

WECC 2002 Adequacy of Supply Assessment

November 6, 2002

A. Executive Summary

The purpose of this report is to present the results of the 2002 Adequacy of Supply assessment based on the January 1, 2002 WECC Loads and Resources data for the years 2002 through 2011.

An Excel-based zonal model provided by the California Energy Commission (CEC) was used to conduct the studies. The model, "Supply Adequacy Model" (SAM) version 4.0, is an updated version of the model that was used last year. The demands and resources data collected for this year's Loads & Resources reports were used as input to the model. WECC made modifications to the model to accommodate enhancements as described in this report.

The study utilized a deterministic approach in evaluating supply adequacy. Uncertainties associated with such factors as resource availability (including adverse hydro conditions), reduced transmission path capability, and seasonal demand variations were therefore considered explicitly by running additional scenario cases. Scenario cases for the effect that reduced forward prices might have on the development of future generating resources were beyond the scope of the assessment methodology.

The scenarios considered include various combinations of:

1. forecast peak demands for August and December
2. generating resources at existing levels (on-line prior to January 1, 2002), planned levels (forecasted to be on-line after January 1, 2002), and committed resources (under construction)
3. reserve margins of 0%, 15%, or as reported by WECC members in the L&R data
4. hydro generation derates of 0%, 15%, or as reported by WECC members in the L&R data
5. path limit derates of 0% or 20%

The study results that took the planned generation additions into account (excluding CISO generic additions identified in the report) indicate that supplies in each zone of WECC will be adequate through 2011, even with the application of a 15% reserve margin and a 15% derate in hydro generation (to simulate adverse water conditions). Under the same extreme conditions, but excluding planned generation additions, deficits occurred as early as 2003 in the southern part of the WECC.

The stated assumptions should be considered together with the presented results. A determination of supply adequacy for a zone does not necessarily mean an adequacy of supply for all demands within that zone. Transmission constraints internal to a zone may limit electricity transfers to local demand areas, leaving them without adequate supply. These transmission-constrained local demand areas may be quite large and may include one or more major metropolitan areas within a zone and may include most of the total population within a zone. WECC's seasonal assessments and Ten-Year Coordinated Plan Summaries address potential intra-zonal resource inadequacies based on information from the various areas.

B. Introduction and Background

The WECC, including its committees, recognized the need to study the adequacy of electricity supply on a council-wide basis and to identify areas within WECC that have the potential for electricity supply shortages based on reported demand and resource data and considering transmission constraints between areas.

The WECC Reliability Subcommittee has the responsibility to establish the tools, methodology, and data requirements for conducting the adequacy of supply assessments. This responsibility is described in the attached document entitled “WECC Power Supply Assessment Policy.” The attached policy document provides additional information regarding the need to conduct such assessments.

The WECC staff was given the assignment to use the WECC Loads and Resources (L&R) data as input for the CEC model and utilize the model’s results to measure the adequacy of supply in the sub-areas within the WECC.

The purpose of this report is to document the results obtained from the CEC model with the updated input data for the years 2002 through 2011.

C. Description of Model

The Supply Adequacy Model (SAM) was developed by the CEC to study the adequacy of resources in California and other WECC areas to meet the forecast peak demands. The model has the capability to perform either multiple-iteration probabilistic (stochastic) studies or single-iteration deterministic studies. Per instructions from the Reliability Subcommittee, all of the studies conducted for this report were deterministic. If probabilistic studies are requested in the future, it will be necessary to collect additional information as outlined in this report.

For the purposes of this model, the WECC region is divided into the following sub-regions or zones. The zones are configured around demand centers and transmission hubs. Note the division of Colorado into an east and a west zone this year. Refer to the topology balloon diagram under Transfer Paths for connections between zones.

Alberta	Calif., San Francisco	Montana
Arizona	California, SMUD	Nevada, North
British Columbia	California, South	Nevada, South
California, Central	CFE-Mexico	New Mexico
California, IID	COB	Northwest
California, LADWP	Colorado, East	Palo Verde
California, North	Colorado, West	Utah
California, San Diego	Idaho	Wyoming

The following acronym definitions apply to this report.

AZ-NM-SNV	Arizona – New Mexico – Southern Nevada
CA-MEX	California – Mexico (CFE –WECC)
CFE	Comision Federal de Electricidad
CISO	California Independent System Operator
COB	California Oregon Border
IID	Imperial Irrigation District
LDWP	Los Angeles Department of Water and Power
MAPP	Mid-Continent Area Power Pool
NWPP	Northwest Power Pool
PSC	Public Service of Colorado
RMPA	Rocky Mountain (Colorado – Wyoming)
SMUD	Sacramento Municipal Utility District
SPP	Southwest Power Pool
WACM	WAPA – Colorado / Missouri
WALC	WAPA – Lower Colorado

Demands

One component of the model’s input data is estimated peak demands for each SAM zone. The control area firm peak demands as submitted for the L&R reporting were used in the model. Where control areas spanned more than one zone, the demands were allocated by percentages (see details in Assumptions). The following table is an area summary of the actual and forecast firm peak August demands through 2006.

Firm August Peak Demands by Sub-Region (MW)

Sub-Region *	2000	2001	2002	2003	2004	2005	2006
AZ-NM-SNV	21,461	22,523	23,848	24,753	25,670	26,511	27,248
CA-MEX	50,253	47,000	50,846	51,798	52,711	53,666	54,663
NWPP	47,422	44,444	47,042	47,969	48,836	49,597	50,364
RMPA	9,560	9,226	9,772	10,072	10,321	10,596	10,860
Total WECC	128,696	123,193	131,508	134,592	137,538	140,370	143,135

* For the purposes of this assessment, interruptible or non-firm demands are not included. Also, PACE-Wyoming demand is assigned to the RMPA sub-region for 2002 forward.

Based on actual demands for 2001, economic conditions and conservation, many control areas have reduced their demand forecasts compared to last year. See graph #1 at the end of the report.

Resources

The model is designed to accept individual resource data including plant names, capacity ratings, forced outage rates, and optimal operating costs. Of these data, WECC currently collects only generator names and seasonal capacity ratings. The existing resources and planned resource additions listed in the L&R data files were used as input for the model. The resource capacities were summarized by zone and type (hydro or non-hydro) before being copied into the model.

The table below shows the generation additions added during 2001 and planned for the sub-regions of WECC from 2002 through 2006 as of August each year.

Generation Additions by Sub-Region (MW)

Sub-Region	2001	2002	2003	2004	2005	2006
AZ-NM-SNV	1,829	2,458	6,232	3,505	3,583	1,100
CA-MEX *	3,371	3,487	6,260	5,513	5,200	172
NWPP	2,243	2,628	3,245	4,387	2,976	1,883
RMPA	496	479	1,220	511	0	0
Total WECC	7,939	9,052	16,957	13,916	11,759	3,155

* The resource data that were compiled for the L&R reports included a significant amount of generic generation additions for California (CISO) that were not included in the supply adequacy studies due to insufficient information. The approximate values of the excluded generic generation are listed below.

Excluded CISO Generic Generation Additions (MW)

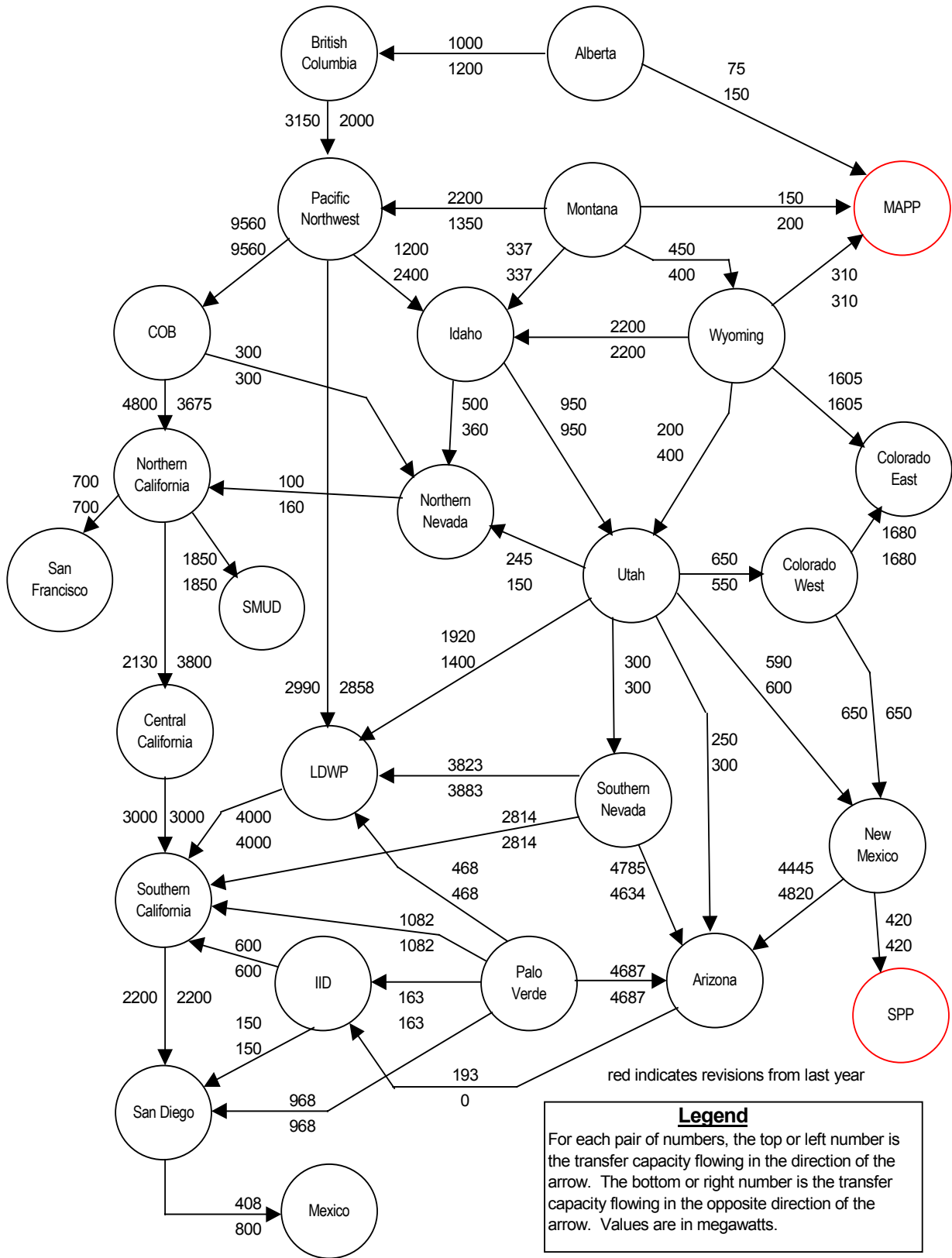
	2001	2002	2003	2004	2005	2006
Generic	0	1600	7600	9800	5800	172

Transfer Paths

The transfer paths used by the program are based on the SAM zones. A path connects one SAM zone to another SAM zone, and the paths from one zone to another are listed in a table with fields for the path, transfer capability, wheeling cost, and loss factor. Since the wheeling costs and loss factors were not requested, the CEC values were used for the studies. The wheeling costs for each path are used to calculate the transfer costs for any imports into a zone. The loss factors are used to calculate the net transfer after losses for any imports into a zone.

A request was sent out to select control areas in each zone to provide information on the transfer capabilities between zones. The responses were used to update the capabilities in the model based on the values provided.

The topology of the CEC model is shown in the following balloon diagram. The lines between zones are intended to represent transmission connections between the zones and the listed numbers are the transfer path capabilities as reported by the control area representatives. The model observes these maximum capabilities as it solves each iteration.



Solution

Microsoft Solver, a third-party tool included with Excel for solving constraint-based problems, is used to solve the demand/resource balance and calculate the surplus generation in each zone.

The solution seeks the lowest overall resource cost subject to the following constraints:

- the demand requirements of each zone must be met (surplus ≥ 0); but it's possible for a zone to be deficit before solver starts.
- the aggregate resources for each zone must be equal to or greater than zero
- the aggregate resources for each zone must not be greater than the available resources
- the aggregate resources for each zone must not be less than the minimum resource allocation

The solution uses transfers between zones to export resources from surplus zones to deficit zones. If a deficit is greater than the available transfer capability from the connected zones, then the zone will have a net deficit. The solution will also back off internal generation in a zone if a connecting zone has a surplus that is less expensive and the transfer path has available capacity.

D. Application Summary

The SAM program uses a statistical methodology to determine the adequacy of supply. By design it isn't intended to perform a sophisticated engineering analysis. The solver add-in attempts to find a solution where resources and imports satisfy the demand requirements in each zone. The stochastic solutions model the system uncertainties based on historical demand and outage factors. The deterministic solutions simply compare total resources to total demands without modeling the uncertainties. For these studies, surplus is defined by the following formula.

$$\text{Surplus} = \text{Internal Resources} + \text{Imports} - \text{Demand} - \text{Exports}$$

While the model does consider transfer capabilities between zones, it is not designed to perform any sophisticated analysis of transfer limitations involving simultaneous flows or loop flows.

WECC Workarounds / Enhancements

WECC has implemented workarounds and enhancements to address problems with using the WECC L&R data in SAM, and problems with external resources and the posting of summary results. An intermediate spreadsheet was developed that reads the L&R data from the standard WECC data files and aggregates the demands and resources by SAM zone. The resulting tables are then manually copied into the SAM data areas prior to running the model. This required some preliminary setup work to allocate the WECC L&R demand and resource data to the appropriate SAM zones. Some modifications to SAM were also necessary. Links between SAM and the intermediate spreadsheet automatically return the imports and exports for each zone so that a net zonal margin can be calculated.

The workaround to account for external resources was developed to force the transfer of some jointly owned generation (such as Palo Verde, Colstrip, and others) from the host zones to the

appropriate participants' zones. This involved listing the joint plants for the most severely impacted zones and the transfer paths used for delivery. The data are then copied to an unused area in SAM and modifications to the program then force the transfer path utilizations to at least the levels required to import the external resources.

A workaround to summarize the detailed results for all the zones was implemented by adding a new worksheet to the model that summarizes the resources, demands, imports, and exports for each zone. The imports had to be adjusted to account for transmission line losses.

An enhancement to account for changes to transfer path capacities was also added. For this assessment, the following transfer path capacity changes (selected from the Phase 3 projects of the WECC Three-Phase Rating Process) were represented.

- Mexico (CFE) – San Diego, new rating of 800 MW south to north due to upgrade of Imperial Valley-La Rosita line, effective December 2001.
- Northwest – Montana, new rating of 1350 MW west to east due to revised path rating, effective May 2002.
- Utah – Northern Nevada, new rating of 400 MW east to west (230 MW west to east) due to planned addition of Falcon-Gonder line, effective July 2003.

Assumptions

The following assumptions were used for the WECC studies:

- The input data represents demand forecasts and resources as of January 1, 2002.
- Peak demands for CISO, PSC, WACM, and WALC were allocated to SAM zones based on the ratios of the zonal demands that came with the SAM model. The ratios shown below were accepted by the PCC representatives as part of their review in April 2002.

Percent of Control Area Demand Allocated to Zones

Zones \ Control Area	CISO	PSC	WACM	WALC
Arizona				72%
Colorado, East		88%	50%	
Colorado, West		10%	35%	
Nevada, South				15%
New Mexico		2%		13%
Wyoming			15%	
California, North	37%			
California, Central	4%			
California, South	43%			
California, San Diego	9%			
California, San Fran.	2%			
California, SMUD	5%			

- Since insufficient data were available for a detailed economic solution, the summary resources in each zone were all assigned the same costs (Hydro = \$5/MWH, Non-hydro = \$20/MWH), with the exception of Palo Verde (\$5/MWH).

- August was chosen as the summer peak month for each year.
- The adjustments for external generation that were used in the studies were for Bridger, Colstrip, Four Corners, Hayden, Hoover, Intermountain, Mohave, Navajo, Palo Verde, and San Onofre. No other adjustments were made for other joint plants or firm purchases.
- Resources were assumed to be at rated output levels with no adjustments for forced outages, scheduled maintenance, or pollution restrictions. Adverse hydro conditions were modeled by applying an overall 15% derate to all hydro resources for certain scenarios.
- There is a possibility that developers may cancel or postpone the construction of some planned resources. Also, some existing facilities could be retired prematurely. The cases that included only committed generation additions were intended to study these factors.
- Ties to MAPP and SPP are not modeled since this would require generation and/or demand to be associated with these external areas.
- The model freely transfers resources from areas with surplus generation to deficit areas, considering transfer path constraints and transmission losses. Simultaneous flows, loop flows, and other transfer restrictions are not modeled, except in the one case where an overall transfer path de-rating of 20% was applied.
- The model is not intended to measure the adequacy of supplies in the individual control areas (unless the zone definition and transfer capabilities exactly match the control area). The model assumes that there are no constraints internal to a zone.

Case Studies

The following deterministic scenarios were run for years 2002 through 2011:

Study Month	Generation	Margin	Hydro Derate	Transfer Derate
August	Existing Only	0%	0%	0%
August	Existing Only	15%	0%	0%
August	Existing Only	15%	15%	0%
August	Existing + Planned	15%	0%	0%
August	Existing + Planned	15%	15%	0%
August	Existing + Committed	15%	15%	20%
August	Existing + Committed - Outages	reported min. reserve	reported outage levels	0%
December	Existing - Outages	reported min. reserve	reported outage levels	0%

Existing Generation is the generation that was on-line as of January 1, 2002. Planned generation is the generation that is expected to come on-line after January 1, 2002. Committed generation is planned generation that is under construction.

A margin of 15% was selected to represent operating reserve requirements, forced outages, demand variations, transmission limitations, pollution limitations, etc. The 15% hydro derate to simulate adverse hydro conditions is based on estimated hydro derates provided by the CISO and

NWPP. The 20% transfer derate was recommended by the Reliability Subcommittee to model the sensitivity of transmission limitations. Note that the Intermountain DC line was not derated.

The L&R data that were collected from the WECC members included estimates for generation outages (scheduled maintenance and inoperable) and minimum reserve requirements. These data were used for the last two case studies for comparison purposes.

E. Results and Conclusions

1. **The studies that included the generation additions that were reported with the L&R data (excluding CISO generics) showed no deficits in any zone, even with a 15% margin (see graph #2 at the end of the report).**
2. An additional series of studies were performed with a 15% hydro adjustment to simulate adverse hydro conditions throughout the WECC. These results also showed that a 15% margin could be met in each zone when the planned generation additions were included.
3. The August case studies that used only existing generation (generation in-service as of January 1, 2002) demonstrated that the WECC would experience resource inadequacies if additional resources were not added in future years (see graph #3). Although these scenarios are unrealistic, the results did identify how transmission constraints could separate the WECC into a surplus section in the north and a deficit section in the south (see the bubble diagram on the next page). The following table lists the years of first deficit for the south and one individual transmission constrained zone (note that the only adjustments for forced outages, scheduled maintenance, pollution restrictions, and adverse hydro conditions are the 15% margin and 15% hydro adjustments).

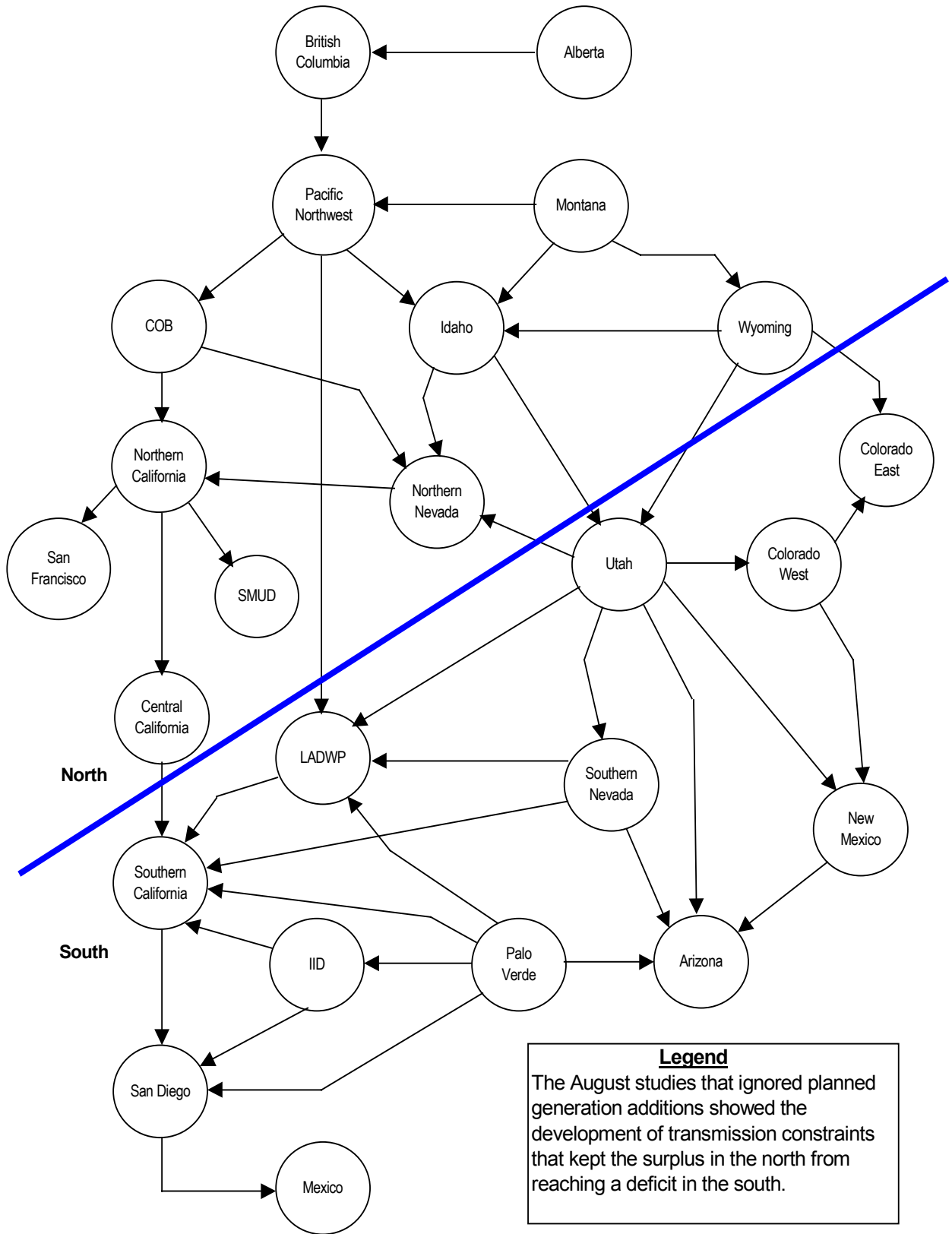
<u>Area / Zone</u>	<u>Normal Hydro (0% margin)</u>	<u>Normal Hydro (15% margin)</u>	<u>Adverse Hydro (15% margin)</u>
WECC - South	2009	2004	2003
CFE-Mexico *	2007	-	-
WECC - Overall	-	2008	2005

* CFE-Mexico is part of the WECC - South section. With a 0% margin, surplus existed in WECC - South that could not be delivered to CFE-Mexico due to transmission constraints. In the cases using a 15% margin, the path to CFE-Mexico was not constrained due to the lack of surplus in the southern section.

Based on the studies that excluded generation additions, the southern portion of the WECC system, including Arizona, Colorado, New Mexico, Southern Nevada, San Diego, and Mexico (CFE), appears to be most dependent on planned generation additions.

4. The case studies using the reported outage/reserve margin estimates and only committed generation additions showed adequate supplies through 2010 (see graph #4 at the end of the report).
5. The December studies using only existing generation and the reported outage/reserve margin estimates indicated that there are adequate winter supplies to meet the forecasted demands. The planned generation additions will further improve the margins.

6. The decreased level of detail in the presented results reflects a concern by members of the Reliability Subcommittee for confidentiality of control area information. In the event the model showed a deficit under the conditions described in items 1 or 2, detailed results would be provided to the deficit control area(s) for their review.
7. The case with every transfer path de-rated by 20% showed a general sensitivity to transfer path limitations (see graph #5). In some cases the transfer derate scaled back the transfer of joint plant shares due to the reduced capabilities. Deficits occurred in Arizona (2009), Colorado-East (2006), Idaho (2009), Nevada-North (2009), New Mexico (2011), and SMUD (2003).



Legend
 The August studies that ignored planned generation additions showed the development of transmission constraints that kept the surplus in the north from reaching a deficit in the south.

Observations

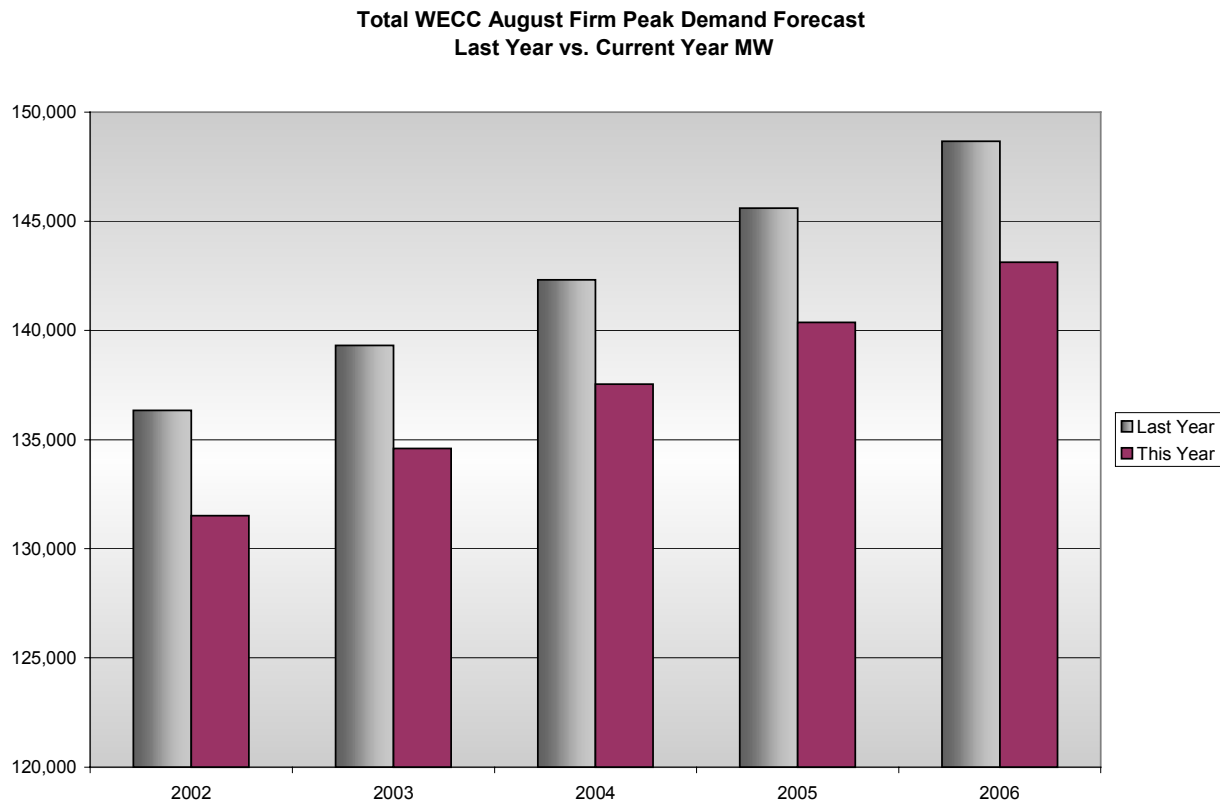
1. The workaround to force the export of externally owned resources to the owner's zones created some interesting flow patterns. In some cases the solution offset the transfers, effectively canceling the forced transfer of Colstrip and Palo Verde shares.
2. Generation in the Pacific Northwest was often stranded due to transmission limitations. The accuracy of the stranded surplus is uncertain, in light of the complicated hydro restrictions that apply to the northwest.
3. Generation in Central California was often stranded due to transmission limitations. This supports preliminary discussions to upgrade the transmission systems in this area.
4. There were cases where surplus resources were available, but transfer path limitations prevented the surplus from reaching the areas with deficits. Whenever an individual zone became deficit while the council overall had a surplus (sum of zonal surpluses greater than zero), the deficit was due to transfer path limitations between the surplus area(s) and the deficit area(s).
5. The reported generation additions that are proposed for the next ten years outpace the forecast demand growth by a significant margin. See graph #6 at the end of the report.
6. The model assumes an idealistic efficiency where resources and transmission become immediately available as necessary to meet demand requirements. The prudent operation of individual systems is unlikely to support this level of efficiency. Starting a steam unit, for example, to supply a four-hour sale, would not make sense under most circumstances.
7. The WECC 10-Year Coordinated Plan (available on WECC web site) also uses the L&R data for its input. Variances in the results and conclusions stem mostly from differences between rated generation capacities and optimum generation capacities, especially for hydro resources.

F. Recommendations For Future Assessments

1. The accuracy of the adequacy study results corresponds directly with the accuracy of the input data. The WECC member systems should continue to be invited to verify the data and take steps to improve the quality of their data submittals.
2. Unlike stochastic solutions, deterministic SAM solutions do not model demand variations, hydro conditions, forced outages, or transfer path de-ratings. Appropriate factors should be applied to the adequacy studies to account for these and other uncertainties.
3. The accelerated construction of new generating plants in the WECC introduces some additional uncertainty to the adequacy studies. The WECC members should be encouraged to provide information about planned resources in a timely manner to WECC for the purpose of conducting supply adequacy studies. Information regarding the retirement of older, less efficient units should also be provided.

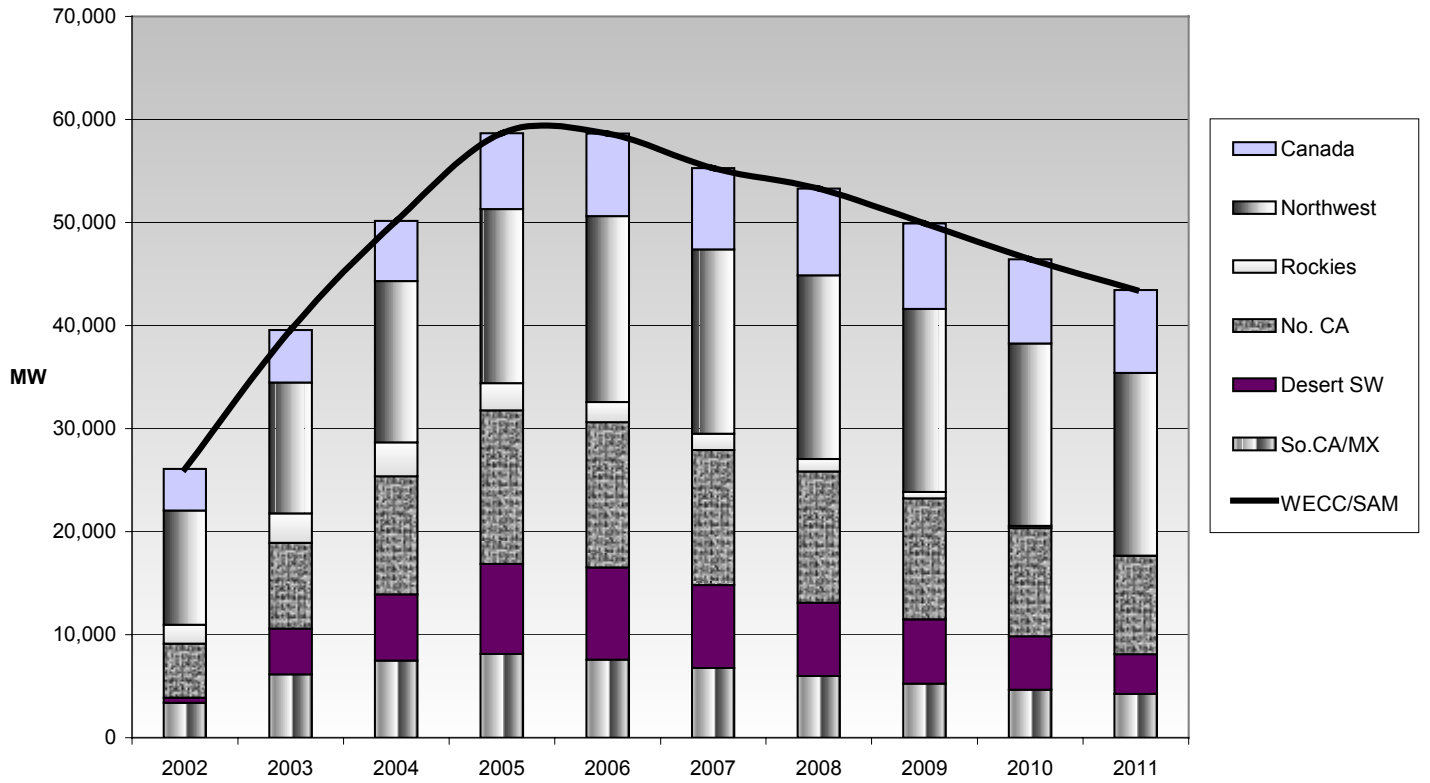
4. WECC should continue to collect demands and resource data in sufficient detail and on a sub-area basis for use in the SAM model as illustrated in the topological zone diagram included in this report.
5. Future plans for the model may include conducting probabilistic or stochastic studies to study the effects of random uncertainties. This would require that the members provide additional information such as resource forced outage rates, resource operating costs, demand variations, transmission loss data, and transmission wheeling costs.
6. It will be necessary to include future changes in the transfer path capabilities in the model to accurately measure their effect on the results. Since they would usually directly affect the results, only changes that are highly probable should be taken into consideration.
7. Each control area should scrutinize the general de-rating of hydro generation and transfer path capabilities. It may be necessary to assign individual de-ratings for each zone and path to more accurately model the normal system operation.

Graph #1 – Demand Forecast Comparison



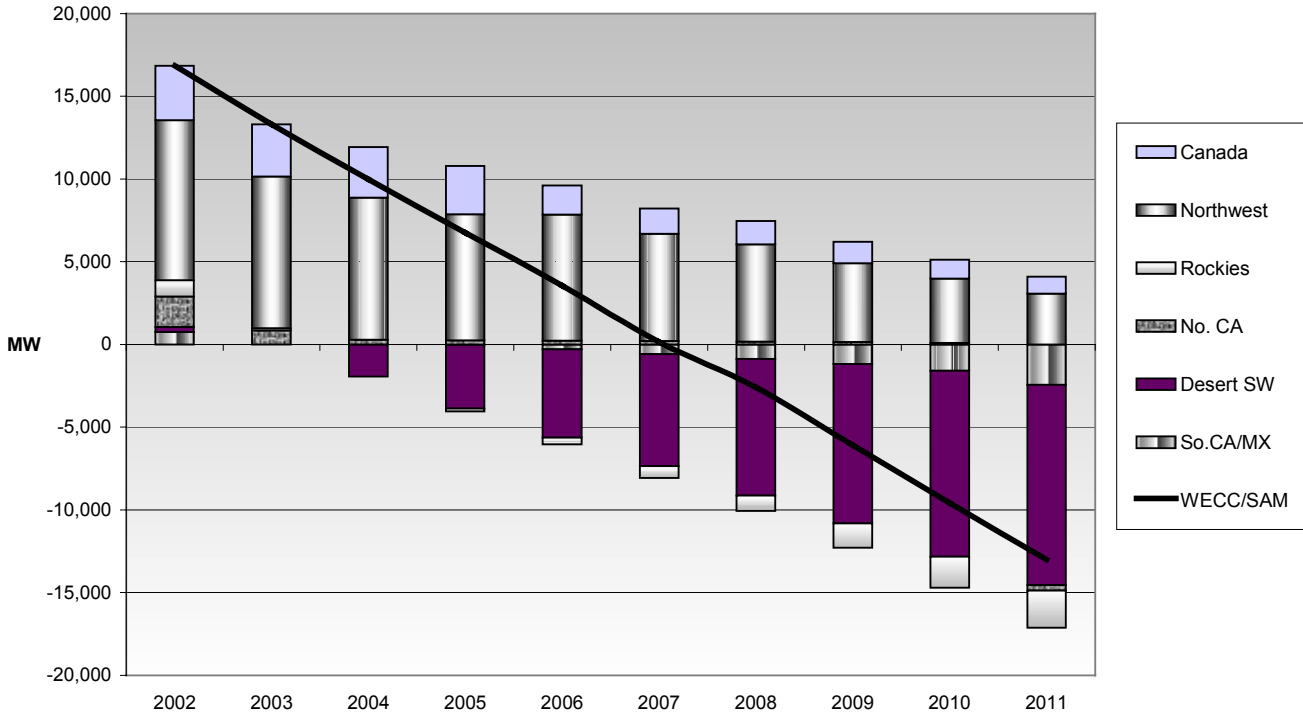
Graph #2 – Surplus Including all Generation Additions (except CISO generic)

SAM Surplus by Area - Adjusted for External Gen
(August - including generation additions 15% margin, Normal Hydro)



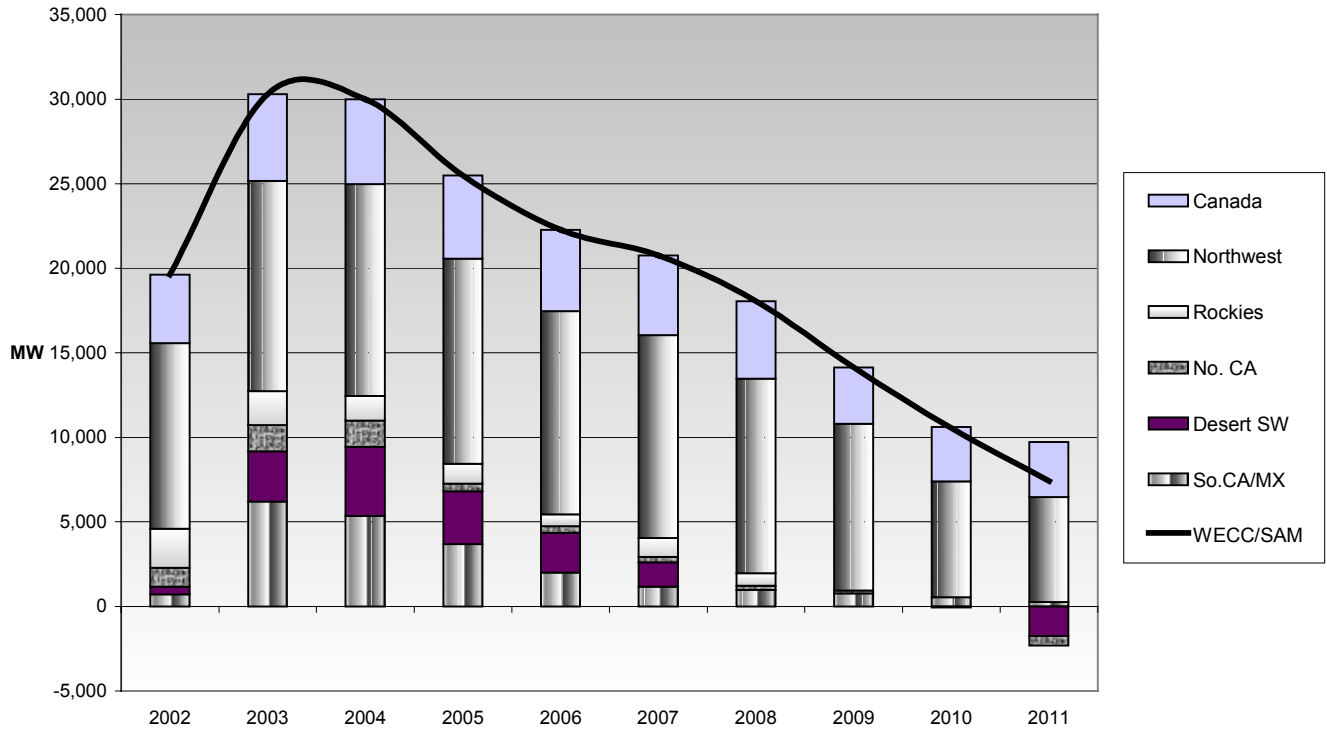
Graph #3 – Surplus Existing Generation only

SAM Surplus by Area - Adjusted for External Gen
 (August - existing generation only 15% margin, Normal Hydro)



Graph #4 – Surplus with only committed additions

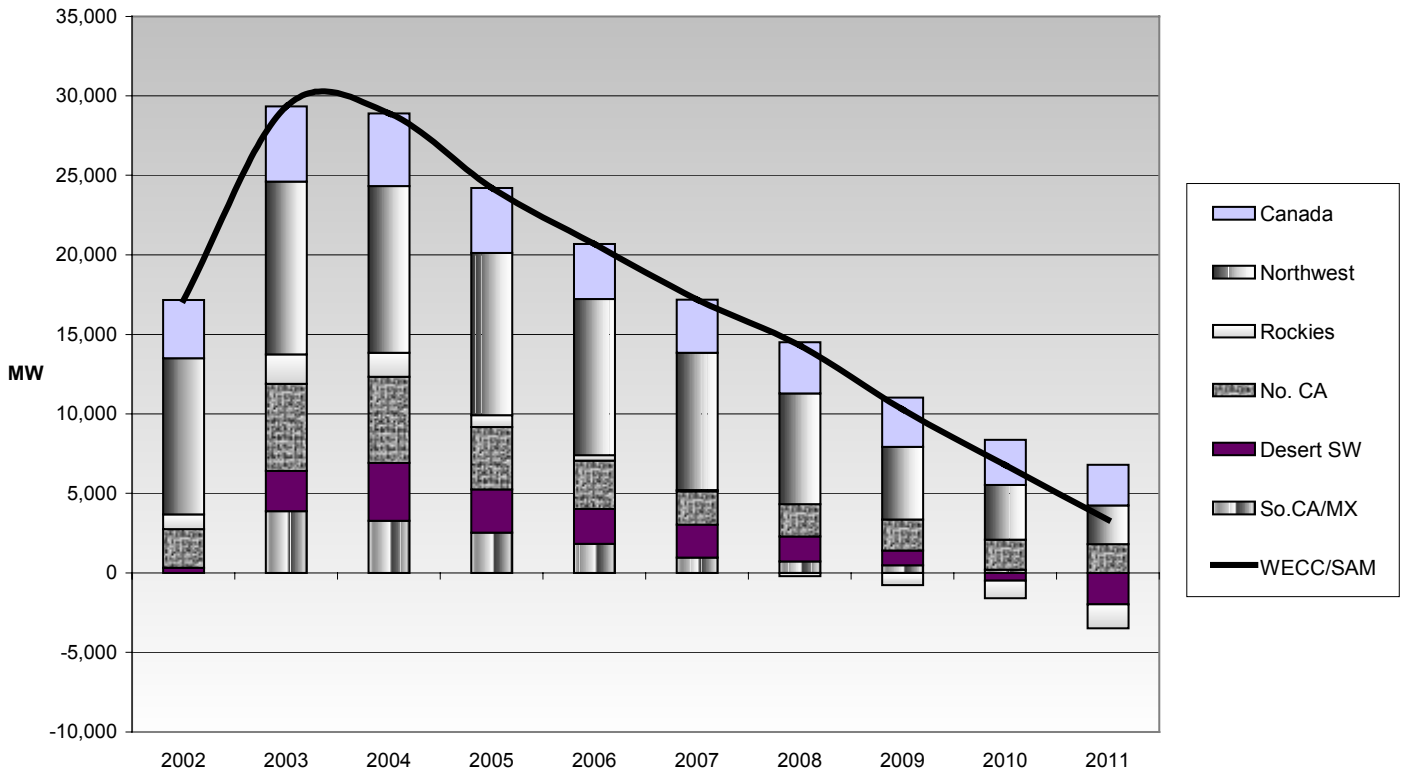
SAM Surplus by Area - Adjusted for External Gen
 (August - including committed generation additions and reported outages / margins)



Graph #5 – Surplus After 20% Transfer De-ration

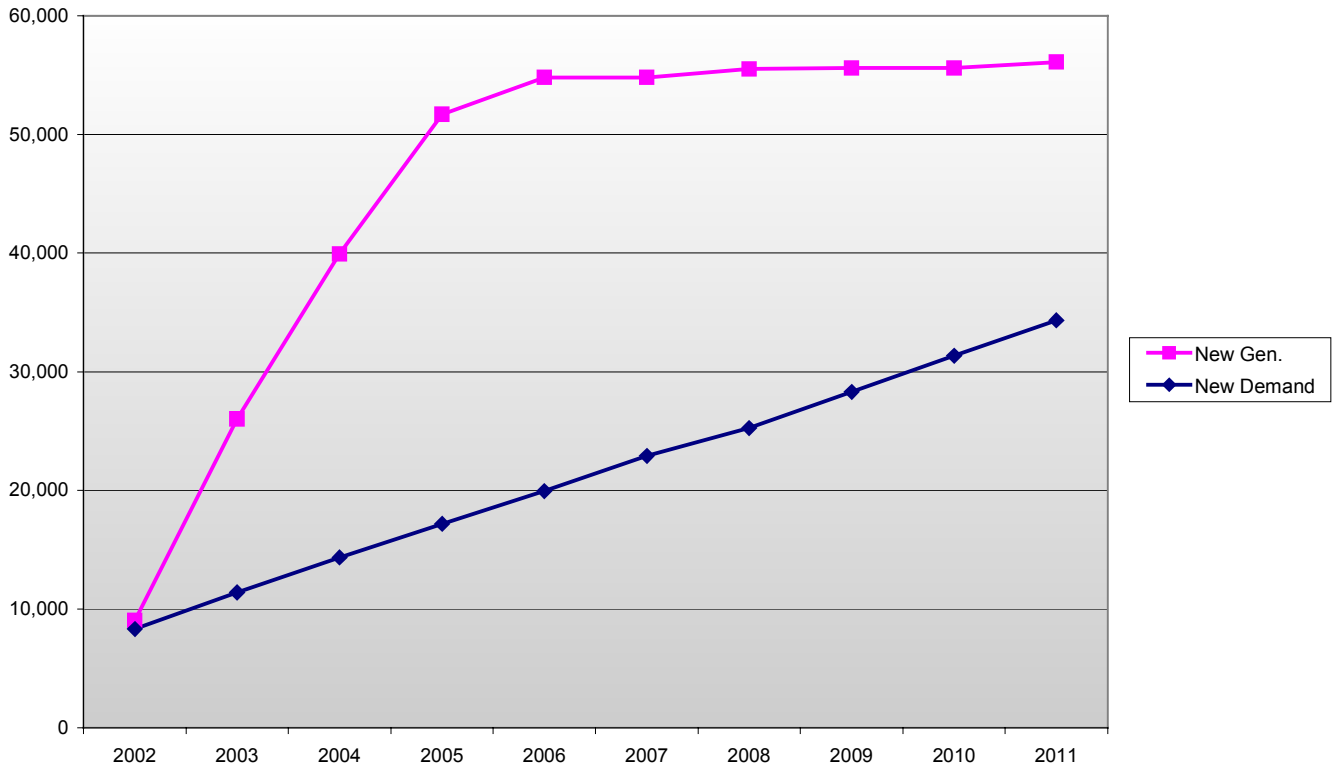
SAM Surplus by Area - Adjusted for External Gen

(August - including committed generation additions, 15% margin, -15% hydro, -20% Transfer)



Graph #6 – Demand vs. Generation

New Generation* vs. Increase in Demand
August - Cumulative MW



* The new generation excludes the CISO generic additions listed on page 5

WESTERN ELECTRICITY COORDINATING COUNCIL
POWER SUPPLY ASSESSMENT POLICY

INTRODUCTION

The Western Electricity Coordinating Council was established to promote the reliable operation of the interconnected bulk power system by the coordination of planning and operation of generating and interconnected transmission facilities.

The Planning Coordination Committee assigned the Reliability Subcommittee the task of developing an Adequacy of Supply Assessment Methodology. This document establishes the policy for conducting power supply assessments using the methodology developed by the Reliability Subcommittee. This policy shall be periodically reviewed and revised as experience indicates.

PURPOSE OF POWER SUPPLY ASSESSMENT

To ensure the reliability of the interconnected bulk electric system, it is necessary to assess both the security and the adequacy of the overall Western Interconnection. This document is focused on the portion of the assessment dealing with the adequacy of power supply. As electric industry restructuring has begun to break apart the traditional model of the vertically integrated utility, the responsibility for maintaining the adequacy of the power supply is moving toward market mechanisms. Though there may not be specific entities entrusted to plan for adequate resources, there exists a need to assess whether projected resources will be sufficient to reliably meet demand. Such information will allow regulators and policy makers to anticipate potential shortfalls so that determinations can be made as to whether impediments or insufficient incentives exist in the market.

It is not the intent of an adequacy assessment to replace the market, create sanctionable criteria or anticipate future energy prices. Its purpose is to project whether enough resources exist, at any price, to meet load and possible reserves while considering the transmission transfer capabilities of major paths. Such an assessment is required to comply with the NERC Planning Standards. These standards require that each region perform a regional assessment of existing and planned (forecast) adequacy of the bulk electric system.

It is recognized that it is impossible to provide 100% adequacy of power supply. It is the purpose of this document to establish a uniform policy for assessing the adequacy of installed and planned resources within the WECC region for the purposes of reporting within the Council, and to outside agencies. The assessments shall cover a period encompassing the next 5 years.

ASSESSMENT METHODOLOGY

The Power Supply Assessment Methodology shall be developed and maintained by the Reliability Subcommittee. Adequacy of supply may be defined and measured in terms of generating reserve margins and transmission limitations between load and resource areas and/or based on probabilistic methods. Appropriate technical tools shall be developed and utilized in conducting the assessments. The assessments shall account for diversity of load and generation, and account for transmission constraints between load and resource areas.

DATA REQUIREMENTS

To aid WECC in assessing resource adequacy, the following information shall be provided by the WECC member systems:

Load Forecasts

- Electricity demand and energy forecasts, including uncertainties
 - Variations due to weather
 - Variations due to other factors affecting forecasts

Demand Side Management (DSM) Programs

- Existing and planned demand-side management programs
 - Direct controlled interruptible loads
 - Aggregate effects of multiple DSM programs

Resource Information

- Supply-side resource characteristics, including uncertainties
 - Consistent generator unit ratings, including seasonal variations and environmental considerations affecting hydro and thermal units
 - Availability of generating units
 - Fuel type

Transmission Information

- Capabilities, availability of transmission capacity, and other uncertainties

REPORTING OF POWER SUPPLY ADEQUACY

The assessment of generating reserve margins and transmission limitations between load and resource areas as well as probabilities of supplying expected load levels, accounting for uncertainties, shall be developed and the results reported on a seasonal basis. The assessment shall be consistent with the requirement for maintaining operating reserves as defined in the *WECC Minimum Operating Reliability Criteria* and NERC Operating Policies.

Approved by Reliability Subcommittee June 16, 2000

Approved by Planning Coordination Committee June 30, 2000

Approved by Board of Trustees August 8, 2000

Revised April 18, 2002