804 OFF-NOMINAL FREQUENCY LOAD SHEDDING AND RESTORATION

1. Purpose

To provide policies for off-nominal load shedding and restoration in the Alberta Interconnected Electric System (AIES), and to define procedures for the System Controller (SC) in restoring load following the operation of the underfrequency load shedding (UFLS) scheme.

2. Background

Off-nominal frequency load shedding is required to maintain the stability of the transmission system in the event of major system disturbances. NERC and the WECC require transmission regions to implement a coordinated automatic UFLS program to help preserve the security of the generation and interconnected transmission systems during major declining system frequency events. Such a program is essential to minimize the risk of total system collapse, protect generating equipment and transmission facilities against damage, provide for equitable load shedding (interruption of electric supply to customers), and help ensure the overall reliability of the interconnected systems.

Load shedding resulting from a system underfrequency event should be controlled to balance generation and customer demand, permit rapid restoration of electric service to customer demand that has been interrupted, and, when necessary, re-establish transmission interconnection ties.

3. Policy

3.1 Design of UFLS

- The ISO is responsible for the design of the UFLS program for the Alberta balancing authority, and for ensuring that the program meets the applicable requirements of NERC and WECC.
- The UFLS program must meet the following criteria:
  - Sufficient load will be available to protect the system against the simultaneous loss of 1201L at maximum import plus the largest two-unit generating plant in Alberta.
  - A minimum of 31.1% of the connected load will be available for instantaneous shedding at any given time in accordance with WECC requirements to correct underfrequency decay. These five instantaneous load blocks, and the corresponding frequency and amount of load to be dropped, are listed in Table 1.
  - A minimum of 14 % of the additional connected load will be available for instantaneous shedding for AIES reliability. These two instantaneous load blocks are identified in Table 1 as "AIES Security 1" and "AIES Security 2" respectively.
  - A minimum of 6% of the additional connected load will be available for time-delayed shedding at any given time in accordance with WECC requirements to

correct underfrequency stalling. The three blocks assigned for time-delayed shedding are identified in Table 1 as D1, D2 and D3.

  - A minimum of 5.1% of the connected load will be available from the 59.1 Hz load shed block for automatic restoration at any given time in accordance with WECC requirements to correct frequency overshoot. The load blocks assigned for this purpose, with the associated pickup frequencies and delays, are listed in Table 2.
  - Underfrequency tripping of generators is coordinated with the UFLS program.

- Load required for the UFLS program will be contributed, on a proportional basis, by the Distribution Facility Owners (DFOs), at the frequencies assigned by the ISO.
- Additional load will be shed if there is insufficient generating capacity to restore system frequency following automatic underfrequency load shedding.
- Load shedding devices will meet the following requirements:
  - For instantaneous load shedding, total time delay to interrupt load will not exceed 14 cycles. This time delay includes underfrequency relay operating time and circuit breaker operating time.
  - All load shed blocks will be equipped with solid-state or microprocessor based relays.

3.2 Frequency relay requirements for Generation Facility Owners (GFOs)

- Underfrequency and overfrequency relaying that automatically disconnects generators from the AIES will not operate for frequencies in the range of >59.4 to <60.6 Hz.
- Underfrequency and overfrequency relaying that automatically disconnects generators from the AIES will have time delays equal to or greater than the values shown in Table 3.

3.3 Load restoration following operation of UFLS

- Automatic load restoration, where used, will meet the following requirements:
  - Delayed automatic load restoration must not begin until the system frequency reaches at least 59.95 Hz and maintains at least 59.95 Hz for a minimum of 30 minutes.
  - Load will be automatically restored in blocks no greater than 2% of customer load, provided the system frequency is stable at 59.95 Hz or greater. Each restoration block will be delayed for a minimum of five minutes following restoration of the previous block.
- Manual load restoration will be at the direct order of the SC, as generating capacity becomes available and, if necessary, the transmission system is restored.

3.4 Maintenance of UFLS program

- The load shed program for each DFO will be reviewed annually, and the results of the review will be provided to the ISO.
- The ISO retains the right to audit the UFLS program of any DFO.

- The ISO retains the right to audit the frequency trip settings, and associated time delays, for each generator of any GFO.

4. Responsibilities

4.1 ISO

The ISO will:

- Coordinate and ensure provincial compliance with NERC and WECC requirements relating to UFLS.
- Submit the compliance template related to UFLS to the WECC
- Design an UFLS program intended to meet the design criteria of Section 3.1.
- Review underfrequency settings and load levels annually to ensure appropriate and effective system protection.
- Ensure that the point of delivery (POD) contracts are updated to reflect current underfrequency load shedding settings.
- Review UFLS business processes annually, and update if required.

System Controller

The SC will:

- Coordinate load restoration with the DFOs.
- Coordinate restoration of the transmission system, if necessary.
- Coordinate restoration of tie lines, if necessary.
- Ensure the Brazeau units are restored to normal or pre-disturbance operation after an underfrequency event, if necessary.
- In order to render maximum assistance to systems in trouble, make every effort to remain connected to the interconnection. However, if the SC determines that remaining interconnected endangers the AIES, the SC will take the necessary action to protect the system, including separating from the interconnection.
- Issue ancillary service directives and/or dispatch generation, and shed additional load if there is insufficient generating capacity to restore system frequency following automatic underfrequency load shedding.

4.2 Distribution Facility Owners

The DFOs will:

- Contribute proportionally to the load shedding requirement as a condition of interconnection with the AIES, at the frequencies assigned by the ISO.
- Actively manage underfrequency blocks within the respective supply area.
- Determine the specific loads on which to apply UFLS.

- At their discretion, make arrangements with the Transmission Facility Owner (TFO) with whom they interconnect, or the DFO with the transmission service contract at the transmission point of delivery (POD), to have UFLS performed by transmission facilities. These arrangements would allow UFLS to be accomplished by opening substation distribution breakers upon operation of frequency-sensing devices located within the substation.
- Ensure that their load shedding devices conform to the requirements of Section 3.1.
- At their discretion, utilize delayed automatic load restoration. However, they must be able to disable it or reduce an equivalent amount of load elsewhere if directed by the SC. Automatic load restoration will meet the requirements of Section 3.3.
- Obtain approval, or by arrangement have the TFO obtain approval, from the SC for any manual load restoration. The DFO must contact the SC by phone to receive approval for each block of load to be restored.
- Annually review the load shed program for their facilities and report to the ISO the estimated load to be shed and to be automatically restored at each UFLS block. DFOs will provide a report to the ISO by April of each year detailing the magnitude in MW of peak load shed and peak load automatically restored at each POD, along with the associated relay setting. The analysis is based on Alberta annual system peak.
- Advise the ISO of any changes to the UFLS settings in a timely manner, no later than 14 days from the day of the change.
- Acknowledge the ISO's right to review the DFO's UFLS program at any time, to ensure that:
  - The DFO has armed at least the proportion of load required by this policy at the required frequency settings.
  - Load shedding devices conform to the requirements of this policy.
  - Auto-restoration policies and devices conform to the requirements of this policy.

4.3 Generation Facility Owners

The GFOs will:

- Ensure that underfrequency and overfrequency relaying that automatically disconnects generators from the AIES will not operate for frequencies in the range of >59.4 Hz to <60.6 Hz.
- Acknowledge the ISO's right to review the GFO's frequency load shed program at any time to ensure that:
  - Underfrequency and overfrequency relaying that automatically disconnects generators from the AIES will have time delays equal to or greater than the values shown in Table 3.
  - The underfrequency and overfrequency relays are set to trip at the frequency settings required in Table 3.
- Provide the ISO with the underfrequency trip settings and associated time delays, for each generator, upon request.

- Advise the ISO of any changes to the underfrequency or overfrequency trip settings for their generators in a timely manner, no later than 14 days from the day of the change.

5. System Controller Procedures

5.1 Underfrequency conditions

When the system frequency declines below the nominal value, the SC will:

1. Identify whether the disturbances that cause the underfrequency event occur inside or outside of Alberta. (Hint: an area control error (ACE) close to zero may suggest that the disturbances are outside of Alberta balancing authority).
2. If the cause of the frequency decline is due to disturbances outside of the Alberta (i.e. Alberta ACE is close to zero),
    a. Monitor the ACE and system conditions.
    b. Respond to a contingency reserve request (CRO) from another NWPP member per OPP 405, if so requested.
3. If the cause of the frequency decline is due to disturbances inside of Alberta,
    a. Coordinate with the TFOs and GFOs to determine the corrective actions.
    b. Issue ancillary service directives to dispatched reserves to the extent to restore the ACE, if required.
    c. Make a CRO request per OPP 405, if required
    d. If the frequency declines to frequencies as shown in Table 1, the underfrequency relay will automatically trigger to shed load. Monitor the ACE and frequency to check if this relief is sufficient.
    e. The load shedding may cause local area overvoltage; coordinate with TFOs to maintain the system voltages within the operating range.
    f. Call the on-call personnel (see confidential OPP 1303).
    g. If the load shedding by automatic underfrequency relays can not sufficiently restore the system frequency, direct more generation, if possible.
    h. If the system frequency is not restored, direct manual load shedding to the extent necessary to restore the system frequency to normal.
    i. Log the event as described in OPP 1301.

5.2 Underfrequency load restoration

The SC will:

1. Before manually restoring loads after an underfrequency event, ensure the following:
    - ACE has returned to zero.
    - Frequency has been restored to between 60.00 and 60.05 Hz.
    - Adequate transmission is available to manage the planned load restoration.
    - Sufficient generating resources are available to return ACE to zero within 10 minutes.

- Communicate with the Vancouver Reliability Coordinator (VRC) to discuss the restoration process.

2. Manage the supply–demand balance while approving manual load restoration with the DFOs or the TFOs.
3. During load restoration, the local area may experience low voltage, coordinate with TFOs to maintain the system voltages within the operating range.
4. Ensure frequency will stay above 59.95 Hz when load is manually restored.
5. Approve transmission restoration as required.
6. Be prepared to direct DFOs to reduce load in the same amount as restored by any automatic restoration scheme.
7. Log events as described in OPP 1301.

6. Figures and Tables

Table 1

Load shed blocks

Load Block	% of Customer Load Shed	Pickup (Hz)	Intentional Delay(s)
1	5.3	59.1	-
2	5.9	58.9	-
3	6.5	58.7	-
4	6.7	58.5	-
5	6.7	58.3	-
AIES security 1	7	58.1	-
AIES security 2	7	58.0	-
D1	2.3	59.3	15*
D2	1.7	59.5	30*
D3	2.0	59.5	60*

Note:

* Load tripped after a time delay may also be included in the 58.1Hz or 58.0 Hz block.

Table 2

Load available for automatic restoration to correct frequency overshoot

% of Customer Load Restored	Pickup (Hz)	Intentional Delay (seconds)
1.1	60.5	30
1.7	60.7	5
2.3	60.9	0.25

Table 3

Generator trip frequency requirements

Underfrequency Limit (Hz)	Overfrequency Limit (Hz)	Minimum Time
>59.4	60 to <60.6	N/A (Continuous operating range)
≤59.4	≥60.6	3 minutes
≤58.4	≥61.6	30 seconds
≤57.8		7.5 seconds
≤57.3		45 cycles
≤57.0	>61.7	Instantaneous trip

7. Revision History

Issued	Description
2008-11-13	Supersedes 2008-05-01
2008-05-01	Approved for interim implementation; supersedes 2005-07-27
2005-07-27	Supersedes 2003-09-30
2003-09-30	Supersedes 2003-07-28
2003-07-28	Issue of combined document.