Appendix 10

RISK MEASURE

VOLUMETRIC RISK ANALYSIS

Risk refers to the existence of volatilities in expected outcomes that can result in adverse events. For Seattle City Light, risk refers to volatilities 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-friendly generating resources at all times.

In general, risk analysis is a technique to identify and assess the factors that cause these volatilities in supply and demand and help to design preventive measures to hedge against possible 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:

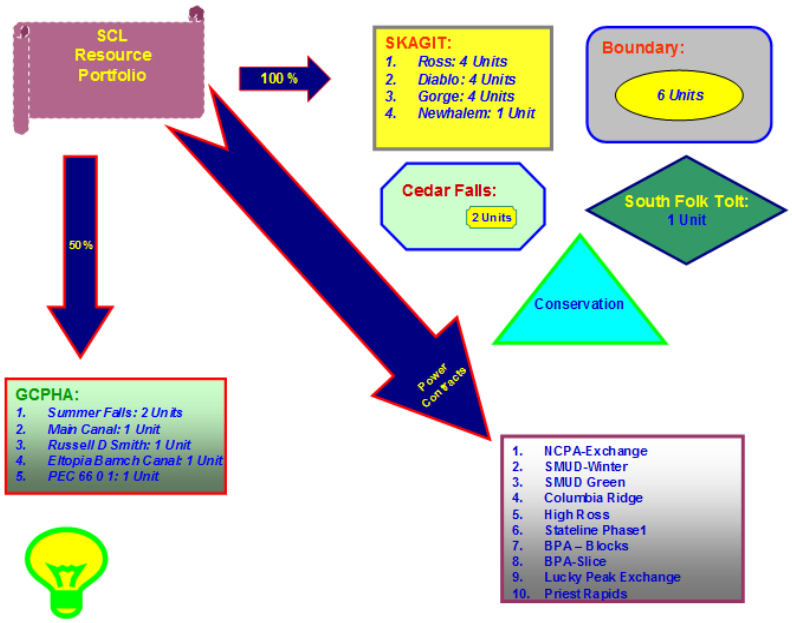
1. **Demand risk** is the volatility in customers' demand (system load) which challenges City Light's ability to meet these changes in real-time, all the time, and

2. **Supply risk** is the volatility in the generation capabilities of City Light's power generating resources, which can affect its ability to meet customer demand.

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.

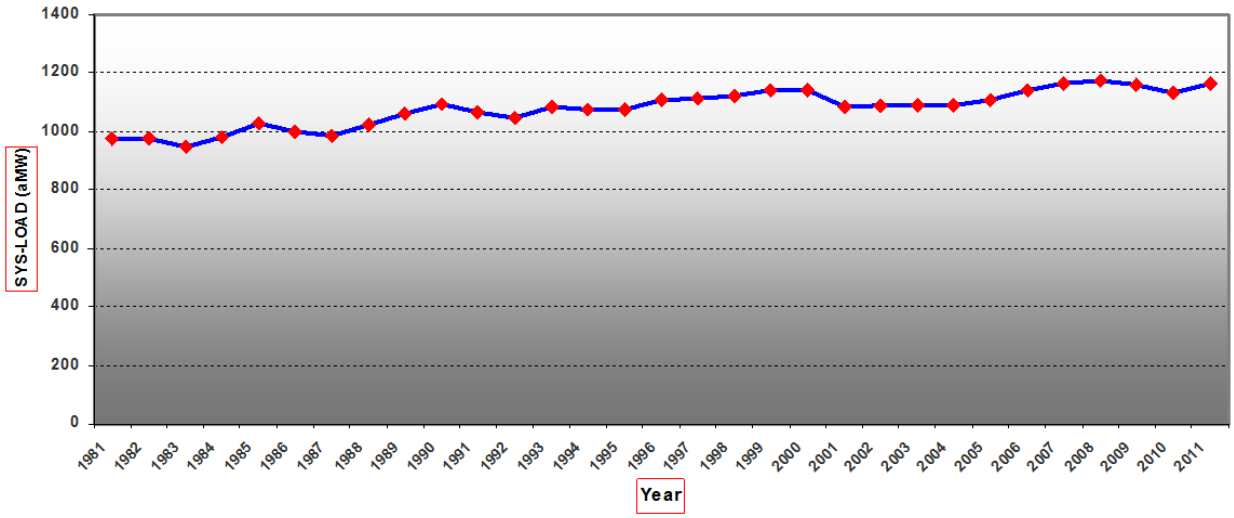
With stakeholder and public input, City Light has elected to use a 90 percent reliability level of supply resources as the risk measure for meeting customer demand for the 2012 IRP. The volatility of supply and demand is incorporated into the probabilistic analysis for calculating this measure. For each portfolio the expected net present value of annual Net Power Costs (NPC's) corresponding to the 90 percent level of reliability has been calculated for purposes of evaluating the candidate portfolios[1].

FIGURE 1: SEATTLE CITY LIGHT RESOURCE PORTFOLIO (EXISTING RESOURCES)



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

FIGURE 2: YEARLY HISTORICAL SYSTEM LOAD (aMW): 1981-2011



RISK ANALYSIS FOR CITY LIGHT

Developing Risk Metrics for City Light Resource Portfolios

1. Demand, Supply and the Aggregate

a. Demand Risk

Demand volatility is one of the main sources of uncertainty for City Light's power system. From a yearly standpoint, the most significant factor that causes this uncertainty is economic upturns and downturns[2].

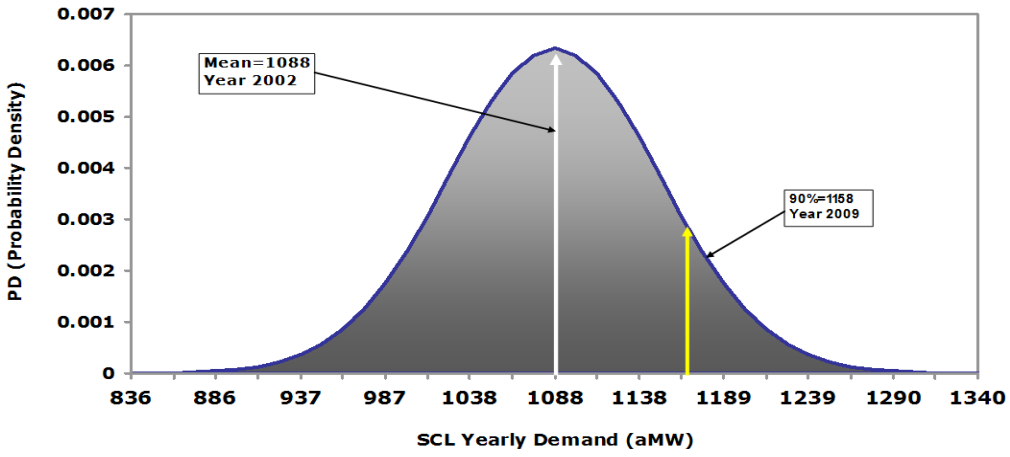
Economic expansions and contractions significantly affect the pattern of the electricity consumption of all three sectors of City Light's customers (industrial, commercial and residential), which causes demand to deviate from expected consumption patterns. City Light completed statistical analyses on historical yearly demand data, 1981 to 2011, and demand volatility (historical variations)

has been incorporated into the probability distribution analysis for simulation.

Figure 2 illustrates historical yearly demand data. As demand data moves progressively into more discrete time periods (e.g. annual to monthly to hourly), demand volatility becomes progressively higher.

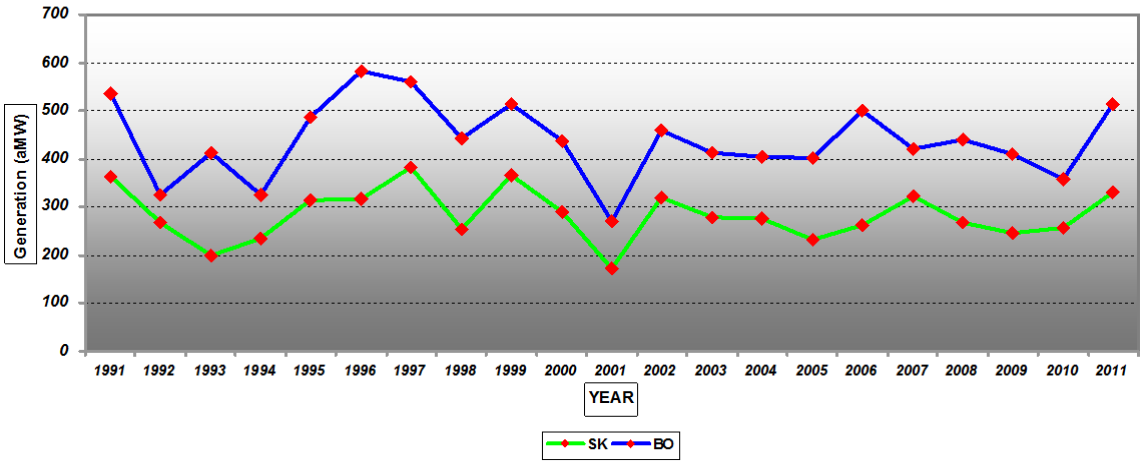
It is assumed that yearly historical demand approximately follows a normal distribution pattern. A normal distribution, mean and standard deviation are used for the purpose of simulation. Figure 3 illustrates the normal distribution fitted to the historical yearly demand.

FIGURE 3: NORMAL (GAUSSIAN) DISTRIBUTION OF HISTORICAL YEARLY SEATTLE CITY LIGHT DEMAND: 1981-2011



[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 studies are done, but it is not as significant as economic upturns or downturns when a yearly study is performed.

FIGURE 4: YEARLY HISTORICAL GENERATION OF SKAGIT AND BOUNDARY: 1991-2011



b. Supply Risk

About 90 percent of electricity supply for City Light comes from hydro generation in a typical year. 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 the supply of City Light's power system significantly affects its 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 City Light's two main hydro projects, Skagit and Boundary, from 1991 to 2011.

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 for the purpose of simulation.

c. The 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.

$$S_T < D_T$$

The net deficits are associated with financial costs for City Light that accrues when power needs to be acquired from the wholesale market.

2. Fuel

Approximately 70 percent of electric generation capacity in the Pacific Northwest is hydropower (Figure 5). Under current power market conditions, it is assumed that the market price

FIGURE 5: PACIFIC NORTHWEST ELECTRIC GENERATION CAPACITY

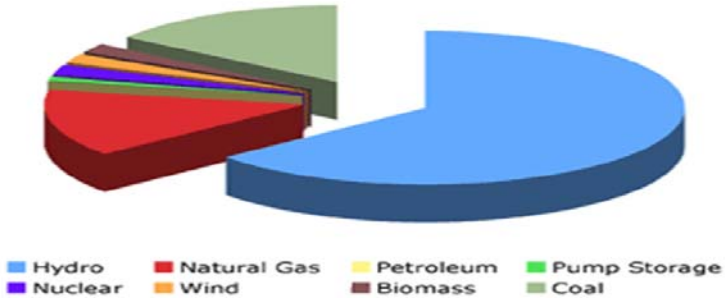
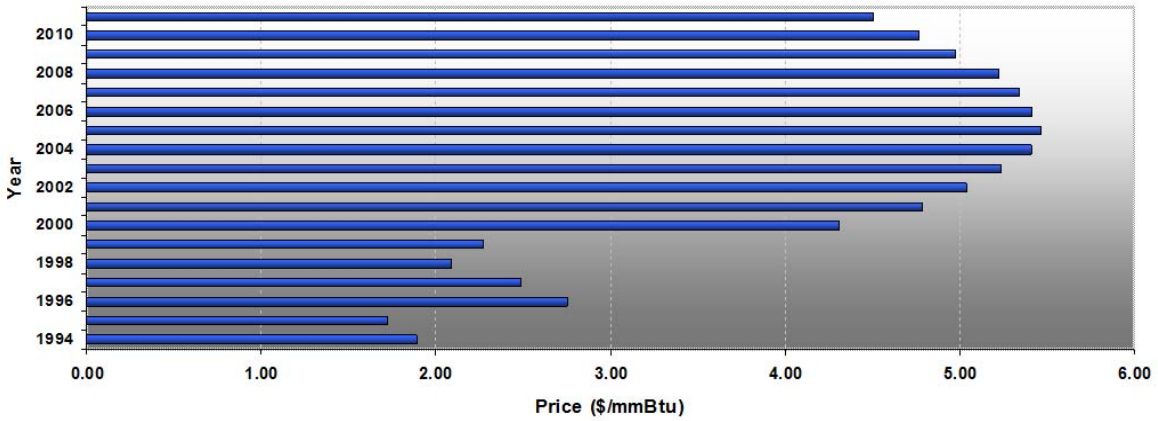


FIGURE 6: HENRY HUB HISTORICAL YEARLY GAS PRICES: 1994-2011



of power is equal to marginal cost. When the market supply is less than the market demand, the power prices equal 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 volatility. 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 1994 to 2011.

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

As stated in appendix G, there is almost no correlation between hydro generation capability and system load (demand). And there is almost no correlation between hydro generation capability and natural gas prices; therefore, all the indicated variables are incorporated independently into the probability distribution analysis for the purpose of simulation.

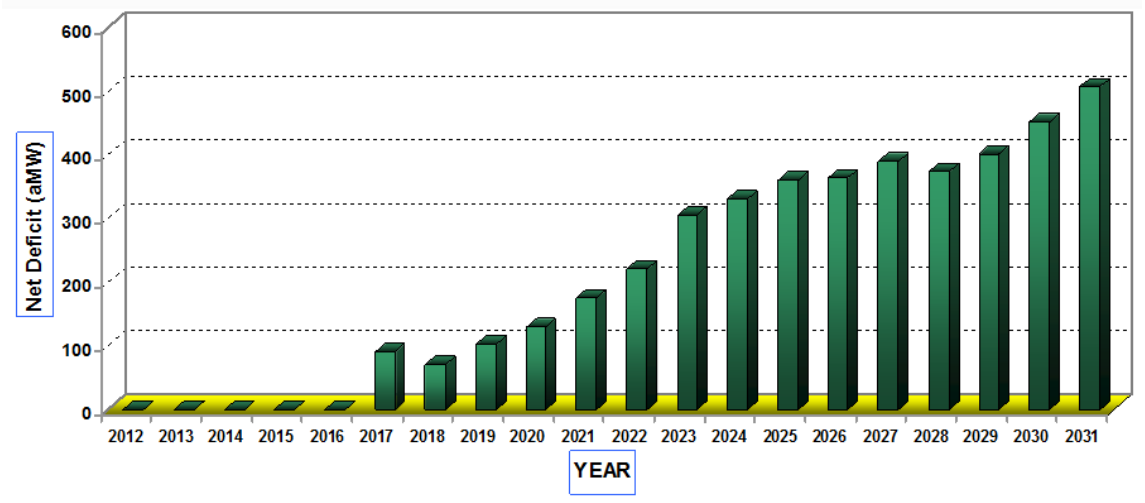
The risk function, in abstract form, can be formulated as follows:

$$Risk_{t_{yr}} = \varphi(D_{t_{yr}}, H_{t_{yr}}, F_{t_{yr}})$$

FINAL RESULT

The simulation together with all the assumptions and considerations for the study period, 2012 through 2031, led to the yearly net deficits at 95 percent reliability level (five percent exceedance) for each portfolio and the associated expected costs of the portfolios corresponding to these net deficits. Figure 7 illustrates the yearly net deficit for City Light's base portfolio at a five percent exceedance.

FIGURE 7: YEARLY NET DEFICIT FOR SEATTLE CITY LIGHT BASE PORTFOLIO WITH 10 PERCENT EXCEEDANCE: 2012-2031

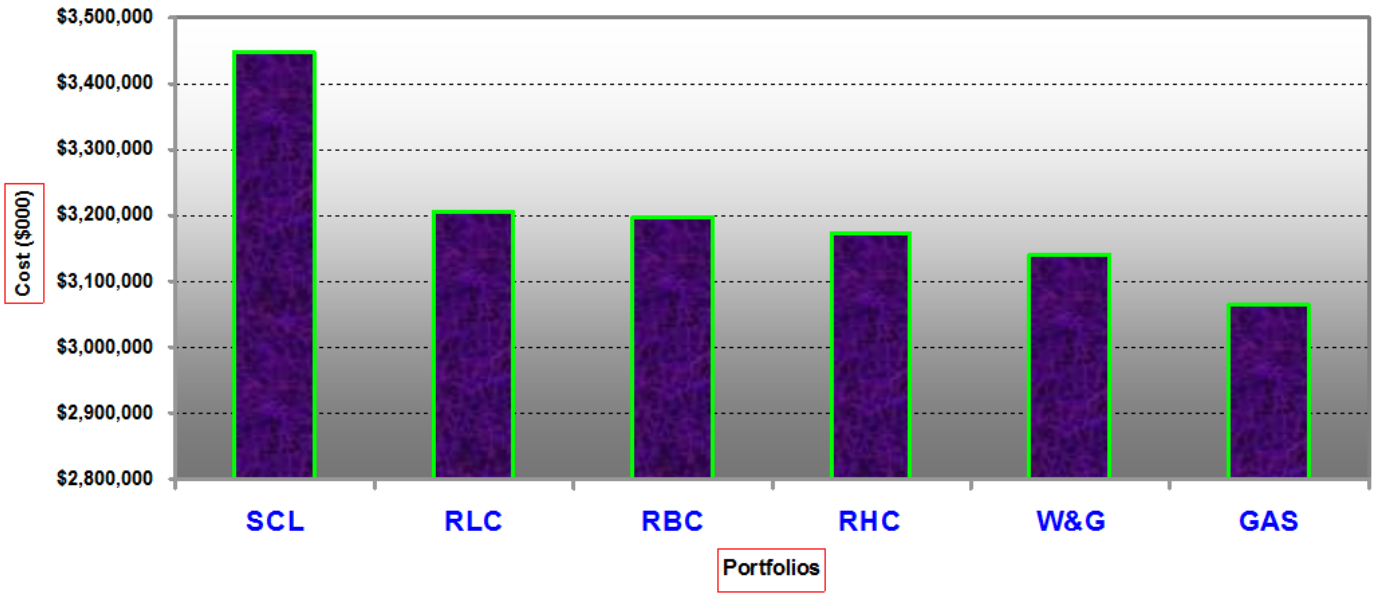


The expected cost of each portfolio, when the 90 percent of reliability level is applied, is illustrated in Figure 8. This illustrates that the gas portfolio has the lowest expected cost associated with a 90 percent reliability measure. City Light's base portfolio has the highest expected cost at 90 percent reliability level.

Based upon the final results of the risk analysis, the portfolios that performed the best (the least cost, lowest risk, and most environmentally-friendly) are: gas, wind and gas, and renewable: higher conservation portfolios.

When the gas portfolio was dropped from further consideration, the top three portfolios under consideration became wind and gas, renewables: higher conservation, and renewables: base conservation.

FIGURE 8: NET PRESENT VALUE OF NET POWER COSTS OF BASE AND CANDIDATE PORTFOLIOS AT 10 PERCENT EXCEEDENCE



SCL=base portfolio
RLC=renewables: lower conservation
RBC=renewables: base conservation
RHC=renewables: higher conservation
W&G=wind and gas