Northwest Power and Conservation Council

September 28, 2011

MEMORANDUM

TO: Council Members

FROM: John Fazio, Senior Power Systems Analyst

SUBJECT: Proposed revisions to the NW resource adequacy standard

In April of 2008, the Council adopted the Resource Adequacy Forum's proposed methodology for assessing the adequacy of the Northwest's power supply. Since then, an assessment has been made every year and the power supply was shown to be adequate in every case. However, during that period, confusion arose regarding the interpretation of static adequacy measures (i.e. load/resource balance and peak planning margins) especially when compared to similar measures reported by others. In addition, it was discovered that performing separate seasonal assessments could lead to an overestimated adequacy value (e.g. LOLP less than 5% when it really should have been greater).

Because of this and other issues, the Forum chose to have the methodology reviewed by an independent consultant, which was done in 2010. The results indicated that the methodology was appropriate but could be improved. Thus, using most of the review recommendations, the Forum redesigned the adequacy standard for the Northwest and proposes to:

- Keep the current loss of load probability (LOLP) metric and 5% threshold.
- Remove the seasonal LOLP assessments and calculate only one annual LOLP value.
- Replace the screening thresholds used to define significant curtailments with the energy and capacity capabilities of demand response and standby resources.
- Remove the translation of the LOLP measure into static values.
- Include a state of the system report that contains more detailed information.

The Forum is meeting on October 4th to discuss these changes. If approved, the Forum will forward its proposal (attached along with a sample report) to the Council at its October meeting, at which time the Council could choose to release it for comment. The Council will have an opportunity to review the comments and discuss this issue at its November meeting and, if appropriate, can vote to adopt the proposal at its December meeting.

Attachments

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A Resource Adequacy Standard for the Pacific Northwest

NW Power and Conservation Council Meeting
October 13, 2011
Portland, Oregon

OUTLINE

- Current Adequacy Standard
- Proposed Revisions
- State of the System Report
- Sample Report
- Next Steps

2

CURRENT ADEQUACY STANDARD

- Proposed by the Resource Adequacy Forum
- Adopted by the Council in April of 2008
- Assesses adequacy of the power supply 3 and 5 years out
- Assumptions
  - Existing thermal resources (or completed by then)
  - Conservation gains from the 6th power plan
  - Use of non-firm resources

3

CURRENT ADEQUACY STANDARD

- Uses loss of load probability as metric
- Sets 5% as the maximum threshold
- Assesses LOLP for winter and summer for both capacity and energy shortfalls
- Translates energy LOLP into a minimum annual load/resource balance threshold
- Translates capacity LOLP into minimum sustained-peak planning margins for winter and summer

4

NON-FIRM RESOURCE ASSUMPTIONS

- Independent Power Producers
  - Full capability in winter (about 3500 MW)
  - Limited capability in summer (1000 MW)
- SW Market
  - 3000 MW maximum import per hour winter
  - No market in summer
- Borrowed Hydro
  - Energy below drafting rights elevations
  - Repaid as soon as possible
  - Maximum of 1000 MW-months per month

5

CURTAILMENT EVENT THRESHOLDS

- Energy: total curtailed energy for each season (3 months) exceeds 28,800 MW-hrs
- Capacity: any hourly curtailment that exceeds 3000 MW
- Used as a surrogate for non-modeled and standby resources

6

CURRENT ADEQUACY STANDARD

- Current standard in use for 3 years
- Led to some confusion (e.g. interpretation of the L/R balance and planning margins)
- Peer reviewed in 2010
  - Eliminate translation to static measures
  - Eliminate seasonal assessments
  - Add measure for size of problem
  - Measure use of standby resources

7

PROPOSED REVISIONS

TO BE CONSIDERED FOR ADOPTION AFTER FORUM APPROVES

- Keep the current methodology, which includes non-firm resources
- Keep the LOLP metric and the 5% threshold
- Annual assessment (all months)
- Quantify demand response (DR) and standby resources (SR) that are contractually available
- Count events that exceed the energy and capacity limits of DR and SR

8

STATE OF THE SYSTEM REPORT

- Adequacy assessment
- Other commonly used adequacy measures
- Reliance on non-firm and standby resources
- Monthly assessment of potential shortfalls
- Frequency, duration and magnitude of events
- Conditions under which events occur

9

SAMPLE REPORT – FOR ILLUSTRATION ONLY

- Not an official assessment
- LOLP is 6.7% = inadequate supply
- Dec, Jan and Aug only months with shortfalls
- LOLP driven by peak shortfalls in August
- Adding 400 MW of capacity in August will bring LOLP below 5%

10

COMPARISON TO OLD STANDARD

- Old standard
  - Winter capacity LOLP = 2.4%
  - Winter energy LOLP = 1.0%
  - Summer capacity LOLP = 4.3%
  - Summer energy LOLP = 1.9%
  - Interpretation – Adequate
- New standard
  - LOLP = 6.7%
  - Interpretation – Inadequate

Winter and summer capacity problems occur in different games thus, seasonal assessment will underestimate overall adequacy.

11

ADEQUACY SUMMARY - IPP

- Availability:
  - 3,500 MW winter (approximate)
  - 1,000 MW summer
- Percent of time used:
  - To some degree every winter
  - To some degree every summer
- Dispatch:
  - Winter months (avg): 750 to 1,500 MW-months
  - Summer months (avg): 250 to 600 MW-months

12

ADEQUACY SUMMARY – SW MARKET

- Availability:
  - On peak (3,000 MW winter , 0 MW summer)
  - Proposed Off peak (1,000 MW year round)
- Percent of time used:
  - On peak used up to 11% of the time in winter
  - Off peak used up to 27% of the time in summer
- Dispatch:
  - Highest on-peak: 1000 MW-months in one Dec
  - Highest off-peak: 400 MW-months in one Aug

13

ADEQUACY SUMMARY – BORROWED HYDRO

- Availability:
  - 1,000 MW-months all months
- Percent of time used:
  - Mostly in summer, about 90% of the time in Aug
  - Less in winter, about 14% in Dec
- Dispatch:
  - About 700 MW-months in one August
  - About 400 MW-months in one December

14

ADEQUACY SUMMARY – DR, SR AND LOLP

- Availability:
  - DR capacity only, 60 MW winter, 120 MW summer
  - SR 602 MW capacity, 83,000 MW-hrs all year
- Percent of time used:
  - DR is used to some degree in 8.6% of the years
  - SR is used somewhat less (no approx yet)
- Dispatch:
  - DR is generally used up to its availability
  - SR energy may be used up before summer

15

NEXT STEPS

- Forum approves revised standard
- Forwards proposal to Council for adoption
- Work continues on better defining non-firm resource assumptions, use of borrowed hydro, demand response and standby resources
- Debate using off-peak summer purchases
- 2012: Forum approves revised non-firm resource assumptions
- June 2012: Adequacy assessment for 2015-17

16

CURTAILMENT STATISTICS

Expected Number of Events*	0.23 per year
Average Event Duration	14 Hours
Average Event Magnitude	14569 MW-hrs
Average Event Peak Shortfall	1098 MW
Expected Number of Shortfall Hours	3.3 per year
Percent of Games With an Event	8.6 percent

*An event is defined as a contiguous set of hours of shortfall.

17

State of the System Report for the Pacific Northwest's Power Supply

Draft – Version 1: For Illustration Only

10/4/2011

State of the System Report for the Pacific Northwest

Pacific Northwest Resource Adequacy Forum

For Illustration Only – Version 1

CONTENTS

EXECUTIVE SUMMARY

Caveat: This state-of-the-system report is meant for illustration only and is provided for the sole purpose of developing the form of the report. While the data used to assess the adequacy of the power supply for this report is current, there remain many unsettled issues regarding assumptions for non-firm and standby resources. Also, work continues on improving the hourly hydro dispatch logic. Thus, conclusions drawn from this report should be characterized as illustrative only and are not for distribution to the general public.

The current estimate of the loss of load probability (LOLP) for the 2015 operating year is 6.7 percent – above the 5 percent threshold that defines an adequate supply for the Pacific Northwest. Single hour shortfalls drive the LOLP to its current value. Assessing the LOLP solely based on energy considerations would yield a value of 1.4 percent. Furthermore, the bulk of the shortfalls occur in August. Adding as little as 400 MW of peaking capability during summer would bring the LOLP below the 5 percent threshold.

The region depends heavily on Northwest independent power producer (IPP) resources, with some level of contribution in every winter and summer month. The average winter energy contribution ranges from 750 to 1,500 megawatts-months per month and from 250 to 600 megawatts-months per month for summer.

The SW market is called upon as much as 11 percent of the time in winter and, if available, about 27 percent of the time in summer. The winter supply is available on peak and the proposed summer market would be available only during off peak hours. The Forum has yet to debate whether summer off peak purchases should be assumed for the adequacy assessment. They were modeled for this exercise to illustrate their potential use and benefit. Average contributions from the market are very small but, in the worst cases, average about 1,000 megawatt-months for January and about 400 megawatt-months for August.

Borrowed hydro (energy below the drafting rights elevation) is also used quite often, about 14 percent of the time in December but nearly 90 percent of the time in August. However, borrowed hydro energy is quickly replaced and the net end of month effect is minimal. In the worst cases, as much as 700 megawatt-months are used in one August and as much as 400 megawatt-months in one December. The assumed limit for borrowed hydro in any month is 1,000 megawatt-months. This level of use should not affect reservoir refill or maintaining minimum river flows for fish.

Demand response (DR) and standby resources SR) are called upon 8.6 percent of the time. By utilizing these resources, the LOLP drops from 8.6 percent to the current value of 6.7 percent.

A shortfall event is defined as a contiguous set of hours when resources fail to meet load. The expected number of shortfall events per year (not counting DR or SR) is 0.23. The average duration for an event is 14 hours and the average magnitude is about 15,000 megawatt-hours. The average peak curtailment is about 1,000 megawatts. Overall, the expected number of hours of curtailment per year (not events) is 3.3.

ADEQUACY ASSESSMENT

The current resource adequacy standard for the Pacific Northwest's power supply is based on the loss of load probability (LOLP) metric. The LOLP represents the percentage of simulated yearly operations in which shortfalls exceed the peaking and energy capabilities of demand response (DR) actions and standby resources (SR) because these resources are not explicitly modeled. An LOLP greater than 5 percent indicates an inadequate supply.

In addition to the LOLP, other commonly used adequacy metrics are assessed. These alternative metrics are not a part of the standard but provide additional information regarding the frequency, duration and size of potential problems. The current assessment results are provided in Table 1.

Adequacy Metrics		
Based on an Annual Assessment		
Metric	**Value**	**Units**
LOLP	6.7	Percent
Use of DR and SR	8.6	Percent
CVaR (energy)	67618	MW-hours
CVaR (peak)	2277	MW
EUE	3399	MW-hours
LOLE	3.3	Hours/yr

Table 1

The 6.7% LOLP value indicates that the power supply is not adequate, in other words, the likelihood of a serious shortfall is greater than the region's tolerance for such events. This high value is driven by single hour shortfalls in August. Assessing the LOLP based solely on energy results in a value of 1.4 percent. Figures 2 and 3 show the curtailment probability curves for total annual energy and single hour shortfalls.

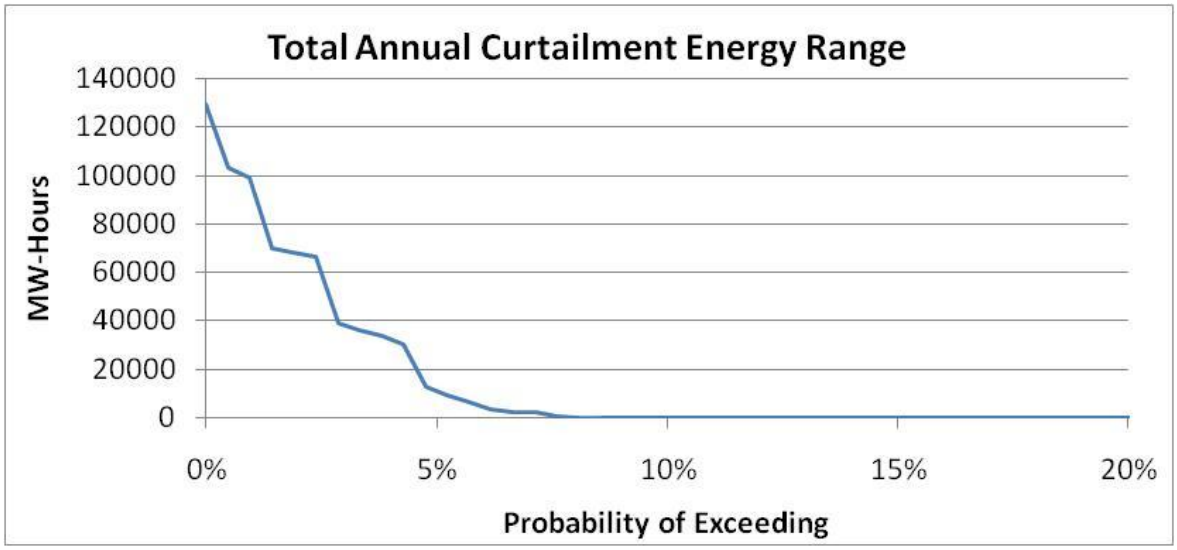

Figure 1

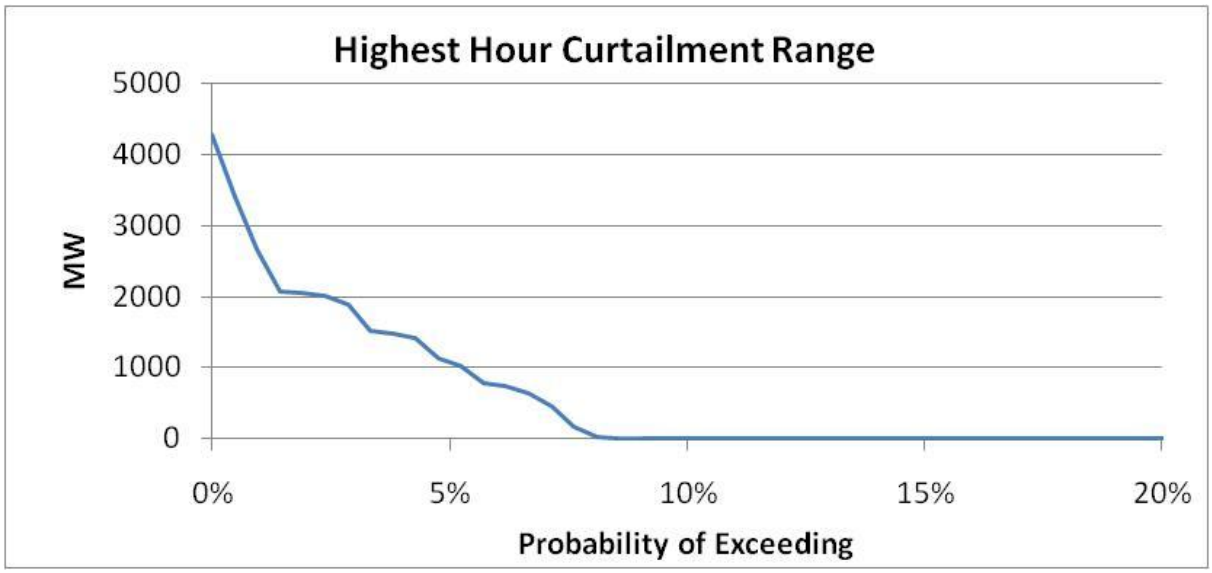

Figure 2

USE OF NON-FIRM RESOURCES

The current adequacy methodology assumes that all reasonably available resources will be dispatched to avoid shortfalls. In this sense, the analysis represents the likelihood that demand will be served, cost notwithstanding. It is not intended to be a resource needs assessment, when costs and other factors are considered. But for this analysis, non-firm resources are included. These resources include regional Independent Power Producer (IPP) generation, out-of-region markets (primarily from the Southwest) and the use of borrowed hydro, which is energy derived by using water below the drafting rights elevation.

The general dispatch order for these resources is to first buy from IPPs, secondly to buy from out-of-region markets and lastly to use borrowed hydro energy. When borrowed hydro is used, it is replaced as quickly as possible, even if it means buying from out-of-region markets at a later time.

Figure 3 below illustrates the expected likelihood of use for each of these three types of non-firm resources by month. It should be noted that the SW market on-peak purchases are limited to the winter months only. Also modeled, but still under debate, is the availability of light load hour purchases made in advance of potential peak hour problems. This purchase-ahead resource is limited to 1000 megawatts in any light load hour and is called upon only when borrowed hydro is expected to be used during the next peak demand period.

Figure 4 shows the average contribution from each resource by month. However, average values are not always very informative. Thus, Figures 5-8 provide the dispatch probability curves for these 4 non-firm resources.

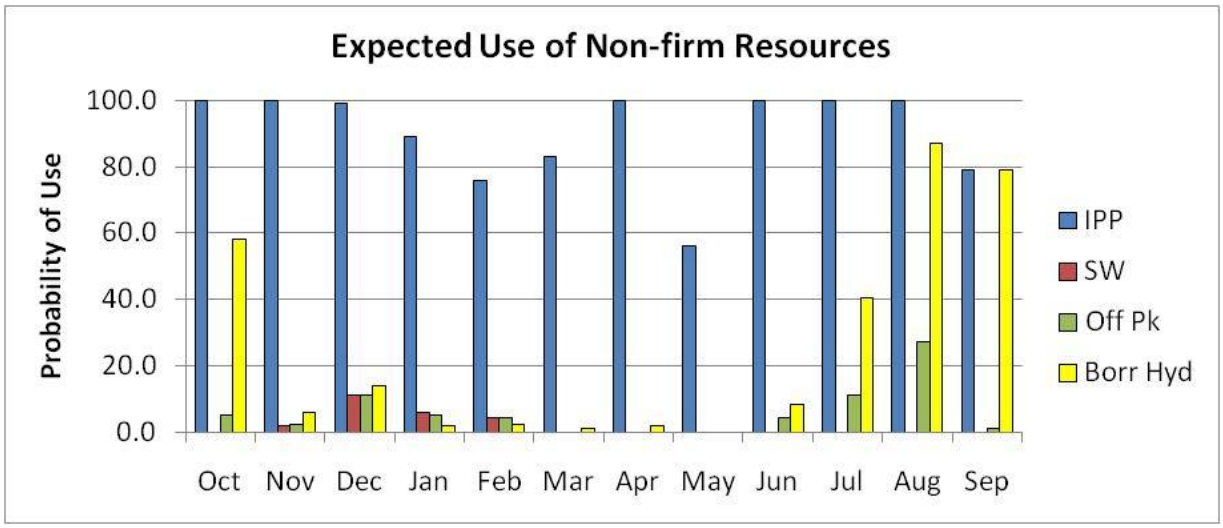

Figure 3

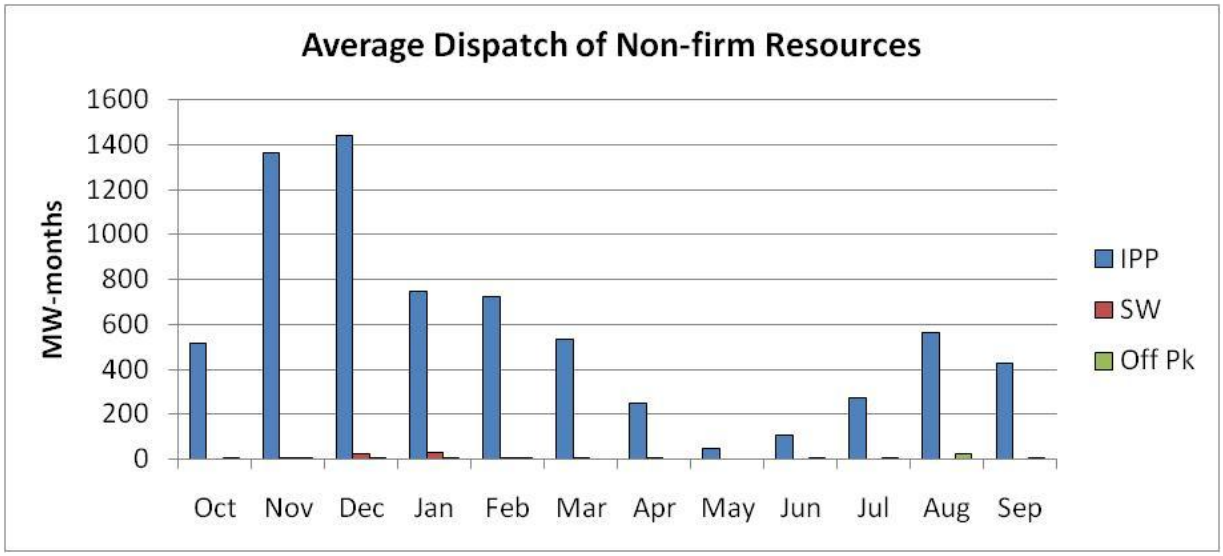

Figure 4

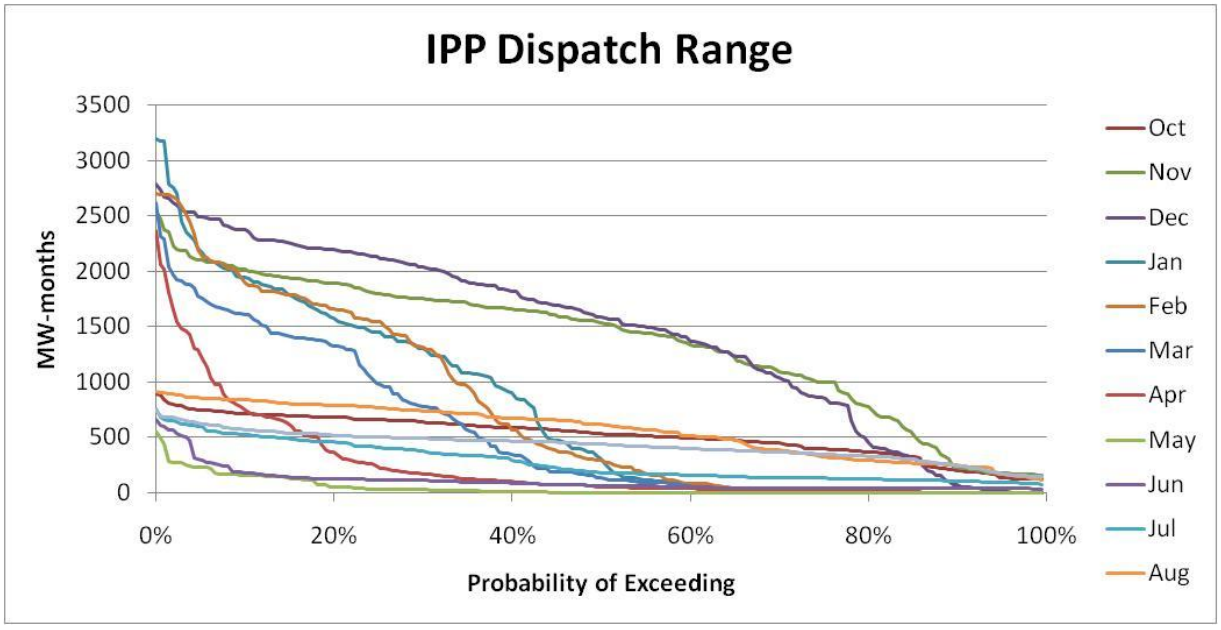

Figure 5

Figure 6

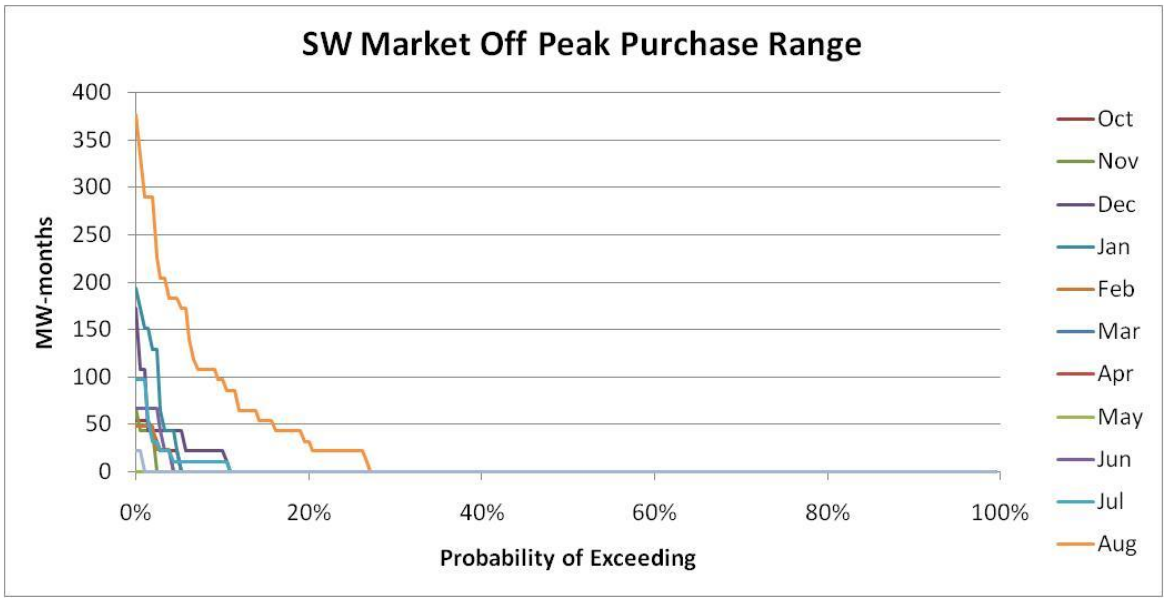

Figure 7

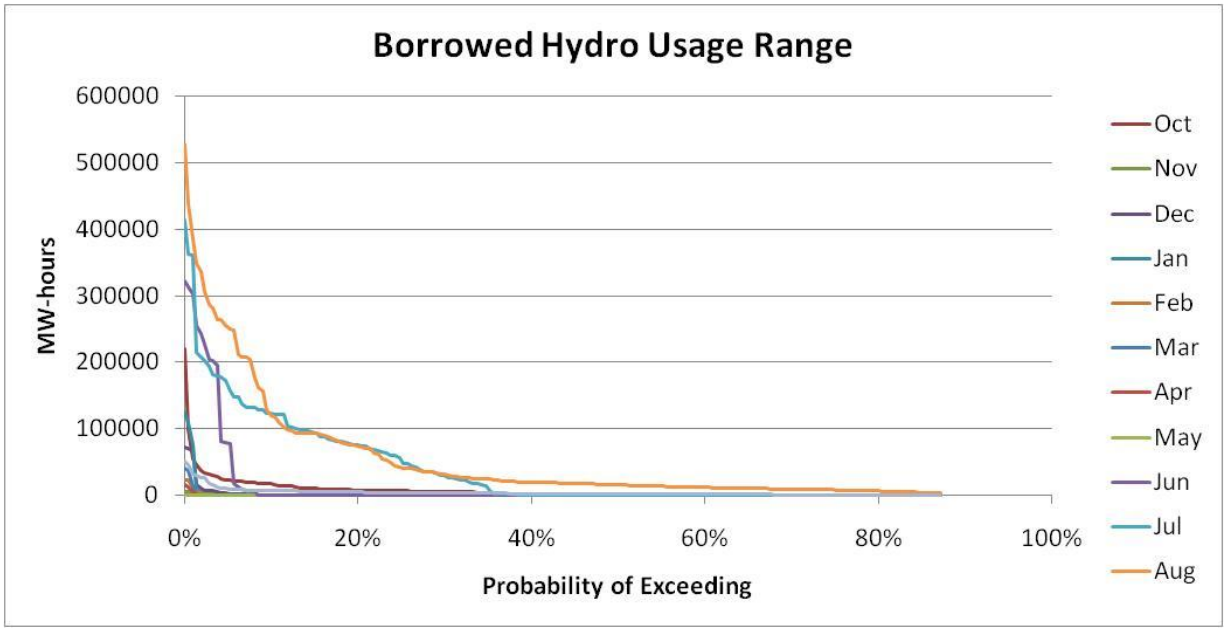
Borrowed Hydro Usage Range
600000
500000
400000
300000
200000
100000
0
MW-hours
0%
20%
40%
60%
80%
100%
Probability of Exceeding
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug

Figure 8

USE OF DEMAND RESPONSE AND STANDBY RESOURCES

Some resources in the Northwest are too small to model explicitly, while others may be available but are not intended to be used every year. The first set of such resources, namely demand response operations, are expected to be used every year to help lower demand during peak hours of the day. These resources only have a capacity component and are not intended to provide extended energy relief.

The second set of resources, or standby resources, are composed of load curtailment actions or generating resources that are contractually available to utilities. These resources are available to help reduce peak hour load and may also provide some energy assistance.

Demand response resources are small, only contributing 60 megawatts of peaking reduction during winter and 120 megawatts during summer. Standby resources have larger capabilities, with about a 600 megawatt peaking contribution and an annual energy availability of 83,000 megawatt-hours.

Figures 9 and 10 show how often these two resource types may be used, by month. Also shown in those figures are the associated energy and peak LOLP values. Note that the LOLP value for peak is greater than the energy value, which means that is the dominate component in assessing the overall annual LOLP value.

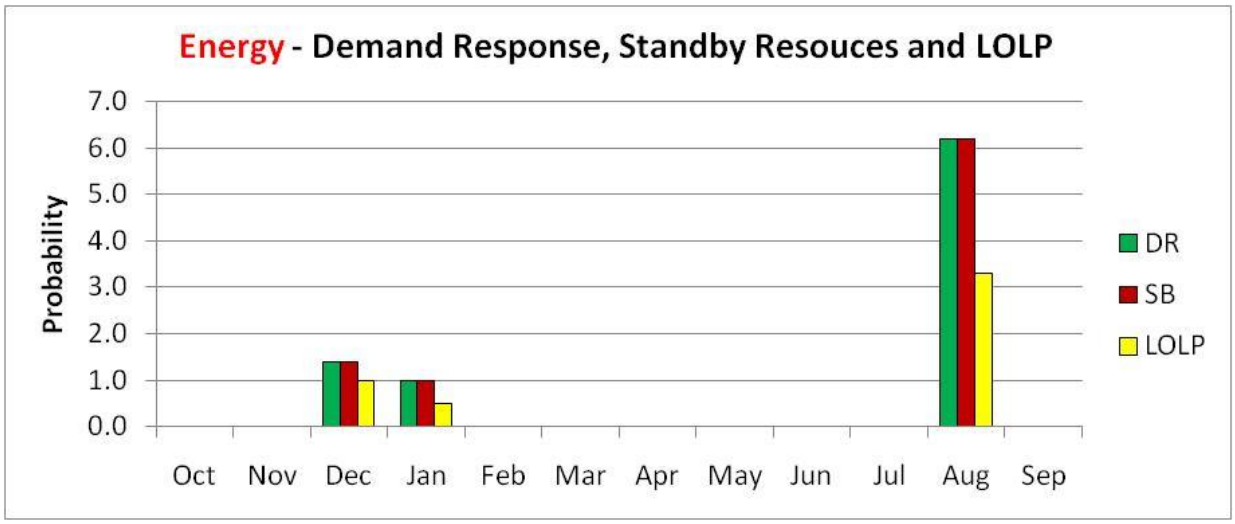

Figure 9

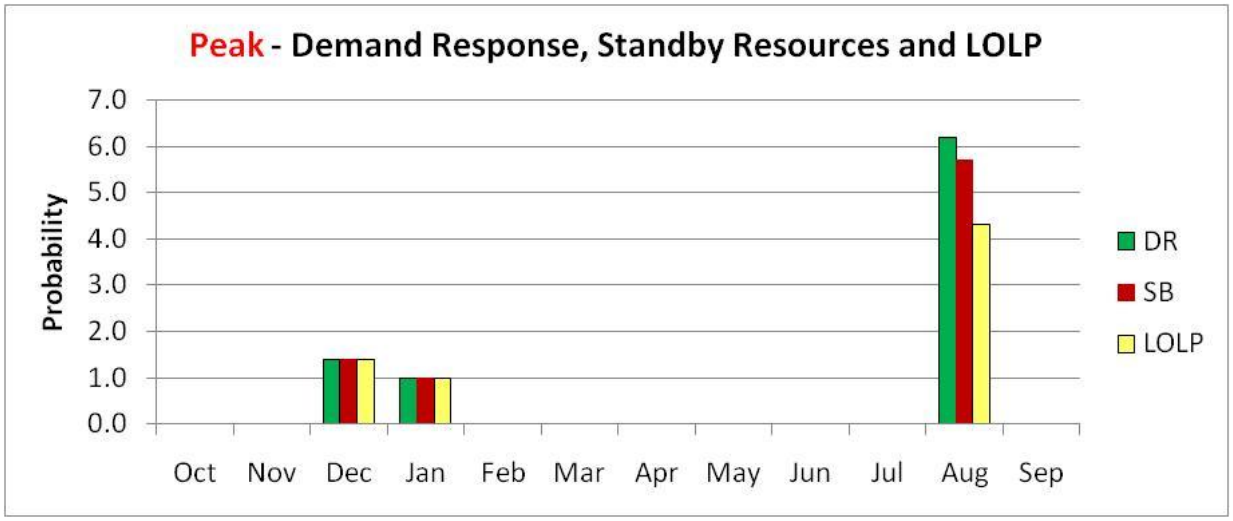
Peak - Demand Response, Standby Resources and LOLP
Probability
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
DR
SB
LOLP

Figure 10

CURTAILMENT STATISTICS

Sometimes, simply looking at simulation results can provide insight into the behavior of the power system. Table 2 below summarizes a few statistics for the curtailment events reported in our analysis. It should be noted that this particular study was only run with 210 simulations and thus the statistics for curtailment events (as well as the adequacy measures) will have a larger error range.

Besides looking at curtailment statistics, it may also be of great use to examine what conditions existed during the time of each shortfall. Thus, a record of all curtailment events along with the values for the four random variables used in the analysis will be provided in a separate spreadsheet (available on the Forum's website). The four random variables displayed in the spreadsheet are;

- Water supply, as a percentage of monthly runoff volume
- Temperature, as a percentage of that day's historical temperature range
- Wind generation, based on historical wind capacity factors from BPA's wind fleet
- Forced outage conditions

Some attempts have been made to correlate shortfall events with the occurrence of certain temperatures, water conditions, wind generation patterns and forced outages, but unfortunately without much success. This is an area of study that should be explored further.

Exp Events/year	0.23	
Avg Event Duration	14	Hours
Avg Event Magnitude	14569	MW-hrs
Avg Event Peak	1098	MW
Exp Curt Hrs/year	3.3	
% games w/curt	8.6%	

Table 2 – Curtailment Statistics

A Resource Adequacy Standard for the Pacific Northwest

Working Draft – Version 3

10/4/2011

A Resource Adequacy Standard for the Pacific Northwest

Pacific Northwest Resource Adequacy Forum

Working Draft for Discussion – Version 3

CONTENTS

ABSTRACT

This paper describes a proposed revision to the Council's Resource Adequacy Standard. The standard is used as an early warning system to indicate when resource development does not adequately keep up with demand growth. Like the current standard, the revised standard uses the system's loss of load probability (LOLP) as the adequacy metric and keeps the maximum allowable LOLP at 5 percent. However, instead of calculating separate LOLP values for winter and summer, a single annual value will be assessed. This bypasses potential problems with assessing seasonal values. In addition, assumptions regarding the use of standby resources have been refined. Those resources are now limited only to non-modeled resources and load management operations that are contractually available to regional utilities. Regarding the use of non-firm resources, the new standard maintains the current philosophy that they should be included in adequacy assessments. The amount of non-firm resources to be used in the assessment is, of course, open for discussion and will undoubtedly need to be reviewed periodically.

In addition to assessing the LOLP, a state-of-the-system report will be produced, which will include information about the frequency, duration, size and timing of potential shortfalls. It could also highlight conditions under which major shortfalls occur. It will also provide statistics on the use of non-firm resources. Thus, the new standard is designed to be simpler and more informative than the current standard and should prove to be much more useful to regional planners, commissioners, policy makers and other involved parties.

Specifically, the Steering Committee will consider the following policy decisions, which when approved, will be forwarded to the Northwest Power and Conservation Council as the Forum's recommendations.

- Keep the current probabilistic methodology, which includes the use of non-firm resources, to assess power supply adequacy.
- Keep the LOLP as the adequacy metric and keep 5% as its maximum threshold.
- Remove the seasonal LOLP assessments and instead calculate only one LOLP value for the entire year.
- Change the assumptions regarding the thresholds used to screen shortfalls. The new thresholds should only count those non-modeled resources and load management actions that are contractually available.
- Remove the translation of the LOLP measure into deterministic values such as load/resource balance and winter and summer sustained-peak planning margins.
- Include a state of the system report will all future assessments.

SUMMARY

In 2008, the Northwest Power and Conservation Council adopted the Resource Adequacy Forum's proposal, which set a standard for power supply adequacy in the Pacific Northwest. Since then the region has used that standard to assess the ability of the power supply to adequately serve Northwest customers. In the past three years, assessments have shown the regional supply to be adequate but also that the surplus of resource capability over demand in summer months was growing smaller.

While the current standard has been very useful to planners, it is somewhat cumbersome to calculate and it invariably leads to misinterpretations every year. The current standard is based on a probabilistic simulation of the region's power supply. That probabilistic measure is converted into more commonly used static measures of power supply, namely annual load/resource balance and hourly planning reserve margins. Comparison of these static measures to similar calculations reported in utility publications has always led planners into a quagmire of confusion, mostly because each set of calculations is used for different purposes.

Because of the issue mentioned above and other considerations, the Forum chose to have its methodology reviewed by a peer group. Results indicated that while the current standard was sound, it could be improved. This paper describes the current standard and the proposed revisions prompted by the peer review.

There are three elements of an adequacy standard that can be addressed separately. Those three elements are; 1) the methodology, 2) the metric and threshold used to define an adequate supply and 3) assumptions made about resources and loads, in particular about non-firm and standby resources. The peer review assured us that the methodology is appropriate. Assumptions regarding non-firm and standby resources are still being refined and the Forum will have an opportunity at a later date to review and approve those assumptions. Thus, this paper focuses only on the metric and threshold. The Forum will be asking the Council to review and approve its suggested metric and corresponding threshold level, which will define an adequate supply for the Pacific Northwest.

The 2011 proposed revisions to the current adequacy standard make it simpler and more informative. It keeps the probabilistic approach to assessing adequacy but drops the conversion to static metrics. Its function is focused on being an early warning should regional resource development fall dangerously short. In this sense, it is like a smoke alarm – must have one but hope it never goes off. But, while the new standard may be simpler, the annual assessment will provide additional analytical information that should prove to be very useful to utility planners. This additional information will be referred to as a "state of the system" report.

The proposed adequacy metric is the loss-of-load probability (LOLP) and the associated threshold is 5 percent. In other words, the power supply is deemed to be adequate if its LOLP is 5 percent or less. The LOLP is based on an annual analysis, in which the operation

of the power supply is simulated over each hour of every month. The LOLP is calculated by dividing the number of yearly simulations with significant curtailment events by the total number of simulations. Significant curtailment events are defined as shortfalls that exceed the capability of standby resources and contractual load management actions.

BACKGROUND

In 2005, the Pacific Northwest Power and Conservation Council (Council) and the Bonneville Power Administration (BPA) created the Pacific Northwest Resource Adequacy Forum (Forum). The Forum includes representatives from the region's electric utilities and utility organizations, public utility commissions and public interest groups, as well as from BPA and the Council. It is made up of a steering committee and a technical committee.

The Forum's overarching goal is to *"establish a resource adequacy framework for the Pacific Northwest to provide a clear, consistent, and unambiguous means of answering the question of whether the region has adequate deliverable resources to meet its load reliably and to develop an effective implementation framework."*

Toward that end, the Forum reached a consensus in recommending a Resource Adequacy Standard[1] (Standard) for the Pacific Northwest region. The Forum's proposed standard was officially adopted by the Council in April of 2008.

The Standard serves as a gauge to assess whether the Northwest's electricity supply is sufficient to meet the region's needs now and in the future. It provides a *minimum threshold* that serves as an early warning should resource development fall dangerously short. It does not mandate compliance or imply any enforcement mechanisms. It does not directly apply to individual utilities – because every utility's circumstances differ. What it is intended to do, is to initiate a discussion among appropriate regional entities, should the assessment indicate that resource development is seriously lagging.

The current standard has been in use since 2008. Every year since then, the adequacy assessment has shown the Northwest's power supply to be adequate. However, the most recently published assessment[2] warned that our summer electricity needs were growing rapidly and that increasing amounts of variable generation (such as wind) are adding to the complexity of system operation.

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[1] The 2008 standard can be found at http://www.nwcouncil.org/library/2008/2008-07.pdf.

[2] The latest published assessment can be found in Chapter 14 of the Council's Sixth Power Plan, at http://www.nwcouncil.org/energy/powerplan/6/final/SixthPowerPlan_Ch14.pdf.

Since its inception, the adequacy assessment has sparked a debate about what it really measures and how it relates to individual utility planning. It was pointed out that an apparent discrepancy existed even in the Council's own power plan. The assessment in the sixth plan indicated that the power supply was adequate at least through 2015, yet the resource acquisition strategy in the same plan encouraged aggressive acquisition of conservation and other resources beyond the adequacy threshold. The answer, of course, is that an adequacy assessment does not equate to a resource needs assessment. The latter involves much more than simply "keeping the lights on." While an adequacy assessment indicates the likelihood of curtailment, cost notwithstanding, a resource needs assessment takes economic, political and environmental effects into consideration. For example, the amount of reliance on market supply becomes a policy decision when performing a resource needs assessment. Some utilities may choose to assess their resource needs in the absence of a market supply.

Nonetheless, it became clear to Forum members that the current standard was not as useful to planners as originally believed. Thus, the Forum initiated a peer review[3] for the methodology used to develop the standard. That review was completed in May of 2011 and recommended that the standard be modified to include a measure of the size of potential problems. It also implied that a secondary measure should be assessed; one that measures how often standby resources might be dispatched. When the dispatch likelihood for standby resources grows too high, system operators are likely to become more uneasy, which may be a good indication that new resources are needed. This secondary measure goes beyond assessing whether the supply is adequate and is likely to be more consistent with utility resource need assessments.

METHODOLOGY

The Council uses a Monte Carlo (probabilistic) methodology to assess the adequacy of the region's power supply. The GENESYS[4] computer model was developed in 1999 and performs a detailed hourly chronological simulation of the Northwest's resources, including the hydroelectric system, over many different possible future conditions. Each future's operation is simulated using different assumptions for uncertain variables, namely; 1) river flows (which affect the amount of water for hydroelectric generation), 2) temperature (which affects demand for electricity), 3) forced outage conditions for generating resources and 4) wind generation.

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[3] A summary of the peer review is provided in Appendix B.

[4] *Northwest Power Supply Adequacy/Reliability Study Phase 1 Report,* Council Document 2000-4, March, 2000. http://www.nwcouncil.org/library/2000/2000-4.pdf

GENESYS provides much more information to decision makers than simple deterministic (static) comparisons between resources and demand. Besides the expected values for hydroelectric and thermal generation, it also provides statistical data regarding the operation of each resource. Most importantly, it records hours when the power supply is not able to meet all demand obligations – and conditions under which these shortfalls occur. The frequency, duration, size and timing of curtailment events are recorded and the overall probability of not being able to fully serve load is calculated. This probability, commonly referred to as the loss-of-load probability (LOLP), is the metric used to assess adequacy of the power supply.

For the Northwest, the Council has defined an adequate power supply to have an LOLP no greater than 5 percent. This means that out of all the simulations run, no more than 5 percent of them had significant curtailments. In other words, the likelihood of the region experiencing a significant shortfall during any time of the year must be 5 percent or less in order for the supply to be deemed adequate.

THE CURRENT STANDARD

The current standard uses the 5 percent LOLP threshold as a basis to calculate minimum thresholds for three deterministic metrics, one for energy, one for winter capacity and one for summer capacity. These deterministic metrics act as a surrogate for the LOLP metric and can be calculated without the use of a Monte Carlo simulation program. It was believed that by defining thresholds for these deterministic metrics, the adequacy of the power supply could more readily be assessed.

The deterministic adequacy metric for energy is the annual balance between resources and demand. The resources include reasonable assumptions about the availability of non-firm resources and market supplies. The demand includes assumptions regarding the anticipated amount of efficiency gains in the year to be analyzed. The threshold for the energy metric is zero, meaning that resources must at least equal the amount of firm demand, on an annual basis, in order to provide an adequate supply.

The deterministic adequacy metric for capacity is the planning reserve margin or the surplus generating capability over a sustained peak period. The sustained peak period is defined to be the 6 highest demand hours of the day over 3 consecutive days. This 18-hour non-contiguous period is intended to capture the highest demand hours over a winter cold snap or summer heat wave event. The minimum thresholds for the winter and summer sustained-peak planning reserve margins are 23 and 24 percent respectively. Resource assumptions used to calculate the system's planning reserve margins are similar to those used for the energy metric, in that they include some non-firm and market resources.

Unfortunately, the use of deterministic adequacy metrics became problematic. For one thing, each time the system changed, deterministic thresholds would have to be recalibrated to the 5 percent LOLP standard. Secondly, it was difficult to compare the annual load/resource balance and the planning reserve margins to similar metrics published in utility reports[5] – because the purposes of each are different. Thus, the Forum spent much time after every assessment explaining why these measures should be different from those in other reports.

Because of these issues with the deterministic metrics, the Forum chose to focus on the probabilistic LOLP metric for its latest assessment. However, this was also problematic because there was not just one LOLP to calculate but three. LOLP assessments were made for winter energy and capacity needs and for summer capacity needs. The current standard implies that as long as all of these LOLP values are 5 percent or less, the power supply is adequate. Unfortunately, this approach is faulty and could yield false negative results because each LOLP value is assessed independently of the others. Situations could easily occur when all three LOLP values are less than 5 percent but the overall likelihood of experiencing a problem in either winter or summer is greater than 5 percent. This happens if winter and summer shortfalls occur in different simulations. The Forum now concedes that using multiple LOLP metrics is faulty and suggests using a single annual LOLP value, which identifies both energy and capacity problems.

Another concern with the current standard is that it provides no indication of the size of potential problems. Just knowing the likelihood of curtailment is important but also knowing the size of the problem can be extremely beneficial to utility planners. In fact, the Forum recognizes that there exists a wealth of analytical data that can be very useful and suggests that it be provided along with each annual adequacy assessment.

THE PROPOSED NEW STANDARD

The Forum's 2011 proposed revisions to the current adequacy standard make it simpler and more informative. It keeps the LOLP as the metric of choice and also keeps the 5 percent threshold for adequacy. However, it differs in many other ways. The first difference is that the LOLP is now calculated on an annual basis (i.e. every hour of the year is simulated, not just winter and summer periods). Secondly, capacity and energy shortfalls are counted together (rather than separately as in the current standard). As before, the assessment will be made three and five years into the future and will count only existing

[5] These reports include the Pacific Northwest Utility Conference Committee's Northwest Regional Forecast of Loads and Resources and the Bonneville Power Administration's White Book.

resources (or those expected to be operational within the 3 and 5-year assessment period) and expected levels of efficiency gains.

Another difference is that capacity and energy shortfalls are defined differently. In the current standard, an energy "event" was counted only if the total curtailed energy in the winter or summer period was greater than 28,800 megawatt-hours. A capacity "event" was counted if any hour's curtailment in winter or summer exceeded 3,000 megawatts. These curtailment thresholds were used as a surrogate for additional actions (not modeled in GENESYS) that the region could take to avoid a shortfall during times of stress. These additional actions include dispatching standby resources or executing contractual load reduction agreements.

The new standard keeps the idea of using additional actions to set the thresholds for counting curtailment events. However, the surrogate values are replaced by the actual aggregate capabilities of these additional actions. These additional actions are divided into two groups. The first group reflects demand response operations that are commonly used every year but are too small to be modeled explicitly in GENESYS. These actions only contribute toward reducing peak-hour demand and, therefore, have no energy component. . This first set of additional actions will be referred to as "non-modeled resources."

The second group of additional actions contains resources or load management actions that utilities have contractual rights to but are not generally used on an annual basis. These resources can have both capacity and energy components. This second set of additional actions will be referred to as "standby resources."

Thus, the new standard is based on an annual LOLP calculated by adding up all simulations in which curtailments exceed the capabilities of non-modeled and standby resources and dividing by the total number of simulations. If the LOLP is 5 percent or less, the power supply is deemed to be adequate.

The Forum kept the new standard simple because it wanted keep the function of the adequacy assessment as an early warning (e.g. like a smoke alarm). The alarm may never go off. However, should resource development lag, for whatever reason, the alarm should sound and the appropriate regional entities should gather to discuss whether the alarm was justified and, if so, what actions should be taken. Had this system been in place in the 1990s, the alarm would have sounded in about 1995.

However, the Forum also recognizes that a lot of very useful information is provided by an adequacy assessment study. For that reason, the Forum has chosen to provide additional information along with the adequacy assessment. This additional information is described in more detail below but basically provides statistical data on the frequency, duration, size and timing of potential problems. It also provides information regarding the use of standby resources, non-firm resources and the seasonality of shortfalls. Even if the power supply is

deemed to be adequate, this additional information, should prove to be very valuable to utility planners. This additional information will be referred to as the "state of the system report."

Specifically, the Steering Committee will consider the following policy decisions, which when approved, will be forwarded to the Northwest Power and Conservation Council as the Forum's recommendations.

- Keep the current probabilistic methodology, which includes the use of non-firm resources, to assess power supply adequacy.
- Keep the LOLP as the adequacy metric and keep 5% as its maximum threshold.
- Remove the seasonal LOLP assessments and instead calculate only one LOLP value for the entire year.
- Change the assumptions regarding the thresholds used to screen shortfalls. The new thresholds should only count those non-modeled resources and load management actions that are contractually available.
- Remove the translation of the LOLP measure into deterministic values such as load/resource balance and winter and summer sustained-peak planning margins.
- Include a state of the system report will all future assessments.

"State of the System" Report

The Forum plans to assess the adequacy of the Northwest's power supply each year, determining whether it can adequately provide for our needs through a five year period. In addition to that assessment, a state-of-the-system report will be produced, which will include information about the frequency, duration, size and timing of potential shortfalls. It could also highlight conditions under which major shortfalls occur. It will also provide statistics on the use of non-firm resources. Thus, the new standard is designed to be simpler and more informative than the current standard and should prove to be much more useful to regional planners, commissioners, policy makers and other involved parties.

Conditional Value at Risk

This metric measures the magnitude of curtailment and is recommended in the peer review of our methodology[6]. It reflects the average magnitude of the worst potential curtailments. It is calculated by summing up the total curtailed energy (in megawatt-hours) for each simulated year. This data is then sorted and the total curtailment for the worst 5 percent of simulations is averaged. As stated in the peer review report, this measure is a coherent

[6] See Appendix B.

measure that is easily incorporated into resource planning optimization models (not currently used by the Council).

An alternative or supplement is to calculate a CVaR measure for the single worst curtailment events. A curtailment event is defined as a series of contiguous hours in which demand is not met. To calculate this variation of CVaR, the largest curtailment event is extracted from each simulated year instead of the total annual curtailment energy. A second variation is to calculate a CVaR measure for the worst single-hour curtailment. The process is similar to that for calculating the worst-event CVaR. However, neither of these variations is recommended by the peer review and so is not included.

Loss of Load Expectation

This metric measures the frequency of curtailments and is commonly used in other parts of the United States and the world. Unfortunately, it not always well defined. In principle it calculates the expected number of hours of curtailment per year. However, many regions use different sets of random variables (future uncertainties) to calculate LOLE. A region that only uses forced outages to calculate LOLE cannot properly compare its value to another region's LOLE that includes a different set of random variables in its simulation. In the Northwest, for example, water supply, temperature, forced outages and wind generation are modeled as future uncertainties.

The common LOLE threshold used to define an adequate supply is one day in ten years, meaning that in a ten-year study, no more than one day can show a failure to meet demand. However, this threshold is also commonly misinterpreted. Since most utilities now do single-year analysis, the one-day-in-ten-year threshold has been redefined as 2.4 hours per year by many regions. In the Forum's opinion, this redefinition is not equivalent to the one-day-in-ten-year threshold – because to make them equal, the "one day" would have to show curtailments for all 24 hours.

Nonetheless, the recommendation is to report an LOLE value for the Northwest's power supply. The suggested calculation is to take the total number of hours of curtailment and divide by the total number of years simulated. The question remains, however, whether the 2.4-hours-per-year threshold should apply to the Northwest because additional random variables are used in our simulation. The Forum recommends that this issue be discussed in more detail at national forums.

Expected Unserved Energy

This metric measures the size of curtailment. As with the LOLE, the EUE is also commonly used across the country. To calculate EUE for the Northwest, the total amount of unserved load (in megawatt-hours) over all simulations is divided by the number of simulations. This yields the average amount of annual energy shortfall.

A variation of this metric is to normalize it by dividing the EUE by the expected load, which yields the average percentage of load that is expected not to be served. As with the LOLE metric, comparing EUE measures across regions could be problematic because of the same issues, namely the number and types of random variables used.

EXPECTED USE OF STANDBY RESOURCES

This is a newly defined metric that measures how often standby resources are likely to be used. Standby resources are resources or load management actions that utilities have contractual rights to and are used only during times of stress to avoid shortfalls. The Expected use of standby resources metric or EUSR is the number of simulations in which standby resources are used is divided by the total number of simulations. It is an LOLP type of metric but will always be larger than the LOLP (assuming that standby resources exist).

EXPECTED USE OF NON-FIRM RESOURCES

The Forum also recommends providing statistics on the use of non-firm resources. Non-firm resources include independent power producers within the region, out-of-region market supplies and the use of "borrowed hydro" (water below drafting rights elevations that is used for short periods and then replaced).

At this time it is not clear how much of this statistical information will prove to be helpful. However, as a starting point, the Forum will report the expected annual and monthly use of these resources. If necessary, probability duration curves, which show the range of use for these resources, can also be reported.

CURTAILMENT STATISTICS

The Forum will also provide statistical information regarding curtailment events (as defined above). The recommended information may include;

- Frequency of events (events/year)
- Average magnitude of events (megawatt-hours)
- Average duration of events (hours)

The information above will be based on "raw" curtailment events, in other words, curtailment is ***not*** reduced by the capability of standby resources. However, the same type of information can be provided for events that have been adjusted by subtracting standby resource capabilities.

MONTHLY STATISTICS

The Forum will also provide a number of monthly statistical values, especially for LOLP, EUSR and the expected use of non-firm resources. Monthly values are calculated in the same manner as annual values. For example, the monthly LOLP value for January is

calculated by adding up the total number simulated Januarys that had curtailment (in excess of the standby resource capability) and dividing by the total number of Januarys simulated.

Non-modeled small resources and standby resources have limited capabilities that can be "used up" prior to the end of the operating year. The raw curtailment record produced by GENESYS will be adjusted to account for the use of non-modeled resources by dispatching them as needed beginning in October (start of the operating year). The same assumption is made for standby resources. Once the capabilities of these resources are used up, they are no longer available to help out during periods of shortfall. Thus, we may see higher impacts to summer months, especially if these resources were dispatched during the winter.

Another issue regarding monthly statistics is that all chronological links across months will be lost. In other words, monthly statistics will be based on each month's simulation results independent of other month's results. Thus, although a monthly report (or graph) will help identify periods of the year that are more susceptible to curtailments, it will have no mathematical connection to the annual values. In a sense, it will show a non-realistic "picture" of the adequacy of the power supply because the worst curtailments for each month do not all occur in the same year. Nonetheless, it is a report (using proper caveats) that the Forum believes will be very informative to planners.

APPENDIX A – CURRENT ASSUMPTIONS

Firm Generating Resources

All existing regionally owned or operated generating resources and those that are expected to be operational in the year being assessed.

Wind

Wind capacity factors are currently based on historic BPA wind fleet data from 2008 through 2010. For the Monte Carlo simulation in GENESYS, wind years are chosen at random among the three historical annual data sets. Work is ongoing to develop a temperature-correlated synthetic data set.

Conservation

The Council's expected level of efficiency improvements (as reported in its power plan) for the year being assessed.

Non-modeled Resources

Non-modeled resources are demand response actions that utilities are anticipating to use on an annual basis to reduce their peak hour load. Current assumptions include 120 megawatts of capacity reduction for summer and 60 megawatts for winter.

Standby Resources

Standby resources are resources or load management actions that utilities have contractual rights to but are not expected to be used commonly. Current assumptions include 602 megawatts of peak hour capacity reduction and 83,000 megawatt-hours of energy. **Out-of-region Market Supply**

Out-of-region purchases can be made during on-peak hours or during light load hours, in anticipation of need over the next day or two. Current assumptions are that 3,000 megawatts of market supply is available during on-peak hours in winter months but none during summer. The use of off-peak purchases is still being debated. **In-region Market Supply**

The in-region market supply is made up of independent power producers (IPP). The operation of these resources is modeled explicitly but they are dispatched at market prices. During October through May they are fully available to meet regional demand but during June through September only 1,000 megawatts of their capability is available for regional use.

Borrowed Hydro

Borrowed hydro is energy derived by drafting projects below their drafting rights elevations for short periods of time. This additional draft is then replaced as soon as possible, usually within the month. The current monthly limit for borrowed hydro use is 1,000 megawatt-months. This level of borrowed hydro does not affect biological opinion refill targets in April and appears to not affect providing minimum flows for Chum salmon. (This latter issue is still being assessed.)

APPENDIX B – PEER REVIEW REPORT

This report was sent in a separate document.