

Appendix 6

RESOURCE ADEQUACY

Resource adequacy is the ability of a utilities' reliable capacity resources (supply) to meet the customers' energy or system loads (demands) at all hours within the study period.

The Northwest Power and Conservation Council defines resource adequacy 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 forecasted future loads reliability."

The main determinant factors of resource adequacy are supply and demand. The factors that affect demand are:

1. Demand growth;
2. Demand characteristics;
3. Demand-side management; and
4. Sensitivity of demand to weather (temperature) and other factors.

The factor that affects supply is the availability of sufficient dispatchable capacity resources in order to meet the demand.

As a result, based upon the definition of resource adequacy and the explanation given above, at any given instance (hour) a utility is concerned with its supply being capable of meeting its demand; hence, the resource adequacy at any given hour becomes the difference between the supply and the demand for a utility. Therefore, the functionality form of this can be formulated as follows:

$$(I) \quad \begin{matrix} R.A_t = S_t - D_t \\ \forall t \in \{1,2,3,\dots,8760\} \end{matrix}$$

Given the formulated definition of resource adequacy, formula (I), at any given hour a utility desires that, $S_t \geq D_t$, consequently meaning $R.A_t \geq 0$. When for a specific hour, $R.A_t < 0$ then the utility needs to acquire the difference from wholesale power market, where it will be exposed to the volatilities of power prices and the uncertainty about the availability of the required amount of energy in the market over the desired time period.

Since supply and demand factors (system characteristics) vary from region to region or system to system, it is difficult to standardize resource adequacy criteria and methodologies. Therefore, different regions and utilities have adopted different standards and methodologies in order to optimally measure their resource adequacy, for example:

North American Electric Reliability Corporation (NERC) general standard for generation reliability or resource adequacy criterion is:

"Loss of load expectation or probability (LOLE or LOLP) equal to 0.1 day per year, or one day in every 10 years."¹

The Northwest Power Conservation Council (NWPCC) has the following standard for peak hourly needs (capacity standard):

"Capacity in this context refers to the peak hourly electricity needs of the region. The measure for this is the planning reserve margin, or the surplus sustained-peaking capacity, in units of percent. It represents the surplus generating capability above the sustained-peak period demand. In determining the planning reserve margin, the standard includes the same firm and non-firm resources used to assess the energy standard for the region. The planning reserve margin is assessed over the six highest load hours of the day for three consecutive days (sustained-peak period). This is intended to simulate a cold snap or heat wave – the periods of the year when the Northwest requires the most capacity. The planning reserve margin is computed relative to normal-weather sustained-peak load. The threshold for this measure is determined by the five percent LOLP analysis and should be sufficient to cover load deviations due to extreme temperatures and the loss of some generating capability."²

Idaho Power has adopted the following planning criteria to measure its required capacity:

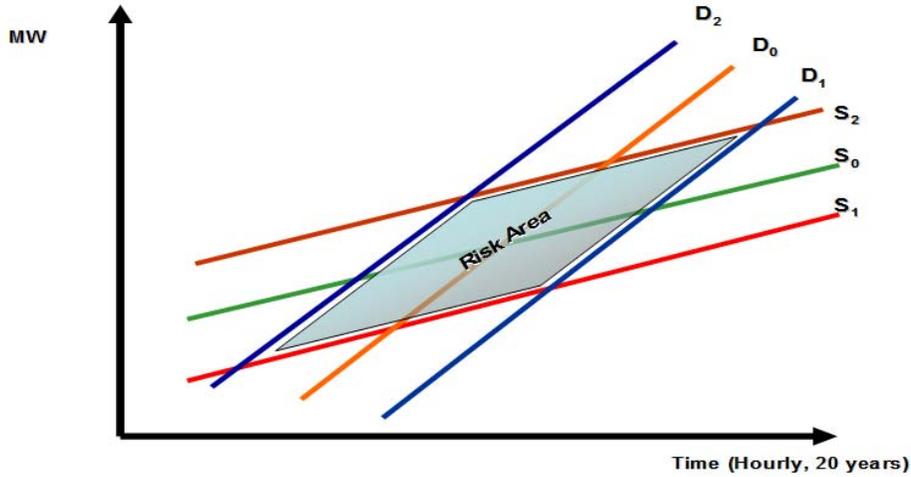
"Capacity-based on monthly peak-hour Northwest transmission deficit assuming 90th percentile water, 70th percentile average load and 95th percentile peak-hour load conditions."³

¹ North American Electric Reliability Corporation, Reliability Standards, June 15 2004.

² Northwest Power Conservation Council, 6th Power Plan, Regional Adequacy Standards, Chapter 14, Page 7, February 2010.

³ 2011 Integrated Resource Planning, Idaho Power Company, Appendix C: Summary of Northwest Utility Planning Criteria, page 196.

Figure 1: Risk Analysis of Supply and Demand (MW)



RESOURCE ADEQUACY ANALYSIS FOR SEATTLE CITY LIGHT

With stakeholder and public input, Seattle City Light has elected to use the following resource adequacy standard for measuring its supply reliability: Seattle City Light plans its reliable capacity resources in order to be able to meet its highest hourly demand 95 percent of the time.

For this, City Light designed a probabilistic approach to perform risk analysis around the utility’s expected hourly supply and demand. This analysis tests simultaneously the ability of the system to withstand sudden disturbances, such as unanticipated loss of system facilities or generation capabilities (supply volatilities) and sudden disturbances in load pattern (demand volatilities). This is illustrated in Figure 1.

The shaded area determines the logical possible disturbances that can occur to the City Light system at any given hour during the study period. Thus, City Light has developed accurate “risk metrics” for demand and supply in order to perform this probabilistic analysis to achieve a precise 95 percent LOLP for the highest hourly load demand. Risk has been evaluated for demand and supply, independently.⁴

⁴ Actual Generation vs. Capability: Risk is applied to supply and demand independently. Increases in load due to lower temperature can be met by increase in generation up to the available generation capability. For example, Boundary capacity is 1040. Now assume that one unit is out and the available capacity is reduced to 880. On average, City Light generates about 500 MW from Boundary; if demand goes up hypothetically by 400 MW then we can generate another 380 from Boundary (880 minus 500). To generate this amount, 800 SFD of stored water is required, which is often available at Boundary dam. Hence, demand changes the actual generation, but not the available capability. Therefore, the following formulaic relationship exists: $CORR[Water(Available_Capability), System_Load] \approx 0$

Demand Risk (D_t)

Heating Demand (Extreme Low Temperature) November through February

In order to develop an accurate risk metric for Seattle City Light demand, City Light has done a thorough statistical analysis on hourly historical demand data (1981-2011). Based upon historical data, City Light has had annual one hour peaks from November through February; however, the greatest frequency of peaks has occurred within the months of December and January. Among all months, December had the highest one hour peak. Therefore, demand volatility for the month of December is incorporated in the probability distribution analysis for the purpose of simulation.

Supply Risk (S_t)

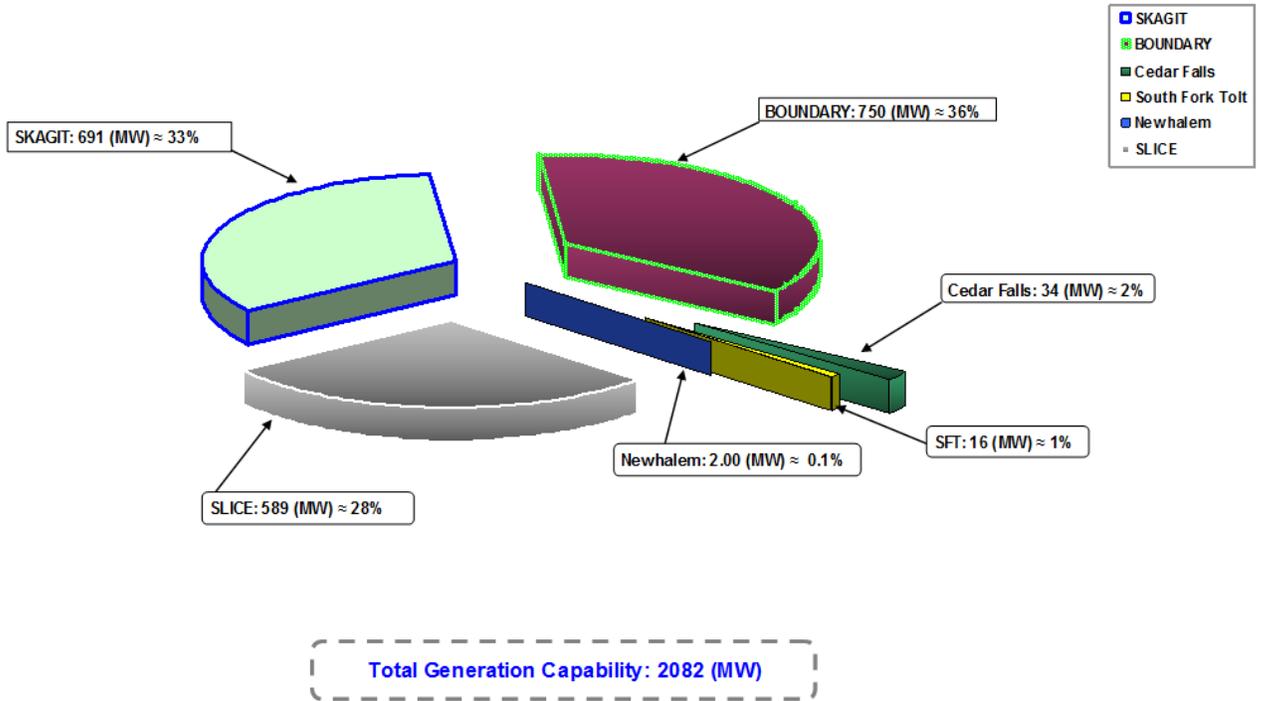
Volatilities in the Dispatchable Capacity Resources

Supply risk is uncertainty in “availability of dispatchable capacity resources”⁵ for any given hour. Since City Light’s resource portfolio is about 90 percent hydroelectric generation; hence, supply risk becomes the volatility in hydro capacity resources.

Hourly hydro generation is a function of stored water and force outages. This is the capacity available for an hour and is less than or equal to the nameplate capacity.

⁵ Dispatchable generation capacity refers to capacity resources that can be dispatched at the request of power grid operators; that is, turned on (or off) at on demand. This should be contrasted with certain types of base load generation capacity, such as nuclear power, which may have limited capability.

Figure 2: Expected One Hour Generation Capability of Hydro Resources for the month of December 2012



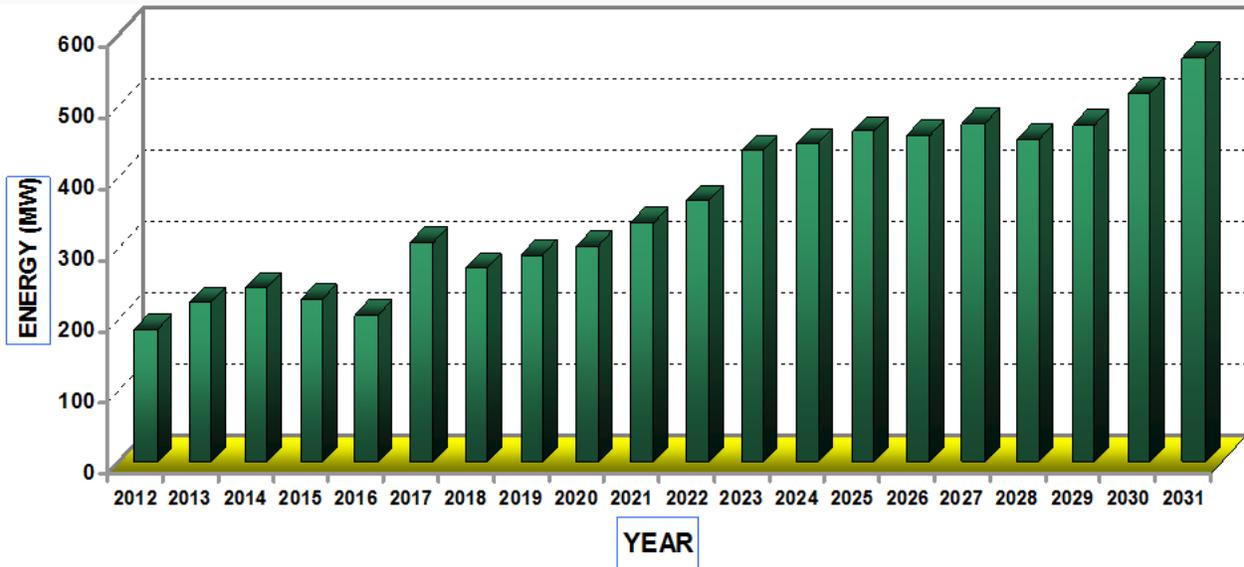
Stored water is a function of water conditions. For example, if City Light is experiencing a dry year, its capability of storing water decreases and consequently so does its generation capability. For two or three days a hydro generation plant with stored water is less dependent upon water condition; however, as hours of operation prolongs then it becomes increasingly dependent on water conditions. Thus, City Light can generate the maximum output of its hydro capacity resources up to available capabilities for an hour.

City Light's generation capability will decrease due to changes in slice resources from Oct 2011 (Figure 2). In Figure 2, only dispatchable hydro capacity resources are included, since other types of electric generation in Seattle City Light's resource portfolio are not dispatchable, such as wind and power contracts.

Seattle City Light historical data shows the highest one hour peak is most likely to occur during the months of December and January, but the highest one hour peak has occurred in December; thus, City Light has incorporated the historical hourly hydro volatilities of its hydro resources for the month of December in the probability distribution analysis.

Hydro volatility is not equal across all hydro resources due to different geographical locations and microclimate conditions associated with these resources. For example, Boundary could have dry water conditions, while at the same time; Skagit could have average water conditions. Therefore, "Cross Sectional" correlations of these resources are applied to the probability distribution analysis for the purpose of simulation.

Figure 3: Additional Resources Needed to Meet Resource Adequacy at 95 percent



FINAL RESULT

As it is stated in previous sections, extensive statistical analyses on historical hourly demand and supply of Seattle City Light have been done for the probability distribution analysis in order to design the risk metrics used in calculating the adequacy of resources.⁶

City Light has made further assumptions about the supply variables as follows:

- Assumptions about the continuing operation of existing resources, taking into account forced outages and scheduled maintenance (planned

outages⁷); for instance, Boundary relicensing and BPA contract renewal;

- An assumption about the operating reserve requirement (ORR) for City Light’s resource portfolio;
- Expiration of existing contracts on schedule;
- Adjusting City Light hydro capabilities for extreme temperatures and shortage conditions; and
- 100 aMW market purchase of electricity under the most extreme temperatures and shortage conditions of planning period.

The resource adequacy analysis described above defines a measure that is used to identify the amount of energy the utility may need each year during the heating season. The simulation together with all these considerations for the study period, 2012 through 2031, led to the estimated resource requirements by year shown in Figure 3.

⁶ As it is stated in the main body of this document resource adequacy is a function of supply and demand; hence, in a general the following abstract form for the function of resource adequacy holds:

$$R.A._t = F_t(S_t, D_t)$$

$$\forall t \in \{1,2,3,\dots,8760\}$$

After developing the risk metrics for the supply and the demand, then the following abstract form can be formulated for Seattle City Light resource adequacy function:

$$R.A._t = F_t(SKAGIT_{DEC}, BOUN_{DEC}, SLICE_{DEC}, D_{DEC})$$

In above formula, note that the subscript t_h indicates hourly time for the month of December, “SKAGIT” indicates Ross, Diablo and Gorge, “BOUN” indicates Boundary, “SLICE” indicates 26 BPA hydro projects from which City Light receives a fixed percentage of generation and other capabilities of the Federal Columbia River power system, and “D” denotes Seattle City Light demand.

Using, Aurora^{amp}, City Light has implemented “Latin Hypercube” simulation to measure its hourly resource adequacy analysis; 1,300 scenarios on hourly supply and the demand have been applied simultaneously for 20 years of study period, 2012 through 2031. Figure 3 illustrates the additional resources that are needed to meet 95 percent of the occurrences of the maximum LOLP of hourly peaks for the month of December and consequently with the five percent chance of exceedance.

⁷ Generic schedule maintenance for Seattle City Light-owned hydro resources is developed from 2012 to 2031.

After taking into account City Light hydro capabilities and 100 aMW market purchases assumption at any given hour, then City Light resource adequacy changes as represented in Figure 4.

Figure 4: Additional Resources Needed to Meet Resource Adequacy After Being Adjusted for City Light Hydro Capabilities and Market Assumptions

