Note on Calculation of Import and Export Loss Factors

The proposed methodology for the calculation of loss factors for imports and exports is a multi-step process.

The set of twelve base case load flows as used in the calculation of generator loss factors will be used as starting conditions for the calculation of import and export loss factors. The base cases have been developed on the assumption of no net flow across each intertie. For the BC intertie, the net flow includes the 500kV connection from Langdon as well as the 138kV connections from Pocaterra and Coleman. Each point of connection for each intertie will be represented in the base case load flows as a radial negative (export) or positive (import) generator. There may be circulating flows through these points of connection but the net flow will be close to zero. Provision has been provided for adding additional connection points to each of the interties as well as additional intertie locations.

The change in Alberta system losses will be determined for several representative operating conditions. It is expected that these will include:

- For peak load conditions, import of 200 from BC, import of 600 MW from BC, import of 150 MW from Saskatchewan, simultaneous import of 200 MW from BC and 150 MW from Sask., simultaneous import of 600 MW from BC and 150 MW from Sask.

- For medium and low load conditions, export of 200 to BC, export of 600 MW to BC, export of 75 MW to Saskatchewan, simultaneous export of 200 MW to BC and 75 MW to Sask., simultaneous export of 600 MW to BC and 75 MW to Sask.

The loss variation cases above can be expanded and modified as required based on future expected loading patterns. Additional interties could be added along with variations such as for example simultaneous import/export conditions from say Sask. to BC, imports on two interties exports on a third, etc.

It is proposed that the losses for each of the cases will be determined using a virtual load flow based on the R-Matrices developed for the generator loss factor calculations. For each virtual load flow, two simultaneous equations are solved:

$$\Delta L = \mathbf{\Delta\vec{P}}^{T}\mathbf{R}\mathbf{\Delta\vec{P}}$$ **Equation 1**

$$\Delta L = \sum_{i} \Delta P_i$$ **Equation 2**

ΔL is the total change in system losses as a result of the imports and/or exports
R is the R-Matrix developed for the base case load flow
$\mathbf{\Delta\vec{P}}$ is a vector of changes in power injections at each affected bus in the system
ΔP_i is the change in power injection at the i^{th} bus in the system

At present, the injection change vector $\mathbf{\Delta\vec{P}}$ for each of the variation cases is based on 'real' load flows carried out by the AESO. I.e. each import or export transaction is based on the marginal unit of the GSO. A total of 60 load flow cases have been solved for the conditions listed above and the changes in injections transcribed from the load flow solution to the 'virtual' load flow solution. As the virtual load flow solution to equation 1 and 2 is only approximate, the slack generation required to balance the virtual load flow is distributed to all of the remaining generators in the Alberta system. This procedure, if adopted would eventually require some interface to the generic stacking order to carry this out efficiently.

An alternative methodology is under investigation where the power change vector consists of only changes to intertie flows. All of the generation in the Alberta system would be adjusted to accommodate the export or import. The disadvantage of this methodology is that the resultant virtual load flows would be more theoretical and less representative of specific operating conditions. The major advantage of this methodology is that the procedure for setting up data is much simplified, less subject to transcription inaccuracies and would not cause specific problems associated with transmission constraints associated with moving power from the next available generators in the GSO to the export (or import facility). This will become even more attractive if a third (or more) intertie is added. Each intertie could increase the number of load flow conditions that must be evaluated by a factor equal to the number of new intertie loading conditions. A new intertie with four loading conditions to be considered would increase the number of representative load flows from 60 to 240. A report on this alternative methodology will be issued shortly.

Once the change in losses has been determined for each of the 'virtual' load flow conditions, a set of individual import and export loss factors are determined for each facility that is 'revenue neutral' to the AESO. The loss factors assigned to the intertie will be such that loss charges (or credits) to the intertie and additional loss charges (or credits) to generators to supply the power to the interties will match the total losses resulting from the transaction. For each loading condition, the following equation can be applied:

$$\begin{aligned}\Delta L = &(\mathbf{P}_{\mathbf{interie}_{\mathrm{change}}} - \mathbf{P}_{\mathbf{interie}_{\mathrm{base}}})^{T} \cdot \mathbf{Lf}_{\mathbf{intertie}} \\ &+ (\mathbf{P}_{\mathbf{gen}_{\mathrm{change}}} - \mathbf{P}_{\mathbf{gen}_{\mathrm{base}}})^{T} \cdot \mathbf{Lf}_{\mathbf{gen}}\end{aligned} \quad \textbf{Equation 3}$$

ΔL is the total change in system losses as a result of the imports and/or exports

$\mathbf{Lf}_{\mathbf{intertie}}$ is a vector of loss factors for each of the interties with separate entries for exports and imports if required.

$\mathbf{P}_{\mathbf{interie}}^{T}$ are vectors of flows over each of the interties for the virtual change case load flow and the base case load flow. Separate entries are provided to correspond to the exports and imports given in the loss factor vector.

$\mathbf{P}_{\mathbf{gen}}$ is a vector of all generators to which losses are assigned

$\mathbf{Lf}_{\mathbf{gen}}$ is a vector of loss factors for each of the assigned generators.

With two interties (both import and export) the results from a total of four variation load flow cases would be required to solve for the two sets of loss factors. With more than four load flow cases, equation 3 above cannot be solved for loss factors that will satisfy each virtual load flow condition hence an averaging procedure is proposed.

Generator 'raw' loss factors are established for each season and are ultimately weighted during 'normalization' to establish a single loss factor for each generator. In a similar fashion, it is proposed that 'raw' intertie loss factors be determined for each season. To take into account the impact on all of the operating conditions, Equation 3 above is modified to:

$$\sum \Delta L = \sum \begin{pmatrix} (\mathbf{P}_{\mathbf{interie}_{\text{change}}} - \mathbf{P}_{\mathbf{interie}_{\text{base}}})^{T} \cdot \mathbf{Lf}_{\mathbf{intertie}} \\ + (\mathbf{P}_{\mathbf{gen}_{\text{change}}} - \mathbf{P}_{\mathbf{gen}_{\text{base}}})^{T} \cdot \mathbf{Lf}_{\mathbf{gen}} \end{pmatrix} \qquad \textbf{Equation 4}$$

The summation is carried out for all cases within the season where there are exports or imports over each intertie. In the case of BC and Sask. imports and exports, the summation would be carried out for:

- All virtual load flow cases with imports from BC
- All virtual load flow cases with exports to BC
- All virtual load flow cases with imports from Sask.
- All virtual load flow cases with exports to Sask.

If the situation were to arise where say there were no expected exports to Sask., an export loss factor for Sask. would not be required and that condition would be dropped from the list of summations. If more interties were added, the summation list would expand to include their impacts.

In the above set of equations for each season, there will be one equation for each of the unknown loss factors. This set of simultaneous equations can be solved for the intertie loss factors establishing a 'raw' loss factor for each season for each intertie for imports and for exports (as applicable).

The methodology effectively applies equal weighting to each of the virtual load flow conditions. Hence with the final loss factors selected, the losses associated with each virtual load flow may be under or over charged. However, the total (or average) losses associated with each of the import or export conditions above will be fully recovered and therefore, the average losses for all of the load flows are fully recovered as well.

As intertie loss factors are subject to the system shift factor and ultimately loss factor compression, they are treated the same as generators during these two stages of loss factor development. The seasonal loss factors are weighted according to projected seasonal volumes to establish an annual uncompressed loss factor. If required, the loss factors are compressed along with the loss factors of the generators to achieve the maximum charge of twice system average loss factor or maximum credit equal to the magnitude of the average system loss factor.