Chapter 5 – Evaluating Candidate Resource Portfolios

This chapter reviews the methodology, assumptions and criteria that City Light staff used to evaluate each of candidate resource portfolio.

Preparing an integrated resource plan requires planning staff to make informed assumptions or forecasts about the future. These assumptions or forecasts pertain to

- Fuel price forecasts (natural gas, coal, and oil)
- Wholesale market power price forecasts
- Customer load forecasts
- Resource capacity factors
- Resource availability
- Transmission availability
- Environmental impacts and regulations

These forecasts and assumptions provide a structured, consistent basis for evaluating and comparing candidate portfolios.

The integrated resource planning team evaluated the candidate resource portfolios using a special-purpose computer model to simulate the dispatch the new resources, along with City Light's existing resources, to serve customer load. The model also simulates short-term sales and purchases of power in the wholesale market. One strength of this modeling approach is the ability to test each candidate portfolio's handling of the variability in hydroelectric generation and the volatility of market prices for fuels and wholesale power.

Once each portfolio was modeled, its performance was evaluated against four criteria. These criteria follow City Light's mission statement and adhere to the requirements of HB 1010: provide reliable service; minimize cost to customers; manage risks; and minimize environmental impacts. They are described in detail in this chapter. Also described is the computer model of the electric market that City Light used to evaluate each portfolio's performance.

The modeling of portfolio performance was conducted in two rounds. Based on information gleaned from the Round 1 analysis, another set of portfolios were constructed for Round 2. Scenarios were used to test and analyze the Round 2 portfolios further.

Scenarios used in the 2008 IRP are conceptually different from the scenarios used in the 2006 IRP. The 2006 IRP scenarios were developed by Global Energy Decisions (now Ventyx), and they represented different paths that the national economy and electrical energy industry might take. Each of the GED scenarios had varying effects on natural gas prices, renewable resource prices, non-renewable resource prices, carbon tax, etc.

For the 2008 IRP, the scenarios focus on specific issues stakeholders and policy makers raised. They address these "what if" questions:

- What if the region experiences unprecedented growth throughout the planning period?
- What if the service area experiences a recession in the near-term years, pushing out the need for resource additions?
- What if climate change proceeds as projected by regional researchers?
- What if plug-in hybrid vehicles become commercially available?
- What if natural gas prices follow a high case rather than the base case forecast?
- What if the cost of renewable resources is much higher than expected?

Each scenario tests the sensitivity of candidate portfolios to changes in model inputs. The scenarios' descriptions appear at the end of this chapter.

Although the focus of City Light's resource planning is on the Pacific Northwest, power price forecasts are driven by the much broader Western wholesale power market, in which City Light conducts power transactions (see Chapter 4). The Western power market is influenced by such diverse factors as high summer temperatures in the Southwest and cold winter temperatures in the Northwest; transmission constraints in various locations in the West; precipitation levels in the Pacific Northwest; nuclear plant outages in California; coal plant

outages in Montana, Wyoming or Utah; natural gas deliveries from Alberta, Canada; and power imports to the U.S. from Canada or Baja, Mexico.

Fuel Prices

As a major determinant of generator costs to produce power, fuel prices are important data for input into a power price outlook. In a competitive power market, fuel prices can drive rapid changes in power prices. This section gives an overview of the how fuel prices affect resource portfolios the IRP.

Natural Gas

The Pacific Northwest market for natural gas is heavily influenced by national market trends because of the national network of natural gas pipelines that allows transport of natural gas across the country. Natural gas-fired generation plays an important role in the West because it is usually the generating unit to be dispatched last (known as the "marginal unit"). Lower cost resources are dispatched before natural gas-fired generation resources if no transmission constraints or reliability concerns exist.

The cost of dispatching the marginal unit frequently determines the short-term power price in the Western wholesale power market, so that the short-term (spot) power prices City Light sees correlate with the price of natural gas. Given the volatility of City Light's own hydro resources and of electricity demand, the utility must buy or sell on the power market to balance its power supply. Even though City Light has no natural gas-fired generation, the price of natural gas will continue as an important factor in determining City Light's wholesale power costs and revenues. In the forecast, the following factors are important in moderating natural gas prices from early 2006 levels:

- Natural gas drilling platforms and pipelines in the Southeastern U.S. damaged by Hurricane Katrina are fully repaired.
- New import terminals for liquefied natural gas (LNG) are constructed at ports in the United States and Mexico, allowing foreign natural gas supplies to bolster declining North American natural gas production and reserves.
- Growth in generation from resources other than natural gas helps to temper the need for more natural gas for power generation.
- In the long run, fuel prices will be influenced less by financial speculation in commodity markets and more by the market fundamentals of supply and demand.

In 2007 and the first half of 2008, the price of natural gas followed the dramatic run-up in the price of oil, rising to above $13.00/MMBTU. This price was well above the 2007 long-term Ventyx forecast of natural gas used in the 2008 IRP. However, at the time of writing, natural gas prices have fallen back to a little above $8.00/MMBTU in the western US, with the prospect of further declines. While the price of natural gas is very important to the price of power in the western wholesale power market, it does not affect the relative performance of the Round 2 resource portfolios in the 2008 IRP. The Round 2 resource portfolios are entirely comprised of conservation and renewable resources. The value of surplus energy is affected, as discussed further in the high natural gas price scenario.

Resource Supply

Most Western states have adopted renewable portfolio standards. Washington state's legislation, Initiative 937, requires utilities to acquire all cost-effective conservation. There's a question whether sufficient renewable resources can be developed within the timeframes specified in state mandates. Ventyx, a consulting firm that provides services to electric utilities, doubts that the supply of renewable resources can keep up with the demand. A California Utility Commission study from several years ago shows the difficulties in bringing renewable resources online on time.

With a tax credit incentive, wind developers have been successful in developing new plants and generating as much energy as possible. There has been some regional development of biomass and geothermal. Some landfills managers have even installed small generation plants and found utilities to buy the output.

Supply Forecast

Most parts of the West, including the Pacific Northwest, currently have surplus generating capacity. A number of assumptions prevail for this supply forecast:

- All City Light owned resources will continue to operate through the forecast period.

- Power purchase contracts will expire according to contract terms.
- The Bonneville Power Administration will continue to supply power to City Light from the Federal Columbia River System at cost-based rates.
- Renewable resources and any transmission necessary to bring power to the service area will be available when needed throughout the planning horizon

Resources that are currently available are added in the near term, with technologies less well-established added later.

Electricity Prices

Electricity price forecasts are used to evaluate the costs of buying power and the revenues from selling power. They determine when it is economical to make sales or to make purchases. Since natural gas fired generation is on the margin most of the time in the West, the spot market price and the price of natural gas tend to move in tandem.

The Evaluation Criteria

City Light staff established four criteria for evaluating alternative resource portfolios:

- Provide reliable service
- Minimize cost to customers
- Manage risks
- Minimize environmental impacts

To quantify the expected performance of each candidate resource portfolio in meeting each of the criteria, City Light chose specific measures, listed in Table 5-1 and described on the following pages.

Table 5-1. Criteria and Measures for Evaluating Resource Portfolios

Criteria	Measures
Provide Reliable Service	Occurrence of unserved customer energy need.
Minimize Costs to Customers	20-Year net present value of portfolio costs.
Manage Risks	Volatility of portfolio costs (net revenue).
Minimize Environmental Impacts	Air emissions of CO2, SO2, NOx, mercury, and particulates. Impacts on land use, surface and groundwater, soils and geology, plants and animals, employment, aesthetics and recreation, environmental health, and cultural and history were also evaluated in the EIS.

Provide Reliable Service

A critical part of City Light's mission is to provide reliable service – electricity is available when customers want to use it. Failure to provide reliable power can have serious and immediate consequences to health, safety and economic security, and City Light has procedures in place to ensure it can provide power or restore power quickly when needed.

The main requirements for providing reliable service are:

- Enough power generation to meet demand.
- Sufficient functioning transmission infrastructure to bring power to City Light's service area.
- Sufficient functioning distribution infrastructure to bring power from the transmission system to the customer.

The distribution aspects of reliability are not considered quantitatively in the IRP, with one exception. Energy savings from conservation programs are assumed to defer investment in new distribution infrastructure. To quantify this benefit, the cost of all energy efficiency measures assessed in the IRP was reduced. The reliability of power supply depends on:

- Adequacy of generating capacity to meet demand (resource adequacy).
- Adequacy of fuel (e.g. natural gas, coal, water) to generate the energy needed.
- Operational capability of the generating facility.

The question of whether there is enough generating capacity was evaluated in the IRP through the resource adequacy analysis (described in Chapter 2). This is an important step

in determining the amount of resources needed and when to meet the reliability standard.

In the resource adequacy analysis, City Light compared energy demand to the energy available from its owned and contracted resources, and a limited amount of market resource. Many possible combinations of hydropower outputs – a critical issue given City Light's dependence on hydropower – and load were considered, and each combination was evaluated by month over the 20-year planning horizon.

In addition to ensuring an adequate amount of generating capacity, fuel sufficiency and the resource's operational reliability must be considered. Each type of resource has its own fuel and operational uncertainties. For example:

- Hydropower depends upon precipitation, snowmelt and variations in the timing of the migration and spawning cycles of fish. Hydroelectric generation in the Northwest produces power between 45 and 65 percent of the time. Hydroelectric resources are the most flexible and least cost resources available for following load.
- Most coal plants in the West are located near the coal mines, so access to fuel is highly certain. Unexpected outages are relatively rare, and most western coal plants operate 85 to 90 percent of the time.
- Wind farms are able to produce electricity only when the wind blows. While generating units are highly dependable, the wind is not. New Northwest wind generating plants produce power on average about 32% of the time, according to the Northwest Power and Conservation Council.
- Natural gas combined cycle plants sometimes face fuel supply issues, particularly in high demand periods, but this is not common when a plant is operated to meet a utility's firm load. Their operations have been limited by the periodic high price of natural gas. These resources can generate electricity over 90% of the time.

In modeling candidate resource portfolios, these uncertainties are addressed by introducing variability of hydro operations, wind patterns and forced outages. If correctly constructed, each candidate portfolio is able to meet the 95% resource adequacy criteria despite the above challenges. In effect, the reliability criterion is "hard-wired" by design into the resource portfolio. Each portfolio can then be examined for the number of hours of unserved energy needs occurring to verify it is meeting the reliability criteria.

Minimize Costs to Customers

A fundamental policy issue is balancing the cost of providing service with providing reliable service. In real terms, the cost of electricity declined in the Northwest for decades until about 1980. Even now, the Northwest enjoys the lowest cost power supply in the country due to its reliance on hydroelectric generating plants. Factors influencing cost vary for each type of resource, as described in Chapter 4.

In calculating the costs of specific resources, the IRP assumes that City Light will contract to buy the output of a resource through a power purchase agreement. Whether it is more advantageous to own a resource rather than contract for its output will be determined at the time the utility is ready to acquire a resource and has received cost information for both approaches through competitive bidding. The exceptions are resource alternatives based on contracting for energy, such as seasonal exchanges and capacity purchases.

Costs in the IRP are evaluated over the entire resource portfolio. For example, a higher cost resource may be included in small amounts in a portfolio, and that small addition can help City Light avoid investment in a much larger resource that may have lower per unit of energy costs, but higher overall costs. The measure chosen for this criterion is 20-year net present value (NPV) of net power costs. The net present value accounts for the costs of the resources through time (including capital, operation and maintenance costs, and fuel), power purchases, and revenues received from selling unneeded energy.

Manage Risk

Current practice in integrated resource planning emphasizes identifying and analyzing sources of risk. Many forms of risk are evaluated in the IRP, some quantitatively and some qualitatively. Quantifiable risks include:

- Variations in demand for electricity (City Light's load) due to factors such as weather and economic conditions.

- Generation plant output, particularly hydropower, where output can vary widely from year to year and month to month, depending on precipitation and snowmelt patterns or wind where output can vary widely from hour to hour and day to day.
- Prices for electricity on the wholesale market.
- Cost of fuel such as natural gas.
- Potential cost of complying with environmental regulations, particularly emissions.

Evaluating these risks does not guarantee that all risks are explicitly known, but it defines a range of possible risk and associated costs. Other types of risk can be more difficult to evaluate, or even impossible to quantify. These include the potential for regulatory or policy changes that could affect the availability and cost of resources, policies related to transportation of fuels by pipeline or rail, and requirements related to resource and transmission adequacy.

Because City Light's hydro output varies dramatically from year to year, and because so many factors determine future market prices, the utility has developed strategies to mitigate the risk. One of the primary goals of the IRP is to illustrate the trade off between these risks and the other criteria, such as cost and reliability. While the IRP does not provide a fool-proof solution, it does show how portfolios can result in more risk than others, and illustrates the options.

Mitigating the risk of buying and selling electricity in the market occurs in three stages:

1. Designing a low-risk resource portfolio, one of the primary goals of the IRP process. This is done by evaluating the portfolios under different combinations of plausible future conditions, such as drastic changes in City Light's demand for electricity, the cost of renewable resources, the cost of natural gas and other fuels, and environmental regulations. The IRP process tests candidate portfolios against a range of conditions that might occur in the future, without knowing which set of conditions will actually happen.
2. Implementing the long-term resource strategy developed in the IRP. This stage includes acquiring new resources, and may also involve entering into long-term transactions designed to improve the overall balance of loads and resources in the utility's portfolio.
3. Managing risk on an ongoing basis. Resource portfolios change over the years, and their output and performance can change daily or even hourly. This presents a significant challenge to utility resource operators, whose responsibility is to guarantee City Light's ability to meet demand at all times.

The criterion used to evaluate risk is the range of variability of net power cost for each candidate portfolio. Risk is attributed to the changes in the net power cost as a result of changes in the total cost or output of resources, total cost of contract purchases, and net market purchases and sales. In other words, the risk of one particular portfolio is larger if the net power cost is more volatile when it experiences drastic changes in cost or amount of resource, contract purchases, and net market purchases and sales. Variability of resource costs includes variation in fuel prices and the extent and frequency of plant operations. Net market purchases and sales are influenced by the extent of surplus generation and the spot market price.

Using the net power cost as the index of evaluation, three methods are used to calculate the risk. The primary risk measure is "net-power-cost at risk." This measure reflects the point value where 95% of the potential outcomes would be better (lower cost). For the 2008 IRP, this measure is calculated for changes in hydro, fuel prices, and demand, both individually and combined. It is the combined measure that is used to evaluate resource portfolios. Generalized variance is applied, where historical information on net power cost is used to simulate out-of-the-ordinary conditions in the demand for electricity and fuel prices. Inspecting the net power cost subject to these extreme conditions allows one to understand the range of variability of the net power cost.

Minimize Environmental Impact

Air emissions were explicitly included in the modeling and analysis of portfolios because of their importance to the environment and because they can be quantified without specific siting information. For other environmental elements including land use, surface and groundwater, soils and geology, plants and animals, employment, aesthetics and recreation, environmental health and cultural resources, each portfolio was assessed for the level of impact in each element. Details of the environmental impact analysis of Round 2 portfolios

are described in the 2008 Addendum to the Environmental Impact Statement for the 2006 IRP.

For each generating resource portfolio, total emissions into the air of carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides (NOx), mercury (Hg), and particulates (PM) are estimated over the 20-year period.

The method chosen to evaluate environmental costs in the IRP is to estimate the mitigation cost (or control cost) for total emissions of each of the five substances. The mitigation cost includes an estimate of the additional costs of meeting more stringent emissions control standards in the future, based upon current legislation. The approach for estimating emissions control costs does not place a value on the damage done by pollutants, but does allow a direct comparison between resource portfolios with respect to estimated cost of mitigating environmental impacts. Environmental mitigation costs of each portfolio are tabulated by year and expressed as a net present value.

Certain assumptions were made in estimating greenhouse gas emissions from the generating resources. Biomass and landfill gas were assumed to have zero net impact on greenhouse gas. They were considered closed-loop systems, where the carbon dioxide emissions are equal to the carbon dioxide captured by the plants and other organic matter prior to being combusted. The air emission impacts of market sales and market purchases were accounted for by using Ventyx forecasts of resources on the margin in the Western power market. City Light market sales were assumed to displace a corresponding amount of energy from the marginal generating unit in the market at the time of the sale. Conversely, market purchases were assumed to be generated by the marginal generating unit at the time of the purchase. Given that City Light's resource portfolio is mostly comprised of hydropower and new resources that have zero net greenhouse gas emissions and low or zero emissions of other pollutants, market sales could have a significant positive air emissions impact by backing down less efficient Western thermal generators on the margin, most often natural gas-fired turbines.

In evaluating and comparing candidate resource portfolios, the largest factor was frequently the amount of carbon dioxide emitted from a resource portfolio. City Light assumes that carbon dioxide emissions must be offset according to City policy.

Using the AURORAxmp® Model to Evaluate Portfolios

This section describes the analytical tool – the computer model – that City Light used to analyze the candidate resource portfolios.

Much of the analysis in the current IRP has been performed using AURORAxmp® Electric Market Model (Aurora) developed by EPIS, Inc. First developed in 1997, the current model has an extensive database of the North American power market and is used by many utilities, resource planners and regulatory agencies for long-term planning. The IRP team worked to capture the features of City Light's existing resources — hydro variability chief among them — in the model, and to describe the operating and financial characteristics of the candidate resources that make up the portfolios.

Aurora forecasts future energy prices, given the structure and characteristics of the past and current market; evaluates the economic performance and reliability of a resource or a portfolio of resources based on cost minimization; and performs risk analysis and tests the reliability of resources under a number of scenarios. The model uses economic dispatch logic to select which resources operate, considering electricity demand, generation and transmission costs, and seasonal hydroelectric generation patterns. The model also has the capability of locational marginal pricing (LMP) market analysis. While the Pacific Northwest does not have an LMP market, the California ISO operates a power market that has been designed using locational marginal pricing principles.

Using time series data on past market characteristics, Aurora simulates supply and demand on an hourly basis to provide both short-term and long-term electric price forecasts. The model forecasts future energy prices, assuming that the market will behave as it has in the past. With the future energy prices, the model identifies the resources likely to perform better than others, enabling resource planners to make long-term decisions. The method used to compare the performance between resources computes the price of supplying an additional MW of load at each location in the system. Resources providing additional load at a lower cost are preferred over resources that cost more per additional load.

Aurora takes the following costs into account: initial costs for capacity building, operation and maintenance costs, environmental costs, transmission congestion costs, among other items.

Once the resource manager has identified candidate resources to test — or a portfolio of resources to test — Aurora dispatches the resources based on their economic performances.

Aurora tests portfolios under a number of scenarios which gives an idea of each portfolio's reliability and how portfolios perform against one another.

Selecting Portfolios for Analysis

Integrated resource planning involves examining a wide range of alternative resources. Three key objectives were considered in constructing the resource portfolios:

- Develop a range of resource portfolios that contain all or predominately renewable resources.
- Ensure sufficient supplies of generation each month during the 20-year period to avoid unserved energy needs with a 95% degree of confidence.
- Utilize a mix of resources believed to be commercially available to City Light and resources specifically recommended for inclusion in the portfolios through the public input process.

For the first round of analysis, City Light developed six portfolios of new resources that in principle would be able to fill the resource gap determined by the resource adequacy study. Based on these results, six new portfolios were defined for analysis in the second round. The resources listed below and described in Chapter 4 were used in various combinations to define the portfolios.

- Accelerated Conservation
- Renewable Generation
  - Hydro (Gorge Tunnel hydro-efficiency improvement)
  - Wind
  - Geothermal
  - Biomass
  - Landfill gas
- Non-renewable Generation
  - Natural gas combined cycle combustion turbine (CCCT), simple cycle combustion turbine (SCCT)
- Mixed resources
  - Seasonal exchanges, capacity purchases
  - Bonneville Power Administration, 100%
  - Bonneville Power Administration, 50% Block, 50% Slice
  - Wholesale power market

Scenarios

Seattle City Light tested Round 2 portfolios against selected scenarios, or sets of potential future conditions, to determine how well they would perform over the 20-year planning horizon. The scenarios used to examine portfolio performance are Climate Change, High Load Growth, Prolonged Recession, High Natural Gas Prices, High Renewable Resource Costs, and Plug-In Hybrid Electric Vehicles (PHEVs). Results of these scenarios are discussed in Chapter 6.

Climate Change Scenario

This scenario uses climate change outlooks from the University of Washington and an analysis from the Northwest Power & Conservation Council to examine some of the potential impacts of climate change for City Light. It includes impacts to demand from warming and impacts to supply from an earlier spring run-off.

High Load Growth Scenario

The High Load growth scenario examines the impacts to City Light's resource needs and resource costs resulting from a prolonged period of high load (demand) growth. City Light examined historical periods of high load growth and selected a pace at the upper end of the range.

Prolonged Recession Scenario

As the 2008 IRP is being prepared, the US economy has already experienced a downturn and may enter a recession. To evaluate the impacts of a prolonged recession upon future resource needs and individual resource portfolios, City Light modeled a scenario patterned after the 2001 recession.

High Renewable Resource Costs Scenario

Eight of 11 western states have passed legislation creating renewable portfolio standards. The renewable portfolio standards of many states are on nearly the same schedule, so that many utilities are required to buy renewable resources at the same time. This has led to concerns about scarcity of renewable resources and the prospect of further price escalation. The scenario examines the impacts of high renewable resource prices, referencing price escalation seen in wind resources since 2002.

High Natural Gas Prices Scenario

Along with the run-up in oil prices seen in 2007-2008, natural gas prices rose dramatically. City Light constructed a scenario using a "high" natural gas forecast from Ventyx and examined the impacts of sustained high natural gas prices for each of the Round 2 resource portfolios.

Plug-In Hybrid Electric Vehicle Scenario

At a time of unprecedented highs in oil and gasoline prices and expanding offerings from manufacturers of plug-in hybrid electric vehicles (PHEVs), it is prudent to examine the load impacts and resource requirements of a potential future where PHEVs gain a growing share of the automobile market. Using a recent study from the Electric Power Research Institute (EPRI) and the Natural Resources Defense Council (NRDC) , City Light examined the implications of a range of assumptions for vehicle energy consumption, PHEV sales growth in the Seattle area, recharging profiles and vehicle replacement for its Seattle area customers.

The PHEV scenario was analyzed, but not modeled in Aurora. PHEVs will be commercially available at the earliest in 2010. Assumptions about future technologies and long-term impacts of PHEVs on specific electric utility operations are highly speculative at this point. Accordingly, the PHEV analysis instead focuses on sensitivities in order to establish a range of possible outcomes.

The next chapter details Round 1 and Round 2 portfolios, their performance on measures of cost, risk, and emissions; and the scenario results.