Resource Adequacy

Introduction

For the purposes of the Power Plan, physical resource adequacy is defined as:

> *A condition in which the Region is assured that, in aggregate, utilities or other load serving entities (LSE) have acquired sufficient resources to satisfy forecast future loads reliably.*

This definition is not intended to include problems such as localized failures in the distribution system or outages caused by operational problems or system element failures in the interconnected transmission system. It is intended to protect against power failures resulting from not having adequate generating capacity available or the inability to fuel generators under extreme conditions. Here in the Northwest, the primary concern has been whether there are sufficient non-hydro resources available to meet loads when the "fuel" for hydroelectric generation is limited under historically low or "critical" water conditions.

As was discussed in Chapter 1, The Western Electricity Crisis of 2001-2002 is widely believed to have had its roots in resource inadequacy. For a number of reasons, resource development in the 1990s failed to keep pace with growth in the region and, in fact, the entire West. When poor hydro conditions manifested themselves in the summer of 2000 and on into 2001, the underlying tight supply was made apparent and wholesale prices went out of control. The lights never went out in the Northwest during 2000 and 2001 but the region experienced extremely high wholesale prices. This is even though large amounts of load, mostly from the Direct Service Industries, were taken off the system. This suggests the possibility of a different adequacy concept – that of "economic" resource adequacy. It may be that a different standard will have to be considered to assure lower risk.

Analysis

To begin to inform the discussion of an adequacy standard, the Council has undertaken two complementary analyses. One addresses physical adequacy – the ability to meet load. The other addresses economic adequacy – the avoidance of extreme high costs that can result from tight supply conditions. The first analysis uses the GENESYS model, which performs a detailed simulation of the Northwest power system, to assess the ability of the system to meet load with variations in hydro conditions, temperature and generator outages. The second analysis uses the portfolio model, described in Chapter __, to explore the cost/risk tradeoff over a large number of possible futures.

GENESYS Analysis

The GENESYS model was developed in 1999 to assess the adequacy of the regional power supply.[1] One of its most important features is that it is a probabilistic model, that is, it incorporates the uncertainty of generation supply into its analysis. Each GENESYS study involves hundreds of simulations of the operation of the power system. Each simulation is

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

performed using different values for uncertain future variables, such as precipitation (which affects the amount of water for hydroelectric generation) and temperature (which affects the demand for electricity).

More precisely, the random (or uncertain) variables modeled in GENESYS are Pacific Northwest stream flows, Pacific Northwest demand and generating-unit forced outages. The variation in stream flow is captured through incorporation of the 50-year (1929–1978) Pacific Northwest streamflow record. Uncertainty in demand is captured through use of a weather (temperature)-driven demand model. The demand algorithm in GENESYS uses daily average temperatures to forecast hourly demands. In order to maintain the correlation between temperature and precipitation (river flows), the model is normally run with these two variables in lockstep, meaning that the corresponding historical temperatures are used for each selection of historical water condition.

GENESYS does not model long-term demand uncertainty (not related to temperature variations in demand) nor does it incorporate any mechanism to add new resources should demands grow more rapidly than expected. It performs its calculations for a known system configuration and a known demand forecast, which can change over time. In order to assess the physical adequacy of the system over different long-term demand scenarios, the model must be rerun using the new demands and the corresponding new resource additions. The portfolio model (described below) deals with long-term demand uncertainty explicitly as well as other long-term uncertainties. .

Another important feature of GENESYS is that it captures the effects of “hydro flexibility,” that is, the ability to draft reservoirs below normal drafting limits in times of emergency. Hydro flexibility can be particularly important in helping address potential supply problems during extended periods of high demand associated with extreme cold events. In order for GENESYS to properly assess the use of this emergency generation, a very detailed hydroelectric-operation simulation algorithm was incorporated into the model. This logic simulates the operation of individual hydroelectric projects over 14 periods of the year (April and August are split because they are the transition months between fall-winter and spring-summer). The portfolio model has a much more simplistic representation of the hydroelectric system.

The probabilistic assessment of adequacy in GENESYS provides much more useful information to decision makers than a simple deterministic (static) counting of resources and demands. Besides the expected values for hydroelectric generation and dispatched hours for thermal resources, the model also provides the distribution (or range) of operations for each resource. It also identifies situations when the power supply is not able to meet all of its obligations. These situations are informative because they identify the conditions under which the power supply is inadequate. The frequency, duration and magnitude of these curtailment events are recorded so that the overall probability of not being able to fully serve loads is calculated for the power system being studied. This probability, commonly referred to as the loss of load probability (LOLP), is the figure of merit provide by GENESYS.

It should be noted that in determining the LOLP, an assumption is made in GENESYS that all available resources will be dispatched in economic order to “keep the lights on, no matter what the cost. As such, the LOLP is a physical metric, not an economic one.

Having a model to assess the LOLP for a given configuration of the power supply is very useful but planning for future expansion cannot occur until a standard is defined. In other words, what value of LOLP defines an adequate system? While many regions in the United States use some form of a probabilistic method to calculate a loss-of-load type of metric, no well-defined standard exists. In fact, there is a great variation in the definition of loss-of-load metrics. For example, some regions calculate a metric using resource forced outage as the only uncertain variable.

For the Northwest, we have defined an adequate system to have an LOLP no greater than 5 percent over the winter period. This means that of all the simulations run, with uncertain water conditions, temperatures and forced outages, no more than 5 percent had winters when not all demands could be met. Such a system faces a maximum 5 percent likelihood that some winter demands will not be served due to inadequacies in the generation system (not counting potential problems in the transmission network).

But what constitutes a curtailment event? Since the GENESYS model cannot possibly simulate all potentially varying parameters nor can it know precisely every single resource that is available, a threshold is used to screen out inconsequential events. Our standard is based on a threshold of 1,200 megawatt-days. This corresponds to the loss of power to a city about the size of Seattle, Washington for a period of 24 hours. It represents 28,800 megawatt-hours of curtailment. In our assessment of the LOLP for the northwest, each simulation performed that shows a total curtailment of 28,800 megawatt-hours or more over the winter period is counted as a curtailment event. More precisely then, a 5 percent LOLP means that there is a 5 percent likelihood that over a winter period 28,800 megawatt-hours of service or more will be curtailed.

The Northwest in not an island

In the past, the Northwest planned (at least in theory)to a critical-water standard, i.e., that there should be sufficient Northwest resources, including the hydroelectric generation produced given the driest historical water condition, to just meet forecast loads. This standard originated when the Northwest was essentially isolated from the rest of the Western system by limited transmission links. However, since the inter-ties were constructed, the region has not necessarily needed to balance in-region resources and demand under critical water conditions in order to maintain a physically adequate power supply. The reasons for this are twofold; 1) in almost all years, hydroelectric generation will exceed that produced under critical water conditions and 2) the Northwest is connected electrically to the southwest, which almost always has surplus winter energy to export (the southwest is a summer peaking region and the northwest is a winter peaking region).

In the past, reservoirs were operated in the fall and early winter under the assumption that the region would realize better than critical water conditions. Should a dry year ensue, the region could import surplus energy from the southwest. There was also the contractual ability to interrupt a portion of the Direct Service Industry load when out-of-region surplus energy was not available. These contractual agreements with the DSIs no longer exist. But, the Northwest is still connected to the southwest. Both regions should be able to benefit from the diversity in peak demand seasons. Consequently, determination of adequacy should reflect the ability to import power from outside the region. However, the implication of this is that any Northwest adequacy standard and determination must be closely coordinated with other entities in the Western Interconnection.

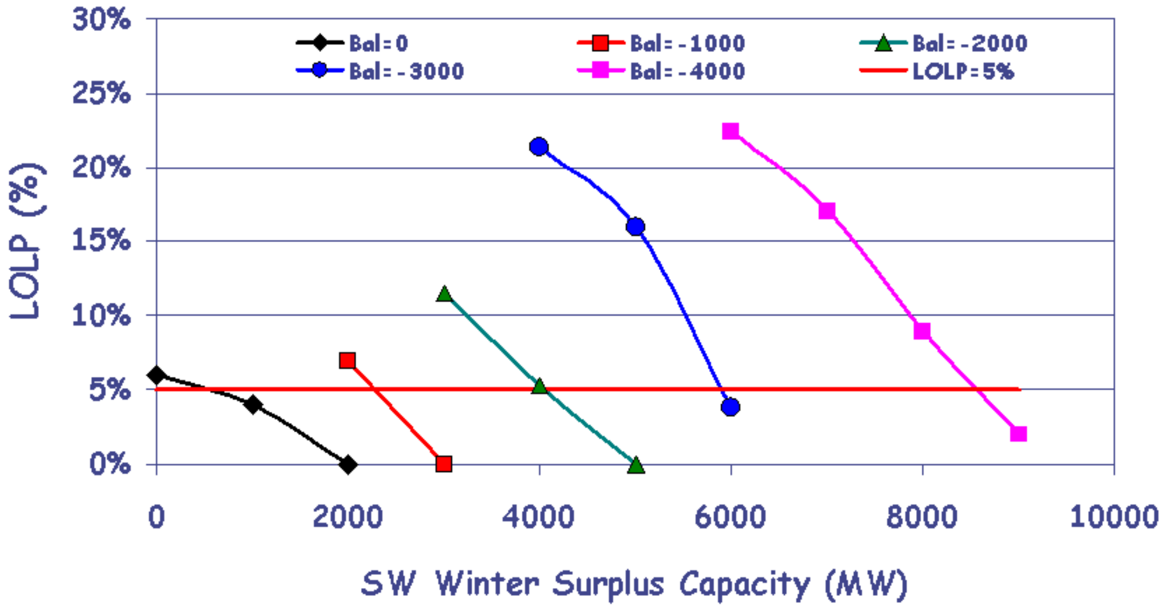
GENESYS models inter-regional transactions among the northwest, Canadian and southwest regions. Northwest contractual export obligations are served as though they were regional demands. During emergencies, when surplus out-of-region capacity is available, it can be dispatched to counter schedule existing exports and, if necessary, to import additional generation into the northwest.

How much should we rely on imports?

A difficult planning question is how much out-of-region surplus capacity should we rely on? Clearly, assuming that no surplus out-of-region capacity is available is too conservative and possibly costly. Assuming the maximum amount of available out-of-region surplus may be too risky. Some level in between, calculated with the tradeoff between risk and cost in mind, should be assessed. Currently the region is over 1,000 average megawatts surplus relative to critical water generation, assuming that generation from northwest merchant resources not associated with load serving entities would be available to serve regional demand. Because of the surplus, the current estimate for LOLP is under one percent, which means that the region does not have to depend on out-of-region imports to maintain an adequate supply. However, it is important to know how the adequacy of the northwest power supply changes as the surplus goes away. At what point does the region need to take action to maintain an adequate supply?

Figure A1 below illustrates the relationship between the LOLP and available out-of-region surplus capacity, for different levels of load/resource balance. Generally speaking, the more surplus that is available from out of region, the lower the LOLP will be. For example, consider the case where the region is 2,000 average megawatts deficit on a firm basis (the curve with the triangular points in Figure A1). Assuming that a 5 percent LOLP represents an adequate power supply, then the northwest would be adequate (even though the load/resource balance is negative) if at least 4,000 megawatts of surplus winter capacity were available from out-of-region utilities. If no out-of-region surplus were available, the projected LOLP would be on the order of 25 percent -- well over the standard. Even if the northwest were in load/resource balance (the far left curve with the diamond points), the LOLP would be over 5 percent with no available out-of-region imports. So, the region should incorporate some level of available out-of-region generation in its planning process. (Replace the chart with and Excel chart or change the fonts so that the graphics are consistent with those elsewhere in the document)

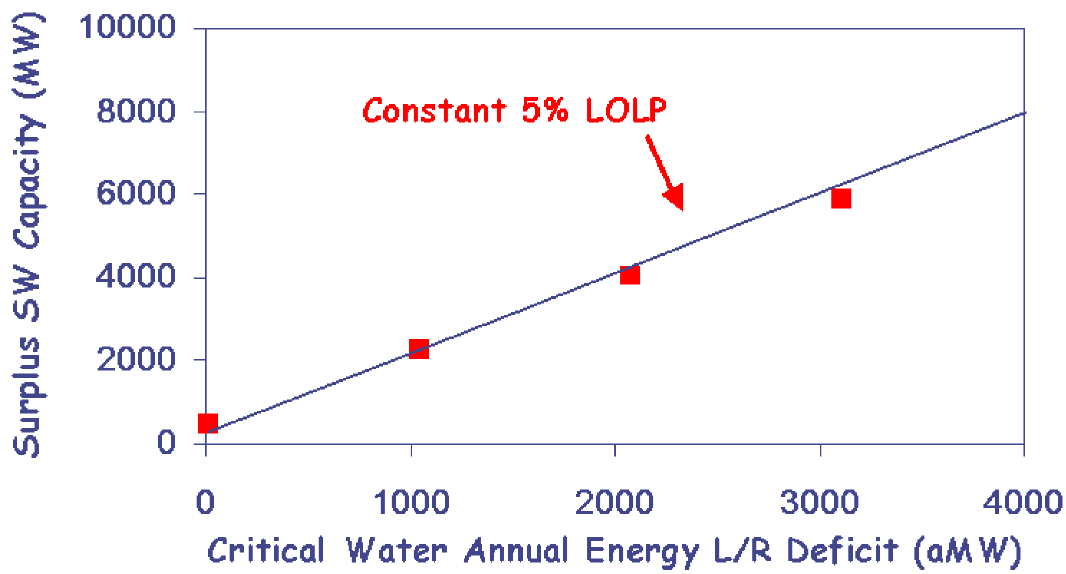
Figure A1
LOLP as a Function of Available SW Capacity
(For Different Load/Resource Balance Conditions)



To make the relationship between LOLP and out-of-region surplus a little easier to see, the values in Figure A1 for all the points that cross the 5 percent LOLP level are plotted in Figure A2. In that figure, every point on the plotted curve has the same reliability, namely a 5 percent LOLP. Given a particular load/resource balance in the northwest (horizontal axis), this graph shows how much out-of-region surplus capacity (vertical axis) is required to maintain an adequate system. Again, using the same example as above, if the region were deficit by 2,000 average megawatts, it would require about 4,000 megawatts of surplus winter capacity in order for the northwest to maintain a 5 percent LOLP. This does not mean that the region would import 4,000 megawatts over the entire winter. In fact, the average amount of imported energy for this case is about half of that but in some hours the full 4,000 megawatts would be imported.

The question of how much out-of-region surplus the northwest should rely on for planning purposes, however, remains unanswered. If California goes forward with aggressive adequacy standards, it should mean that California should have ample surplus for years to come. However, current and potentially new air-quality concerns may limit the operation of surplus resources in California. In addition, future proposals to add a carbon tax to the operation of fossil-fuel burning resources may diminish their availability to the northwest. For the time being, with a surplus northwest, this issue is not urgent but at some point in the near future the region must assess what level of inter-regional dependence it wishes to rely on to plan future power system expansion.

Figure A2
Relationship between Surplus Capacity and L/R Balance



Portfolio Analysis

As described in Chapter _, the portfolio model tests different regional resource plans, calculating the expected cost and risk associated with those plans over a large number of possible "futures". Those plans consist of the types, quantities and schedules for new resource development. The futures involve different patterns of load growth, hydro conditions, fuel prices and electricity market prices over the planning period. While the model calculates physical loads and resources, it makes its choices purely on economics. Does this plan lower the average net present value system cost? What is the risk? Is there a plan that lowers the risk? What is the cost? For a given level of risk, the model searches for the mix of resource types, amounts and schedule for resource development that yields the minimum expected cost over a wide range of possible futures.

In the portfolio model, the region is exposed to the market price of electricity. That market is essentially the West Coast. If there are excess Northwest resources whose variable costs are less than the market price, they can be sold into that market up to the export capability of the transmission system. Conversely, if there are insufficient Northwest resources to meet load, the region can purchase from that market up to the import capabilities of the transmission system. The average market price over all the futures corresponds to the electricity market price forecast described in Chapter 2. However, for any given future, the market price can look much different. The market price is affected by a number of factors such as natural gas prices and hydro production. And, it also reflects other factors such as possible extended forced outages of major resources outside the region, new technologies, extreme weather and even the psychology of the market. It is only when the region is "islanded" by virtue of the import or export capability being reached does the market price reduce to the equilibrium price balancing regional loads and regional resources. The tradeoff the portfolio model is evaluating is between the risk of exposure to high market prices against the fixed costs of the additional resources to protect against that exposure.

The conventional wisdom has been that we are better off to risk some exposure to the market than to incur additional fixed costs for resources that may run relatively infrequently. That was clearly so when the market was well behaved and the resource choices tended to be highly capital intensive, have long construction lead times and costs of capital were very high. The Council's earlier plans devoted a great deal of attention to managing this fixed cost risk.

The current analysis suggests that this view should perhaps shift. Certainly the characteristics of most of the resources have changed in such a way as to reduce fixed cost risk – smaller unit sizes, shorter lead times, lower capital costs. Similarly the cost of capital is much reduced from earlier plans. However, recent experience would also lead us to believe the market may be less well-behaved than it was in the past and that there is little tolerance among the public and policy-makers for price volatility. While people are aware of many of the issues that brought about the 2000-2001 electricity crisis, certainly not all them have been resolved. In characterizing the uncertainty about electricity market prices, the analysis did not include periods as severe as 2000-2001 and maintained the current $250 per megawatt hour price cap. But it did include a number of futures with significant market price excursions.

The results of the portfolio analysis suggest maintaining a higher level of in-region resources than indicated in the GENESYS analysis. Specifically, …..

Adequacy "Standards"

Most of the discussion in the region and the rest of the West has been directed toward the development some sort of adequacy standard that would apply to load serving entities (LSEs). The Federal Energy Regulatory Commission (FERC) proposed an adequacy standard as part of its Standard Market Design. However, that standard was inappropriate for an energy-constrained, hydro dominated system like that in the Northwest. FERC has subsequently deferred to the states but in the absence of state or regional action, it might attempt to reassert authority in this area. In addition, the North American Electrical Reliability Council (NERC) has begun the process of developing a power supply adequacy standard.

The NERC Resource and Transmission Adequacy Task Force of the Planning Committee recently released a report that contains recommendations for both resource and transmission adequacy. If these recommendations were adopted by NERC they would call for the regions, e.g. the WECC, to establish a resource adequacy criterion (or criteria). The regions or subregions should be accountable and/or hold the control areas, individual systems, or other subdivisions of the region or sub regions accountable for compliance with the established adequacy requirements. This would presumably require resource construction, as opposed to other less rigorous ways of trying to assure resource adequacy, e.g., improving data transparency.[2]

[2] The reliability title of the proposed National Energy Bill prohibits the NERC successor organization and FERC from requiring resource construction as part of implementing the reliability responsibility under the bill, which would make reliability standards legally binding. Currently, standards are ultimately voluntary, but almost universally followed by the industry.

In response to potential NERC action and work done by a group from the Committee on Regional Electric Power Cooperation (CREPC, of which the Council is a member), WECC is evaluating proposing a power supply adequacy standard, although the details have not been fleshed out. The Council has been working with others in the region to address the question of adequacy for the Northwest. The Council convened the Adequacy Forum and has been working with CREPC and its Western Resource Assessment Team (WRAT). The hierarchy of options for increasing the assurance of resource adequacy that have been identified are:

- Improving the availability and transparency of relevant information;
- Enhancing the assessment of adequacy through consistent metrics;
- Establishing voluntary adequacy targets; and
- Establishing enforceable standards.

In the current absence of a standard, a focus has been placed on improving information about the status of resource adequacy. The Northwest Power Pool is working to improve the consistency of information reported by control areas in the region so that meaningful assessments can be performed. Supported by the WRAT, WECC is currently enhancing the scope and utility of its twice-yearly resource assessments. Improvements include using probabilistic methods to assess both peak hour and longer-term energy supply inadequacies. The aim is to provide a better description of the Western energy market as context for decisions by LSEs, commissions and developers.

If NERC eventually follows the recommendations of its Resource and Transmission Adequacy Task Force, its standard will provide for a compliance review process of the standards of its regional reliability councils, such as WECC, and for accountability to WECC for compliance by subregional entities like the Northwest Power Pool, or more likely, the individual LSEs. The latter are the only ones in a position to comply with such a resource adequacy requirement. While compliance is not ultimately legally enforceable, the standards would most likely be adopted and implemented anyway, as are current NERC and WECC standards.

Some states, through their public utility commissions (PUCs), do have the ability to implement adequacy standards for the utilities they regulate. The California PUC recently adopted an adequacy standard. The order requires that the investor-owned utilities it regulates have a 15-17 percent reserve margin over their peak loads, with the requirement being phased in by no later than January 1, 2008. This 15 percent reserve includes the approximately seven percent operating reserve required by WECC. The order also requires that LSEs forward contract for coverage of 90 percent of their summer (May through September) requirements, which consist of their peak load plus the 15 percent reserve, one year in advance. This requirement will be phased in to 2007 (no month specified). It is generally agreed that this standard goes beyond that which would be required to assure adequacy in a purely physical sense and is intended to limit California's exposure to the risk of extreme prices.

An adequacy standard for the Northwest

While activities at the NERC and WECC levels could lead to enforceable standards, the outcome is uncertain. The Council believes that other regional actions can and should be pursued. This is made more critical by the possibility of changes in the role of the Bonneville Power Administration (Chapter __) that could result in more responsibility for the assurance of adequacy being placed on entities that have not heretofore directly had that responsibility. While some may desire an enforceable adequacy standard, there are currently no institutions in the Northwest that could enforce one. And even if there were, it is possible that by building on the Northwest's tradition of regional cooperation, a voluntary adequacy standard supported by voluntary reporting of the underlying data by regional load serving entities could be as successful as enforceable standards and, if necessary, could transition

It is also clear that establishing a regional adequacy standard that is incompatible with actions in the rest of the West could be less than effective. It will therefore be necessary to continue to work in the context of the WECC and other west-wide organizations.

Physical or Economic Adequacy or Both?

In establishing an adequacy standard, it will be essential that the purpose of an adequacy standard be well understood and agreed upon. In particular, is the purpose of an adequacy standard to ensure that the "lights stay on" with an acceptably high probability or is it to protect against the economic and social costs that can accompany periods of short supply? As noted earlier, the Council's analysis indicates that the latter implies a somewhat greater level of resources than the former. Or alternatively, could different adequacy standards be appropriately applied in different ways? For instance, a physical standard might be most appropriately applied at the WECC level. At this level it would act to set a baseline for expectations about physical reliability of the system and for actions by LSEs and their regulators to address those expectations. Considerations of economic adequacy might better be addressed at the individual LSE (or perhaps state policy) level, where different degrees of risk tolerance might exist and different mechanisms for mitigating price risk could be put in place.

The Council believes that the question of economic versus physical adequacy should be addressed as part of the dialog surrounding the establishment of a Western and Northwestern adequacy standard. The Council will raise this issue in the appropriate forums.

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