Risk Assessment Framework

Scenario Assessment of Risks to the Western Interconnection

Westwide Resource Assessment Team
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BACKGROUND

This paper provides an overview of the key uncertainties affecting reliability and energy costs to which the Westwide Resource Assessment Team (WRAT) believes the Western Interconnection is vulnerable, and suggests analytic assessment using a series of scenarios that would reveal the outcomes of these uncertainties. Subsequent analyses would be needed to fully characterize risks and risk mitigation options.[1] WECC has taken some initial steps to collect vital information from its members about weather assumptions embedded within their load forecast and to document the sensitivity of peak loads to hot summer and cold winter weather. However, more progress is needed to identify how WRAT believes each of several assessments could be conducted. This brief paper attempts to enumerate several key uncertainties, define scenarios that might be used in assessment efforts, and suggests the sort of techniques that might be needed to quantify the risks resulting from these uncertainties.

KEY UNCERTAINTIES AND EXPLORATORY SCENARIOS

There is no doubt that reliability threats are induced by extreme temperatures. Hot summer weather is well understood to induce stresses on the system, and these can be exacerbated by various supply-side problems if they occur simultaneously. Similarly, the winter peaking subregions are well aware of cold weather extremes that might induce difficulties. The risk of these reliability threats may be increasing as generation shifts more toward gas-fired combined cycle facilities and as domestic space heating becomes more and more dominated by natural gas.

To these clear reliability risks, WRAT adds several additional uncertainties that emphasize a different outcome measure than physical reliability -- energy resource adequacy and total electricity costs. As public agency representatives, WRAT believes this outcome measure also merits some form of assessment by a competent technical organization so that those responsible for load service and other policy makers can understand and mitigate problems, if warranted.

[1] As used in this paper, uncertainty is the variation in a variable around a mean or expected value. The probability distribution of this uncertainty may or may not be known. For purposes of this paper, reliability of electricity supply and total annual cost of providing power to consumers are the outcomes affected by these uncertainties. Risk is the product of an uncertainty and its associated outcome relative to a reference value.

Key Uncertainties

The following seven factors are WRAT's initial list of uncertainties which could affect reliability or impose major cost increases on electricity consumers.

- Hot summer weather
- Cold winter weather
- Rainfall patterns inducing adverse hydro generation conditions
- Sudden unforeseen increases in natural gas prices
- Precipitous shutdown of nuclear plants resulting from NRC safety concerns
- Sudden, extensive retirement of aging fossil power plants
- Impacts of global climate change

Suggested Scenarios to Perform Reliability and Cost Impact Assessments

WRAT believes the following scenario definitions would be helpful in developing a plan to evaluate reliability and energy cost impacts from key uncertainties. In each case the scenario should compared to a "base" or "reference" case with "normal" conditions. It is acknowledged that the distribution of values around "normal" is poorly understood in some instances. More detailed scenario definitions would be required once modeling efforts to quantify these risks were undertaken.

1. Hot summer weather

Intensely hot summer weather over a large part of the WI would increase total WI peak demand and disrupt normal patterns of transmission loading between regions.

2. Cold winter weather

Intensely cold weather for a week during January along the Pacific coast states would greatly increase domestic natural gas demand, diminishing natural gas supplies to industrial facilities and generators, possibly creating both natural gas curtailments for generators and threatening electricity reliability.

3. Prolonged drought

Prolonged drought in the Pacific Northwest for two successive years meeting or exceeding historic adverse hydro generation conditions, thus triggering possible energy shortages in the PNW or even threatening firm hydro capacity contracts with loads outside the PNW.

4. Sudden, unexpected, sustained shift in fuel prices

Sudden shift upward in natural gas prices and gas futures as market takes new, tighter supply-demand expectations into account.

5. Shutdown of category of power plants as a result safety concerns

Sudden, long standing shutdown of nuclear power plants as NRC identifies a previously unrevealed safety concern.

6. Sudden, Extensive Retirement of Aging fossil Power Plants

A sudden, extensive shutdown of aging fossil power plants due to air quality concerns would both threaten general reliability as well as induce local reliability problems in local areas with constrained transmission capability.

7. Climate change impacts on generation and load

Change in rainfall amounts, patterns, and timing that reduces snowpack and results in reduced hydro-generation both in Pacific Northwest and in California combined with increased summer peak temperatures magnifying summer peak loads.[2]

ASSESSING RELIABILITY VERSUS COST RISKS

Summary of Techniques

Evaluation of the seven scenarios listed previously require varying degrees of alternative methodology. Some are amenable to analysis using modifications to the SAM assessments prepared by WECC staff under RS guidance, while others probably require quite different analytic techniques. The following table summarizes an approach to assess each of the scenarios in two alternative formats. The first explores the scenario from the perspective of its impact on WI or subregion reliability. The second explores the scenario from its impact on energy adequacy, which emphasizes cost impacts on electricity consumers.

Suggested Analysis Techniques

A series of Appendices to this paper provide a more detailed description of the data and analyses that would be required to conduct the assessments WRAT believes are needed for three high priority scenarios. These scenarios are the ones which have received the greatest level of attention in various discussions among WRAT, WECC RS and CREPC participants. As noted in the summary table, improved evaluation of some scenarios requires only modest stretches from existing data and analysis techniques, while others may require much greater effort and development. In all cases, an iterative assessment process will be necessary to actually develop a complete understanding of risk and risk mitigation options. The analyses suggested here are the beginning of this iterative process.

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[2] While there is much uncertainty about the localized impacts of global climate change, a substantial body of opinion believes that rainfall in the West would shift to earlier portions of the winter, resulting in less precipitation stored as snowpack.

Next Steps

While the full set of seven scenarios address the risks threatening the electricity system WRAT suggests that scenarios 1-3 are sufficiently well recognized by WECC and the government agencies represented in CREPC that they should be pursued now. The immediate steps for each of these are somewhat different.

Hot Summer Weather

As a result of previous discussions between WRAT and WECC, WECC Staff has issued a data request to its member control areas requesting information be provided that identifies the summer and winter load impacts of temperature change at the point of summer and winter peak demand.[3] With this supplemental information in hand WECC staff could use minor variants of the SAM model to undertake an improved analysis of summer peak demand reliability with relatively little additional delay. Appendix A to this paper provides a description of an assessment technique using this load sensitivity information in conjunction with a Westwide weather database to develop probability-based summer peak demand impact. Other than competing assignments, there is no reason that WECC staff cannot successfully undertake this effort.

Cold Winter Weather

Assessment of this scenario requires development of natural gas demand and curtailment impacts on power plants that is quite different from previous work that has been documented in the publicly available literature. Appendix B provides a step by step assessment methodology that would bring traditional winter electric load assessment together with new work to determine the availability of natural gas for power plants in a severe winter cold snap scenario. Such an analysis goes beyond what WECC has previously conducted. Formation of a team of cooperative WECC members and WRAT members might be useful to identify unrecognized entities that can contribute to this effort. Such a team might also help to fine tune the proposed analysis methodology and to define the scenario more precisely. Thus the initial next step is an organizational one.

Energy Impacts of Prolonged Pacific Northwest Drought

As result of recent discussions among a team of WECC RS members and WRAT members seeking to organize an energy assessment project, WECC PCC has approved a preliminary effort. Appendix C describes the initial analysis approach, which focuses on energy assessment using a monthly energy balance approach for a range of WI subregions. Assuming this effort can be accomplished and that it provides a sufficiently compelling justification for energy risk concerns, the expectation is that a more sophisticated analysis approach would be endorsed, which would repeat the analysis one or more times to produce results considered accurate enough to be actionable.

[3] WECC Data Request dated January 13, 2004.

Combination Scenarios

Each of three previous scenarios involved a single-variable and how key uncertainties for that variable might be assessed. It is possible that combinations of uncertainties actually produce more risk than single scenarios. For example, very cold weather in conjunction with adverse hydro might produce greatest winter impacts on electric reliability. In parallel with the previous scenario assessments, a combination scenario should be developed. Once a more complete scenario description is developed, it will be more clear what combination of assessment techniques is best suited for the quantitative analysis. The immediate next step is to convene a panel of experts to develop such a combination scenario. To the extent that WRAT then judges that this scenario would likely lead to incremental electricity impacts beyond those of any of the single scenarios, then a specific assessment technique would have to be developed.

CONCLUSION

In its presentations to CREPC and WECC Committees, WRAT has expressed concern that current assessments of uncertainties that threaten reliability and major impacts to electricity consumers in the WI are not being fully evaluated. This paper is written to provide improved precision for these efforts. This is a work in progress that should be expected to evolve as WRAT, WECC and other interested groups actually tackle these assessment efforts and learn from the results.

Summary of Likely Assessment Techniques for Each Risk Scenario

Risk Type	Reliability Approach	Cost Impact Approach
Hot summer weather	Existing SAM with augmented load sensitivity to hot weather; precise definition of scope of hot weather event; and probability assessment of the weather assumptions.	Cost impacts limited to short duration prices spikes in spot market. LSE-specific costs impacts defined by exposure to spot markets, which is poorly known.
Cold winter weather	Existing SAM with augmented load sensitivity to cold weather; precise definition of scope of cold weather event; dependence of generators on gas pipeline deliveries; constraints on pipeline and storage flows; regulations guiding non-domestic curtailments, and probability assessment of the weather assumptions.	Like hot weather scenario, cost impacts limited to short duration prices spikes in spot market. LSE-specific costs impacts defined by exposure to electricity spot markets, which are poorly known, and natural gas fuel price links to NG spot markets which are even more poorly known.
Prolonged drought	Special assessment of impacts of extremely limited water on firm capacity contracts given new realities of fisheries.	A phased assessment has been proposed by WRAT to WECC RS, beginning with a monthly energy balance method. To the extent this analysis would reveal actual risks, then a more sophisticated modeling technique might be warranted.
Sudden, unexpected, sustained shift in fuel prices	Reliability not expected to be stressed under these conditions, but analyses might be of interest to identify whether some differences in the mix of resources serving load at time of peak .	Production cost modeling likely to be used to determine how fuel price increases translate into higher aggregate costs, and how capacity expansion strategies might be modified to ameliorate the impacts.
Shutdown of category of power plants as a result safety concerns	Modified SAM inputs should be able to reveal consequences of this scenario.	Production cost models used to determine how available generation should be dispatched to meet load and minimize consequences.
Shutdown of Aging Fossil Power Plants	Modified SAM inputs should be able to reveal consequences of this scenario.	Production cost models used to determine how available generation should be dispatched to meet load and minimize consequences.

Climate change impacts on generation and load	There are estimates of possible changes in hydro generation seasonal patterns (NWPCC). It is possible to estimate the load impacts of forecasted temperature changes	Theses could be sensitivities of the scenarios above. Generally it expected to lessen winter peak risks and increase summer peak risks.

APPENDIX A
INDEPTH ANALYSIS OF HOT SUMMER WEATHER SCENARIO

Summary

This section proposes an analytic method for developing and assessing the supply adequacy implications of WECC-wide extremely hot summer temperatures. This approach relies upon the supplemental data request issued by WECC to its members that gathers new information about the sensitivity of summer and winter peak loads to temperature extremes.[4] This analysis assumes that WECC staff uses the new information available in early 2004 to conduct WECC-wide and WECC transmission zone studies, rather than simply compiling the submissions of the control areas. At this point an updated version of SAM is the most likely modeling application in which these weather sensitive, coincidence adjusted loads might be used to assess reliability.

Analytic Steps

A five step process is proposed to develop an improved assessment of reliability under hot summer weather scenarios. While pursuing this goal has been a mainstay of WECC's activity for years, the proposed analytic method, combined with newly available data from WECC members, would provide an improved assessment.

Step 1 – Compile Control Area Base Case Load Forecasts

The January 2004 data request to WECC members clarified that expected monthly peak demand should be interpreted as the maximum integrated hourly demand in that month forecast on the basis of a 50% probability of being exceeded. This is a refinement of what WECC members have been asked to provide in the past, but clarification that it is average peak weather is necessary to improve comparisons across systems, to able to resolve coincidence issues, and to devise common weather scenarios for use in SAM.

Step 2 – Obtain Load Forecast Temperature Sensitivity Information

The December 2003 Supplemental data request proposed to require that each load forecast submission should specify the temperature assumption used to develop each month's peak demand. If a control area encompasses a broad geographic area, then such a control area should report individual weather station locations and the weights to determine a control area average where multiple weather assumptions are used because of geographic diversity.

In addition, the submitters were asked to provide a parameter defining the sensitivity of their loads to temperature (MW/degree Fahrenheit) under summer peak demand (most likely August) conditions. The specific weather station used as the point of measurement

[4] WECC has issueda supplemental data request to elicit new information from WECC control area about the sensitivity of their loads to hot and cold weather extremes. It was issued on January 13, 2004 with a due date of February 13, 2004.

for that sensitivity or multiple weather stations with appropriate weights should also be reported. To the extent that entities with a larger footprint than control areas have this kind of information, then a control may use it as long as the source is documented.

Step 3 – Adjustments for Coincidence

WECC Staff would use results of coincidence studies to develop summer peak condition coincidence adjustment factors to be applied when summing control area peaks to obtain WECC-wide and WECC transmission zone peak demands. Studies of data from recent years reveal this to be 2-3 percent for summer peak conditions. This step would allow SAM to be operated with a coincident peak loads when a scenario assessment included this attribute.

Step 4 – Developing Weather Sensitive Loads for SAM

4.a WECC would compile and maintain a 50-year weather database for a relevant set of weather stations and statistics that are the same as used by the control areas in their load forecasts.[5]

4.b WECC would define WECC-wide or WECC transmission zone load scenarios using assumptions about the scope and intensity of extreme weather and the coincidence of peak loads that it wished to evaluate. The details of the scenario would be determined once the assessment effort was underway. Weather based on full 50-year averages or observed trends toward warmer weather are two obvious options. The temperatures data compiled in Step 4.a for major Western load centers, would be used to derive load forecasts with any given probability of being exceeded (e.g. 10%) for WECC as a whole, using load center expected loads or control area MW/Degree sensitivities and the weights for the weather stations reported in Step 1.

4.c WECC would compute WECC-wide or WECC transmission zone loads using the expected load forecasts submitted by control areas in Step 1, the summer or winter load sensitivity to weather statistic for each control area, and the weather assumptions for a scenario to prepare either control area or transmission zone load forecasts for that scenario.

Step 5. Use Weather-Sensitive Loads in SAM and Interpreting Results

5.a WECC would use the load forecasts developed in Step 4.c as an input to SAM assessments of scenarios and in evaluating adequacy of WECC-wide and transmission zone resources to serve load.

[5] The CEC has verified that long term historic temperature data for an adequate set of weather stations to cover the entire WECC region exists. The CEC has this data from the late 1940s to 2000 for 60+ weather stations covering all of the West. Some updating and some additional cleaning are needed to put this data into full working order to be used as the basis for Step 4a.

5.b WECC could devise different scenarios that might reveal different transmission or resource adequacy concerns. For example, this analysis could potentially give two equally probable WECC load levels that have different spatial distributions. This means that we might infer generation levels are adequate if there were no transmission constraints, but transmission limitations might imply different levels of regional problems in the two different cases.

APPENDIX B
INDEPTH ANALYSIS OF COLD WINTER WEATHER SCENARIO

Summary

This appendix proposes an analytic method for developing and assessing the supply adequacy implications of WECC-wide extremely cold winter temperatures. This approach relies upon the supplemental data request issued by WECC to its members that gathers new information about the sensitivity of summer and winter peak loads to temperature extremes. This analysis assumes that the new information is available in early 2004 to conduct WECC-wide and WECC transmission zone studies, rather than simply compiling the submissions of the control areas. At this point an updated version of SAM may only be partially helpful as the modeling application in which these weather sensitive, coincidence adjusted loads might be used to assess reliability. In addition to the standard load increments and transmission exchange capabilities that would be used in the hot summer weather scenario, a cold winter weather scenario must address curtailments of natural gas for power plants as direct domestic space heating loads increase aggregate natural gas demand. It is possible that a side analysis of these gas supply, and curtailment priority issues might result in a degraded set of generation available that could then be modeled using SAM to produce the final assessment.

Analytic Steps

A multi-step process is proposed to develop an improved assessment of reliability under cold winter weather scenarios.[6] While pursuing this goal has been a mainstay of WECC's activity for years, the explosion of natural gas fired power plants with limited or no alternate fuel capability suggests changes in the methodology that would be used to thoroughly assess this scenario.

<u>Step 1 – Compile Control Area Base Case Load Forecasts</u>

The December 2003 data request to WECC members clarified that expected monthly peak demand should be interpreted as the maximum integrated hourly demand in that month forecast on the basis of a 50% probability of being exceeded. In part this is a refinement of what they are being asked for now, but the additional weather data specification is needed to be able to resolve coincidence issues and devise common weather scenarios for SAM.

<u>Step 2 – Obtain Load Forecast Temperature Sensitivity Information</u>

The December 2003 Supplemental data request proposed to require that each load forecast submission should specify the temperature assumption used to develop each month's peak demand. If a control area encompasses a broad geographic area, then such

[6] The initial steps of this process virtually duplicate the approach for the hot weather scenario described in Appendix A, but the final steps in degrading natural gas power plant availability are substantially different from a hot summer weather assessment.

a control area should report individual weather station locations and the weights to determine a control area average where multiple weather assumptions are used because of geographic diversity.

In addition, the submitters were asked to provide a parameter defining the sensitivity of their loads to temperature (MW/degree Fahrenheit) under winter peak demand (most likely January) conditions. The specific weather station used as the point of measurement for that sensitivity or multiple weather stations with appropriate weights should also be reported. To the extent that entities with a larger footprint than control areas have this kind of information, then a control may use it as long as the source is documented.

Step 3 – Adjustments for Coincidence

WECC Staff would use results of coincidence studies to develop winter peak condition coincidence adjustment factors to be applied when summing control area peaks to obtain WECC-wide and WECC transmission zone peak demands. It is currently unclear whether studies of data from recent years have identified an appropriate adjustment for winter peak conditions. This step would allow SAM to be operated with a coincident peak loads when a scenario assessment included this attribute.

Step 4 – Developing Weather Sensitive Electric Loads for SAM

4.a WECC would compile and maintain 50-year weather database for a relevant set of weather stations and statistics that are the same as used by the control areas in their load forecasts.

4.b WECC would define WECC-wide or WECC transmission zone load scenarios using assumptions about the scope and intensity of extreme weather and the coincidence of peak loads that it wished to evaluate. The details of the scenario would be determined once the assessment effort was underway. Weather based on full 50-year averages or observed trends in recent decades are two obvious options. The temperatures data compiled in Step 4.a for major Western load centers, would be used to derive load forecasts with any given probability of being exceeded (e.g. 10%) for WECC as a whole, using load center expected loads or control area MW/Degree sensitivities and the weights for the weather stations reported in Step 1.

4.c WECC would compute WECC-wide or WECC transmission zone loads using the expected load forecasts submitted by control areas in Step 1, the winter load sensitivity to weather statistic for each control area, and the weather assumptions for a scenario to prepare either control area or transmission zone load forecasts for that scenario.

Step 5. Developing Weather Sensitive Domestic Natural Gas Loads for SAM

5.a WECC would compile and maintain a 50-year weather database for a relevant set of weather stations and statistics that are the same as used by the control areas in their load forecasts. [Same data base as used in Step 4.a of Appendix A.] In this assessment the issues are change in **both** electric and natural gas loads as a function of extremely cold winter weather compared to more usual winter weather, and thus the nature of the weather stations and the analysis using these data may need to be different than what would have traditionally be assessed from an electricity-only assessment perspective.

5.b WECC would define WECC-wide or WECC transmission zone load scenarios using assumptions about the scope and intensity of extreme weather and the coincidence of peak loads that it wished to evaluate. The temperatures data compiled in Step 4.a for major Western load centers, would be used to derive load forecasts with any given probability of being exceeded (e.g. 10%) for WECC as a whole, using load center expected loads or control area MW/Degree sensitivities and the weights for the weather stations reported in Step 1.

Step 6. Adjusting Natural Gas-Fired Power Plant Availabilities

This step identifies the degree to which the winter weather scenario leads to aggregate natural gas demand that induces curtailments, and the degree to which these curtailments would reduce natural gas available for power plants. To the extent such power plants were curtailed, a degraded set of power plant capabilities would be used in Step 7.

6.a Understanding Power Plant Curtailment Procedures

Natural gas power plants have a variety of mechanisms to purchase fuel supplies, and a wide range of exposure to curtailments under shortage conditions. In this step, the exposure of classes of power plant (most likely defined by ownership, state location, existence of dual fuel capabilities) to curtailments is developed.

6.b Understanding Power Plant Access to, and Use of, Storage Facilities

Natural gas storage facilities are used by a wide range of users to store gas supplies. In this step procedures governing access to supplies owned by power plants and potential for regulatory-curtailments under emergency conditions are developed.

6.c Estimating Need for Curtailment of Low Priority Users

In this step the incremental gas loads of step 5b are combined with an analysis of gas supply capability to determine shortages and the need to curtail low priority users in some locales.

6.d Devising Power Plant Availability Impacts of Weather Scenarios

In this step the curtailment of low priority users and power plant curtailment priorities are combined with information about access to storage facilities to determine the magnitude of natural gas curtailment to electric power plants. In addition, subscenarios that define which plants might be curtailed in broad subregions are translated into specific power plants.

Step 7. Use Weather-Sensitive Loads and Generation in SAM and Interpret the Results

7.a WECC would use the electric load forecasts developed in Step 4.c as an input to SAM assessments of scenarios and in evaluating adequacy of WECC-wide and transmission zone resources to serve load.

7.b WECC would use the degraded generation availabilities from Step 6d as inputs into the SAM data set for use in this scenario.

7.c WECC could devise different scenarios that might reveal different consequences on transmission or resource adequacy concerns if different sets of power plants were curtailed. For example, this analysis could potentially give two equally probable WECC generation levels that have different spatial distributions assuming different policies for power plant curtailments. There may be no *a priori* rationale for knowing that specific natural gas-fueled power plants create fewer problems for electric reliability and others. Insight into the various means by which a given power plant curtailment should be allocated among power plants could emerge from these assessments.

APPENDIX C
INDEPTH ANALYSIS OF ADVERSE HYDRO SCENARIO

Summary

This appendix proposes an analytic method for developing and assessing the supply adequacy implications of an adverse hydro scenario which creates potential energy shortfalls for the Northwest with possible spillovers to other regions. An ad hoc committee of WECC member technical staff and WRAT regulatory agency staff are developing possible methods for assessing this scenario. It is anticipated that this group will prepare a preliminary specification of a method or methods at the WECC RS meeting in April 2004.

Analytic Steps

[to be completed by mid-March 2004]