The AESO must calculate hourly raw loss factors for each system access service provided under Rate STS, Rate DOS, or Rate IOS, as required under subsection 8 of section 501.10 of the ISO rules, *Transmission Loss Factors* ("Loss Factor Rule"). The following procedure describes the steps used to calculate transmission system losses for a pool asset in an hour:

(i)   first, using the historical volume for that pool asset in that hour, in accordance with subsection 8(4) of the Loss Factor Rule; and

(ii)   second, after removing the pool asset's volume and replacing it by redispatching other assets, using the historical merit order for that hour, in accordance with subsection 8(5) of the Loss Factor Rule.

Transmission system losses are calculated for every hour in a year in accordance with the Loss Factor Rule by using a Python script to control PSS/E power system simulation software from Siemens. The script was developed and loss factors were calculated using version 33.9.0 of PSS/E, and the script and calculations were not tested on other versions of PSS/E.

This procedure uses terms from the PSS/E power system simulation software. The procedure assumes familiarity with PSS/E and with using Python scripts to control PSS/E.

System Topologies Used to Calculate Loss Factors

1   In accordance with subsection 7 of the Loss Factor Rule, the AESO creates twelve (12) monthly system topologies, which are saved base case (*.sav) files from PSS/E. The system topologies are adjusted to:

(a)   accommodate the determination of loss factors for locations addressed in subsections 5(3) and 5(4) of the Loss Factor Rule, including generating facilities that are:
- part of an industrial system;
- connected to an electric distribution system;
- connected to facilities owned by the City of Medicine Hat;
- subject to power purchase arrangements; or
- owned by TransAlta Corporation on the Bow River system;

and

(b)   exclude facilities owned and operated by market participants, in accordance with subsection 8(3) of the Loss Factor Rule.

2   Each system topology models the transmission system under typical conditions for the month to enable the calculation of transmission system losses for an initial state for each hour of the month in accordance with subsection 8(4) of the Loss Factor Rule.

3   The saved base case (*.sav) file for each monthly system topology contains the following data:
- transmission line impedances and charging admittances;
- transformer impedances and tap ratios;
- admittances of shunt-connected devices such as static capacitors and reactors;
- real and reactive power consumption of each load facility;

- real power output of each generating facility;
- either voltage magnitude at each generator bus or reactive power output of each generating facility;
- maximum and minimum reactive power output capability of each generating facility;
- magnitude of the voltage at every bus where this is not specified in the input data;
- phase of the voltage at every bus; and
- real power, reactive power, and current flow in each transmission line and transformer.

Calculation of Transmission System Losses for Initial State for Hour

4   Steps 5 through 15 are carried out by the Python script.

5   To calculate transmission system losses for the initial state for an hour, create an hourly base case in PSS/E using:

- the system topology for the month in which that hour occurs;
- metered energy data for all sink assets for that hour;
- metered volume data for source assets, added in the merit order established in accordance with subsection 6(1) of the Loss Factor Rule until estimated to be sufficient for total supply to balance total load plus transmission system losses for that hour; and
- additional data for load facilities from the AESO's transmission settlement system ("TSS").

6   If any of the data used in step 5 is missing or unavailable, record a value of "XA-MISSIN" for that hour. End the calculation of transmission system losses for that hour and continue with the next hour.

7   Record the real power flow, in MW, on the Alberta-BC intertie included in the hourly base case created in step 5 above. The Alberta-BC intertie comprises three lines:

- 1201L between Bus 456 (LANGDON2) and Bus 90000 (1201L), monitored as the flow in to Bus 456;
- 887L between Bus 329 (POCATERA7) and Bus 819 (BRITT TP), monitored as the flow in to Bus 329; and
- 786L between Bus 232 (COLEMAN9) and Bus 1501 (NATAL 7), monitored as the flow in to Bus 232.

    (a) For each system access service for which a loss factor is being determined, except for service under Rate IOS on the Alberta-BC intertie, the target power flow is the flow on the Alberta-BC intertie recorded above.

    (b) For system access service under Rate IOS on the Alberta-BC intertie, the target power flow is 0.00 MW.

8   Set solution parameters to the following initial values.

    (a) Initial settings for loadflow solutions:
    - Solution method: Full Newton-Raphson
    - Tap adjustment: Lock taps
    - Switched shunt adjustments: Enable continuous, disable discrete
    - Area interchange control: Disabled
    - Flat start, non-divergent solution, adjust phase shift, adjust DC taps: Selected
    - VAR limits: Apply automatically

(b) Initial settings for solution parameters – general:

- Largest voltage change threshold: 5.000
- Constant power characteristic threshold: 0.700
- Zero impedance line threshold: 0.000100
- Automatic adjustment threshold tolerance: 0.0050
- Tap movement deceleration factor: 1.000
- Maximum ratio change: 0.05000
- Percent of voltage band switched shunts: 100.000
- Maximum number of tap/switched shunt adjustment cycles: 99
- Maximum number of induction machine state switchings: 10

(c) Initial settings for solution parameters – Newton:

- Acceleration factor: 1.000
- Largest mismatch in MW and MVAR: 0.01
- Iteration limit: 50
- Largest Delta V: 0.990
- Non-divergent improvement factor: 0.990
- Controlled bus Q mismatch convergence tolerance: 0.100
- Controlled bus voltage error convergence tolerance: 0.000010

9   Calculate transmission system losses for the initial state for the hour by:

(a) determining a power flow solution that reaches tolerance, if possible, using step 10 below and increasing or decreasing metered volumes for the last-added source asset (and additional source assets if necessary) up or down the merit order for the hour;

(b) adjusting flows on the western Alberta and eastern Alberta high-voltage direct current transmission lines to minimize overall system losses in accordance with the AESO's loss optimization practice, using the Alberta-BC intertie as the PSS/E swing bus; and

(c) determining a power flow solution that reaches tolerance, if possible, by increasing or decreasing metered volumes for the last-added source asset (and additional source assets if necessary) up or down the merit order for the hour such that the flow on the Alberta-BC intertie is returned to the target flow from step 6 above, within ±0.005 MW.

10   To determine a power flow solution, complete each of the following substeps sequentially until a power flow solution reaches tolerance with the final substep. After the first substep which results in a solution that reaches tolerance or after the final substep if no solution reaches tolerance, exit the substeps and continue the next applicable step of the procedure.

(a) Attempt a power flow solution with initial values and confirm it reaches tolerance.

(b) Change the following settings, attempt a power flow solution and confirm it reaches tolerance:

- Solution method: Fixed slope decoupled Newton-Raphson
- Switched shunt adjustments: Lock all

(c) Change the following settings, attempt a power flow solution and confirm it reaches tolerance:

- Solution method: Fixed slope decoupled Newton-Raphson
- Switched shunt adjustments: Enable all

(d) Change the following settings, attempt a power flow solution and confirm it reaches tolerance:

- Solution method: Fixed slope decoupled Newton-Raphson
- Switched shunt adjustments: Enable continuous, disable discrete

(e) Change the following settings, attempt a power flow solution and confirm it reaches tolerance:

- Solution method: Full Newton-Raphson
- Switched shunt adjustments: Lock all

(f) Change the following settings, attempt a power flow solution and confirm it reaches tolerance:

- Solution method: Full Newton-Raphson
- Switched shunt adjustments: Enable all

(g) Change the following settings, attempt a power flow solution and confirm it reaches tolerance:

- Solution method: Full Newton-Raphson
- Switched shunt adjustments: Enable continuous, disable discrete

(h) If a power flow solution does not reach tolerance through the above substeps, continue the next steps of this procedure.

11   After completing step 9:

(a) If a power flow solution reached tolerance with the final substep from step 10, record the system losses for the initial state for that hour. Save the base case (*.sav) file from PSS/E for that hour. Continue with step 12.

(b) If a power flow solution does not reach tolerance due to insufficient source assets to balance total load plus transmission system losses, record a value of "XA-INSUF1" for that hour. End the calculation of transmission system losses for that hour and return to step 5 for the next hour.

(c) If a power flow solution does not reach tolerance due to any other reason, record a value of "XS-UNSOL1" for that hour. End the calculation of transmission system losses for that hour and return to step 5 for the next hour.

Calculation of Transmission System Losses for Redispatched State for Hour

12   If there is no dispatched volume or dispatched volume is less than 1.00 MW for a location, record a value of "XS-NODISP" for that location for that hour. End the calculation of transmission system losses for that location and continue with the next location.

13   For each hour in which system losses for the initial state were recorded, calculate transmission system losses for a redispatched state for each system access service provided under Rate STS, Rate IOS, or Rate DOS by using the hourly base case (*.sav) file from step 11(a) and:

(a) removing all net-to-grid volumes associated with the system access service in accordance with subsection 8(5) of the Loss Factor Rule;

(b) determining a power flow solution that reaches tolerance by increasing or decreasing metered volumes for the last-added source asset (and additional source assets if necessary) up or down the merit order for the hour until estimated to be sufficient for total supply to

balance total load plus transmission system losses for that hour, using the last-added source asset as the PSS/E swing bus;

(c) resetting flows on the western Alberta and eastern Alberta high-voltage direct current transmission lines to the flows originally included in the system topology for the month in which that hour occurs;

(d) adjusting flows on the western Alberta and eastern Alberta high-voltage direct current transmission lines to minimize overall system losses in accordance with the AESO's loss optimization practice, using the last-added source asset as the PSS/E swing bus; and

(e) determining a power flow solution that reaches tolerance by increasing or decreasing metered volumes for the last-added source asset (and additional source assets if necessary) up or down the merit order for the hour until estimated to be sufficient for total supply to balance total load plus transmission system losses for that hour using the last-added source asset as the PSS/E swing bus.

14   After completing step 13:

(a) If a power flow solution reached tolerance with the final substep from step 10, record the system losses for the redispatched state for that hour for each system access service provided under Rate STS, Rate IOS, or Rate DOS. Save the base case (*.sav) file from PSS/E for that location for that hour. Continue with step 15.

(b) If a power flow solution does not reach tolerance due to insufficient source assets to balance total load plus transmission system losses, record a value of "XA-INSUF2" for that hour. End the calculation of transmission system losses for that hour and return to step 5 for the next hour.

(c) If transmission system losses for the redispatched state cannot be calculated due to missing or unavailable data for that location for that hour, record a value of "XS-MISSIN" for that location for that hour. End the calculation of transmission system losses for that location and return to step 12 for the next location.

(d) If a power flow solution does not reach tolerance due to any other reason, record a value of "XS-UNSOL2" for that hour. End the calculation of transmission system losses for that location and return to step 12 for the next location.

15   To record system losses for initial and redispatched states for each hour in the data set for each system access service for which a loss factor must be determined:

(a) repeat steps 12 through 14 for the redispatched state for each subsequent location on the transmission system; and

(b) repeat from step 5 (including the repetitions of steps 12 through 14) for each subsequent hour in the data set.

Calculation of Raw Loss Factor for Hour

16   Use the system losses recorded in step 11 for the initial state and in step 15 for the redispatched state to calculate raw loss factors in accordance with subsection 8(6) of the Loss Factor Rule.

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Summary of Exclusion Codes

17   In the steps of this procedure, certain hours are excluded from the calculation of raw loss factors for all locations or for a single location in accordance with subsections 8(7) and 8(8) of the Loss Factor Rule. Codes to indicate the reason for an exclusion in an hour are provided in the workbook that shows the calculations from hourly raw loss factors to final loss factors. For convenient reference, the codes are provided in Table 1 below, with references to the relevant subsection of the Loss Factor Rule.

Table 1 – Exclusion Codes

Code	Reason for Exclusion	Rule Subsection
Hour Excluded From Calculations for All Locations		
XA-MISSIN	Missing or unavailable historic data in hour	8(7)(a)
XA-INSUF1	Insufficient source assets to balance system in initial state	8(7)(b)
XA-INSUF2	Insufficient source assets to balance system in redispatched state	8(7)(b)
Hour Excluded From Calculations for Single Location		
XS-NODISP	No dispatched volume or dispatched volume less than 1.00 MW for location in hour	8(8)(a-b)
XS-MISSIN	Missing or unavailable data for location in hour	8(8)(c)
XS-UNSOL1	Cannot solve for transmission system losses in initial state	8(8)(c)
XS-UNSOL2	Cannot solve for transmission system losses in redispatched state	8(8)(c)

Revision History

Posting Date	Description
2017-05-11	Initial release.