Appendix M
Risk Measure

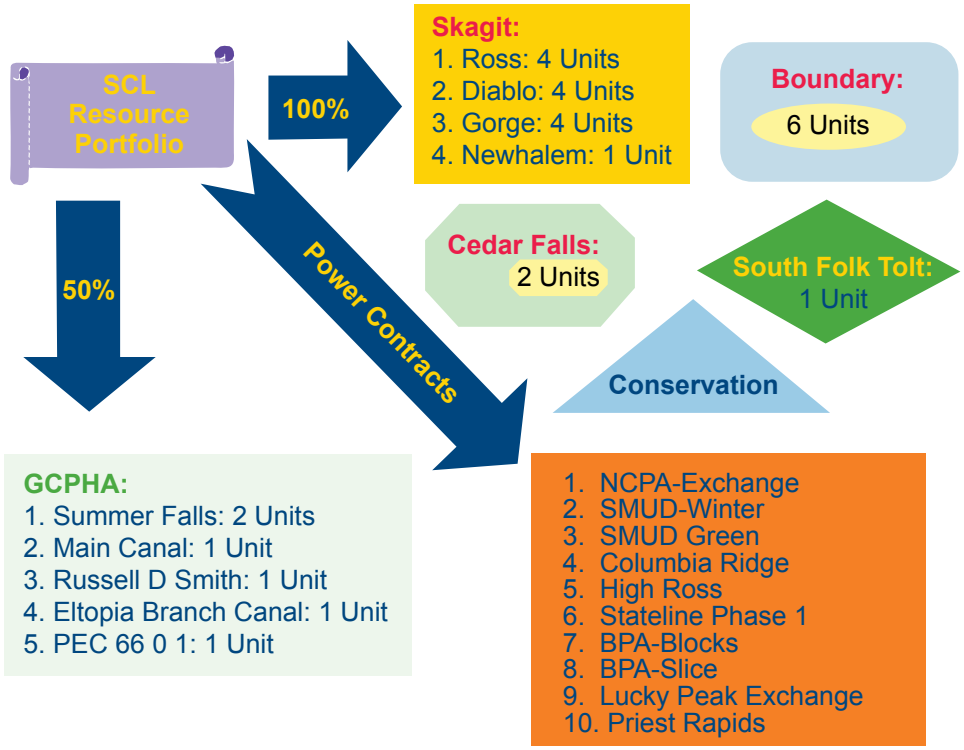
Risk refers to the volatility in expected outcomes that can arise from adverse events. For City Light, risk refers to volatility in supply resources and system load (demand). Volatility can affect City Light's ability to meet the demand of its customers with cost-effective and environmentally-responsible generating resources at all times. In general, risk analysis is a technique to identify and assess the factors that cause volatility in supply and demand and to help to design preventive measures to hedge against probable adverse events, increasing the reliability of City Light's power system.

A resource portfolio is a collection of power generating resources which is owned totally or partially by an entity or an organization. Figure 1 illustrates the elements of City Light's resource portfolio (existing resources).

City Light faces two main sources of risk that affect the reliability of its power system:

1. Demand Risk is the volatility in customer demand (system load) which challenges City Light's ability to meet these disturbances at all times, and
2. Supply Risk is the volatility in the generation capability of City Light's power generating resources, which can affect its ability to meet demand volatility.

Figure 1.



Both of these sources of risk can change the reliability of City Light's power system. If adverse events for both supply and demand are encountered singly or simultaneously, countermeasures need to be identified to successfully deal with these events.

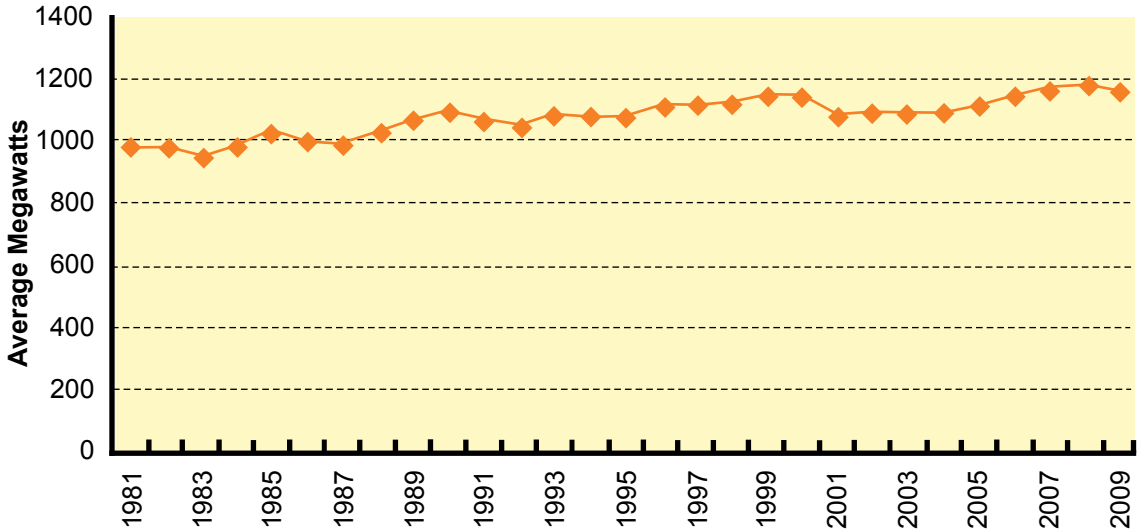
With stakeholder and public input, City Light has elected to use a 95 percent reliability level for supply resources as the risk measure for meeting customer demand. The volatility of supply and demand is incorporated into the probabilistic analysis for calculating this measure. For each portfolio, the expected net present value of annual net power costs[1] corresponding to the 95 percent level of reliability has been calculated for purposes of evaluating the candidate portfolios.

Developing Risk Metrics for Candidate Resource Portfolios

Demand, Supply and the Aggregate

Demand Risk Demand volatility is one source of uncertainty for City Light's power system. From a yearly standpoint, the most significant factor that causes this uncertainty is a level of economic activity.[2] Economic expansions and contractions significantly affect the pattern of the electricity consumption of all three sectors of City Light's customers (Industrial, Commercial, and Residential), causing demand to deviate from expected consumption patterns. City Light completed statistical analyses on historical yearly demand data, 1981 to 2009, and demand volatility (historical variation) is incorporated into the probability distribution analysis for simulation. Figure 2 illustrates historical yearly demand data.

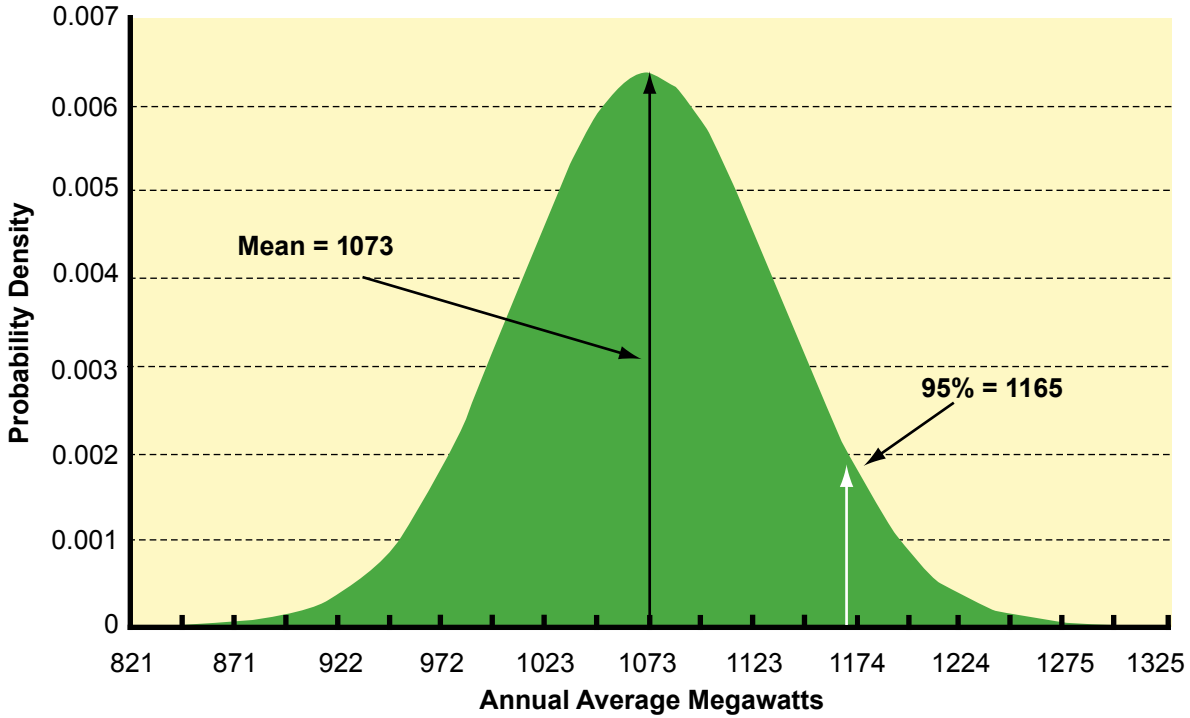
Figure 2. System Load History 1981-2009



As demand data move progressively into shorter discrete time periods (e.g., annual to monthly to hourly), demand volatility becomes progressively higher, especially in response to extremes in temperature.

It is assumed that yearly historical demand approximately follows a normal distribution pattern. A normal distribution, mean, and standard deviation are used for the purpose of the simulation. Figure 3 illustrates the normal distribution fitted to the historical yearly demand.

Figure 3. Normal Distribution for Historical Annual Demand 1981-2009

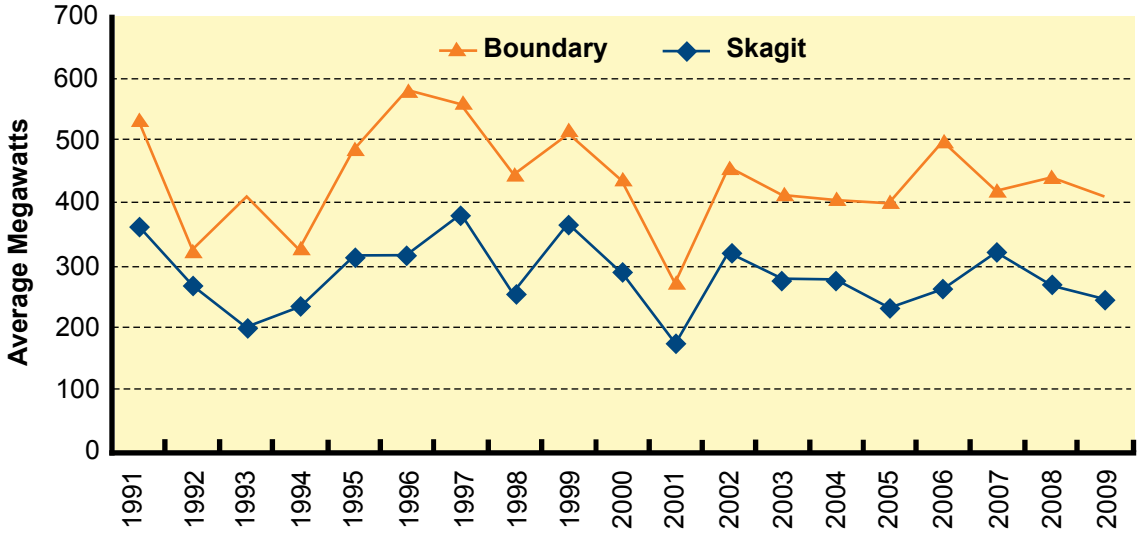


*The mean of this normal distribution is the average of all yearly demand.

Supply Risk Over ninety percent of electricity supply for City Light comes from hydro generation. Yearly hydro generation capability is highly correlated to water conditions (High, Average and Low). Water conditions are very uncertain, consequently hydro generation capability is very uncertain. This uncertainty in supply can significantly affect City Light's ability to cope with demand volatility and can affect resource reliability. City Light has completed statistical analyses on yearly historical hydro generation, hydro volatility, and their cross sectional correlations (Appendix G – Resource Adequacy). These are incorporated into the probability distribution analysis for the purpose of simulation. Figure 4 illustrates historical yearly generation and the associated volatility of two main hydro projects, Skagit and Boundary, from 1991 to 2009.

As with demand, it is assumed that yearly historical hydro generation approximately follows a normal distribution. The historical mean of hydro generation and the associated standard deviation of each hydro project are taken into account in the probability distribution analysis. Yearly cross-sectional correlations between hydro projects are also taken into account for the total probability distribution analysis.

Figure 4. Boundary & Skagit Generation 1991-2009



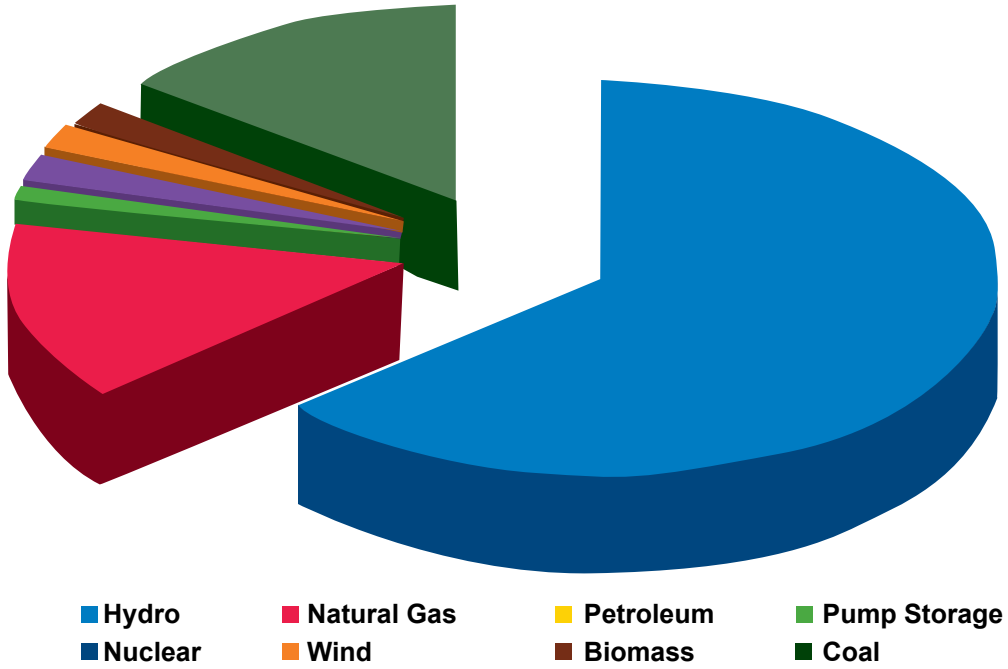
Aggregate of Supply and Demand Uncertainties If the uncertainties of demand and supply were highly correlated, then it would be much easier to manage a balance between the demand and supply for City Light's power system (Load-Resource Balance). However, there is almost no correlation between these uncertainties; hence, the simultaneous compositions of these uncertainties cause significant variation in the load-resource balance such that City Light's portfolio changes from surplus to deficit. The net deficits are associated with financial costs for City Light that accrue when power needs to be acquired from the wholesale market.

Fuel

Approximately 70 percent of the electric generation capacity in the Pacific Northwest is hydropower (Figure 5). Under current power market conditions, it is assumed that the market price of power is equal to its marginal cost. When the market supply is less than the market demand, the power prices are equal to the marginal costs of the incremental generating units that meet demand at any given time. The generic marginal units that are called on to meet the demand are most often gas-fired generators such as combustion turbines. Given an average heat rate in the Pacific Northwest, fuel prices determine the average power prices when market supply is less than market demand. Therefore, natural gas prices are a determining factor for the financial costs associated with the net deficits for City Light's portfolio.

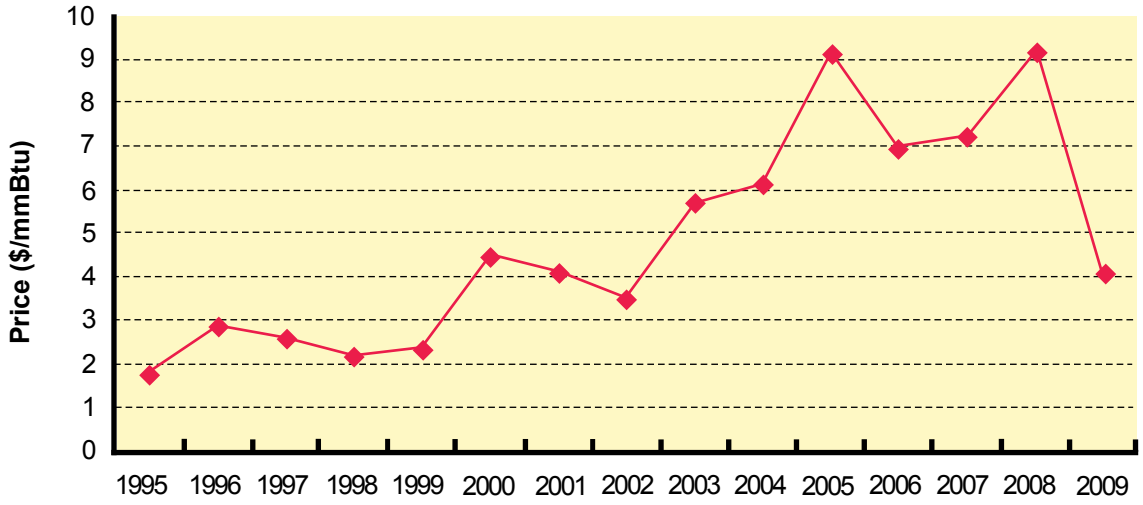
City Light has completed statistical analyses on yearly historical natural gas prices to determine fuel price volatilities. These historical volatilities are incorporated into the probability distribution analysis for the purpose of simulation. Figure 6 illustrates the yearly historical natural gas prices of Henry Hub from 1995 to 2009.

Figure 5. Pacific Northwest Generation Capacity



Source: Northwest River Partners

Figure 6. Historical Yearly Henry Hub Natural Gas Price



It is assumed that yearly historical natural gas prices approximately follow a lognormal distribution pattern. The historical mean and associated standard deviation are taken into account in the probability distribution analysis.

As stated in Appendix G – Resource Adequacy, there is almost no correlation between hydro generation capability and system load (demand). Also, there is almost no correlation between hydro generation capability and natural gas prices. Hence, all these variables are incorporated independently into the probability distribution analysis for the purpose of simulation.

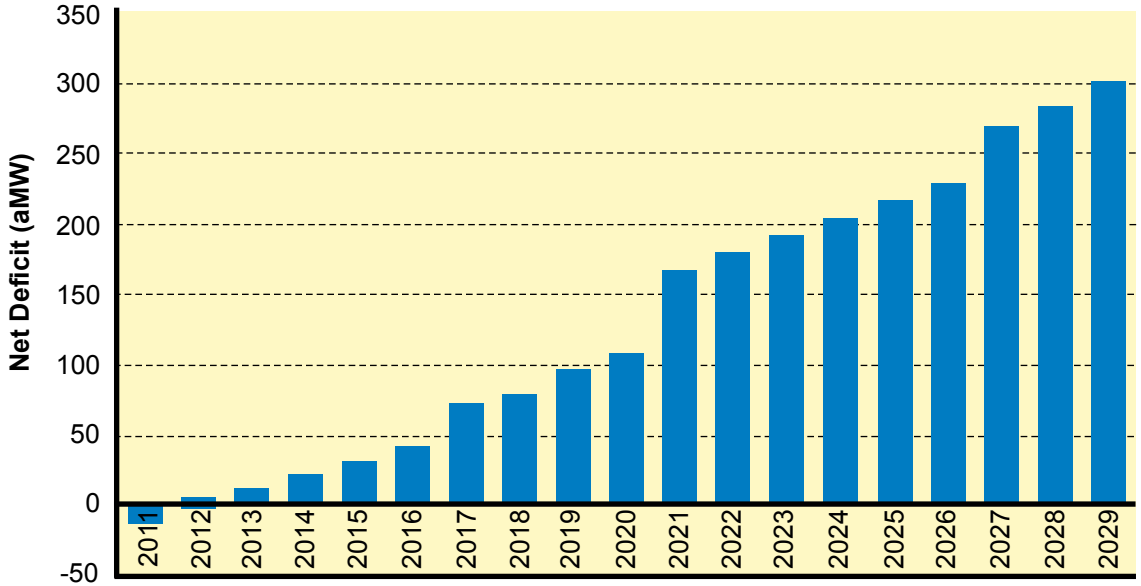
The risk function, in abstract form, can be formulated as follows:

$$Risk_t = \varphi\ (D_t, H_t, F_t)$$

Final Results

The simulation, together with all the assumptions for the study period 2010 through 2029, led to yearly net deficits at the 95 percent reliability level (5 percent exceedance) for each portfolio. Unlike deterministic analyses of supply position, which often present a static view of average demand and critical water, this simulation considers the volatility of both supply and demand. The associated expected costs of the portfolios corresponding to the net deficits, including net sales and purchases, were calculated. Figure 7 illustrates the yearly net deficit for City Light's base portfolio at 5 percent exceedance.

Figure 7. Annual Net Deficit for City Light Base Portfolio at 5% Exceedance 2011-2029

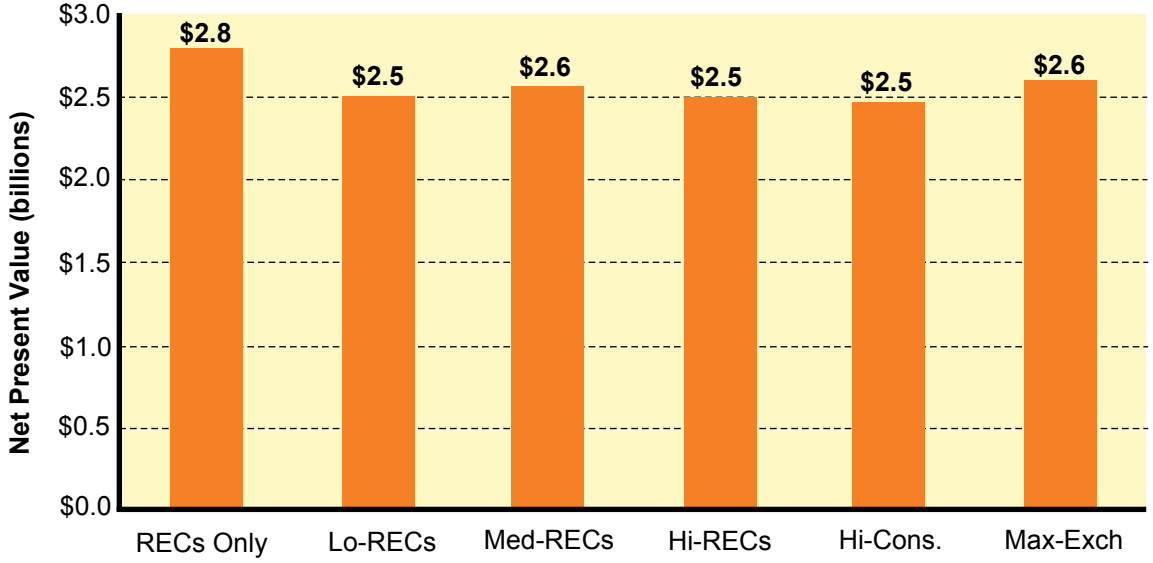


The expected cost of each portfolio, when the 95 percent of reliability level is applied, is illustrated in Figure 8.

As it can be observed in Figure 8, the Higher Conservation portfolio has the lowest expected cost associated with 95 percent reliability measure. City Light's base portfolio (RECs Only) has the highest expected cost at 95 percent reliability level.

Based upon the final results of the risk analysis, the three portfolios that performed the best (the least cost, lowest risk, and most environmentally-responsible) are rank ordered as follows: Higher Conservation, Low RECs, and High RECs portfolios.

Figure 8. 20-Year NPV of Net Power Cost at 5% Exceedance for Each Portfolio



[1] Net power cost is the sum of the costs of owned power generating resources, power contracts and net export (the difference between market sales and market purchases).

[2] Extreme weather conditions, very high or low temperatures, significantly affect the expected pattern of the usage of the electricity of City Light's customers when monthly study is considered, but it is not as significant as economic upturns or downturns when yearly study is considered.