their Critical Component testing program
- Participate in revisions to the OPSRP

The *IESO* recommends that the person fulfilling this role should have sufficient technical/operational background to act as a subject matter expert on the operation of their facilities.

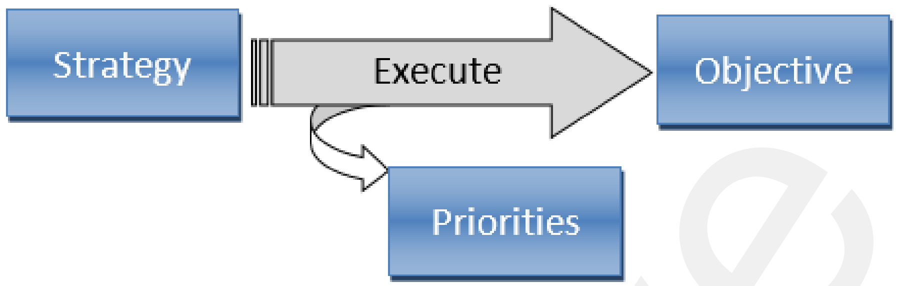
2.5 IESO General Obligations

The *IESO* is registered with *NERC* as Ontario's Reliability Coordinator, Transmission Operator, and Balancing Authority. These roles in conjunction with those set out in its license and the *market rules* obligate the *IESO* to:

- Direct system restoration, including the synchronization of islands and with external areas
- Work with restoration participants to achieve the OPSRP objective. Coordinate restoration with other Reliability Coordinators, which includes the authority to act as the point of contact for sharing information regarding restoration

– End of Section –

3. Restoration Plan Objective, Strategy, and Priorities



3.1 Objective

Following a blackout, our objective is to regain a reliable *integrated power system* by restoring the grid using the available equipment. In doing so, we must ensure that voltage, frequency, and power flows are controlled so that restoration does not damage customer or power system equipment or re-collapse the grid. We meet this objective through execution of the strategy.

3.2 Strategy

Following a major disturbance, the grid may be totally or partially blacked-out and may contain isolated electrical islands consisting of load and generation. The overall strategy is to:

- Stabilize any surviving islands
- Recover generation
- Energize transmission
- Restore loads
- Synchronize islands to each other and to the remainder of the Eastern Interconnection

Execution of the strategy should reflect the priorities and load restoration principles below.

3.3 Priorities

1. Restore grid-supplied power to all nuclear sites – to secure the *generation units* and make them available to assist in restoration as soon as possible
2. Restore grid-supplied power to critical power system loads at transmission and *generation facilities* – to supply *station service* to allow restoration to proceed
3. Restore grid-supplied power to critical power system loads fed from *distributors* – to supply telecommunications within their *distribution systems* needed to facilitate restoration
4. Restore loads needed to control voltage and reload *generation units*

5. Synchronize islands to each other and the broader *Interconnection*

Note that the strategy cannot be compromised to meet the priorities at the expense of the objectives. For example, although restoring power to nuclear sites is the number one priority, we will first need to restore some critical power system loads to enable this outcome.

3.4 Load Restoration Principles

Although the ultimate goal is to get back to normal and restore all Ontario load, the early stages of restoration are focused on restoring the *transmission system* and recovering generation. Load is only re-supplied for three reasons in the early stages of restoration:

- Critical power system loads - Loads essential to perform restoration.
- Voltage control - Unloaded or lightly loaded transmission lines act as capacitors and increase voltage on the system. As transmission is energized, load is often required to help keep voltage within limits.
- Reloading generation - Surviving large thermal *generation units* (fossil and nuclear) need to be reloaded as soon as possible after the disturbance, otherwise the thermal stresses and other physical limitations can slow recovery or prevent them from recovering. So after the transmission path to these *generation units* is built, they must be reloaded as quickly as possible, typically using large blocks of load.

Critical power system loads are re-supplied first as transmission is energized along a path. Once these are taken care of, other loads can be added to provide voltage control or to allow *generation units* to reload.

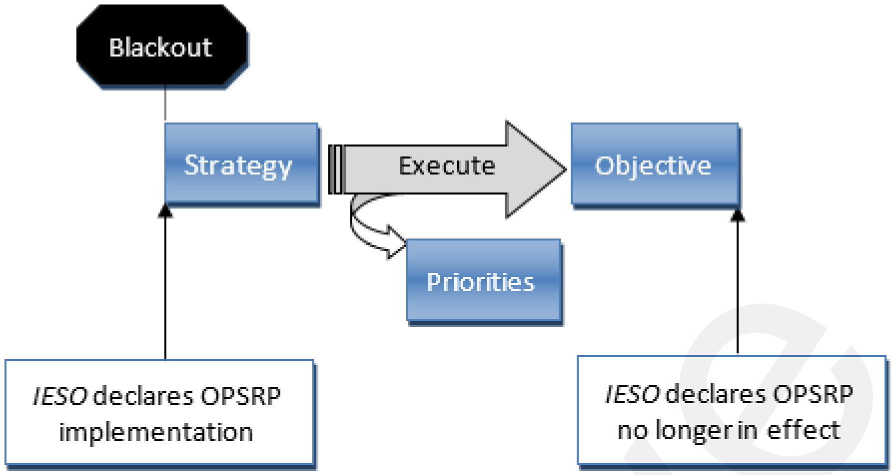
3.5 Priority Customer Loads

Some customer loads are especially important to supply and should be re-supplied as soon as practical after a blackout. The interruption of these priority customer loads can have undesirable impacts on health and safety and the environment. The *distributor* or *connected wholesale customer*, in consultation with their *transmitter*, identifies these loads ahead of time. *Transmitters* can also designate priority customer loads. Priority customer loads are excluded from rotational load shedding schemes and are normally re-supplied ahead of any non-designated load.

The urgency in restoring a priority customer load depends on the specific circumstances of the interruption, such as how long it has been off, the consequence of it remaining unsupplied, and how effective any mitigation efforts have been. Priority customer loads[8] will be resupplied at the earliest opportunity, provided that this does not significantly delay achieving the restoration plan objectives or priorities.

[8] Refer to Section 16: Definitions

3.6 Achieving the Objective



The *IESO*[9], at the discretion of the on-shift Manager–Operations, is responsible for declaring the OPSRP in effect after assessing the conditions during and after a partial or complete blackout. The on-shift Manager–Operations is also responsible for declaring when the OPSRP is no longer in effect, which occurs when the overall objective has been met, i.e.:

- Available transmission has been restored, and
- Available generation has been recovered, and
- Major islands have been synchronized to each other and the Eastern Interconnection, and
- Load restoration has progressed to the point where the choice of load to restore is not driven by the need to restore critical power system loads, or to control voltage or frequency.

Note that even when the objective is met, an *emergency operating state* may still exist. The management of the *emergency* and the return to normal conditions is covered under other operating procedures, such as Market Manual 7.1: IESO-Controlled Grid Operating Procedures.

– End of Section –

[9] Refer to Section 5.3 for more detail

4. Restoration Guidelines

Figure 1 illustrates the IESO's overall restoration strategy.

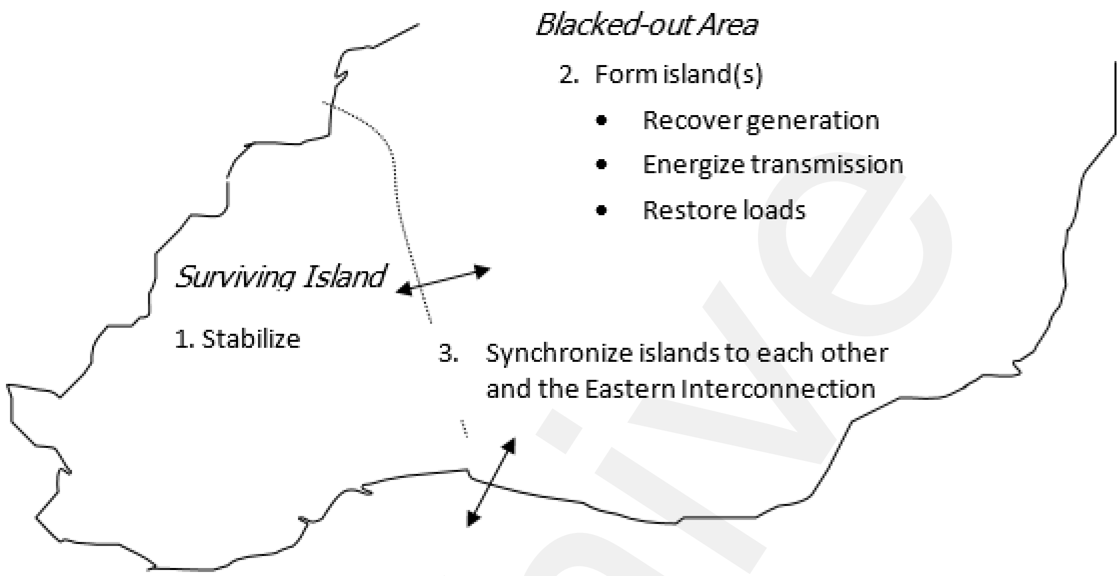


Figure 1: Restoration Strategy

4.1 Stabilize Islands

Post-disturbance electrical islands often experience abnormal ranges of frequency and voltage. Immediate steps, following approved operating procedures, must be taken to stabilize these surviving islands, that is, actions to ensure they operate within normal frequency and voltage tolerances. This includes:

- Determining the extent and conditions of any isolated area(s)
- Adjusting:
    - Reactive resources to manage voltage
    - Interchange flows and/or schedules, if needed
    - *Generation units'* real power output and/or shedding load to achieve a sustainable frequency, if needed

4.2 Recover Generation

In blacked-out areas, the first stage of restoration is the black-starting of available *generation units* and the stabilization of surviving *generation units*, which are separated from the grid and are at synchronous speed or carrying a small amount of local load.

The IESO expects:

- *Generator* operators who are restoration participants to act immediately and independently to stabilize and secure their units, regardless of whether the *generation units* have survived or tripped off-line; and
- *Certified black start facility* operators to independently start those units and energize their *station service* bus to supply their *station service* as soon as possible.

The IESO recognizes that surviving fossil and nuclear facilities must be loaded to respective minimum load points as soon as possible to ensure they remain available to support restoration. This may include providing their own unit service. Failure to respect these minimums may mean loss of the *generation unit* (poisoned out nuclear units) or very slow reloading times.

4.2.1 Wind and Solar Generation

Wind and solar power are becoming more prevalent forms of generation, and have unique characteristics that must be considered during restoration. Wind and solar generators have variable outputs that are a function of wind speed or irradiance, respectively.

Wind and solar *generation facilities* can be *IESO-controlled grid connected facilities* or *embedded generation facilities* into *distribution systems*. All *IESO-controlled grid connected generation facilities* and some *embedded* wind and solar *generation facilities*[10] receive *dispatch instructions* from the *IESO*. The *IESO* has limited visibility over *embedded* wind and solar *generation* that are not *registered market participants*.

Normally, automatic controls, within a generation facility, vary the output as a function of wind speed or irradiance according to the *generation facilities'* capabilities and if applicable, *dispatch instructions* issued by the IESO. The variability of output is not a concern when the system is in a normal state, but can be problematic during early stages of restoration, particularly when trying to stabilize or synchronize islands. The *IESO* will consider the following guidelines for both *connected* and dispatchable *embedded* wind and solar generation during a restoration:

- In electrical islands:
  - The wind and/or solar generation capacity (MVA) should not be counted as part of the island's generation capacity when determining the amount of load that can be added or whether they can be safely disconnected.
  - *Disconnect* wind and solar *generation* if their varying outputs cause unacceptable voltage or frequency deviations.
    - *Disconnecting* all wind and solar generation at once may cause the island to collapse if their output exceeds 5% of the island's *generation capacity*.
    - *Disconnect* wind and solar generation in blocks. Compensate with other generation or load shedding to maintain frequency.
- In blacked-out areas:
  - Ensure wind and solar *generation facilities* are disconnected and leave them out of service until the latter stages of restoration.

[10] Non-*registered participants* and *embedded* Wind and Solar *generation facilities* < 5 MW are not dispatchable.

4.2.2 Electricity Storage

The *IESO* will consider the following guidelines for both *connected* and dispatchable *embedded electricity storage facilities* during a restoration:

- In electrical islands:
  - The electricity storage generation capacity (MVA) should not be counted as part of the island's generation capacity when determining the amount of load that can be added or whether they can be safely disconnected.
  - Disconnect any *electricity storage facilities* if their operation (either injection or withdrawal) causes unacceptable voltage or frequency deviations.
    - Disconnecting all electricity storage facilities which are injecting at once may cause the island to collapse if their output exceeds 5% of the island's generation capacity
    - If the disconnection of *electricity storage facilities* that are injecting is required, disconnect in blocks. Compensate with other generation or load shedding to maintain frequency.
- In blacked-out areas:
  - Ensure *electricity storage facilities* are disconnected and leave them out of service until the latter stages of restoration.

4.3 Energize Transmission

4.3.1 Energizing Capability

A *generation unit's* ability to energize transmission circuits is a function of its excitation system, as represented by its generation capability curve. As a rule of thumb, a transmission line can be safely energized when the available capability of the connected *generation units* is 20% greater than the line charging MX. For example, a *generation unit* should have >120 MX spare reactive capability to safely energize a transmission line with 100 MX charging current.

Generation unit terminal voltages may have to be reduced to offset the anticipated voltage rise. However, they must not be reduced to the point where under-excitation protection trips the *generation unit* when the line energization is attempted. *Generators* should check their capability curves after they have performed any terminal voltage reductions to ensure they have sufficient margin to meet the rule of thumb. *Generators* must also consider the impact on *station service* voltages and other local transient limitations.

4.3.2 Voltage Rise

Local bus voltages and line-end-open (LEO) voltages can rise dramatically when energizing unloaded or lightly loaded transmission circuits. Both must be managed to avoid exceeding equipment limitations.

Local bus voltage rise at the energizing station cannot be accurately predicted, as it is a function of:

- The electrical distance from generation (series impedance),
- The line charging current, and

- The type of excitation system on the connected generating units.

These factors vary greatly depending on the specifics of the post-disturbance system. The rule of thumb is based on studies that indicate the worst case bus voltage rise is 1 kV for every 4 MX charging current, regardless of the voltage level.

Once the energizing terminal voltage settles out from the rise in initial bus voltage, the Ferranti effect will increase LEO voltage. The following graphs are used to anticipate LEO voltage rise as a function of line length and nominal voltage. The vertical axis indicates the kV rise at the open end of the line. The graphs do not apply to composite (overhead/cable) circuits or circuits constructed for a higher nominal voltage class than they operate (e.g., a circuit strung for 500 kV operating at 230 kV).

For example, when energizing a 100 km, 230 kV circuit, with 24 MX charging current and an initial local bus voltage of 240 kV, you would anticipate:

- Local bus voltage rise = 24/4 = 6 kV (worst case)
- Local bus voltage = 240 + 6 = 246 kV
- LEO voltage = 246 + 2 = 248 kV (use Figure 3: 230 kV LEO Voltages)

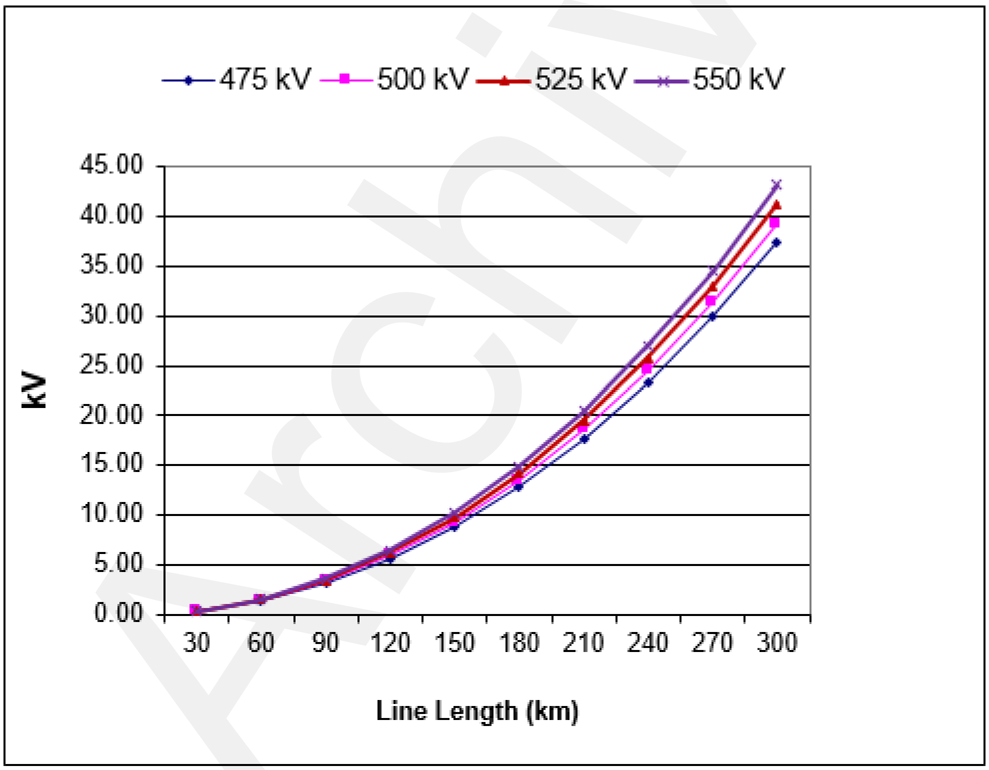


Figure 2: 500 kV LEO Voltages

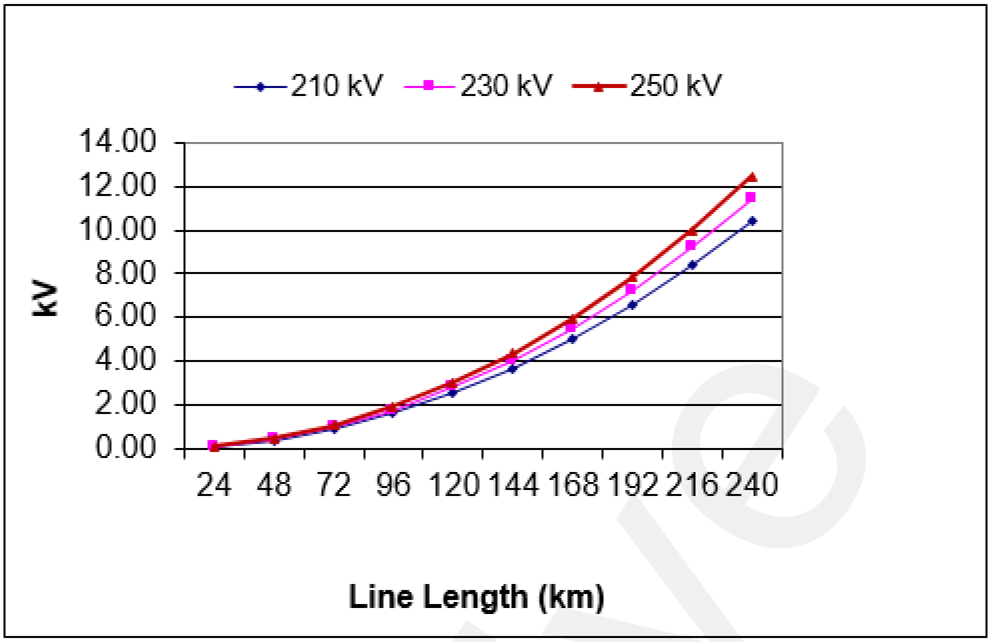


Figure 3: 230 kV LEO Voltages

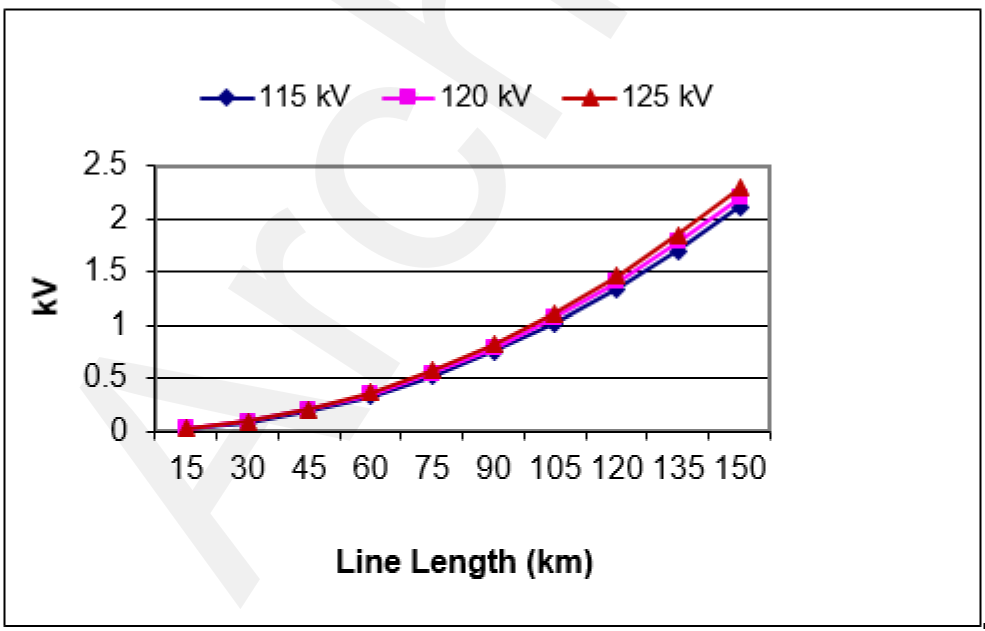


Figure 4: 115 kV LEO Voltages

4.4 Load Restoration

In the early stages of restoration, load is restored solely to maintain an acceptable voltage profile and to ensure the survival of nuclear and fossil *generation units* so they will be available for subsequent phases of restoration. Nuclear units are unavailable to the grid for a minimum of 36 hours if they are allowed to poison out.

Priority is given to re-establishing supply to generation, transmission sites and telecommunications to secure operator voice and teleprotection communications so that restoration can proceed. With input from *transmitters*, the *IESO* maintains a list of key telecommunications sites.

The maximum load block that can be restored in an island is a function of the available generation (inertia and governor response). The rule of thumb for restoring load in an island is that the maximum amount of load to be energized in a single switching operation must not exceed 5% of the connected *generation units*' nominal MVA, assuming a starting frequency of slightly greater than 60 Hz[11]. This prevents a transient frequency decline to the level where underfrequency load shedding relays would operate.

Island frequency is very sensitive to load and generation changes, so they must be carefully controlled. Load restoration must not exceed the rates specified by the affected *generator* operators. Similarly, the type, rate and amount of load being restored must be controlled by the *restoration participant* who has direct operational control of the restoration- related breaker.

When restoring load, the initial amount of load drawn by a given feeder will increase in proportion to the length of time the load has been off-potential (cold load pick-up). To mitigate this unknown, follow these practices:

- Maximize the amount of synchronized generation to increase inertia in the island before adding load. This limits frequency step-changes and oscillations
- Restore relatively small blocks of load.
- Wait for voltage and frequency to stabilize before picking up the next block of load.

4.5 Dynamic Reserve

Dynamic reserve is reserve that automatically responds to a frequency deviation. It is provided by *generation unit* inertia and governor action on connected *generation units* and load armed to trip via under frequency load shedding relays. The *security* of an island is greatly improved when there is sufficient dynamic reserve to cover the loss of the single largest *generation unit*.

4.6 Starting Synchronous Machines

Synchronous condensers and pump *generation unit*s (in pump mode) are large induction motors that draw high currents when they are started (up to 5 times full load current). The resulting voltage

[11] Hydroelectric *generation units* generally exhibit lower inertia coefficients than thermal-based generation. In hydroelectric-based islands only, to prevent activation of the first stage underfrequency load shedding relays (59.5 Hz), slightly higher island frequencies may be directed by the IESO prior to adding load blocks using the 5% rule of thumb. Additional options include using smaller load blocks (3% of units' nominal MVA) or, if *generation units* are available, increasing the capacity (MVA) of the island.

and current transients (especially across-the-line start machines) can pose a significant threat to island *security* during restoration. Consequently, starting synchronous machines should be deferred to the advanced stages of restoration and reduced voltage start machines should be placed in service before across-the-line start machines.

When a synchronous machine is started the nominal MVA capacity of synchronized *generation units* in the island should be 20 times greater than the nominal MVA rating of the synchronous machine. For example, there should be 600 MVA capacity of synchronized generation in the island before starting a synchronous machine rated at 30 MVA.

4.7 Synchronizing Islands

Both simulations and experience show that the probability of successful synchronization of islands is enhanced when the following guidelines are used.

4.7.1 Closing Transient

The closing transient phenomenon occurs in the first few milliseconds after the synchronizing breaker is closed. A near instantaneous current surge occurs across the breaker due to the difference in voltage that exists just before the breaker is closed. This voltage difference may be due to differences in peak voltages and/or differences in phase angle between the two islands, which may be as large as two per unit.

The current surge is limited by the series impedance of the synchronizing path between the systems. A high voltage difference in conjunction with low series impedance can result in current surge magnitude approaching that of a fault.

To minimize the current surge when synchronizing islands, choose a path that maximizes series impedance, and ensure the voltage difference is kept to a minimum.

The following rules of thumb are recommended:

- Synchronize at locations electrically remote from major generation
- Synchronize at 230 kV rather than 500 kV
- Use longer lines for synchronizing: greater than 50 km for 230 kV and greater than 100 km for 500 kV
- Avoid synchronizing islands using 230 kV lines shorter than 30 km
- Ensure voltage difference across the synchronizing breaker is as close to zero as possible

4.7.2 Synchronizing Transient

Immediately following the closing transient, there is transfer of *energy* across the synchronizing breaker as the two islands establish an *energy* balance. The speed and amount of the *energy* transfer is proportional to the frequency difference between the islands. The speed difference is called the slip frequency.

At a slip frequency of 0.1 Hz the voltage phasors of the ‘incoming’ and ‘running’ islands are moving relative to one another at a rate of 36 degrees per second. This would appear on the synchroscope as the needle taking 10 seconds to complete one revolution. Islands must not be synchronized at slip frequencies greater than 0.1 Hz. This rule of thumb is a maximum value; successful synchronization and minimal system impact are achieved when the slip frequency across the synchronizing breaker is as close to zero as possible.

The 0.1 Hz slip frequency criterion is as stringent as that used in the auto synchronizing schemes at nuclear and fossil stations. Also, where programmable synchrocheck relay schemes are used at transmission *facilities* they are set at a slip frequency of 0.1 Hz or less.

4.7.3 Post-Synchronization Frequency

Transient power flows take place between the newly synchronized islands due to load/generation imbalances as they seek to reach equilibrium. In the absence of any automatic control, these oscillations can grow to create an out-of-step condition and trip the synchronizing breaker. This outcome is mitigated by restoring additional transmission circuits between the islands as soon as possible (paralleling).

4.8 Interconnections

The *IESO* has *operating agreements* with all of Ontario's interconnected jurisdictions that describe mutual obligations for *emergency* assistance and the requirement to share *reliability-related information* to meet these obligations. During a restoration, the *IESO* will, in coordination with other Reliability Coordinators, determine the appropriate time to resynchronize the Ontario grid with external systems. This assessment requires the affected areas to share their current system status and develop the operating plan to be followed once the two areas are successfully synchronized. The principles for synchronizing the areas are the same as outlined in 4.7 above.

The *IESO* and the other Reliability Coordinators should share the following types of information about their areas:

- The magnitude of load and generation (island size)
- Largest contingency and available operating reserve
- Prevailing voltage and frequency ranges
- The adequacy of reactive reserves
- The progress of their internal restoration, including anticipated rate and timing of increases to island size
- Any plans to synchronize with other Reliability Coordinator areas
- Any known risks to the security of their islands (e.g., severe weather)

The operating plan to be followed once a portion of the Ontario grid has been successfully synchronized to an external area should consider:

- Regulation mode and interchange schedules (if appropriate)
- Which area(s) will provide regulation/frequency control
- Projected and acceptable power flows/ limits
- Control actions in case of a contingency on either system (including load shedding, if needed)
- Any conditions that would require the two systems to be separated to avoid re-collapse

Although resynchronization with the Eastern *Interconnection* is highly desirable, the timing for this step requires *IESO* judgment and must be made in the context of respecting the OPSRP's priorities and overall objective.

- End of Section -

5. Performing Restoration

Execution of the restoration strategy must be managed and coordinated. The *IESO* directs the restoration process using the procedures in this section along with Section 4: Restoration Guidelines.

Restoring grid-supplied power to nuclear *generation units* is the OPSRP's number one priority and is accomplished using established communication protocols along with mutually developed and agreed-to procedures, including Alternative Arrangements[12] and Enhanced Capabilities[13].

During restoration, voltage and frequency should be controlled within the ranges specified in the *IESO* grid performance standards[14] and to respect *facility* equipment ratings.

Restoration participants must follow the procedures in this section and apply approved *emergency* procedures as needed, such as manual load shedding for underfrequency.

Restoration participants must consider the impact on equipment, employee or public safety and the environment for any independent or *IESO*-directed actions they take.

5.1 Communication

During restoration, the activation of other *emergency response* organizations and their need for information can put an additional burden on operators. Operators must ensure that communications affecting real-time operation use normal operating channels.

Prompt communications between key *restoration participants* will ensure that resources are used most efficiently.

5.2 Opening Off-Potential Breakers

The following participant-specific sections detail how off-potential breakers should be opened in blacked-out areas. *Restoration participants* with direct operational control of a large number of breakers should prioritize which breakers to open first.

In the initial conversation with these participants, The *IESO* will communicate the intended restoration paths, including probable sources of potential. Breakers can then be opened in the most efficient sequence to expedite the restoration – typically all off-potential breakers on the restoration path, starting with the transmission and step-down stations closest to the potential sources. This does not preclude independent opening of all other off-potential breakers if there are sufficient resources to do so.

[12] As defined in section 5.6.

[13] Enhanced Capabilities are optional, pre-approved procedures available to, and directed by, the IESO to use at its discretion.

[14] Refer to *Market Rules* Appendix 4.1

Any exceptions or different arrangements to independently open circuit breakers, other than noted above, must be:

- Identified by the restoration participant,
- Approved by the IESO, and
- Documented within the restoration participant attachment.

It is acceptable to initially open the transformer secondary breakers at step-down stations, leaving the bus tie and feeder breakers closed until later in the restoration when load may be restored.

5.3 IESO Responsibilities

The *IESO* is responsible for assessing conditions during and after a partial or complete system blackout and:

- Declaring an emergency operating state
- Declaring the implementation of the OPSRP
- Advising restoration participants needed to implement restoration paths
- Declaring when the OPSRP is no longer in effect in an area and resuming normal operation, following approved operating procedures

5.4 Coordination Discussion with Transmitters

Following the post-disturbance assessment, the *IESO* will have an initial discussion with *transmitters* to share their plan, which will include sources of potential to begin restoration, restoration paths, number of paths to be restored simultaneously, and any other restoration-related priorities. This will help *transmitters*:

- Prioritize off-potential circuit breaker opening
- Assign staff to assist the IESO in restoration
- Address the need to send staff to remote facilities

5.5 Islands

The *IESO* directs operations to stabilize surviving electrical islands. This may include load shedding to achieve a sustainable operating frequency or collapsing an island in which frequency cannot be monitored or controlled. Post-disturbance actions are taken in accordance with approved operating procedures and Market Manual 7.1: IESO-Controlled Grid Operating Procedures. The *IESO* determines and directs which *generation facilities* are required to perform *regulation* (frequency control) for the electrical island being restored. Following the successful start of a *certified black start facility* this *regulation* role should be transferred to other *generation facilities* if they are available and better suited to this role.

Adequate distributed reactive regulation should be maintained throughout the system and reactive reserves maintained on *generation units* under automatic voltage regulation control. To maintain suitable voltage, the *IESO* balances reactive requirements using line charging, shunt capacitors, reactors and Static VAR Compensators (SVCs), if available. Selected SVCs under automatic controls are placed in service as soon as practical when energizing circuits to help manage high voltages [15]. The *IESO* directs the synchronizing of all electrical islands.

5.6 Alternative Arrangements

Alternative arrangements are tasks that can be assigned by the *IESO* to *restoration participants* to expedite restoration. Alternative arrangements require a *generator* and *transmitter* to act independently to achieve clearly defined objectives that are limited to specific electrical boundaries once initiated by *IESO* direction.

5.7 Transmitters

In addition to the independent actions described below, *transmitters* should take any other pre-approved independent actions to respond to emergencies as set out in the *market rules*, *market manuals* or local instructions (e.g., load shedding for low frequency or unacceptable voltage).

5.7.1 Independent Actions on Loss of Potential

Following a complete loss of potential to significant portions of their service territory affecting stations under their direct operational control, *transmitter* operators must independently take the following actions:

- Open all off-potential 500, 230, and 115 kV circuit breakers and step down transformer station transformer secondary breakers on the grid
- Open all off-potential capacitor, reactor and synchronous condenser circuit breakers
- Report conditions to the IESO

5.7.2 Prioritizing Off-Potential Breaker Opening

Until the *IESO* has had the initial coordination discussion with the *transmitters*, *transmitter*s should first open off-potential circuit breakers at transmission stations and step down transformer stations closest to:

- Certified black start facilities
- Surviving islands or other sources of potential that they are aware of

Once the plan for restoration has been communicated, the *transmitter* must adjust its breaker opening sequence to reflect the sources of potential and restoration paths the *IESO* specifies.

5.7.3 Air Blast Circuit Breaker Considerations

Large transmission stations consist of many high voltage air blast breakers and their supporting compressed air systems. *Transmitters* that own such assets must:

- Pre-determine the ability of the air systems to support multiple breaker operations

[15] In the early stages of restoration, SVCs can increase frequency decline when large load blocks are energized in one step. The impact of SVCs can vary depending on their location and the size of the island. Use of SVC's must be carefully considered to avoid potential adverse effects on island frequency.

- Adopt local operating procedures to monitor for problems and to mitigate any identified shortfalls in capability (e.g., use of a diesel generator)
- Include these measures in their *restoration participant attachment*

5.7.4 Potential Restored

Once potential is restored to step down transformer stations, *transmitter* operators must independently perform *station service* switching to restore key equipment such as communications *facilities*, high voltage cable oil pressurization systems and battery chargers.

5.7.5 IESO Direction

Under *IESO* direction, *transmitters* must:

- Perform *transmission system* switching to build electrical islands
- Perform restoration-related operating tasks the *IESO* assigns
- Perform *transmission system* switching required to synchronize islands to each other or to Ontario's *interconnections*

5.7.6 Other Roles

Transmitters that exercise direct operational control on behalf of a *distributor* must meet the obligations described in Section 5.8.

5.8 Distributors

5.8.1 Independent Actions on Loss of Potential

Distributor operators must independently take the following actions after a complete loss of potential to all stations under their direct operational control:

1. Open all off-potential transformer secondary breakers at step down transformer stations and distribution stations that are directly-connected to the grid. (i.e., tapped off circuits > 50 kV nominal)
2. If the *distributor* knows that the initiating disturbance is local - report conditions to the *IESO*.
3. If the *distributor* does not know the extent of the initiating disturbance they should take steps 4 and 5 before reporting conditions to the *IESO*.
4. Open all off-potential feeder breakers and bus tie breakers at step down transformer stations and distribution stations that are directly connected to the grid (i.e., tapped off circuits > 50 kV nominal) only as necessary to control cold load pickup. As necessary, adjust these actions to limit the impact upon your ability to restore station service.
5. Open all off-potential capacitor, reactor and synchronous condenser circuit breakers.

Distributors must not open low voltage *distribution system* breakers downstream from step down transformer stations unless necessary to control load pickup or cold load pickup. As restoration progresses, more generation becomes available and there is a need to frequently restore large blocks of load to ensure the generation remains available to continue the restoration. This is most efficiently accomplished by closing the breakers at step down transformer stations rather than by closing many breakers within a *distribution system*.

Any islands formed within a *distribution system* may continue to operate in this state provided that these islands do not impede the restoration activities. These islands may need to be collapsed at the discretion of the *IESO* prior to connecting to the transmission system in order to support system restoration.

5.8.2 Potential Restored

When potential is restored to a blacked-out station, *distributors* must independently perform *station service* switching at step down transformer stations and distribution stations to restore key equipment such as communications *facilities*, high voltage cable oil pressurization systems and battery chargers, subject to the following:

- Customer load must not be restored before the IESO's direction to do so
- The placing on potential of a low tension bus must not trigger automatic restoration of feeder load from another blacked out station via the distribution network
- Any companion transmission circuits must not be energized or paralleled via backfeed
- Station service switching does not delay any other key aspect of the restoration in progress

Normally, the configuration at *distributor* controlled stations does not allow this independent switching to take place without violating the restriction on picking up customer load. Under this circumstance, *distributors* should prioritize their feeder breaker loads so that when the *IESO* directs load restoration, these critical power system loads are energized first.

5.8.3 Load Restoration

Distributor operators must independently perform low voltage switching to restore load in amounts and at rates the *IESO* specifies directly, or as relayed through the *transmitter*. As load is restored, *distributors* must monitor voltage and ampacities. *Distributors* need to be aware of distributed energy resources connected within their system, in order to ensure that net load restoration amounts can be sustained, recognizing that gross load may be higher.

5.9 Connected Wholesale Customers

5.9.1 Independent Actions on Loss of Potential

Connected wholesale customer operators must independently take the following actions after a complete loss of potential to stations under their direct operational control:

1. Open all off-potential transformer secondary breakers at step down transformer stations that are directly-connected to the grid. (i.e., tapped off circuits > 50 kV nominal)
2. Report conditions to the *IESO*.
3. If the *IESO* identifies that the disturbance is widespread, the *connected wholesale customer* should take steps 4 and 5 before reporting conditions to the *IESO*.
4. Open all off-potential feeder breakers and bus tie breakers at step down transformer stations that are directly connected to the grid (i.e., tapped off circuits > 50 kV nominal).

5. Open all off-potential capacitor, reactor, and synchronous condenser circuit breakers.

5.9.2 Load Restoration

Connected wholesale customer operators must carry out low voltage switching to restore load in amounts and respecting any restrictions the *IESO* specifies directly or as relayed through their *transmitter*. As load is restored, *distributors* must monitor voltage and ampacities.

Initially only base loads should be restored (such as lights, heating, and essential loads including those required for safety). Once the *IESO* declares the system stable, process loads can be restored in amounts and at rates the *IESO* specifies directly or as relayed through the *transmitter*.

5.10 Generators

5.10.1 Abnormal Frequency

Refer to Market Manual 7.1: IESO-Controlled Grid Operating Procedures, Section 11.2: Generators Experiencing Abnormal Frequency.

5.10.2 Independent Actions on Loss of Potential

Generator operators must independently take the following actions following a loss of potential to a *generation facility* under their direct operational control:

- Open all off-potential unit and switchyard circuit breakers under a generator operator's direct operational control.
- Begin black start procedures for certified black start facilities – in conjunction, contact the IESO to determine the extent of the blackout. If the blackout is localized, the IESO may suspend black start procedures and use other parts of the grid to restore.
- Secure station service with any available generation units in accordance with local instructions and agreements. This may include restarting hydroelectric generation units to run them at speed-no-load by closing the unit breaker (using synch bypass or synchronizing to other units). If the unit breaker must be closed to pick up station service, operators must ensure they do not energize external transmission elements – transformer air break switches may have to be opened prior to closing the unit breaker.
- For generation facilities with the capability to energize-out via synch bypass, operators must stabilize units and prepare them to energize transmission circuits as directed by the IESO.

5.10.3 Other Post-Disturbance Considerations

Circuit energization and generating unit synchronization to the grid must only take place under *IESO* direction or authorization, except for hydroelectric *generation units* operating under abnormal frequency conditions as noted in Market Manual 7.1, Section 11.2.

5.10.4 Generator Actions during Abnormal Frequency

When directed by the *IESO*, a *generator* operator must regulate frequency to the specified frequency (normally 60 Hz or slightly above) by adjusting the governor of the designated *generation units*.

The *generator* operator must maintain unit voltages within the normal range and keep the *generation unit*'s automatic voltage regulator in service where possible.

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11. Black Start Requirements

11.1 General

Black start is the ability of a *generation facility* to start without power from grid-supplied *station service* or other *generation unit* support. The *IESO* procures *black start capability* through an *ancillary service* contracting process. These contracted *generation units* are *certified black start facilities* and must satisfy *NERC*, *NPCC*, and OPSRP requirements.

Following a blackout, *certified black start facilities* must be capable of:

- Being started by the *generator* operator in the absence of any communication with the *IESO*
- Energizing transmission in a defined area of the grid
- Providing power to facilitate the start-up of other generation capable of assisting in restoration
- Supplying the power requirements of its restoration path, which depend on the configuration and priority of connected loads and the need to supply load for voltage or frequency control

11.2 Number and Location

The *IESO* determines the need for *certified black start facilities*; ideally one in each of the four electrical areas. A *certified black start facility* can be located anywhere in an electrical area provided there is sufficient transmission capability.

11.3 Performance Criteria

The *IESO* assesses or tests each black start *facility* to certify it:

- Can start and deliver power without externally supplied *station service* or another *generation unit*'s support
- Can annually energize-out on its associated transmission circuit
- Has sufficient MW and MVAr capability to energize the required transmission circuits and supply the power requirements of its path
- Can sustain this MW and MVAr capability long enough to complete all required transmission circuit switching and start-up of other generation on its path capable of assisting in restoration
- Can complete at least three black starts in eight hours - due to the transients in an island, there is a possibility of re-collapse during a real event, so this capability is essential
- Can close its unit breaker to energize its associated transmission circuit within the time limits shown below:

Generation Type	Time to complete black start
Hydroelectric	30 minutes
Aero-derivative gas turbine	30 minutes
Industrial/Frame type gas turbine	60 minutes
Hot steam driven turbine	2.5 hours

The *IESO* assesses timelines for other generation technologies on a case-by-case basis. The *IESO* uses these times to assess black start performance under planned circumstances and stable system conditions. The *IESO* recognizes that during a restoration, *start-up times* may deviate from these due to the actual conditions following a system disturbance.

Test details are available in Section 12 'Testing'.

11.4 Other Requirements

The *restoration participant* operating a *certified black start facility* must:

- Ensure the *facility* has real-time frequency measurement that they can monitor in real-time
- Have reliable primary and alternate voice circuits between the black start control *facility* location and the *IESO*
- Have reliable primary and alternate control circuits between the black start *facility* and any remote control location
- Be capable of sustaining voice communication, telemetry, and control for eight hours without an external AC supply
- Maintain up-to-date written start-up procedures, which must be provided to the *IESO* within 14 days of a request, at no cost to us

11.5 Availability

Certified black start facilities must be available 98% of the hours in a year unless otherwise specified in the *ancillary service* contract. This allows an opportunity to perform maintenance on the *facility*. To ensure adequate *certified black start facilities* are available, all maintenance must be scheduled using the *IESO*'s *outage* management process.

- End of Section -

12. Testing

12.1 General

Prompt restoration depends on the successful response of equipment and people. Preparedness is ensured through regular equipment testing and the periodic practice of restoration procedures through drills and exercises. Successful restoration depends on the ability of station and auxiliary equipment to remain operable when normal AC *station service* is lost. *Restoration participants* should regularly test station auxiliary equipment in accordance with *good utility practice* to help assure its operability during a blackout. Additional diligence is provided through verifying the performance of Critical Components at Key Facilities and performing integrated tests, such as energizing off-potential circuits from certain *generation facilities*.

Restoration participants may request that the *IESO* consider an actual system event as a successful completion of one of the tests described below, as long as the event met the test's objectives, performance standards, and reporting requirements.

12.2 Critical Component Testing

NPCC Directory #8 System Restoration[16] contains the testing requirements for Critical Components at the Key Facilities that comprise the Basic Minimum Power System in Ontario. These requirements include the type of test, frequency, duration, and success criteria. Prompt restoration depends on the successful operation of Critical Components. Testing these components with an appropriate frequency gives reasonable assurance they will operate as required during an actual event.

The *IESO* is responsible for:

- Identifying Ontario's Basic Minimum Power System and associated Key Facilities
- Maintaining a list of Key Facilities, in consultation with affected asset owners
- Annually reporting the status of Ontario's Critical Component tests to *NPCC*

Participants with Key Facilities must:

- Identify their associated Critical Components
- Meet all testing requirements (*NPCC* and additional requirements described below)
- Report any failed tests or degradation of Critical Components to the IESO in real-time
- Self-certify their compliance via the Reliability Compliance Program

The time table below can be used as a general guideline to help manage Critical Component tests for compliance with *NPCC* test frequency requirements.

[16] NPCC Directories

Term	Time between tests should be…	Time between tests should not exceed…
Annually	at least 180 days	450 days
Semi-annually	at least 3 months	8 months
Quarterly	at least 7 weeks	18 weeks
Monthly	at least 15 days	39 days

12.3 Additional Testing Requirements

The following testing requirements are in addition to those specified by *NPCC*.

12.3.1 Supplemental Generators

Any supplemental *generation unit* that is required to support the start-up of a *certified black start facility* must be tested monthly. For example, certain hydroelectric *certified black start facilities* require a supplemental *generation unit* (usually a diesel) to supply *station service* to allow the head gates to be raised. A successful test requires the supplemental *generation unit* to start without grid supply, synchronize, and carry load for 15 minutes. This testing does not have to use the *IESO*'s *outage* management process.

The black start service provider must:

- Maintain local records of the test results, which we may audit. (Successful tests do not require any reporting to the *IESO*)
- Immediately report test failures to the *IESO*, including the expected remedial actions and an estimated time when the supplemental generator will be capable of meeting the success criteria
- Send the *IESO* a written report within one month of the failure

12.4 Certified Black Start Facilities

To satisfy their certification, *certified black start facilities* must be tested annually. A successful test requires the black start *generation unit* to start and re-supply its station service under the same conditions as expected under blackout conditions. Test scheduling must use the *IESO*'s *outage* management process[17] and provide sufficient lead-time to allow *IESO* staff to observe the test at the *facility*.

12.4.1 Test conditions

While isolated from all power sources and related *generation unit* support:

- The black start *generation unit* must start and re-supply its *station service* within the time specified in Section 11.3. This time is measured from the time *station service* is interrupted

[17] Market Manual 7.3: Outage Management

until it is re-supplied by the black start *generation unit*. The black start *generation unit* must then maintain acceptable frequency and voltage for 10 minutes, while isolated from the power system.

- Key operating aids and auxiliary systems, such as voice communications and control systems must be verified to operate adequately.
- Hydroelectric *generation units* must start from a shutdown state, with head gates fully lowered and governor systems depressurized to the alarm state.
- Fossil *generation units* must start while in the hot state. The turbine can be on turning gear, but all related support (such as cooling water) must be isolated from power supplies external to the testing unit.

The black start service provider must:

- Immediately report test results to the *IESO*
- Send the *IESO* a written test report within one month, which includes how the test was conducted, problems encountered, and the degree to which the test was a success

For failed tests, both the verbal and written reports must include the expected remedial actions, an estimated time to implement them, and a retest date.

12.5 Line Energization Tests

Following a blackout, *certified black start facilities* and other surviving *generation units* are used to reenergize the grid. Although off-line studies can be used to determine the feasibility of re-energization from these *facilities*, actual line energization tests are used to validate:

- Study results
- Operating procedures
- The effectiveness of operator training

In conjunction with the annual OPRSP review, the *IESO* updates the line energization test program in consultation with affected participants.

12.5.1 Certified Black Start Facilities

Certified black start facilities must perform a line energization test annually, which may be conducted in conjunction with their annual black start test. Test scheduling must use the *IESO*'s *outage* management process. If requested by the black start provider, the *IESO* will coordinate with other involved *restoration participants* to find a mutually acceptable time for the test.

A successful test requires the *certified black start facility* to energize the circuits designated in the test plan and maintain acceptable frequency and voltage at the remote end of the line for 10 minutes. During the test, the *certified black start facility* must be isolated from the power system and must supply its own *station service*. The *IESO* directs the energization of the circuits designated in the test plan.

Following the test, participants must verbally report the following to the *IESO*:

- Frequency
- Voltages at both ends of the energized line
- Any problems identified during the test

The *IESO* is responsible for determining the need for a written report and writing it. In support of this report and the *IESO*'s off-line studies, participants must submit the data identified in the test plan within 14 days of the test, when requested.

12.5.2 Other Generation Facilities

Following a blackout, any surviving *generation facilities* are expected to participate in subsequent restoration, to the extent that they are capable. In consultation with affected *restoration participants*, the *IESO* will pursue opportunities to conduct line energization tests with *generation facilities* that are capable of energizing off-potential circuits. Performance of these tests will only take place if all equipment ratings and limitations can be respected and the affected *generator* and *transmitter* agree with the test plan. Test scheduling must use the *IESO*'s *outage* management process.

A successful test requires the *generation facility* to energize the circuits designated in the test plan and maintain acceptable frequency and voltage at the remote end of the line for 10 minutes. During the test the *generation facility* must be isolated from the power system, but the *IESO* may waive the requirement that the *facility* supply its own *station service*. The *IESO* directs the energization of the circuits designated in the test plan. Following a successful line energization, the *generator* will decide whether to allow the *transmitter* to synchronize their unit back to the grid or take the circuit off potential.

Following the test, participants must verbally report the following to the *IESO*:

- Frequency
- Voltages at both ends of the energized line
- Any problems identified during the test

The *IESO* is responsible for determining the need for a written report and writing it. In support of this report and the *IESO*'s off-line studies, participants must submit the data identified in the test plan when requested.

12.6 Drills and Exercises

Scenario-based drills and exercises allow *restoration participant* operators to practice their response to disturbances. In addition, these sessions are used to identify equipment, procedure, and operating gaps that could impact a real restoration event.

The design and execution of drills and exercises is consistent with industry best practices and is described in the Emergency Drills and Exercises document.

The schedule, scope, objectives, and format for drills and exercises are developed through consultation with *restoration participants* and are endorsed annually through the Emergency Preparedness Task Force.

- End of Section –

13. Restoration Participant Attachment

13.1 General

All *restoration participants* must submit a *restoration participant attachment* to the *IESO*. *Restoration participants* are obligated to:

- Ensure that the attachment information is correct
- Inform the IESO if they discover any errors
- Review the attachment at least annually and submit a revised attachment or a statement asserting that the review was completed and no changes were required

Restoration participants submit their initial restoration attachments as part of the market entry process. The annual statement of review or revised attachment should be sent to the Reliability Compliance Program.

13.2 Content

Restoration participant attachments must contain the following information. For ease of preparation, a check box is provided beside each item that must be included in your attachment, as applicable.

13.3 Facilities

☐ All *facilities* covered by the attachment are identified

☐ All directly-*connected facilities* including control centres that are pre-wired to accept backup/portable generation and loads that can be supplied from this source are identified

☐ All *facilities* with permanently installed emergency power generators and loads that can be supplied from this source are identified

13.4 Limitations

Any known condition that would prevent or restrict a *facility* from performing in accordance with the OPSRP must be identified when the *restoration participant attachment* is filed. This allows alternate strategies and operator training to be developed to mitigate the risk. These limitations are normally identified during the *facility* registration process and must be reflected in the *restoration participant attachment* or other means as agreed to by the *IESO*. The *IESO* will help *restoration participants* determine whether a potential limitation should be included in the attachment.

☐ Limitations identified

Examples of limitations:

- Inability to synchronize islands, whether by SCADA control, relay supervision, or manually

- *Transmission system* circuit breakers that cannot be used as an open point between two electrical islands
- *Generation units* that cannot energize transmission lines, because they do not have synch bypass capability or cannot operate under-excited
- *Generation facility* circuit breakers under a *transmitter*'s direct operational control that cannot energize a transmission line by synch bypass

If a participant subsequently becomes aware of a *facility* limitation, they must report it using the normal protocols, e.g., directly to the *IESO* control room and through the *outage* management process. If the limitation is not of the type normally reported through these methods, they must report it to the *IESO* by the end of the next *business day*.

If the new limitation is expected to last for more than one week, the participant must:

- Submit a written notification to marketentry@ieso.ca within two weeks of its discovery
- Describe the limitation, its impact on restoration capability, and its expected duration

The *IESO* will help *restoration participants* determine whether an on-going limitation should be included in the restoration attachment. *Restoration participants* must immediately notify the *IESO* when any limitation is removed.

13.5 Testing Critical Components

Restoration participants with Key Facilities must meet the testing requirements described in the Testing section and must verify that they:

- Have a Critical Component testing program
- Have tested all their Critical Components in accordance with *NPCC* criteria
- Maintain test records

13.6 Supplemental Generation Supporting Key Facilities

Restoration participants with supplemental *generation units* that support Key Facilities must verify that they:

- Are able to place these *generation units* in service for their intended purpose, consistent with restoration plan priorities
- Have pre-arranged provisions to replenish fuel

13.7 Unattended Facilities

Restoration participants that operate *unattended facilities* on a restoration path must verify they:

- Have the capability to send staff to perform switching or troubleshoot problems that affect restoration.

13.8 Trained Operating Staff

Restoration participants must verify that they:

- ☐ Deliver a training program to operators, which includes their restoration obligations and expected actions, and is based on the equipment and tools that they operate
- ☐ Provide two hours of restoration-related training every two calendar years to their field switching personnel that perform unique restoration-related tasks that are outside their normal tasks
- ☐ Have shown due diligence in preparing their operators to fulfill their restoration obligations by ensuring they have *attended* restoration training within the last three years
- ☐ Maintain operator training records

Restoration participants that operate certified black start facilities must verify that they:

- ☐ Provide two hours of restoration-related training every two calendar years to any operating personnel responsible for performing startup of black start *generation units* and energization of the associated initial bus/circuit on the restoration path

13.9 Operating Agents

Restoration participants that use agents to fulfill any restoration-related operating obligations remain responsible for fulfilling those obligations, including training of the agents. In addition, the *restoration participant* must:

- ☐ Identify that agents are used and the *facilities* they operate
- ☐ Identify the agreements that govern the use of their operating agents

13.10 Contact Information

Restoration participants must provide the following contact information for their Restoration Plan Planning Coordinator:

- ☐ Name and/or position
- ☐ Phone number and email or mail address

Restoration participants must also ensure that their real-time *facility* location operator contact information is up-to-date. This is provided using the Online IESO Registration tool.

- End of Section -

14. Maintaining the OPSRP

14.1 OPSRP Review and Maintenance

The *IESO* is responsible for:

- Maintaining the OPSRP and ensuring that *restoration participants* receive all updates
- Performing an annual review of the OPSRP in consultation with *restoration participants*
- Verifying at least every five years through analysis of actual events, simulations, or testing that the restoration plan accomplishes its intended function
- Filing the current OPSRP with the *Minister*
- Having an independent audit of the OPSRP performed, when directed by the *Minister*

14.2 Reasons for Revision

The OPSRP may require revision for any of the following reasons:

- Changes to standards, operating policies, or procedures
- Changes in grid configuration, black start facilities, *market participant* organizations, or *applicable law*
- Recommendations from drills and exercises or analysis of actual disturbance events
- Audit findings

14.3 Coordination with Other Reliability Coordinators

The *IESO* is responsible for:

- Sharing any updates to the OPSRP with all neighbouring Reliability Coordinators, so they can identify any conflicts with their restoration plans
- Reviewing neighbouring Reliability Coordinator restoration plans for conflicts with the OPSRP

- End of Section -

15. OPSRP Training Program Guidelines

15.1 General

In order to meet the training obligations described in Section 13, *restoration participants* should consider designing their training programs to include the elements that support a systematic approach to training, namely:

- Task based learning objectives that:
  - Reflect the company specific restoration- related tasks operating staff are expected to perform to meet their obligations under the OPSRP
  - Address the required enabling knowledge - Includes the restoration plan objective, strategy, priorities, the role of the different types of restoration participants, and the relevant information for their participant type as described in Sections 5-10
- Verification – Assessment of knowledge transfer through some form of measurement such as tests, drills or exercises
- Training records

Participation in *IESO* sponsored restoration-related drills and exercises is recommended to help fulfill training requirements.

15.2 Training Topics

15.2.1 Applicable to All Restoration Participants

- Understanding of roles and responsibilities of the *IESO*, *generator*'s, *transmitter*'s, distributor's and *connected wholesale customer*'s operators
- Understanding of independent actions
  - Reasoning
  - Defined limitations of actions
- Understanding communications protocol during restoration
  - Normal communications
  - Contingency communications
  - Coordination of communications
- Understanding the priorities of the OPSRP
  - Restoration of critical *station service* loads
  - Restoration of customer loads to control voltage
- Understanding of the OPSRP principles and rules of thumb
  - Control magnitude of frequency excursions
  - Control magnitude of voltage excursions

15.2.2 Generators

- Operation and correction of sustained high or low frequency
  - Sustained operation >60.2 or < 59.8
  - Securing of *generation units*
- Operation and correction of sustained high or low voltage
  - Automatic *AVR* response
  - Manual *AVR* response
- Independent actions on complete loss of potential (to the generating station)
  - Open all off potential breakers under your direct operational control considering operator time constraints, station service resource limits, prioritized pathways and environmental conditions.
  - Report conditions
- Effect on units when energizing transmission lines
  - *Generation unit* capability curves
  - Local bus voltage limitations
  - Circuit charging currents
- Identification of critical *station service* loads
  - Class IV Power
  - Shared switchyard *station service* loads
- Effect of loading of unit(s) during load restoration at remote site
  - Load blocks
  - 5% rule of thumb[18]
- Communication needs
  - Loading rates
  - *Generation unit* operating curves
  - Station voltage limitations
- Frequency control
  - Governor set points
  - Load set points
  - Governor dashpot settings
- Parallel operation with a small number of units in an island
  - Governor speed droop

[18] Hydroelectric *generation units* generally exhibit lower inertia coefficients than thermal-based generation. In hydroelectric-based islands only, to prevent activation of the first stage underfrequency load shedding relays, slightly higher island frequencies may be directed by the IESO prior to adding load blocks using the 5% rule of thumb. Additional options include using smaller load blocks (3% of units' nominal MVA) or, if *generation units* are available, increasing the capacity (MVA) of the island.

    - Stabilizer/*AVR* interaction

- *Certified black start facility* procedures
    - Switching procedures
- Station specific operating instructions
    - Switching procedures
    - Equipment idiosyncrasies

15.2.3 Transmitters

- Independent actions on complete loss of potential to transmission stations or major portions of the *transmission system*
    - Open all off potential breakers under your direct operational control considering operator time constraints, station service resource limits, prioritized pathways and environmental conditions.
    - Report conditions
- Actions for securing *station service* if potential available
    - Battery chargers operable
    - Battery voltage acceptable
    - Priority *station service* loads restored
    - Back-up supply made available
- Calculations of line energization requirements (voltage and line charging currents) of circuits under their direct operational control
    - Operating Diagrams
    - Formulas
- Understand the coordination of switching and loading rates of units
    - Communication with the *IESO* and *generation facilities*
    - System configurations
- Paralleling procedures
    - Phase angle
    - Incoming vs. Running potential
    - Rotating scope
    - Adjusting generation
    - Flow across switch
    - Loading rates of *generation units*
    - Open-end voltage considerations
- PSR (Programmable Synchrocheck Relays) (understanding of changing read outs)
    - PSR commands (Abort, Sync Bypass, Execute Disable ON, Execute Disable Off)
    - Interface with RTU
    - Power supply
    - Potential value definition (‘incoming’ vs. ‘running’)

- Identification of critical *station service* loads
    - *Station service*
    - Telecommunication *facility station service* supply
    - Class IV power
- Station specific operating instructions
    - Switching procedures
    - Equipment idiosyncrasies
- Control Actions for abnormal frequency
    - UFLS relays – operation, connected load, reporting requirements, restoration
    - Manual Underfrequency Load Shedding
    - Independent action for declining frequency
    - Reporting
    - Restoration of load automatically interrupted
- Voltage control
    - ULTC's
    - 3 and 5 % voltage reduction
    - kV > 15 % below normal
    - kV 10 -15 % below normal
    - kV > 15 % above normal
    - kV 10 – 15 % above normal
- Loading rates
    - Restoration of load rules of thumb

15.2.4 Distributors

- Independent actions on complete loss of potential to step down transformer station(s)
    - Open all off potential breakers under your direct operational control considering operator time constraints, station service resource limits, prioritized pathways and environmental conditions.
    - Report conditions
- Control Actions for abnormal frequency
    - UFLS relays – operation, connected load, reporting requirements, restoration
    - Manual Underfrequency Load Shedding
    - Reporting

Restoration of load automatically interrupted

- Voltage control
    - ULTC's
    - 3 and 5 % voltage reduction
    - kV > 15 % below normal

    - kV 10 -15 % below normal
    - kV > 15 % above normal
    - kV 10 – 15 % above normal
- Loading rates
    - Restoration of load rules of thumb
    - Awareness of DER within their distribution system and its impact's on load restoration (Gross versus Net Load and Ramp rates of *generation units* and limitations)
- Identification of priority *station service* loads
    - *Station service*
    - Telecommunication *Facility station service* supply
- Station specific operating instructions
    - Switching procedures
    - Equipment idiosyncrasies
    - Micro-Grid operations

15.2.5 Connected Wholesale Customers

- Independent actions on complete loss of potential to step down transformer station(s)
    - Open all off potential breakers under your direct operational control considering operator time constraints, station service resource limits, prioritized pathways and environmental conditions.
    - Report conditions
- Voltage control
    - ULTCs
    - 3 and 5 % voltage reduction
    - kV > 15 % below normal
    - kV 10 -15 % below normal
    - kV > 15 % above normal
    - kV 10 – 15 % above normal
- Loading rates
    - Restoration of load rules of thumb
    - Awareness of load displacement generation within their system and its impacts on load restoration (Gross versus Net Load and Ramp rates of *generation units* and limitations)
- Identification of customers *station service* loads
- Station specific operating instructions
    - Switching procedures
    - Equipment idiosyncrasies

- End of Section -

16. Definitions

Note: For the purposes of this Market Manual 7.8, the terms referenced under the headings "Basic Minimum Power System", "Critical Component", and "Key Facilities" have the meanings ascribed to them in the *NPCC* Glossary of Terms.

Basic Minimum Power System (BMPS)

Consists of one or more generating stations, transmission lines, and substations operating in the form of an island for the purpose of initiating the restoration process

Critical Component

Equipment required for continued operation of a Key Facility in the event of a total loss of grid supply. Critical Components include but are not limited to the following:

- Generating units with black start capability
- Backup power supplies
- *Control centre* and telecommunication centre computer systems and computer room HVAC
- Telecommunications *facilities* backup power supplies
- Cable pressurization units
- Synchronizing systems

Critical Power System Loads

Critical power system loads are those loads essential to perform restoration. Critical power system loads include AC and DC *station service* loads necessary to operate power system auxiliaries at control centres, transmission, generating, and step-down transformer stations. In some cases, these loads are also found within *distribution system*s. Examples of the types of auxiliaries supplied as critical power system loads include telecommunications, protective relaying, monitoring and control systems. During a restoration, other loads may be designated as critical power system loads if they are needed to proceed with restoration, such as for voltage control.

Direct Operational Control

Direct operational control is the ability of a *restoration participant* to promptly operate equipment using remote or direct control, such as SCADA or hardwired benchboard control. Direct operational control does not mean the ability to locally operate equipment at its mechanism box or from a control room at an *unattended facility*, since neither of these options can occur promptly.

Distributed Energy Resource

A Distributed Energy Resource (DER) is any resource that is used to produce electricity or used for demand response and is connected to a Distribution System within the jurisdiction of a Distributor.

DER includes, but is not limited to, generation, storage, and controllable load resources. These DERs may connect directly to a distribution system or be located at an end user facility to serve or offset the customer's internal electric loads.

Energize-Out

Energize-out describes the capability of a generating unit to be able energize its switchyard and/or transmission lines to the grid.

Independent Actions

Independent actions are those operating actions required to enable power system restoration without prior communication to the *IESO* for approval.

Key Facilities

Facilities required to establish a Basic Minimum Power System following a system blackout. These facilities are essential to the restoration plan of the Reliability Coordinator Area and include generating stations having black start units and other selected generating stations, transmission elements which are part of the Basic Minimum Power System, control centers, telecommunication centers and telecommunication facilities. Such facilities are necessary to support Special Protection Systems, protection and control systems, voice and data between and within control centers and voice and data between control centers and key generating / transmission stations. Key Facilities include but are not limited to the following:

- Generating stations having black start capability
- Transmission facilities and generating stations
- Control and telecommunications centers
- Telecommunication facilities

Priority Customer Loads

Priority customer loads are important *consumer* loads that need to be restored promptly to mitigate the impact on public health and safety, the environment, or the economy. *Market participants* who are local distribution companies and *connected wholesale customers* need to identify their priority customer loads.

Restoration-related Breaker

A restoration-related breaker is any load interrupting device that is:

- Connected to the grid, including transformer secondary breakers, bus tie and feeder breakers at directly connected step-down transformer stations and,
- Is capable of being operated by direct operational control

Step down Transformer Station

A step down transformer station is one that is directly-connected to the grid and where power is reduced from *transmission system* voltage levels (≥50 kV) to sub-transmission or distribution voltage levels to supply load.

- Note for the purposes of the OPSRP, distribution stations are excluded from this definition unless they have secondary breakers/reclosers/load interrupting devices that are remotely controlled.

- End of Section –

17. References

Market Rules Chapter 5

Market Manual 7.1: IESO-Controlled Grid Operating Procedures

NPCC Directory #8: Restoration

NPCC Glossary of Terms

NERC EOP-005-3: System Restoration from Black Start Resources

NERC EOP-006-3: System Restoration Coordination

– End of Document –