



Alberta Electric System Operator

Report on Audit of Current Loss Factor Method

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Draft	Dec 11, 2003 Report issued to AESO for delivery to CMC
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EXECUTIVE SUMMARY

This report is prepared to document the findings of an Audit into the methods and processes followed by the Alberta Electric System Operator (AESO), (formerly TA Alberta Ltd) in determining loss factors in the AIES. The report is prepared in accordance with the RFP dated 24th December 2002 (received 6th January 2003) and Teshmont's proposal dated 21st January 2003.

The audit of the loss factor calculation seeks to answer four basic questions as follows:

- a) Do the procedures and methodology followed implement the directives of the AEUB in Decisions 2000-1 and 2000-27?
- b) Are the procedures, tools and processes adequate for calculation of loss factors?
- c) If any assumptions are needed, do they accurately reflect the AIES situation within the context of the Board Directives?
- d) Is the model of the AIES used in calculation of the loss factors sufficiently accurate for the purpose?

The calculation of loss factors is a complex process and thus some of the answers to the above questions are also complex and cannot be stated without some qualifications and explanation. The amount of material to be reviewed together with complexity of the process and the difficulty in retrieving some of the data, especially data from prior to 2001, has made it difficult and, in some cases impossible to quantify some of the questions posed by the CMC. In such cases, the conclusions of the auditor are based on judgment of the overall result rather than rigorous examination of the accuracy of each subset of the process.

It is important to note that the entire process of loss factor calculation needed to be developed from scratch and then later had to be modified to implement the directives of the Board. Often there was extreme time pressure to get results. Given this situation, it is not surprising that during the development and revision phase, the procedures, methods, storage of inputs, and saving of results was not always rigorous and auditable. It is not reasonable to fully document a process until it has become stable.

It is also noted that the system model used by the AESO and as implemented in TASMO has undergone (and is still undergoing) continuous review and improvement over the period of time in question. The system model is reviewed annually and compared with SCADA data to verify that it accurately reflects the current status of the system. It has not been possible to determine the extent to which the system model changes have affected the calculation of loss factors.

The Auditor has carried out an extensive review of the process and the history of loss factor calculations from 2000 until the present. Details of the review are given in the body of this report and the associated appendices. Based on this assessment, the conclusions of the auditor are:

The procedures and methodology followed by the AESO in the calculations generally do follow the directives of the Board.

The procedures, tools and processes that are now in place are generally suitable (or can be improved to acceptable status) for the calculation of loss factors in accordance with the methodology prescribed by the Board. There has been a noticeable improvement in the documentation of the process within the last year. Process templates that were previously available but not signed have been finalized for each of the major sub-processes in the calculation of loss factors. In addition, the process of filing and archiving results has been improved allowing for repeatability of results. In the auditor's assessment, these templates are generally complete, well written, clear and concise. However, in view of the significant impact of the process on individual generators, the auditor would suggest that the template documents be modified to include check boxes so that the performer of work can verify and check off each step as it is completed.

There are a number of areas where the directives of the Board allow some room for interpretation on the part of the AESO. The auditor considers that the most significant areas are as follows:

- Procedures for solution of load flows including adjustment of system voltage profile
- Maintenance of stacking order
- Dispatch of import and export on the interties

The auditor has reviewed the methods and assumptions used by the AESO in each of the above areas. The assumptions and methods followed by the AESO are documented in its own internal reports. The underlying principle that appears to have been used by the AESO in establishing assumptions to be used in any of these areas is to ensure that the resulting load flows should be consistent with anticipated actual operating conditions on the system. This is ensured by check against system operational procedures, operational records and statistical records of utilization. Generally, the assumptions documented by the AESO seem to be logical and are consistent with the directives of the Board.

The methods used by the AESO in the forecast of system load and losses are another area where there is an element of discretion on the part of the AESO. Details of these processes and the assumptions inherent in these processes were not provided and thus were not included in the audit.

The question of whether or not the load flow model of the AIES is suitably or sufficiently accurate for the calculation of loss factors is hard to quantify. In the Auditor's tests, and also in the year 2002 Model Verification carried out by the AESO, there were a number of discrepancies between actual flows and load flow simulation values. Many of these discrepancies can be

explained as being due to misinterpretation of the metered data or differences between the metered point and the load flow model. However there were also a number of cases where flow differences were attributed to inaccurate impedances, inappropriate or incomplete modelling of in-house load or duplication of facilities. The impact of these modeling problems on the calculation of loss factors could not be quantified.

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or

Appendix 1 Audit of Procedures and Calculations (Confidential Version)

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Alberta Electric System Operator

Report On Audit Of Current Loss Factor Method

1 INTRODUCTION

This report is prepared to document the findings of an Audit into the methods and processes followed by the Alberta Electric System Operator (AESO), (formerly TA Alberta Ltd) in determining loss factors in the AIES. The report is prepared in accordance with the RFP dated 24th December 2002 (received 6th January 2003) and Teshmont's proposal dated 21st January 2003.

The Alberta Electric Utilities Board (AEUB) in its decisions 2000-1 and 2000-27 has instructed The TA in the methods to be followed and assumptions to be made in the calculation of loss factors, including the fixing of raw loss factors for existing generators for the period ending 31st December 2005. The TA has been charged with evaluation of loss factors in compliance with the Board directives.

The purpose of the work carried out by the Auditor is outlined in the TA's RFP and is restated below:

“To verify that the TA's calculation of loss factors is performed in accordance with the Board approved method established in Decisions 2000-1 and 2000-27. Additionally it is to verify that (1) the power flow model(s) used by the TA properly reflects the AIES with sufficient accuracy to calculate loss factors and (2) the procedures, tools, and processes associated with loss factor calculation methodology are adequate for the purposes of the loss factor calculation. Where assumptions are required, these should also accurately and properly reflect the AIES situation, within the context of the Board Directives.”

The RFP further defines the steps to be followed by the auditor in assessing the TA's compliance with the Board directives. The Auditor is to review the procedures, methods and transmission models used by the AESO in evaluating loss factors.

In preparation of his findings, the Auditor was instructed to consider and respond to a list of questions posed by the CMC (included in the RFP as Appendix B). These questions and the Auditor's response are included in Attachment A of this document for reference.

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2 SUMMARY OF FINDINGS

In the Auditor's assessment, the methods and procedures followed by the TA (now AESO) in the calculation of loss factors do follow the directives of the Board.

In those areas where the TA has applied discretion because the directives of the Board were not detailed, the underlying principle that appears to have been used in establishing assumptions to be used in any of these areas was to ensure that the resulting load flows should be consistent with anticipated actual operating conditions on the system. This is ensured by check against system operational procedures, operational records, and statistical records of utilization. Generally, the assumptions documented by the AESO seem to be logical and are consistent with the directives of the Board. A reconciliation between the directives of the Board and the actions taken by the TA or AESO is given in Table 2-1.

However, the audit did highlight a number of areas where the procedures, tools and methodology could be improved. Specifically the following issues were noted:

a) Lack of QA Documents

Even though templates and procedures exist for all major processes in the loss factor calculation, it is not obvious that there is discipline being applied to ensure that compliance is verified against the template at each step. Such verification would require the existence of documents with check boxes or boxes for initialling at every significant point in the processes. No such documents were observed or provided for review.

b) Non-rigorous Archival of Documents

The process of archiving of original documents containing input data, calculation sheets and important results seems, in the Auditor's impression, to be too informal. When comparing background information and calculation sheets with posted loss factors minor inconsistencies were noted. This implies that the final calculation sheets used in the determination of posted loss factors have not been stored and that only working copies of the calculation sheets at a non-final state are available.

The apparent absence of an archived list of Raw Loss Factors was particularly surprising given the importance of these numbers. The back calculation of raw loss factors from the posted normalized loss factors was observed in the calculation sheet for the shift factors implying that a direct source of raw loss factors was not available. It is also stated in "Process – Calculating Shift Factor" [14] that "Raw loss factors are not presently stored in an authoritative location." While the result may be the same, it seems unnecessarily indirect to perform a back calculation of raw loss factors rather than starting from a verified list of raw loss factors.

**TABLE 2-1
RECONCILIATION BETWEEN BOARD DIRECTIVES AND THE TA/AESO RESPONSE**

Board Directive	TA/AESO Response	Fulfills the Directives of the Board
<p>The tariffs shall be redesigned to allocate 100 percent of transmission losses to all generators using the Board procedures to be effective January 1, 2001 on an energy basis with a fixed 5-year period of loss factors</p>	<p>Transmission Losses are 100% allocated to generators.</p>	<p>Yes</p>
<p>A common methodology for loss factor calculation based on “last MW in” should be applied in calculation of loss factors for all generators in the AIES. The load flow base cases used in the calculations should include all generation including IBOC units. Base cases are to be prepared for 2002 (and any other required base cases) that reflect IBOC generation locations, in service dates and capacities.</p>	<p>Loss factors were recalculated using a “LAST MW IN” approach for all generators. The IBOC generation is included as appropriate in all load flows.</p>	<p>Yes</p>
<p>The swing bus approach shall be applied for calculating losses in conjunction with the approved subtraction of shift method to ensure that the correct amount of revenue is received to cover the losses.</p>	<p>The swing bus approach to calculation of loss factors is implemented in a number of special purpose EPCL programs. Shift factors are calculated in special purpose Excel spreadsheets.</p> <p>Normalization of raw loss factors is implemented by subtraction of a shift factor from all raw loss factors.</p>	<p>Yes</p>

**TABLE 2-1
RECONCILIATION BETWEEN BOARD DIRECTIVES AND THE TA/AESO RESPONSE**

Board Directive	TA/AESO Response	Fulfills the Directives of the Board
<p>The loss factors for the City of Medicine Hat (CMH) in 2001 shall be adjusted to better reflect the physical capacity of CMH to deliver energy to the AIES. Assumptions made shall be carried forward to any future major recalculation of the loss factors.</p>	<p>The City of Medicine Hat is now treated in exactly the same way as any other generator on the AIES.</p>	<p>Yes</p>
<p>Loss factors should be implemented for opportunity service customers consistent with the approach approved for supply customers. However, the loss factors should be updated quarterly, as opposed to loss factors for standard supply customers, which are fixed for a 5-year period. This would apply to both in-province customers as well as to interties with neighboring provinces.</p>	<p>Loss factors are calculated for DOS customers and the two interties in an analogous way to those calculated for generators, except they are calculated quarterly.</p>	<p>Yes</p>

c) Apparent Inconsistency Between Stacking Orders and Base Case Load Flows Prior to 2003

The Auditor has reviewed and compared the seasonal stacking orders provided by the AESO and the generation dispatch in the base-case load flows in years 2001, 2002 and 2003. In 2003, the comparison is quite good. However, in the load flows for years 2001 and 2002, there are numerous apparent inconsistencies between the load flows and the stacking order.

d) Non-Converged Load Flow Solutions in the Raw Loss Factor Calculations

The process of loss factor calculations requires repetitive modifications and solutions to the base-case load flows to calculate loss factors for each generator in turn. A software program has been developed by the TA to automate these repetitive calculations. The Auditor has reviewed the software, which is implemented in a propriety program language (EPCL) used in the GE PSLF power system study software.

The TA's EPCL software code includes all of the required functions to implement the calculations. However, in the auditor's test of the software, the power flow would reach an iteration limit in many of the cases indicating that the program had not solved to within the required tolerance. The check to verify that convergence had been reached within the specified accuracy relied solely on a return value from the power flow software (GE PSLF software) rather than directly checking the iteration number or the MW and Mvar mismatch values.

The version used in the LF calculations was Revision 11.2. It was also discovered that there are least two different versions of Release 11.2 of the GE PSLF software that would give different answers. The auditor was not able to reproduce the TA's LF calculations until we obtained a copy of the TA's version of the program. On further testing, it was found that the GE PSLF program did not return values that indicated a non-convergent solution. Hence, results would have been accepted as being correct and no further check would have been done.

In the Auditor's own tests, the non-convergent solutions were observed and prevented the auditor from being able to replicate results provided by the TA. When this was explored in more detail, it was discovered that the PSLF software was not returning the right return code. In the process, the Auditor investigated a number of versions of the PSLF software (PSLF Release 11.2, PSLF Release 12.0, PLSF Release 13.0 and PSLF Release 14.0). It was found that the program did not correctly report non-converged solutions until Release 14. Therefore, the raw loss factors calculated using prior releases have to be considered as suspect. Release 11.2 was used by the AESO in calculation of the raw loss factors.

The auditor has investigated the extent to which the loss factors may be affected by the non-convergence of load flows for four generators (Redwater, Sundance, Valleyview, and Muskeg). The auditor was able to replicate the raw loss factor calculations for these units, as data was available. In the Auditor's tests, the number of iterations was increased and decreased by 1. The observed impact on the calculated raw loss factors was less than 0.01% and would not affect the raw loss factors or normalized loss factors for these units.

For the units that were investigated, the load flow solution had come close to a solution, where at the bus with the largest mismatch, the solution was only marginally outside the solution tolerance. However, had the solution been characterized by hunting and if the bus at which hunting was occurring was near the generator for which loss factors were being calculated, larger errors would have occurred with possible impact on loss factors.

The TA was clearly aware that solution difficulties and failure to converge could occur in the process as code was provided to detect this condition and the question of solution difficulty is discussed in [1]. The implications are:

- This portion of the code was not validated, and
- Users of the code failed to observe that the solutions were going to the maximum number of iterations, or
- Users of the code observed that solutions were going to maximum iterations but considered the results acceptable.

The information provided to the Auditor showed no indication that the problem of non-convergence had been noted in the final loss factor calculations. With the benefit of hindsight, more rigorous testing for non-convergent load flow solutions could have been included in the TA's EPCL software.

e) Manual Intervention Permitted or Required in EPCL Program Code

The auditor noted that there are several locations in the EPCL code where there are instructions to the study performer to make changes to items such as solution parameters etc. There are warnings included instructing the performer to be sure to reset the values to the defaults on the final run.

In the Auditor's view, user intervention in production code is inherently unsafe and can be a source of inconsistency unless the user knows exactly what he is doing and is very systematic in his work habits. We note that the process templates do not contain instructions to ensure that EPCL programs used to generate final results be compared against the originals using a file difference utility program to verify that changes made, if any, are either valid or are removed prior to doing the final runs.

f) Inconsistencies in Shift Factor and Normalized Loss Factor Calculations

The calculation of shift factors and Normalized loss factors is carried out using Microsoft Excel software. When constructing the Excel spreadsheets it is necessary to manually cut and paste values and or program steps from other spreadsheets. This can lead to lead to errors unless the operator is extremely careful.

A weakness with using Excel spreadsheets is that is that the program steps are not easily visible and thus cannot be readily checked except on a cell-by-cell basis. Another factor is that variables are identified by cell reference rather than by name. This makes it very difficult to check that all of the calculations are being correctly carried out.

One aspect that the auditor had difficulty resolving was different generator names for the same unit in different years. Initially generators were identified by name rather than by a unique identifier code. In at least one location, the name and generator information did not match in the working sheet. However, in the published output this error was not present. This shortcoming has been addressed in more recent calculations, where generators are identified by a generator “MP_ID” code.

There were also instances where generators are present in a given year then are not present in the following year. It would be less confusing if generators would appear every year even if not dispatched. The addition of a comment column to give reasons for a generator not being considered in any year would also be helpful especially when going back to review results.

The Auditor has not exhaustively checked the program steps in each Excel sheet but has noted at least one apparent error in an Excel program. The noted error was in the allocation of forecast losses into seasonal components using seasonal distribution factors from a previous year’s measurements. Fortunately, the apparent error was not serious in that it had the effect of reducing the forecast losses by less than 1% of the intended value.

The value of raw loss factor for generator H.R. Milner that was used in the 2003 winter calculations of 4% appears to be in error. The raw loss factor as indicated in the AESO report and as reverse engineered (by the Auditor) from the published 2003 normalized loss factors is -16.4%. Using the latter value, the 2003 winter shift factor would have been -7.0% instead of the published value of -6.7%.

g) Lack of Formality in Introducing Changes to Processes and Software

The Auditor notes that, even though process templates are in place, there may be times when it becomes obvious that more suitable ways of achieving the same result may be available. In such case, there should be a defined methodology of updating the process templates in parallel with the changes in processes. At present, changes in process that achieve the same functionality can be simply implemented by the performers without

formal update of the process templates. Even though the output may be no different in the short term, problems can result later when inevitable changes in personnel occur.

This was also observed to be the case for the custom EPCL code used in the raw loss factor calculations. User changes can be introduced but there does not seem to be a formal process for ensuring that necessary changes are made to centrally stored versions of the code.

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3 METHODOLOGY FOR AUDIT OF LOSS FACTOR METHODOLOGY AND PROCEDURES

3.1 General

The audit of the loss factor calculation seeks to answer four basic questions as follows:

- a) Do the procedures and methodology followed implement the directives of the AEUB in Decisions 2000-1 and 2000-27?
- b) Are the procedures, tools and processes adequate for calculation of loss factors?
- c) If any assumptions are needed, do they accurately reflect the AIES situation within the context of the Board Directives?
- d) Is the model of the AIES used in calculation of the loss factors sufficiently accurate for the purpose?

Each of these questions is discussed below in Sections 3.2 through 3.6 of the report.

Beyond these general questions, the audit is also to address specific questions provided by the CMC. These questions from the CMC are considered separately in Attachment A. Further details relating to the audit are found in Appendices A and B to this report.

3.2 Consistency Between LFM and AEUB Decisions 2000-1 and 2000-27

The directions of the AEUB to the TA with regard to calculation of loss factors going forward from year 2001 can be summarized as follows:

- a) The tariffs shall be redesigned to allocate 100 percent of transmission losses to all generators using the Board procedures to be effective January 1, 2001 on an energy basis with a fixed 5-year period of loss factors.
- b) A common methodology for loss factor calculation based on “last MW in” should be applied in calculation of loss factors for all generators in the AIES. The load flow base cases used in the calculations should include all generation including IBOC units. Base cases are to be prepared for 2002 (and any other required base cases) that reflect IBOC generation locations, in service dates and capacities.

For IBOC generation only, a separate calculation is also made to determine loss factors for the IBOC generation based on “first MW in”.

- c) The swing bus approach shall be applied for calculating losses in conjunction with the approved subtraction of shift method to ensure that the correct amount of revenue is received to cover the losses.
- d) The loss factors for the City of Medicine Hat (CMH) in 2001 shall be adjusted to better reflect the physical capacity of CMH to deliver energy to the AIES. Assumptions made shall be carried forward to any future major recalculation of the loss factors
- e) Loss factors should be implemented for opportunity service customers consistent with the approach approved for supply customers. However, the loss factors are updated quarterly, as opposed to loss factors for standard supply customers, which are fixed for a 5-year period. This would apply to both in-province customers as well as to interties with neighboring provinces.

In response to these Board directives, the TA/AESO has developed detailed and systematic methodology, software tools and process documents for the purposes of implementing of the loss factor calculation.

The document “Loss Factor Calculation Methodology” Revision 3 dated 9th May 2001 is the most definitive reference [1][2]. This report restates the directives of the Board and indicates that in principle the directions of the Board are being followed. Software tools, and sample reports relating to the loss factor calculation were obtained from AESO and a review indicates that the directives of the Board are being implemented.

However, the Auditor’s review of both the processes and software tools indicates that both suffer from a number of weakness and limitations as further elaborated herein. The discussion and conclusions in the following sections are based on review of the documents as well as trial runs carried out by the Auditor to try to duplicate the calculations performed by the TA and more recently by the AESO.

3.3 Adequacy of Procedures, Tools and Processes

3.3.1 Process Control Documentation

The process of calculation of loss factors for new generators is shown conceptually in Figure 3.3-1. In the figure, process flow is generally from left to right with generally no backward flow of information or outputs. Shaded bars represent processes while boxes are inputs or outputs.

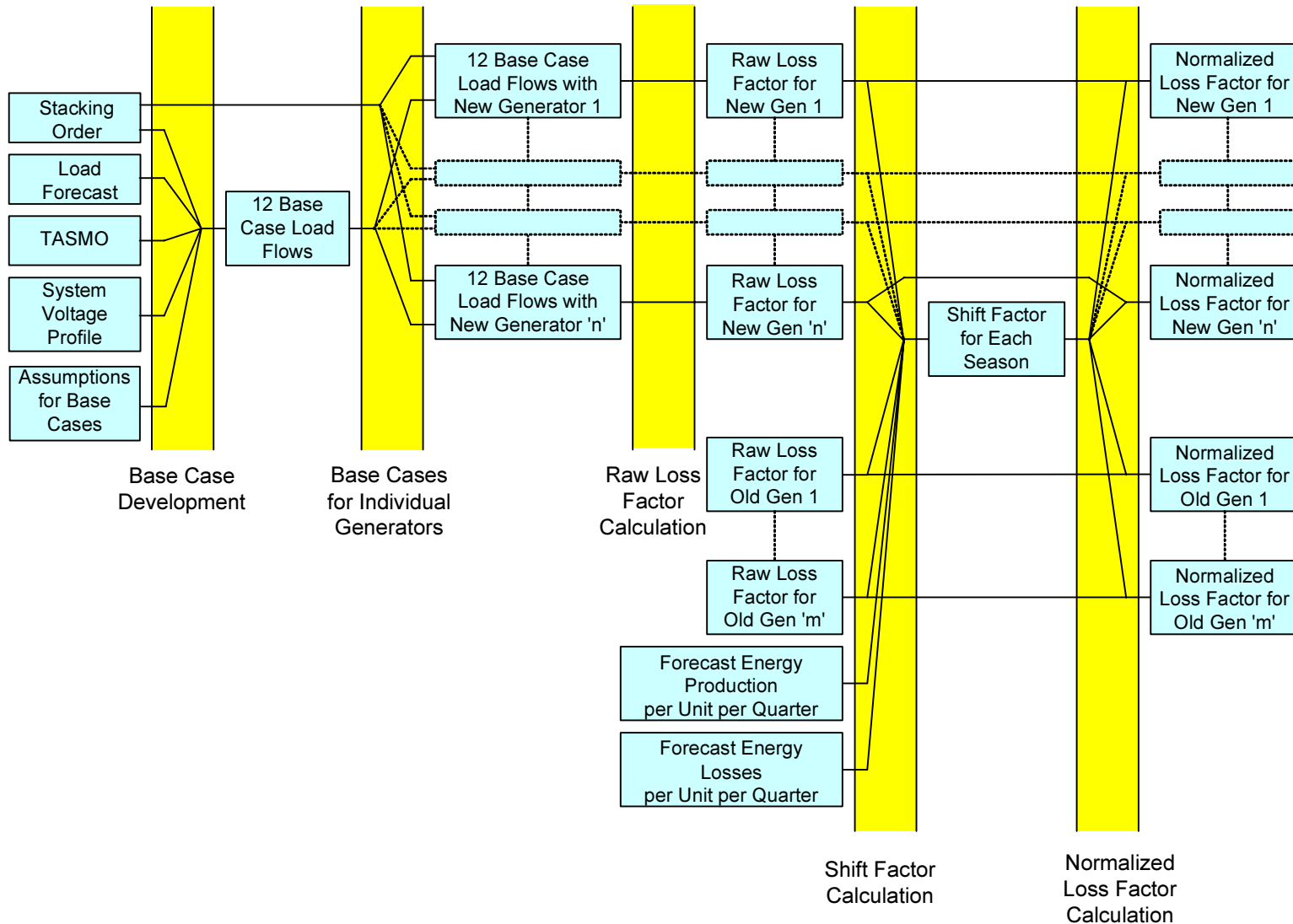


Figure 3.3-1
Process Flow Diagram Flow Diagram for Loss Factor Calculations for New Generators

Process templates have been prepared by the AESO for the following activities relating to the loss factor calculations:

- Process - Generic Stacking Order Maintenance [11]
- Process - Loss Factor Base case maintenance [6]
- Process - Model Validation [8]
- Process - Loss Factor Calculation [12]
- Process - BC, SaskPower ties and DOS Loss Factor Calculations [13]
- Process - Calculating Shift Factor [14]
- Process - Provide New or Revised System Access [9]

Validation of the ac system model is not formally a part of the loss factor calculation. Validation of the system model against SCADA data is done on an annual basis at the beginning of a new planning cycle and any necessary modifications are then made to the TASMO database of system information. Updated system models are used in any subsequent loss factor calculation process.

In addition to the process templates, there is also an informative document “Transmission Administrator’s Loss Factor Determination Process” [3] and a detailed description of the loss factor calculation method is given in the report “Loss factor Calculation Methodology”[1][2]. Several other Reports round out the documentation.

The process templates provide step-by-step procedures for carrying out each task in the loss factor calculation process. The personnel responsible for each step are defined, and deliverables are described. A review of the content indicates the template documents to be well written, clear and concise. Use of the template documents in a QA capacity is however not obvious since there are no boxes for checking or signing by the responsible individuals.

It is not known if there is a second level of process control documentation that is used to carry out the QA associated with the process template since samples were not provided.

Sample reports produced as part of the deliverables presumably using the process templates as reference documents were also reviewed. There is no back reference from these reports to the process template suggesting that the link between the template and the process deliverables may be tenuous.

Similarly, the report “Loss factor Methodology” while providing essential background and methodology would not be suitable for providing QA for the loss factor calculation process since it also does not include checkboxes or signature boxes to indicate that a given activity has been completed.

3.3.2 Development of Base Cases

Base Cases are developed semi-annually (twice a year prior to June and November) using the system models from TASMO, the load forecasts for the next two seasons of the year in question, generation stacking order in the given season and knowledge of the expected system voltage profile for the seasonal load distribution.

The process begins with defining assumptions to be used in the base-case load flows. A process template was not provided and may not be possible given that some judgment is needed. A detailed internal report is prepared by the AESO documenting the assumptions to be used in the development of base cases to be used in loss factor calculations. Based on our review of the document “Assumptions for 2003 Loss Factor Base Cases” [5] assumptions are developed based on operational characteristics of the system, usage data from the previous 12 months and knowledge of the projects that should be included in the cases based on information filed by new generators. The main output from this work is the generation dispatch and intertie flows in the seasonal load flows used for loss factor calculations. In the Auditor’s view, the report provides a suitable level of detail for the development of the base-case load flows.

In addition to the assumptions as noted above, the following template documents used in this process are:

- Process - Generic Stacking Order Maintenance [11]
- Process - Loss Factor Base Case Maintenance [6]

The auditor’s review of each of these templates are given below:

Generic Stacking Order Maintenance

The generic stacking order is maintained on an annual basis in November before loss factor base case development. This process is not an integral part of the loss factor calculation but is a necessary predecessor. (Another necessary predecessor is the validation of the system model, which is described separately in Section 3.5.) The process of maintaining the stacking order requires significant judgment on the part of the personnel carrying out the analysis. It requires a detailed knowledge of the unit obligation price, operational characteristics of the generation units available in the system and the historical operational patterns system, as well as records of:

- Previous 12-month actual net hourly outputs from billing or PI database.
- Previous 12-month generator offer blocks.
- Previous 12-month period for operating reserve dispatch.
- Previous 12-month period for transmission must run (TMR).
- Previous 12-month interchange flows for the BCH and SaskPower ties.
- Generator maintenance schedules provided by Owners on a confidential basis.

The stacking order in any season is based either on known operating costs or generic industry standard heat rates for the specific technology used at each individual generator together with estimates of fuel price escalation. Maintenance of the stacking order is done by obtaining the stacking order for the previous season then adjusting it to take into account the above factors. Adjustments are made if, in the judgment of the performer, there is an inconsistency between the existing stacking order and the previous 12-month record. At this time, new units added in the previous year would be added and any retired units would be removed.

The process of starting from pre-existing stacking order and making incremental adjustments based on new generator additions or deletions of retired units, planned maintenance, forced outage data and usage information for the previous 12 months is, in the Auditor's judgment, a reasonable approach.

Loss Factor Base Case Maintenance

The template "Loss Factor Base Case Maintenance" describes the process for creating the 12 seasonal base cases for the loss factor calculations. The template is detailed and describes a reasonable sequence of steps to generate the base-case load flows.

As with all of the process templates reviewed there is no provision to use the document as a checklist. However, if the persons doing the work are careful and thorough they should be able to complete the work in accordance with the template.

One observed weakness in the process is that before 2002 the inputs, (TASMO output, load forecasts, generator stacking order, EPCL code files, etc) were not required to be stored and archived. Only the final load flows were saved. This makes it very difficult if not impossible to replicate the load flows or to go back and check assumptions etc if required.

This concern has been addressed in the process templates in that the calculations are performed in a new directory, which is presumably saved and archived in its entirety at the completion of the calculations.

The process template contains an incomplete section called "Test Requirements" which is intended to define a methodology for verification that the base case load flows meet the needs of the Loss Factor Calculation process. If this were completed it could at least partially address the noted absence of QA documentation for the process.

3.3.3 Raw Loss Factor Calculation

The raw loss factor calculation is described in the following documents:

- Transmission Administrator's (the "TA") Loss Factor Determination Process [3]

- Loss Factor Calculation Methodology [1] [2]

The first of these documents is a good general description of the entire process and is not intended to be a definitive reference or source of information to be used in the process of determination of loss factors.

There are two versions of the second document (both at Revision 3); the confidential internal version and the public version as follows:

- a) “Loss Factor Calculation Methodology” dated 5th April 2001 (on the cover) [1]. This version contains 69 pages and is labelled “Confidential”. The version provided is unsigned and contains a live date in the footer, which automatically updates to the date that the document was printed (in this case 25 April 2003), which leads to confusion. A revision history in Appendix 1 indicates that Revision 3 was made on May 9, 2001. Revision history information for Revisions 1 and 2 is not included in the document.
- b) “Loss Factor Calculation Methodology” dated 24th June 2002 [2]. This version contains 26 pages (including cover and Appendices). This version is not labelled “Confidential” and is publicly available on the AESO Website. This version is also unsigned and, in this document, the date in the footer has been fixed. No revision history is provided suggesting that the revision status of this document is derived not from its own history but rather from the revision history of the confidential document of the same name.

The content of these two documents is similar. The Tables of Contents have the same main headings but are shifted by one since in the confidential version the “Introduction” section is not numbered. Differences are due primarily to the omission of confidential materials from the public version. Both versions directly reference and summarize the Board directives and give the general methodology followed in implementation of the loss factor calculations.

The loss factor calculation process as described in this report closely follows the Board’s directives. The document identifies a number of areas where the Board’s directives are not detailed and where assumptions and or judgment must be applied by the AESO in performing the loss factor calculations as follows:

- Adjustments to stacking order
- Load forecast
- Losses forecast
- Load duration curves
- Multiple loss factors for a given site
- Tie line loss factors
- Load flow solution tolerances and number of iterations

The Auditor’s review of the AESO’s treatment of these factors is discussed in Section 3.6.

In a number of instances, it has been noted that some details provided in this report are no longer current indicating that refinements to the loss factor calculation methodology are still being made. An example of this is differences in the maximum number of iterations at different stages of the solution.

In addition, the following process templates are applicable:

- Process - Loss Factor Calculation [12]
- Process - BC, SaskPower Ties and DOS Loss Factor Calculation [13]

The auditor's review of each of these templates are given below:

Process - Loss Factor Calculation

This template provides a step-by-step description of the process of calculation of loss factors. The calculations are performed largely automatically using custom EPCL programs developed for the purpose. Three EPCL programs are used routinely:

- Run_LossFactors.p - A main program whose main function is to call the SERP_lossfactor_2passes.p program)
- SERP-lossfactor_2passes.p - The main calculation routine for the loss factor calculations.
- add-gen.p or other file name selected by the user - The purpose is to add the generator to the case, ramp down other generation and make any other changes to the base cases that need to be done on a consistent basis. It is called by SERP_lossfactor_2passes.p. This file is not a standard file but must be modified by the user to suit each generator loss factor calculation. The process template quotes an example file to be used. It is not known if it is enforced to use the example file or if the user can copy a file from an earlier study.

Additional EPCL programs must be added if it is noted that any project is missing or incorrectly represented in the base-case load flows. These additional EPCL programs must then be called from the "add_gen.p" program. This requires that the user modify the add_gen.p program to call the additional programs or alternately to directly include any required changes in the add-gen.p file. Changes to the base-case load flows are required to be reported back to the loss factor base case developer.

Other manual changes to the add-gen.p file are required to add the STS of the generator being added and bus number at which the new generation is being added. Mvar limits for the new generator also need to be added. Generators that are to be skipped when readjusting the generation to accommodate the new generator are also identified.

Before 2003 the stacking order information was hard coded into the add-gen.p file and had to be hand modified by the user if the order was changed. As a result of modifications made in late 2002 the stacking order information is now read from a separate file.

Of the templates reviewed, this is the only one that included any steps that involved checking of the results for either reasonableness or repeatability. It was also one of the few templates in which the section “Test Requirements” had been completed. It also included a procedure for carrying out the test but indicated that the testing had never been performed.

Noted shortcomings related to use of possibly corrupt Excel spreadsheets from previous studies rather than standard templates and lack of specifics for filing of results were also identified but the action required to overcome the shortcomings was not identified nor assigned.

This template (Step 12) refers to an MNBP (Metering and Billing By Plant database) raw loss factor table where the results are to be entered. However, in template “Process – Calculating Shift Factor it is stated the normalized loss factors are stored in MNBP. The shift factor calculation sheets also imply that normalized loss factors are stored rather than raw loss factors.

Calculation of multiple loss factors for a given location such as could occur in a staged project is not specifically addressed.

Process - BC, SaskPower Ties and DOS Loss Factor Calculation

This process template provides a step-by-step description of the calculation of loss factors for the interties and DOS customers. The template is inconsistent with the template “Process –Loss Factor Calculation” regarding locations of files to be used in the processes. This is likely due to differences in mapping of shared drives but it was noted that in the case of the reference to the stacking order file “stacking_order.csv” there is also a difference in the final directory nesting entry which is taken to be a typo. (In one case it reads ...\\23\10 while in the other it reads ...\\23\01).

This process template is notably less detailed than the “Process - Loss Factor Calculation” [12] and would clearly need to be applied by someone who is very familiar with the process.

It is noted that the only check for convergence of load flows in the calculations is the check of return value from the PSLF program. Test requirements to show that the output meets the need and procedures for testing the output are not defined.

3.3.4 Shift Factor and Normalized Loss Factor Calculation

The applicable process template in this case is “Process - Calculating Shift Factor” [14]

The auditor’s review of this template and a summary of the Auditors review of the calculations performed using the template are given below:

Process – Calculating Shift Factor

This process template provides a systematic description of the calculation of shift factor and normalized loss factors. The calculations are carried out using Excel spreadsheets. The starting point is a template rather than a previous calculation. This template notes the difficulties with not having the raw loss factors stored in an authoritative location and gives an indication that the situation is being addressed by changes to the MNBP database which will store both raw loss factors and shift factors and calculate normalized loss factors.

The process template includes instructions for checking and updating the Excel template file to include new projects.

Consistency of the normalized loss factors is checked by verifying the match between the forecast losses and the total normalized losses calculated as the sum of all the losses for individual POS (point of supply), which are calculated by multiplying the loss factor for that point of supply by the normalized loss factor for that point of supply.

The normalized loss factors are stored in the MNBP database and a hard copy is filed in a specified location. The process template does not state how and where to file and archive the calculation spreadsheet.

The sections of the template dealing with testing requirements and test procedures for testing that the deliverable meets the need are not completed.

In his review of the calculations of shift factors and normalized loss factors, the auditor noted at least one apparent error in an Excel spreadsheet. (The error resulted in a small <1% reduction in forecast losses and did not materially affect the results). This highlights the difficulties with using unprotected Excel spreadsheets as a tool for involved calculations.

In another case, the raw loss factor for generator H.R. Milner that was used in the 2003 winter calculations of 4% appears to be in error. The raw loss factor as indicated in the AESO report and as reverse engineered (by the Auditor) from the published 2003 normalized loss factors is -16.4%. Using the latter value, the 2003 winter shift factor would have been -7.0% instead of the published value of -6.7%.

The anticipated changes to the MNBP database noted in the process template should eventually address all of the problems noted. However, the schedule for completion of those revisions is not known.

3.3.5 Business Processes

The business processes for the provision of new or revised system access are described in the process template “Process – Provide New or Revised System Access” [9].

This template does not affect the loss factor calculation process except when loss factor calculations are initiated by an application for new or revised STS.

The most relevant portions of the template are those dealing with the entry of data for the new projects into two of the AESO's databases (the TASMO and CASPIR) and safeguards, which are in place to ensure that data of proposed projects are:

- correctly used in preliminary loss factor calculations,
- not used in final loss factor calculations before project commissioning, and
- data for cancelled projects cannot be used inappropriately.

The Auditor's review was focused on these processes. Data entry to TASMO was found to be carried out in several stages with more preliminary data being permitted early in the project and fully complete data being required after energization.

The process template does not define how the data that is entered in TASMO is used. The main emphasis is to ensure that some data is entered in a timely fashion in the detail that is available at that phase of the project. It is up to the person calculating loss factors to ensure that all projects are correctly represented based on data that is available in CASPIR and TASMO and in paper files.

Similarly, when a project is cancelled, the procedure for handling the expiry of data in TASMO (or removal of data) is not defined in this template. For loss factor calculations, the responsibility for ensuring that projects are correctly excluded from loss factor calculations remains with the loss factor calculation personnel.

This transfer of responsibility for correctly modeling project status to the loss factor calculation personnel is seen as being acceptable for the loss factor process but the impact on other studies using data extracted from TASMO is unclear. The TA/AESO's own model validation exercise indicates that there may be some concerns as discussed in Section 3.5.1 below.

3.4 Suitability of Tools used in the Loss Factor Calculations

The following systems and software tools are used by the TA/AESO in the loss factor calculations:

- The TASMO Database of system data and project information
- The PI (Plant Information) database of historic SCADA data for the system
- The CASPIR (Customer Access Services Project Information Resource)
- The MNBP (Billing and Metering) database
- The PTI - PSS/E power system study software
- The GE - PSLF power system study software Release 11.2

- Custom programs written by the TA/AESO in EPCL (a proprietary programming language which is supplied with PSLF) including:
 - Run_LossFactors.p
 - SERP-lossfactor_2passes.p
 - add-*gen*.p (where * is assigned by the user for a particular calculation)
- Microsoft Excel spreadsheets

3.4.1 Databases

The TASMO, PI, CASPIR, and MNBP are databases which represent the only practical way of storing and maintaining the large volumes of data that are subject to changes, additions and versions. The Auditors review covered only TASMO and to a limited extent the PI database. Minor discrepancies in the PI records have been documented in Appendix 2 of this report. The Auditor's review of the TASMO data entry and update process did not result in any concerns.

However, in the AESO's internal model validation process [7] there was concern expressed over the TASMO handling of on-line/off-line status of certain motors and generators. Recommendations were made to improve the handling of this issue.

3.4.2 Power System Study Software

The PSS/E and PSLF power system study packages are widely used in the power industry and represent the industry standard for these types of programs. The use of these programs in an application such as loss factor calculations with the tolerances reduced to very low values is an unusual application of these programs and requires careful consideration and monitoring in order to achieve consistent results.

In the case of final raw loss factor calculations, almost all variable factors are frozen (i.e. tapchangers, reactor bank switching and phase shifters). In spite of this, the program still frequently goes to the specified maximum number of iterations without reaching the specified mismatch. The failure to reach a satisfactory solution could be due to two factors:

- generators going on and off of var limits on successive iterations. Other than the constant MVA loads this is the only non-linearity left in the case.
- the numerical precision being requested is too tight.

If the problem is due to generators going on or off of var limits it could possibly be overcome by freezing the var output of all generators that are already on limits and slightly increasing the limits on other generators in steps until a satisfactory solution is reached. The impact of the final answers would be small and should be repeatable regardless of other factors such as program version. This change could be easily implemented in the software currently used in the calculations.

If the problem is due to numerical precision then the situation is more difficult since it might then be dependent on program version, compiler version, and even computer hardware. In that case, the only reasonable approach would be to determine the limits of tolerance that can be reliably applied to achieve repeatable and robust results. The impact on loss factors of these larger tolerances would need to be assessed to determine if the degree of precision is adequate for the purpose.

3.4.3 Custom EPCL Code

The custom EPCL programs contain all of the required functions that are needed to implement the raw loss factor calculations. However, in the Auditor’s review, a number of weaknesses and concerns were noted as follows:

- a) **weak testing for program convergence.** The program relies on a return value from the PSLF “soln” module to establish whether or not the solution has converged (return value of 0) or diverged (return value of -1). The TA/AESO documentation for the program also looks for a return value of -2 to indicate the condition “run out of iterations”. However the Auditor’s review of the GE documentation for the “soln” routine indicates that only two return values are possible 0 and -1 with 0 indicating converged and -1 indicating diverged. The TA/AESO use of a -2 return value is either an error or makes use of an undocumented return value. Thus any case which runs to the maximum iterations would be expected to return a 0 value since it is not technically diverged. This was verified to be the case for PSLF releases 11.2, 12, and 13. At release 14 GE must have changed the internal logic. Release 14 returns a -1 for cases that run to the maximum number of iterations. In the Auditors tests, many of the loss factor calculations run to maximum number of iterations and were not flagged as being non-converged.

More rigorous testing for non-converged solutions should have been implemented. The apparent change in internal logic by GE at Release 14 of PSLF also illustrates the danger in relying on return values for important tests.

- b) **program steps that perform default actions.** This can lead to unexpected and erroneous results without providing any warning to the user indicating that something is wrong. This can be illustrated by showing examples of code snippets from the “add_gen2003.p” EPCL program as received from the AESO:

Example 1:

```
@mwgen = 445 /* this is the MW value of the new generator (or import or export */
          /* Negative is export or DOS, Positive is Generator or import) */
@extbusnumber = 9161
```

In this example, the user has assigned the value of 9161 to the variable “extbusnumber”. This bus number does not exist in the power system database. Rather than stopping and advising that this is an error condition, the program goes on to solve all 12 load flows and produces loss factor files for each. It may have been the programmer’s intent to allow this condition for testing or other purpose but it demonstrates the very real danger that if a user inadvertently types in an erroneous bus number then the program continues to run anyway and produces erroneous results.

Example 2:

```

@idx_case = 0
logterm("<@idx_case=",@idx_case,"<")
if (findstr($casenam,"Winter") > -1 or findstr($casenam,"WINTER") > -1 or
findstr($casenam,"winter") > -1 )
    @idx_case = 0
elseif (findstr($casenam,"Spring") > -1 or findstr($casenam,"SPRING") > -1 or
findstr($casenam,"spring") > -1 )
    @idx_case = 3
elseif (findstr($casenam,"Summer") > -1 or findstr($casenam,"SUMMER") > -1 or
findstr($casenam,"summer") > -1 )
    @idx_case = 6
elseif (findstr($casenam,"Fall") > -1 or findstr($casenam,"FALL") > -1 or
findstr($casenam,"fall") > -1 )
    @idx_case = 9
endif

logterm("<@idx_case=",@idx_case,"<")
if (findstr($casenam,"Medium") > -1 or findstr($casenam,"MEDIUM") > -1 or
findstr($casenam,"medium") > -1 )
    @idx_case = @idx_case + 1
elseif (findstr($casenam,"Median") > -1 or findstr($casenam,"MEDIAN") > -1 or
findstr($casenam,"median") > -1 )
    @idx_case = @idx_case + 1
elseif (findstr($casenam,"Light") > -1 or findstr($casenam,"LIGHT") > -1 or
findstr($casenam,"light") > -1 )
    @idx_case = @idx_case + 2
elseif (findstr($casenam,"Low") > -1 or findstr($casenam,"LOW") > -1 or
findstr($casenam,"low") > -1 )
    @idx_case = @idx_case + 2
endif

```

The above code shows two examples of default actions.

In the first series of tests, the program looks for the season in the case name. Note that the “idx_case” variable has already been set to “0” before the tests start. If the season string is not found in the case name, then the default value of “idx-case” is “0” which corresponds to winter. In the cases provided to the Auditor, it was actually the case that none of the season strings were found in the case names. The program continued to run in spite of the fact that the season string was not found.

In the second series of tests, the program looks at whether the loading is medium, median, light or low but a test for heavy or peak is not provided. This suggests that the default action is to assume heavy in which case the “idx_case” variable is not incremented. Again, if the strings are not found in the case name the default action is unexpected.

High reliability code should test for strings or values that **must appear** and, if they do not, the program should terminate with an error message. Sneak paths via default actions should not be permitted.

- c) **Weak testing for case sensitivity.** Both tests in Example 2 above try to deal with case sensitivity in the strings but do not cover all of the possibilities. A much more rigorous test would have been very easy to implement by casting the entire case name to upper case or lower case letters prior to testing for the string using the built in EPCL functions “toupper” or “tolower”.
- d) **Weak testing for status of McNeill Station.** The following code snippet from the EPCL program add_gen2003.p illustrates another example of weak testing.

```
$logid = "1 "
@logindx = rec_index(0, 4, @logfrom, -1, $logid, 0, -1)

if (@logindx = -1)
@saskmw = 0
logterm("Sask tie is neither import or export", "<")
else
```

This code uses the built-in EPCL function “rec_index” to test whether a load is present at McNeill. If a load is not present at the bus then it is assumed that McNeill is not operating (i.e. neither import nor export). In one case supplied by AESO McNeill was actually represented as a generator, was not discovered as a load by the above test, and the resulting adjustments to the load flows were incorrectly performed.

- e) **User changes/intervention required in production code.** The Auditor considers that user intervention or modification of production code to carry out loss factor calculations is inherently unsafe. Errors can be introduced into previously working code and the practice can lead to inconsistency in results if different assumptions are used.

- f) **Apparent lack of formal process for EPCL code revision or review.** The Auditor did not witness any evidence of a formal process for review and approval of changes made to EPCL programs.

The Auditor did not exhaustively review all of the code but considers that the above examples are sufficient to illustrate that the custom EPCL code that is being used for loss factor calculations is not of production quality and has not been adequately tested. This would not necessarily prevent a skilled user from achieving correct results but would certainly increase the possibility of errors especially if the personnel performing the work are changed.

3.4.4 Excel Spreadsheets

The calculation of shift factors and Normalized loss factors is carried out using Microsoft Excel software. When constructing the Excel spreadsheets, the documentation sometime suggests that the user start from sheets prepared for a previous study. This is recognized as being unsafe by the AESO and Excel spreadsheet template files are being prepared to serve as starting points.

In preparing the spreadsheets, it is necessary to manually cut and paste values and or program steps from other spreadsheets or external data sources. This can lead to errors unless the operator is extremely careful.

Another weakness with using Excel spreadsheets is that the program steps are not easily visible and thus cannot be readily checked except on a cell-by-cell basis. Another factor is that variables are identified by cell reference rather than by name. This makes it very difficult to check that all of the calculations are being correctly carried out.

The Auditor has not exhaustively checked the program steps in each Excel sheet but has noted at least one apparent error in an Excel program. The noted error was in the allocation of forecast losses into seasonal components using seasonal distribution factors from a previous year's measurements. Fortunately, the apparent error was not serious in that it had the effect of reducing the forecast losses by less than 1% of the intended value.

3.5 Suitability of the AIES System Model for Loss Factor Calculations

The suitability of the AIES system models as derived from TASMO are evaluated annually by the TA/AESO to assess their suitability for both planning studies and for the loss factor calculations using the process template "Process - Model Validation" [8]. The auditor has reviewed this template, the TA/AESO's report on the 2002 model validation [7] and has carried out his own review of the system data as obtained from the TASMO.

It is important to note that the system model is in state of constant change due to addition of new supply or demand customers and because the amount and quality of SCADA information

available to test the model continues to improve. The TA/AESO carries out an annual comparison of the system model against the SCADA data. Discrepancies that are discovered are corrected but, in general, it is not practical to go back and assess the result of such corrections on historical studies. Studies going forward from the date that discrepancies were rectified should however use the best available data.

The Auditor's review of the process template and the TA's report on model verification is given below.

Process - Model Validation

This process template outlines the methodology used by the TA/AESO in assessing the suitability of the system model for planning and for the loss factor calculation. In the Auditor's assessment, the template adequately describes the process of obtaining both the SCADA data and the corresponding TASMO model data. The steps to be followed in tuning the power flow to match the TASMO data are also described, as are the means of identifying correspondence between the PI tags and the powerflow results. The auditors only suggestion would be formally identify and file reference documents such as "Christopher's cross reference table".

3.5.1 Integrity of the System Model

The Auditor's review of the system data is described in Appendix 2 of this report. This review did not show any material errors in system topology or glaring impedance errors. Minor errors have been advised to AESO.

The TA/AESO's own tests to validate the system data against the PI model are described in report "2002 TA System Model Verification" [7]. This report was completed before the Auditor's review and probed more deeply into the cause for discrepancies than the Auditor's review. Most of the problems discovered in that review were corrected prior to the release of the report.

Most of the problems discovered in the TA/AESO's model validation can be grouped into five general categories:

- a) System topology errors: usually this was associated with improper internal representation of project behind the fence load or capacitive compensation
- b) Project status discrepancy in TASMO: this was noted as loads or motors that were not turned on but should have been or vice versa.
- c) Missing loads in TASMO
- d) Conflicting Voltage control requirements (minor)
- e) Unknown status of low voltage lines and capacitors that have no visibility in the SCADA database.

In spite of the discrepancies, the comparison of calculated major line flows with recorded values is relatively good, generally within 10 percent of calculated values or (<10 MW) in 820 of 862 branches.

Some of these observed deficiencies indicate that the data entry and project status entries need to be given greater attention. In other cases, the problems result from inadequate modeling or SCADA information that has existed for some time.

The impact that the observed discrepancies might have on the loss factor calculation process is not easy to quantify. As the raw loss factors are based on net generator output at the point of supply, the impact of not explicitly representing or inaccurately representing some portion of a project's behind the fence load may be small but this would need to be studied.

3.5.2 Data Change Management Process

Very few of the discrepancies noted in the TA/AESO's model validation study can be attributed to keying errors. Instead, the most significant discrepancies seem to arise from misunderstandings regarding the status of projects once again suggesting the need for more emphasis and checking of what has been implemented in TASMO by the project engineers involved with providing new or revised STS access.

3.6 Possible Areas of Discretion in the Loss Factor Calculations

The Board's directions are not specific in some aspects. In these areas, the TA/AESO is required to make assumptions or apply judgment in the calculation of loss factors.

One area where discretion is involved is in the assumptions used in development of the base-case load flows to be used in the calculation. This includes such factors as:

- System loads
- Generation dispatch
- Adjustment of system voltage profile
- Maintenance of stacking order
- Dispatch of imports and exports on the interties

The auditor has reviewed the methods and assumptions used by the AESO in each of the above areas. The assumptions and methods followed by the AESO are documented in its own internal reports. The underlying principle that appears to have been used by the AESO in establishing assumptions to be used in any of these areas is to ensure that the resulting load flows should be consistent with anticipated actual operating conditions on the system. This is ensured by checking against system operational procedures, operational records and statistical records of

utilization. Generally, the assumptions documented by the AESO seem to be logical and are consistent with the directives of the Board.

The methods used by the AESO in the forecast of system load and losses for the purposes of the loss factor calculations are another area where there is an element of discretion on the part of the AESO. Details of these processes and the assumptions inherent in these processes were not provided and thus were not included in the audit.

Another area in which there is some discretion on the part of the AESO is in the detailed calculation methodology. This includes factors such as:

- Load flow solution tolerances and maximum number of iterations that has been discussed in section 3.4.2.
- Calculation of losses.
 - The custom EPCL code calculates losses by summing the losses in all lines and transformers. This is the most direct method and is considered satisfactory. Other methods such as looking at the difference in swing bus generation could also have been used.
- Handling of computational errors (load flow non-convergence) encountered in the calculations. The document “Loss Factor Calculation Methodology” [1] contains a short discussion of a possible methodology to be followed in the event that convergence problems are encountered in the calculations. The suggested method includes recalculation of the loss factors at nearby values of generator output ($\pm 1\text{MW}$) and then plotting the points. Obviously inconsistent points would be rejected and the calculated raw loss factors for the points that seem consistent would be averaged. This is not handled automatically in the custom EPCL programs, and would require manual intervention in the loss factor calculation process.

3.7 Replication of Historical Results

One of the measures that can be applied to test the integrity of a process is to verify that it is possible to go back to historical results and demonstrate that these can be repeated.

The Auditor made repeated attempts to try to replicate the calculations of raw loss factors for individual units but was generally unsuccessful except for a few cases performed for units commissioned after December 2002.

The Auditor’s requests for additional data and detail were handled by the AESO with full cooperation and the AESO spent considerable effort to try to locate and provide original data for the cases. The AESO also went back to try to repeat historical cases [15]. In the end, it was not possible to replicate the results to an exact match for units commissioned before 2001. The AESO’s recalculation of loss factors for randomly chosen cases using available data indicated the results would be within about 0.2% of the posted results on average.

This lack of success in being able to provide data, base cases and programs that would allow exact replication of raw loss factor calculations is attributed by the AESO to the following factors:

- Data, programs and base cases used in the original cases were not systematically stored and archived.
- There are multiple versions of the PSLF custom EPCL programs. Often it is not possible to determine which version was used with a particular calculation.
- Directory references are hard coded within the EPCL code (modifications are needed to execute the files if they are moved from their original location)
- Control files are different for different versions of code and modifications are needed to run them.
- Manual intervention may have been used during the case.
- Other PSLF and EPCL programs may have been used to modify the base cases prior to calculation. This is not always obvious from the stored files.
- Personnel originally involved in the calculation have left the AESO.

For units commissioned in 2001 and 2002 the AESO was able to verify exact matches of posted normalized loss factors for all units but did note a filing error in that base cases were not saved correctly for one unit.

For units commissioned after December 2002, the final loss calculation, program files, base cases and all other input data are stored in an archive and the AESO has no difficulty in repeating the calculations exactly.

4 REFERENCES

The following documents were provided for the Auditor’s review. We note that a number of the documents have year 2003 dates. However, the existence of older unsigned versions of many documents was observed, indicating that documents did exist prior to the indicated dates but may not have been formally approved.

No.	Type	Status	Title
1	Report	Confidential	Loss Factor Calculation Methodology - Revision 3, 9 th May-2001
2	Report	Public	Loss Factor Calculation Methodology – Revision 3, 24 th June 2002
3	Report	Public	Transmission Administrator’s (the “TA”) Loss Factor Determination Process –No Revision or Date
4	Report	Confidential	Guidelines to Establishing the Stacking Order (2002) - Revision 0
5	Report	Confidential	Assumptions for 2003 Loss Factor Base Cases - Revision 00, 26 th June 2002
6	Process Template	Confidential	Process – Loss Factor Base Case Maintenance – Revision 1 draft, 3 rd March 2003
7	Report	Confidential	2002 TA System Model Validation, 8-November-2002
8	Process Template	Confidential	Process – Model validation - Revision 0, 12 th February 2003
9	Process Template	Confidential	Process – Provide New or Revised System Access Revision 1, 24 th March 2003
10	Report	Confidential	Generic Stacking Order January 29 2003 – Revision 1
11	Process Template	Confidential	Generic Stacking Order Maintenance – Revision 1, 23-April-2003
12	Process Template	Confidential	Process – Loss Factor Calculation – Revision 0, 10-February-2003
13	Process Template	Confidential	Process – BC, SaskPower Ties and DOS Loss Factor Calculation Revision 1, 30-January-2003
14	Process Template	Confidential	Process – Calculating Shift Factor –Revision 0, 12-Feb-2003
15	Report	Confidential	Loss Factor Audit – Historical Loss Factor Calculations – Received 31 st July 2003

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ATTACHMENT A

**ANSWERS TO SPECIFIC QUESTIONS
POSED BY THE CMC**

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SPECIFIC QUESTIONS POSED BY THE CMC

1. *What caused the magnitude of the (forecast) shift-factor in the Feb. 12, 2002 version of the Normalized Loss Factor Table for 2002? What are the causes (including difference in the accuracy of the network model between 2000 and 2002)? What is the relative contribution of each cause?*

The auditor has reviewed the calculation of loss factors using data provided by the AESO. The variation between the 2002(report) shift factors and the Final 2002 shift factors is due primarily to a 32% increase in forecast transmission losses. There was some adjustment of individual generator volumes to accommodate the modest increase in forecast generation (1%), and redistribution of generation, presumably to reflect changes in market conditions. The breakdown of the causes for the variation in 2002 shift factors is shown in Table A1-1.

**Table A1-1
Causes of Variation in Shift Factors (2002)**

	Shift Factor			
	Winter	Spring	Summer	Fall
2002 (report)	-4.75%	-4.29%	-4.79%	-4.28%
Adjustment due to increased load and distribution	-0.49%	-0.55%	-0.67%	-0.36%
Adjustment due to increased losses	-1.00%	-2.25%	-1.83%	-1.49%
Final 2002	-6.24%	-7.08%	-7.29%	-6.13%

The AESO was not able to supply load flow data files to support the raw loss factor calculations prior to 2002. Thus, it was not possible to quantify the impact of network modeling changes between 2000 and 2002. The AESO as part of its 2002 system model validation process identified a number of areas where the system model needed improvement but these would not have come into effect until load flows for 2003 loss factor calculations were prepared.

2. *Does the seasonal adjustment to the current Normalized Loss Factor table (Feb 12, 2002) appear reasonable? How does the seasonal adjustment compare to the metering information collected by the TA?*

The final shift factor calculations for 2002 were based on a forecast increase in annual system loss volumes of 32% (894,000 MWh), which subsequently did not materialize.

The increase in forecast loss volumes does not appear to be consistent with the forecast increase in total generation volumes. The total forecast generator volumes increased by only 540,000 MWh implying a reduction in forecast load on the system of about 354,000 MWh.

It is however noted that the system losses are very strongly dependent on the flows on the 240kV north-south interconnection. The increase in forecast losses is consistent with an increase in loading of between 200 to 600 MW on the 240 kV north-south transmission corridor. The assumptions used in establishing the forecast losses were not provided by the AESO. However, given that the increase could be attributed to a modest increase in flow on the north-south interconnection it may be reasonable.

The seasonal adjustment to loss factors in the 2002 posted loss factors (and in the 2003 posted loss factors) is achieved by apportioning of the forecast annual loss volumes for the entire year in the same proportions as determined from measured loss volumes from the same seasons in the previous year.

3. *Is the treatment of import and export loss factors consistent with the Board's decisions?*

The Auditor's review of the process templates indicates that the loss factors for import and export on the BC and SaskPower interties are being treated in accordance with the board directives.

4. *Is the procedure used to update the stack-order reasonable and consistent with the Board's direction?*

The stacking order in any season is based either on known operating costs or generic industry standard heat rates for the specific technology used at each individual generator together with estimates of fuel price escalation. Maintenance of the stacking order is done by obtaining the stacking order for the previous season then adjusting it to take into account the above factors. Adjustments are made if, in the judgment of the performer, there is an inconsistency between the existing stacking order and the previous 12-month record. At this time, new units added in the previous year would be added and any retired units would be removed.

The process of starting from pre-existing stacking order and making incremental adjustments based on new generator additions or deletions of retired units and usage information for the previous 12 months is, in the Auditor's judgment, a reasonable approach.

5. *Are the procedures and processes which the Auditor is auditing properly documented?*

The AESO has prepared a comprehensive set of process templates in order to formalize the steps involved in each of the sub-processes involved in the loss factor calculations. The documentation is generally clear and concise. However, no obvious QA process is in place to check that every step has been rigorously completed.

6. *Include a reconciliation with the Board's direction under Decisions 2000-01 and 2000-27.*

Please refer to Table 2-1 of the report.

7. *Identify where the Board's directives are lacking in detail and the TA is required to use its own discretion.*

Please refer to Section 3.6 of the Report.

8. *Identify the basis for the TA's adopted procedures where such procedures require discretion on the TA's part.*

The underlying principle that appears to have been used by the AESO in establishing assumptions to be used in any of these areas is to ensure that the resulting load flows should be consistent with anticipated actual operating conditions on the system. This is ensured by checking against system operational procedures, operational records and statistical records of utilization. Generally, the assumptions documented by the AESO seem to be logical and are consistent with the directives of the Board.

9. *Is the method to determine the capacity of a new generation facility, for purposes of loss factor calculations, reasonable and consistent with the Board's directions?*

The raw loss factor calculations for new generation facilities are based on the STS contracted output, net into the grid at point of supply. This is consistent with the Board's directions.

10. *Outline the relationship between the forecast used to determine system losses to calculate the shift factor and the load forecast used for the calculation of raw loss factor.*

The basis for the load forecasts used to determine system losses to calculate shift factor and the load forecasts used for calculation of raw loss factors was not provided for detailed review. It is believed that the two load forecasts are the same but this was not confirmed.

11. *Confirm that the publicly available information from TASMO is exactly the same as the non-confidential information available to the TA's internal staff for the purpose of establishing loss factors. Specifically, address the question "can any knowledgeable AIES stakeholder replicate the loss factors established by the TA extraction of the Powerflow models from the publicly available TASMO database?" If the Auditor cannot confirm this, the Auditor will provide details as to why this may be so.*

The Auditors review indicates that the data that is publicly available from the TASMO is exactly the same as the data that is available to the TA/AESO's staff for the purposes of calculating loss factors.

However, it is not possible for AIES stakeholders or any other knowledgeable person to replicate the loss factors established by the TA vis-à-vis the powerflow models extracted from the TASMO. This is because the TA/AESO also uses additional information in the calculation of loss factors that is not available on the TASMO. For example:

- Confidential information from IPP's for proposed new projects from CASPIR
 - Generator maintenance plans and expected forced outage rates
 - Generator stacking order information (also confidential)
 - System operational details including voltage profiles and details of hydro and wind project dispatch.
 - Historical information regarding interties import and export levels
12. *Confirm that system changes introduced to the TASM database is accurately reflected at the database's output in both internally available as well as externally available TASM database. If the Auditor cannot confirm this, the Auditor will provide details as to why this may be so.*

The Auditors review indicates that exactly the same information will be reflected in internal and externally available data outputs unless such information is of a confidential nature. Confidential information will not be made available to the public. If the data is accurate, it will be accurate in both internal and public output files. Similarly, erroneous data would be present in both outputs.

13. *Where modeling errors have been identified as a result of the audit, confirm that the data and information provided to the TA –related to the error(s) identified - by the Transmission Facilities Owners (TFO) and Generation Facilities Owners (GFO) are reflected in the model as submitted to the TA. (The Auditor may ask TFOs/ GFOs - to provide them with the original data submission to the TA for this evaluation).*

The Auditor did not discover any significant system modeling errors in the audit process. Minor discrepancies noted would have affected the solution only in a localized way.