THE POWER OF POSSIBILITY

Alberta Electric System Operator

Loss Factor Methodologies Evaluation
Part 2 – Conversion of Power to Energy Loss Factors

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ALBERTA ELECTRIC SYSTEM OPERATOR

LOSS FACTOR METHODOLOGIES EVALUATION
PART 2 – CONVERSION OF POWER TO ENERGY LOSS FACTORS

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1 INTRODUCTION

This report discusses the results of full system testing of methodologies to convert load flow based loss factors to energy-based values, based on the 50% corrected 'R-Matrix' area load adjustment loss factor calculation methodology.

2 EVALUATION METHODOLOGY

The full Alberta Integrated Electric System (AIES) was used as the basis for all calculations. A full set of 2003 load flow conditions was used as the reference power flow. The load flow model consists of about 1700 busses, with about 190 generators and about 700 loads connected. Bus number 1520 (the 500 kV equivalent of the BC Hydro and WECC system) was designated as the swing bus for the system.

Loss factors were calculated for each generator in the load flow for each of the 12 load flow conditions using the 50% corrected R-Matrix area load adjustment methodology. The load flows represent peak, medium and light load conditions for each of the winter, spring, summer and fall season. The 12 sets of loss factors were combined to give a single loss factor for each generator using two approaches:

1. Un-weighted approach in which the loss factor assigned to each generator is the average of the loss factors determined for each of the load flow conditions.

2. Weighted approach in which the loss factor assigned to each generator is a weighted average of the 12 load flow loss factors. The weighting assigned to each loss factor is discussed in Section 3.

The two sets of loss factors were used to compute the shift factor that would be required to recover all of the energy losses based on the 2004 forecast of generator volumes and total system energy losses. These shift factors were compared to the factors calculated using the existing 'swing' bus methodology and which form the basis of the posted 'normalized' loss factors. The comparison is discussed in Section 4.

Loss factors were not available for 14 of the generators contributing in the range of 5.18% to 5.86% of the total forecast energy volumes. To include the effects of these units in the evaluation of approaches, the units were assigned a loss factor equal to the average loss factor of the system based on load flow results or 5.21%.

3 DETERMINATION OF LOSS FACTOR WEIGHTINGS

In the present AESO loss factor methodology, loss factors are determined for each generator for each of three loading conditions in each of the four seasons. Separate loss factors are assigned to each generator for each season, equal to the average of the three loss factors calculated for each season.

The Alberta Department of Energy has indicated that for the new methodology, each generator will be assigned a single loss factor based on annual impact on losses. Extending the present philosophy to the new methodology, one method of converting load flow loss factors to energy loss factors is to determine the annual loss factor based on the average of all 12 individual loss factors. This is referenced herein as “equal weighting” since the loss factor from each load flow is assigned the same weighting.

An alternative approach considered was to assign a weighting to each loss factor based on the load duration curve for each season. The projected load duration curve for each of the four seasons for 2005 are shown in Figure 1 through Figure 4. If it is assumed that the shape of the load duration curve for 2003 is not significantly different from the shape for 2005, then the load levels represented by each of the load flows studied can be superimposed on the individual load duration curves. Each of the figures also indicates the average load level for each one-third of the load duration curve (superimposed boxes).

Figure 1 shows that the load flow levels represented by the winter peak and winter medium load flows are less than the respective averages with the winter low load level, greater than its respective average. Similar trends are shown in Figure 2 and Figure 3 for spring and summer conditions. In the fall load flow series, the peak load is greater than the average but the medium and low load conditions exhibit similar trends in all four seasons.

Based on the figures it was concluded that the load flows were not very representative of the average energy associated with each load flow, particularly if equal weighting is assigned to each load flow.

Weightings were determined for each load flow that would minimize the total difference between the load energy represented by each load flow and the load duration curve. These weightings are given in Table 1 and shown graphically in Figure 5 through Figure 8. The difference between the energy for each season and the energy calculated using the load flow load levels and the weighting factors given in Table 1 are almost five orders of magnitude less that the total energy as is shown in Table 2.

4 COMPARISON OF RESULTS

The calculation of shift factors for the year 2004 based on the 2003 load flows and the current AESO loss factor methodology is summarized in Table 3. The shift factors vary from –3.89% for the fall conditions to –4.53% for the spring loading conditions. The shift factors are subtracted from the generator individual raw loss factor to determine the normalized loss factors for each generator. As all four shift factors are negative, the normalized loss factor for all of the generators is increased.

The shift factors for 2004 have been re-calculated using the 'raw' loss factors determined with the 50% area load adjustment methodology. The same individual estimated generator volumes and total estimated system losses were used. Only the 'raw' loss factors for each generator were changed. The 'raw' loss factor for each generator was set equal to the direct average of the 'raw' loss factors determined for each load flow.

Raw loss factors were not generated for 14 of the generators. To include their effects, each of these units was assigned a 'raw' loss factor equal to the average annual load flow loss factor of 5.21%. As the total generation associated with these units is about 5% of the total, the net effect of this approximation is to reduce the magnitude of the required shift factor by about ¼%. After including the small adjustment, the shift factors required for the new methodology would be reduced considerably to approximately –1% as shown in Table 4.

The shift factor was recalculated using loss factors for each generator that are weighted by the weighting assigned to each load flow. Table 5 shows that although there is an improvement in the shift factors for each season, the improvement is not considered sufficient to warrant the extra refinement (and its risk of introducing other inaccuracies).

Even though there is a significant improvement in shift factors over the existing methodology, the shift factor (at about –1%) is still considered large. As the 'raw' loss factors account for 100% of the individual load flow losses, the difference can be directly attributed to differences between load levels and individual generation modeled in each of the load flows and the generator forecasts and total energy loss forecasts used in the calculation of seasonal shift factors.

Work is in progress to investigate the roots of the differences and could be the subject of further investigations into improving the correlation between load flow results and energy forecasts.

Table 1 Load Flow Weighting Factors to Minimize Energy Error

	Winter	Spring	Summer	Fall
Peak	0.51	0.54	0.32	0.24
Medium	0.32	0.14	0.28	0.49
Low	0.17	0.32	0.4	0.27

Table 2 Energy Mismatch With Weighting Factors

	Winter	Spring	Summer	Fall
Actual Energy (TWh)	17.8	16.8	16.8	17.2
Mismatch (GWh)	-0.13	0.12	-0.09	0.010

Table 3 Shift Factors Based on Current Swing Bus Methodology, Equal Weighting

Season	Winter	Spring	Summer	Fall
Total forecast generator volumes (MWh)	15,104,377	14,077,162	14,516,509	14,595,855
Total forecast losses (MWh)	768,108	723,355	700,193	681,626
Total non-normalized energy losses	119,662	130,427	43,739	113,926
Unassigned energy losses	648,447	592,929	656,455	567,699
Required Shift Factor	-4.29%	-4.21%	-4.52%	-3.89%
Note Shift factor is subtracted from individual generator raw loss factors to obtain normalised loss factors				

Table 4 Shift Factors Based on 50% Area Load Adjustment Methodology, Equal Weighting

Season	Winter	Spring	Summer	Fall
Total forecast generator volumes (MWh)	15,104,377	14,077,162	14,516,509	14,595,855
Total forecast losses (MWh)	768,108	723,355	700,193	681,626
Non-normalized energy losses based on available raw loss factors	575,648	517,801	510,353	537,749
Estimate of other contributions	40,710	39,665	42,408	44,546
Total non-normalized energy losses	641,506	565,092	556,671	607,466
Unassigned Energy Losses	126,603	158,263	143,523	74,159
Required Shift Factor	-0.84%	-1.12%	-0.99%	-0.51%
Note Shift factor is subtracted from individual generator raw loss factors to obtain normalised loss factors				

Table 5 Shift Factors Based on 50% Area Load Adjustment Methodology, Optimized Weighting

Season	Winter	Spring	Summer	Fall
Total forecast generator volumes (MWh)	15,104,377	14,077,162	14,516,509	14,595,855
Total forecast losses (MWh)	768,108	723,355	700,193	681,626
Non-normalized energy losses based on available raw loss factors	576,964	519,636	512,419	538,743
Estimate of other contributions	40,710	39,665	42,408	44,546
Total non-normalized energy losses	641,770	566,498	558,172	607,297
Unassigned Energy Losses	126,338	156,857	142,021	74,329
Required Shift Factor	-0.84%	-1.11%	-0.98%	-0.51%
Note Shift factor is subtracted from individual generator raw loss factors to obtain normalised loss factors				

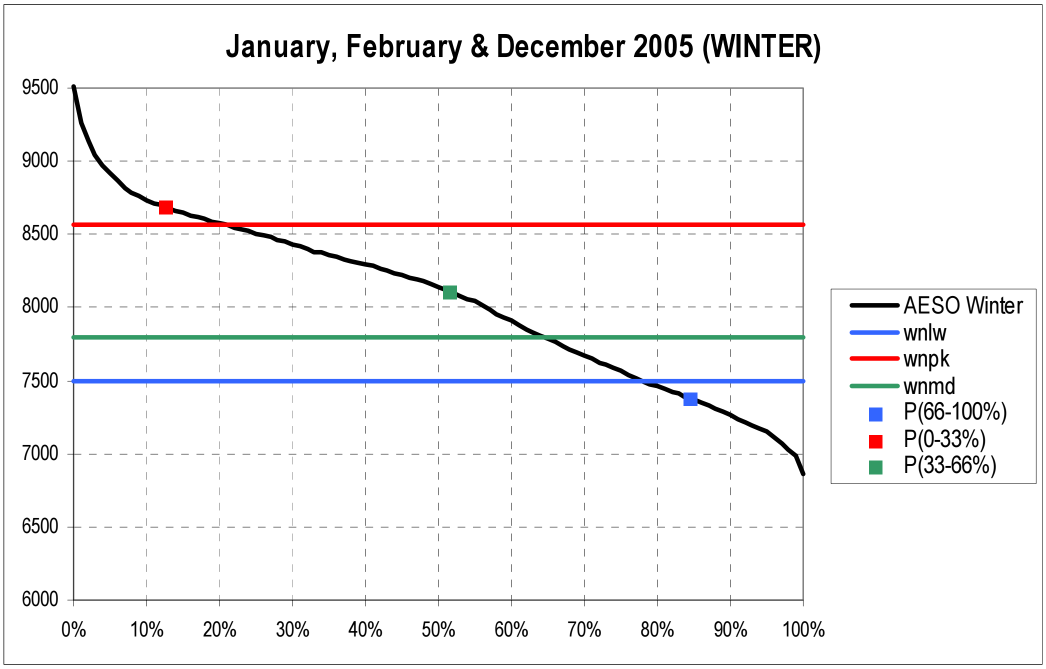

Figure 1Comparison of 2003 Winter Load Flow Levels with 2005 Load Duration Curve

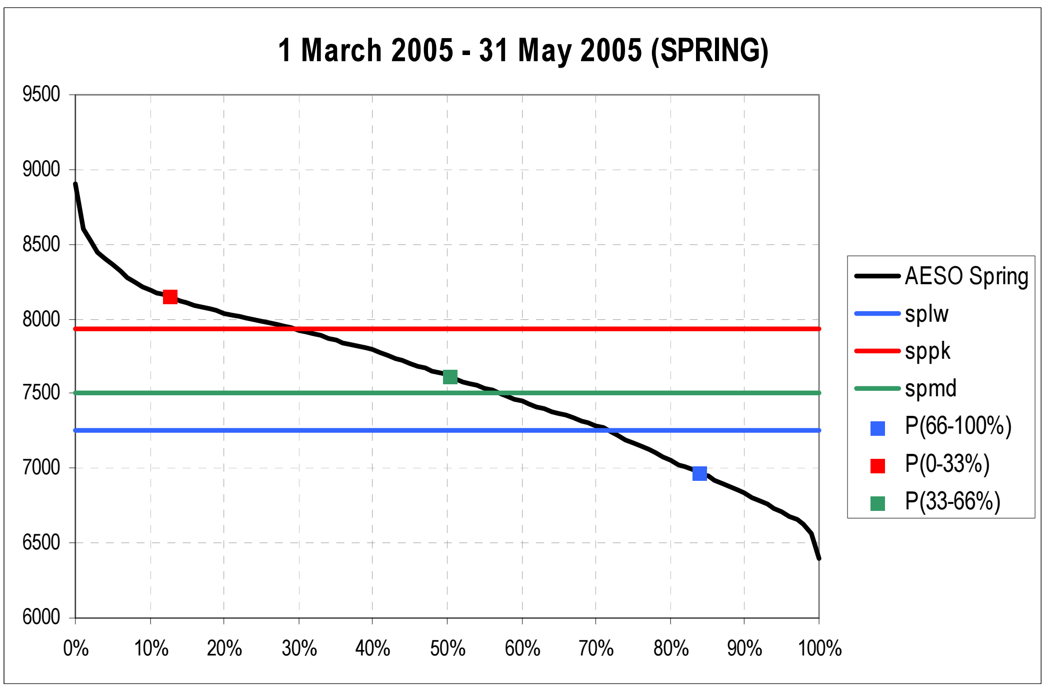

Figure 2Comparison of 2003 Spring Load Flow Levels with 2005 Load Duration Curve

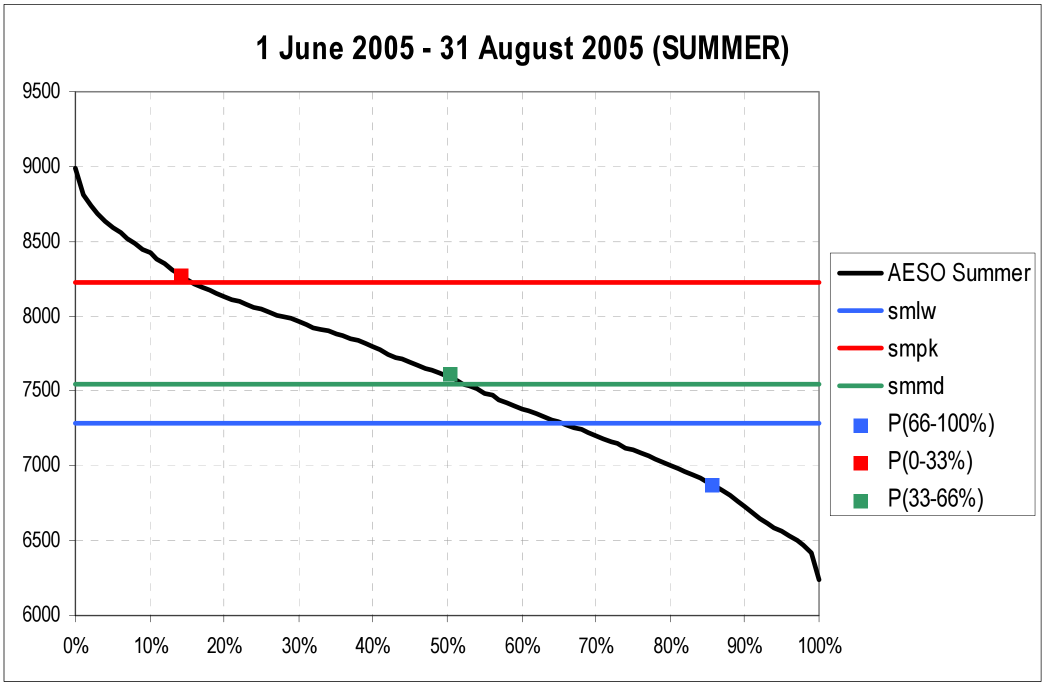

Figure 3Comparison of 2003 Summer Load Flow Levels with 2005 Load Duration Curve

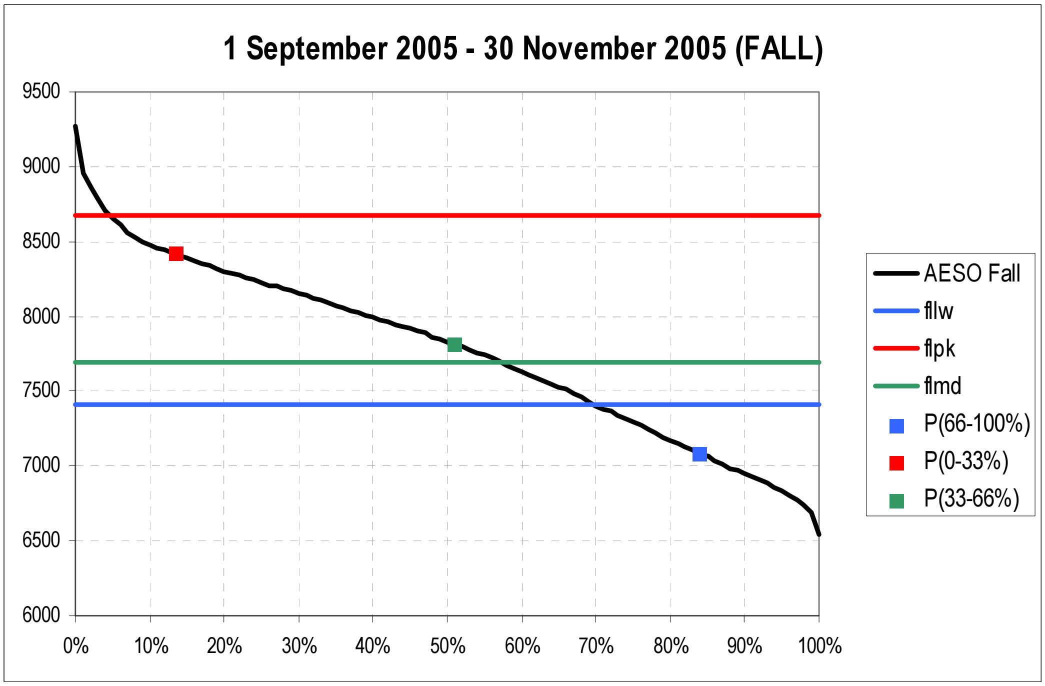

Figure 4Comparison of 2003 Fall Load Flow Levels with 2005 Load Duration Curve

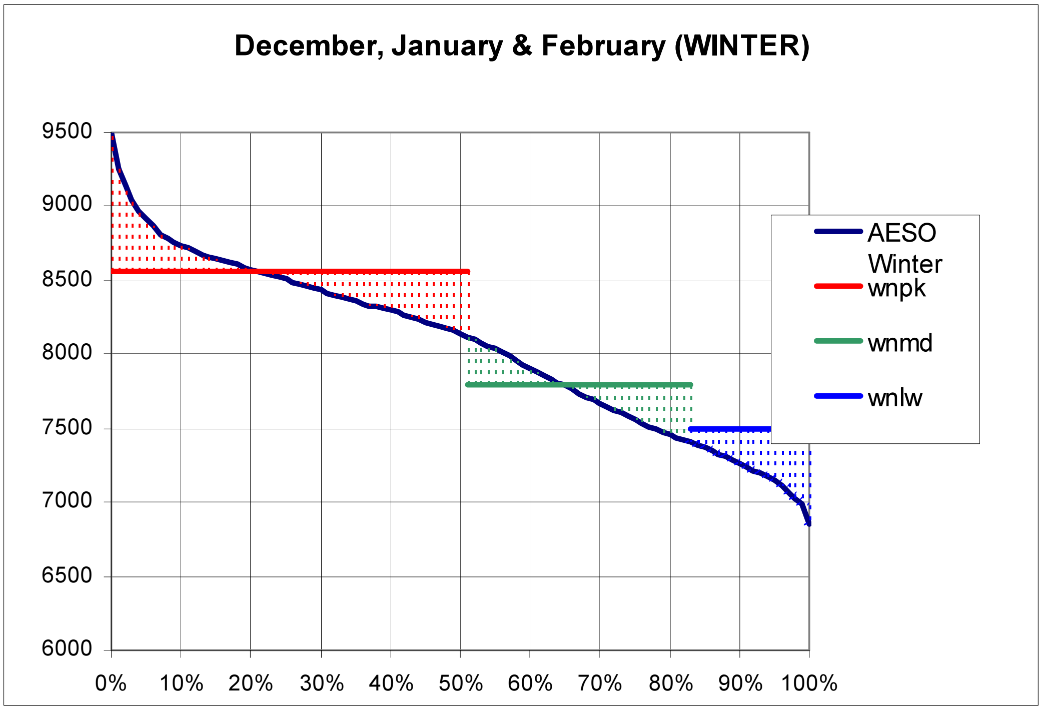

Figure 5Weightings Based on Winter Load Flow Levels

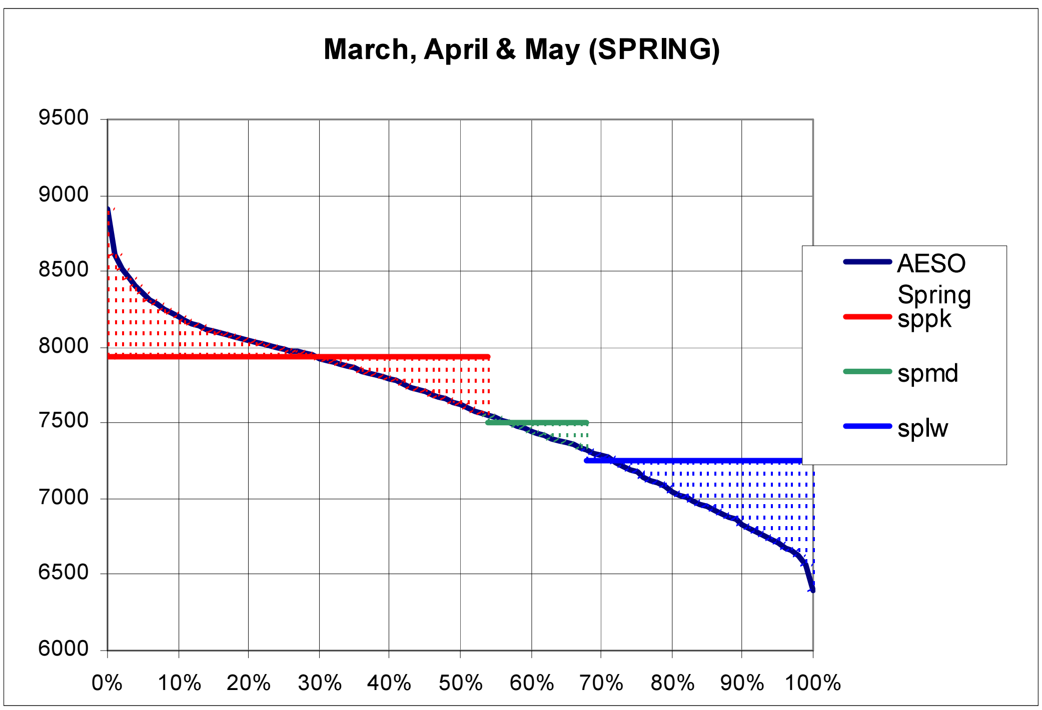

Figure 6Weightings Based on Spring Load Flow Levels

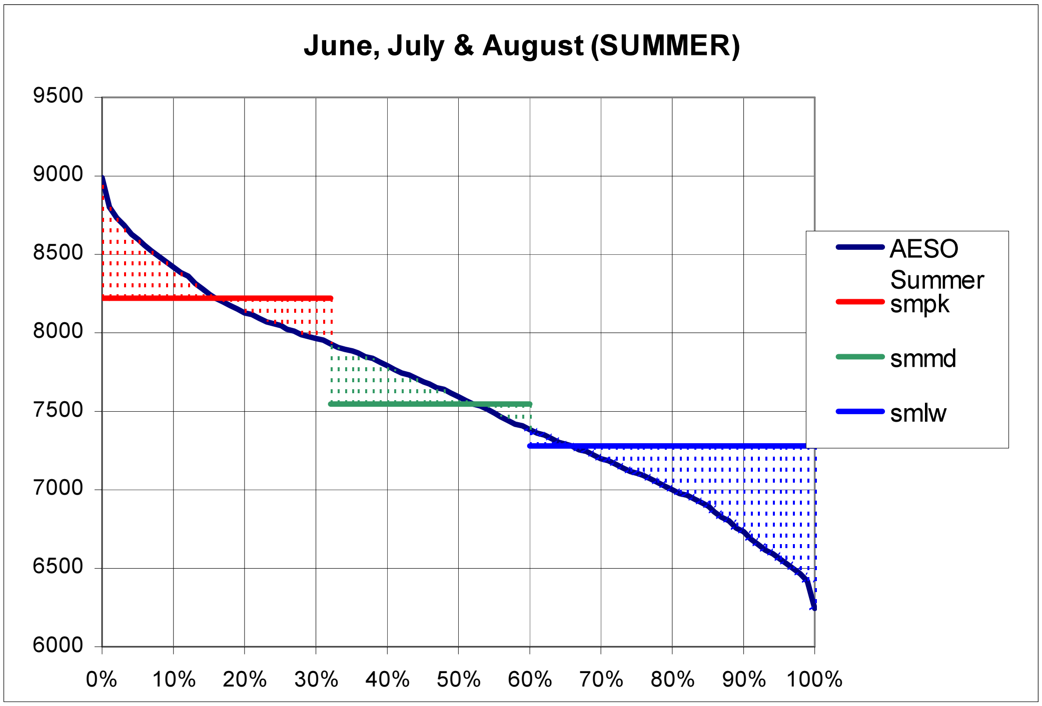

Figure 7Weightings Based on Summer Load Flow Levels

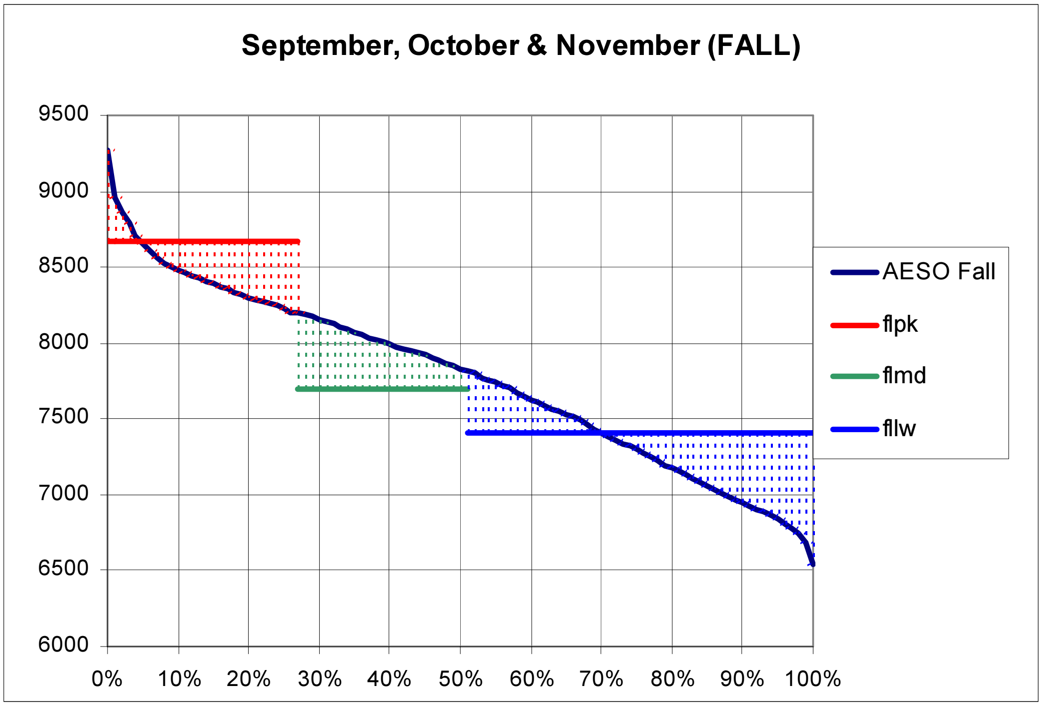

Figure 8Weightings Based on Fall Load Flow Levels