Chapter 6 – Identifying the Best Portfolio for Seattle City Light

This chapter presents the results from two rounds of portfolio analysis, showing how the candidate resource portfolios would perform and meet the four evaluation criteria.

The Integrated Resource Plan (IRP) team evaluated two rounds of resource portfolios. This chapter details the portfolios selected for each round of analysis, compares their performance in terms of the four criteria defined in Chapter 5, summarizes the conclusions and presents the recommended portfolio.

In Round 1, a range of resource types were included in each of six candidate portfolios. Each portfolio was evaluated in comparison to the current City Light resource portfolio, augmented by spot market purchases only. Although most of the candidate portfolios relied on conservation, renewable resources and seasonal power exchanges, two portfolios also included natural gas-fired combustion turbines, the only fossil fuel generation resource considered. The Bonneville Power Administration resource was modeled in accordance with the existing power purchase contract through 2011; after 2011, changes to that resource reflect likely new contract provisions.

Information gained from this exercise guided portfolio construction for the Round 2 analysis. Power generation from fossil fuel, for example, was eliminated from further consideration because of the high costs associated with the assumption of allowances for carbon emissions. Round 2 focuses on a smaller number of resource types, varying the sizing and timing of the most promising resources. Round 2 portfolios were tested against the scenarios described at the end of Chapter 5.

This process gave the team invaluable information about how the portfolios would perform over the 20-year planning period. It also allowed for a comprehensive review by utility management and the stakeholder committee as well as public review and commentary, promoting the opportunity to build consensus with stakeholders and the public.

Round 1 Analysis

The purposes of the first round of portfolio analysis were threefold:

1. To utilize the capabilities of the Aurora model to simulate the operation of candidate resources within a defined quantitative framework.
2. To observe how a varied mix of resource technologies with different fixed costs, marginal costs, and capacity factors would influence overall portfolio performance.
3. To eliminate from consideration the worst performing resource technologies and portfolios before conducting the Round 2 analysis.

Round 1 was successful in accomplishing these purposes. Many complexities of the resources and portfolios were uncovered, and evaluating the six resource portfolios resulted in a wealth of performance data. This data enabled IRP staff to gain insights to the importance of resource availability, resource sizing and scalability, transmission requirements, tradeoffs between resources and the optimal level of conservation, fuel risk and capitalization issues.

Round 1 Portfolios

The six alternative portfolio designations are listed below and the resources in each portfolio by 2027 are given in Table 6-1:

- Portfolio 1: High Landfill Gas (LFG) and High Biomass
- Portfolio 2: Simple Cycle Combustion Turbine (SCCT) and High Wind
- Portfolio 3: High Geothermal and High Biomass
- Portfolio 4: Combined Cycle Combustion Turbine (CCCT) and Biomass
- Portfolio 5: High Exchange and High Geothermal
- Portfolio 6: High Geothermal and Wind

Table 6-1. Total New Resources in Round 1 Portfolios (Average Megawatts in January by 2027)

Resource	1 High Landfill Gas & High Biomass	2 SCCT & High Wind	3 High Geothermal & High Biomass	4 CCCT & Biomass	5 High Exchange & High Geothermal	6 High Geothermal & Wind
I-937 Conservation	159	159	159	159	159	159
Capacity Purchase	20	10	5	5	20	5
Exchange 1	50	50	50	50	50	50
Exchange 2	50	55	55	55	0	55
Exchange 3	0	0	0	0	95	0
Gorge Tunnel II	13	13	13	13	13	13
Landfill Gas	31	21	21	21	21	21
Geothermal	100	0	125	45	125	125
Wind	0	140	0	40	40	125
Biomass	125	0	125	60	25	0
CCCT	0	0	0	100	0	0
SCCT	0	100	0	0	0	0
2027 Total	548	548	553	548	548	553

Common to all resource portfolios are accelerated conservation and seasonal exchanges. Conservation and exchanges are cost-effective approaches to meeting seasonal resource needs.

Also common to all Round 1 portfolios is the planned construction of a second tunnel for Gorge dam at the utility's Skagit project. This hydro efficiency measure would count toward the satisfaction of I-937 requirements and increase output by 5 megawatts during January, possibly beginning as early as 2012.

With the exception of Rely on the Market, all portfolios contain a capacity purchase of 20 megawatts in 2008, with the amounts in the out years varying by portfolio. Capacity purchases provide a means to acquire power under improbable but possible circumstances. As such, a capacity purchase is not likely to be exercised, but it would help the utility to make sure load will be met in such events as the combination of severe drought and an extended period of extreme weather conditions. A capacity purchase was unnecessary in 2008, since it was an average water year

Renewable resources are added to each of the portfolios to supplement conservation, hydro efficiency, exchanges, and capacity purchases. Resource additions are made in recognition of amounts likely to be available at the time they are needed. Landfill gas, for example, is more likely to be available in the near-term, with resources such as geothermal further out.

A simple cycle and combined cycle natural gas turbine are included in each of two of the Round 1 portfolios. Although they have environmental drawbacks, combustion turbines can work well partnered with certain renewable resources to improve portfolio performance.

Each candidate portfolio was evaluated by simulating how the new resources in it, plus City Light's existing resources, would perform over the 20-year planning period. Results from the evaluation of the candidate resource portfolios were then compared to City Light's current portfolio, with all new power requirements met by short-term purchases in the Western wholesale power market, rather than new generation or new conservation. Short-term (spot) market purchases are made at the forecasted market price, set by the marginal generating unit in the West. From an environmental perspective, this means that at any given time, air emissions will be driven by whatever generating unit is on the margin in the spot market at that time. Currently in the West, natural gas-fired generation is on the margin more than 90% of the time.

Portfolio 1: High Landfill Gas & High Biomass

This portfolio contains mainly landfill gas and biomass in the early years, plus some geothermal later, in addition to conservation, hydro efficiency at Gorge, two seasonal exchanges, and occasional capacity purchases. Four of this portfolio's resources–biomass, landfill gas, the capacity purchase, and the exchange–emit pollutants. The biomass (assumed to be wood) and landfill gas resources are treated as greenhouse gas neutral, but they have some limited emissions such as sulfur dioxide and nitrogen oxides. While the generating resources supplying the exchange would operate seasonally each year, the generating resources backing up the capacity purchase would seldom operate–only if called upon. The capacity purchase would not be exercised under normal weather and hydro conditions. Table 6-2 shows the schedule for new resource acquisition through 2027.

Table 6-2. High Landfill Gas & High Biomass Portfolio – New Resources (Average Megawatts in January for 2008 through 2027)

High Landfill Gas & High Biomass

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	CCCT	SCCT	Total
2008	8	20	50									78
2009	18		50	50		6						124
2010	29		50	50		6						135
2011	42		50	50		9						151
2012	55		50	50	13	19						186
2013	68		50	50	13	21			50			252
2014	81		50	50	13	21			50			265
2015	94		50	50	13	24			50			280
2016	106		50	50	13	24			50			293
2017	120		50	50	13	26			50			309
2018	131	30	50	50	13	26			50			350
2019	140	40	50	50	13	28			50			371
2020	148		50	50	13	28			125			415
2021	150		50	50	13	31			125			419
2022	152	5	50	50	13	31			125			425
2023	153		50	50	13	31	100		125			522
2024	154		50	50	13	31	100		125			523
2025	156		50	50	13	31	100		125			525
2026	158	5	50	50	13	31	100		125			531
2027	159	20	50	50	13	31	100		125			548

Portfolio 2: Simple Cycle Combustion Turbine (SCCT) & High Wind

The SCCT & High Wind portfolio pairs a renewable resource–wind–with a simple–cycle combustion turbine. Emissions in this portfolio come from the simple cycle turbine (SCCT) and the exchanges. This portfolio has more generation capacity than any of the other portfolios: the variability of wind resources causes them to generate, on average, roughly 32% of their nameplate capacity (a 32% capacity factor). At this capacity factor, more wind plant resource must be added to get the same amount of generation as other resources with higher capacity factors. A simple cycle combustion turbine can be ramped up and down more easily than other resources, and can complement wind resource generation. The SCCT is assumed to be sited in western Washington and therefore would have relatively low transmission costs. The SCCT is the main source of emissions in this portfolio, along with the exchanges, the capacity purchase, and the landfill gas resource. Table 6-3 shows the schedule for acquisition of a new wind resource and a SCCT through 2027.

Table 6-3. SCCT & High Wind Portfolio – New Resources (Average Megawatts in January for 2008 through 2027)

SCCT & High Wind

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	CCCT	SCCT	Total
2008	8	20	50									78
2009	18		50	55		6						129
2010	29		50	55		6						140
2011	42		50	55		9						156
2012	55		50	55	13	9					50	231
2013	68		50	55	13	11					50	247
2014	81		50	55	13	11					50	260
2015	94		50	55	13	14					50	275
2016	106		50	5	13	14					50	288
2017	120		50	55	13	16					50	304
2018	131		50	55	13	16		50			50	365
2019	140		50	55	13	18		50			50	376
2020	148		50	55	13	18		100			100	485
2021	150		50	55	13	21		100			100	489
2022	152		50	55	13	21		100			100	490
2023	153		50	55	13	21		140			100	532
2024	154		50	55	13	21		140			100	533
2025	156		50	55	13	21		140			100	535
2026	158		50	55	13	21		140			100	536
2027	159	10	50	55	13	21		140			100	548

Portfolio 3: High Geothermal & High Biomass

In addition to the conservation, capacity purchase and exchanges present in all portfolios, the High Geothermal portfolio also has landfill gas in the near-term and some biomass in the out years. Emissions in this portfolio come from the exchanges, the capacity purchase, the landfill gas, and biomass. Table 6-4 shows the schedule for new resource acquisition through 2027.

Table 6-4. High Geothermal & High Biomass Portfolio – New Resources (Average Megawatts in January for 2008 through 2027)

High Geothermal & High Biomass

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	CCCT	SCCT	Total
2008	8	20	50									78
2009	18		50	55		6						129
2010	29		50	55		6						140
2011	42		50	55		9						156
2012	55		50	55	13	9						181
2013	68		50	55	13	11	55					252
2014	81		50	55	13	11	55					265
2015	94		50	55	13	14	55					280
2016	106		50	55	13	14	55					293
2017	120		50	55	13	16	55					309
2018	131		50	55	13	16	55		40			360
2019	140		50	55	13	18	55		40			371
2020	148		50	55	13	18	125		40			450
2021	150		50	55	13	21	125		40			454
2022	152		50	55	13	21	125		40			455
2023	153		50	55	13	21	125		40			457
2024	154		50	5	13	21	125		125			543
2025	156		50	55	13	21	125		125			545
2026	158		50	55	13	21	125		125			546
2027	159	5	50	55	13	21	125		125			553

Portfolio 4: CCCT & Biomass

In addition to conservation, a capacity contract, and two long-term exchanges, the High CCCT portfolio contains 50 MW of natural gas turbine capacity beginning in 2013, which is doubled in 2024. In addition to emissions from the CCCT, other resources with air emissions are the exchanges, the capacity purchase, the landfill gas resource, and the biomass resource. Table 6-5 shows the schedule for new resource acquisition through 2027.

Table 6-5. CCCT & Biomass Portfolio – New Resources (Average Megawatts in January for 2008 through 2027)

CCCT & Biomass

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	CCCT	SCCT	Total
2008	8	20	50									78
2009	18		50	55		6						129
2010	29		50	55		6						140
2011	42		50	55		9						156
2012	55		50	55	13	9						181
2013	68		50	55	13	11				50		247
2014	81		50	55	13	11				50		260
2015	94		50	55	13	14				50		275
2016	106		50	55	13	14			40	50		328
2017	120		50	55	13	16			40	50		344
2018	131		50	55	13	16			40	50		355
2019	140		50	55	13	18	45		40	50		411
2020	148		50	55	13	18	45		40	50		420
2021	150		50	55	13	21	45		60	50		444
2022	152		50	55	13	21	45	40	60	50		485
2023	153		50	55	13	21	45	40	60	50		487
2024	154		50	55	13	21	45	40	60	100		538
2025	156		50	55	13	21	45	40	60	100		540
2026	158		50	55	13	21	45	40	60	100		541
2027	159	5	50	55	13	21	45	40	60	100		548

Portfolio 5: High Exchange & High Geothermal

The High Exchange & High Geothermal portfolio contains a larger exchange than the other portfolios. Exchanges should compare favorably to other resources in terms of cost, because summer surplus power, which is of lower value to City Light for serving its native load, is exchanged for power in winter, when power is most needed by the utility's customers. Exchanges may not be as reliable as owned resources or long-term contracts for the output from specific resources. Emissions from this portfolio are from the exchanges, the capacity purchase, and small amounts of landfill gas and biomass resources. Like the High Wind portfolio, this portfolio has a larger amount of total generating capacity than portfolios without wind resources. As in the High Wind portfolio, more wind capacity is required because of the low capacity factor. Table 6-6 shows the schedule for new resource acquisition through 2027.

Table 6-6. High Exchange & High Geothermal Portfolio - New Resources (Average Megawatts in January for 2008 through 2027)

High Exchange & High Geothermal

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	CCCT	SCCT	Total
2008	8	20	50									78
2009	18		50	55		6						129
2010	29		50	95		6						180
2011	42		50	95		9						196
2012	55		50	95	13	9						221
2013	68		50	95	13	11			25			262
2014	81		50	95	13	11			25			275
2015	94		50	95	13	14			25			290
2016	106		50	95	13	14			25			303
2017	120		50	95	13	16			25			319
2018	131		50	95	13	16			25			330
2019	140		50	95	13	18	75		25			416
2020	148		50	95	13	18	75		25			425
2021	150		50	95	13	21	75		25			429
2022	152		50	95	13	21	75	40	25			470
2023	153		50	95	13	21	125	40	25			522
2024	154		50	95	13	21	125	40	25			523
2025	156		50	95	13	21	125	40	25			525
2026	158	5	50	95	13	21	125	40	25			531
2027	159	20	50	95	13	21	125	40	25			548

Portfolio 6: High Geothermal & Wind

This portfolio features acquisition of 55 aMW of geothermal resource by 2013, with an additional 70 aMW in 2020. This amount of geothermal can be helpful in managing the addition of 40 aMW of a wind resource for 2018-2022, increasing to 125 aMW in 2024. Table 6-7 shows the schedule for new resource acquisition through 2027.

Table 6-7. High Geothermal & Wind Portfolio - New Resources (Average Megawatts in January for 2008 through 2027)

High Geothermal & Wind

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	CCCT	SCCT	Total
2008	8	20	50									78
2009	18		50	55		6						129
2010	29		50	55		6						140
2011	42		50	55		9						156
2012	55		50	55	13	9						181
2013	68		50	55	13	11	55					252
2014	81		50	55	13	11	55					265
2015	94		50	55	13	14	55					280
2016	106		50	55	13	14	55					293
2017	120		50	55	13	16	55					309
2018	131		50	55	13	16	55	40				360
2019	140		50	55	13	18	55	40				371
2020	148		50	55	13	18	125	40				450
2021	150		50	55	13	21	125	40				454
2022	152		50	55	13	21	125	40				455
2023	153		50	55	13	21	125	40				457
2024	154		50	55	13	21	125	125				543
2025	156		50	55	13	21	125	125				545
2026	158		50	55	13	21	125	125				546
2027	159	5	50	55	13	21	125	125				553

Results of Portfolio Evaluations

As described in Chapter 5, quantitative measures were devised in order to compare the portfolios against four evaluation criteria: reliability, cost, risk and environmental impact. The criteria and corresponding measures are shown in Chapter 5, Table 5-1.

The results of the portfolio evaluations, with rankings, are displayed in Table 6-8.

Table 6-8. Summary of Round 1 Portfolios, with Rankings
Net Present Value (Millions of Dollars)

	Portfolios in Round 1	Net Power Cost		5% Chance of Higher Cost		Direct Emissions Costs		Overall Rank
P0	Rely on Market (No Action)	$254	6	$2,998	7	$ 0	1	7
P1	High Landfill Gas & Biomass	$157	2	$2,415	2	$ 4.0	6	3
P2	High Wind & SCCT	$287	7	$2,614	6	$ 3.1	5	6
P3	High Geothermal, Biomass	$150	1	$2,414	1	$ 2.1	4	1
P4	CCCT & Wind	$217	5	$2,458	4	$19.9	7	5
P5	High Exchange	$198	4	$2,574	5	$ 0.8	2	4
P6	High Geothermal, Wind	$172	3	$2,427	3	$ 0.9	3	2

The two best-performing Round 1 portfolios across all measures are:

- High Geothermal and Biomass
- High Geothermal and Wind

The top two Round 1 portfolios in terms of net present value of net power costs (revenue net of cost) are

- High Geothermal and Biomass
- High Landfill Gas and Biomass

The portfolios having the least direct emissions, including residual air emissions from generation (carbon dioxide, sulfur dioxide, nitrogen oxide, particulates and mercury) are

- High Exchange
- High Geothermal and Wind

Environmental Impact Summary

Since Round 1 portfolios were only used to perform a broad overview analysis of potential resource combinations and do not make up the set of alternatives considered for the 2008 IRP Action Plan, they are not evaluated in the 2008 Addendum to the EIS for the 2006 IRP. However, the discussion below highlights a few of the key findings on environmental impacts of the Round 1 portfolios.

In the Round 1 portfolios, the highest levels of potential impact are associated with natural gas-fired resources and, to a lesser extent, biomass and landfill gas. Conservation, the hydro efficiency improvement at the Skagit project's Gorge tunnel and wind are expected to have the fewest emissions impacts, followed by geothermal resources. More broadly, the following resources could have the following potential environmental impacts:

- Landfill gas – air quality impacts
- Wind - high aesthetic impacts and possible impacts on birds and bats
- Geothermal – physical disturbance to geologic structures, groundwater impacts and the possibility of development in pristine areas where land use and recreation impacts would be an issue
- Biomass – substantial land disturbance over an extensive area if a dedicated crop is the fuel source, as well as impacts from transporting biomass fuel
- Gas turbines – air quality impacts, water use impacts, and depending on location, land use impacts and noise
- Market transactions – air emissions and fuel extraction, based on the assumption of fossil fuel resources used in market transactions

Conclusions from Round 1 Analysis

Analysis of the Round 1 portfolios led to these conclusions:

- Portfolios with geothermal and landfill gas perform well using a broader range of risk metrics
- The expected value NPV range between the most costly and least costly portfolio was 82%
- The range between the most risky and least risky portfolio was 8% when looking at the tail risk for the worst 5% of outcomes. Other measures of risk are also evaluated.
- Diversification of resources brings significant measurable benefits for reducing portfolio risk
- The assumption of an emissions allowance cost for CO2 emissions was an important factor in the poor performance of the portfolios with natural gas-fired resources relative to those without.
- In the later years of the planning period, the supply of energy available for exchanges in the summer may not be sufficient unless new investment in baseload generation and conservation along the way maintains a level of surplus power in the summer.
- Seasonal energy exchanges with summer-peaking utilities are generally seen as very cost effective since they can help to substantially delay the need for capital investment, while helping to ensure winter resource adequacy. However, the High Exchange portfolio did not perform as well as expected. The net power cost and risk measures were the reasons. The risk is higher with exchanges because City Light only receives power a few months of the year, meaning that the resource is unavailable for about nine months of the year. For the same reason, there is little opportunity to sell power into the wholesale power market and thereby help to offset overall portfolio costs.
- Accelerated conservation compares favorably to the cost of acquired generation resources.

Round 2 Portfolios

The Round 2 portfolios were designed with the following objectives in mind:

1. Increase the pace of accelerated conservation from the Round 1 resource portfolios.
2. Minimize the amount of resources required to meet resource adequacy requirement and when applicable, Initiative I-937
3. Use lower cost resources in the early years to maximize the net present value of the portfolios
4. Avoid large resource commitments in the early years by relying on exchanges, capacity purchases, and conservation
5. Produce portfolios that will meet the resource adequacy requirement and I-937 requirements
6. Use scalable resources, such as wind and geothermal, when possible
7. Ensure that there is sufficient new generation in summer months to meet any seasonal exchanges
8. Avoid exchanges or resources in the early years that would require new transmission to be constructed on an unreasonably short timeline
9. Recognize that there are limitations on the amount of each resource type that can reasonably be included in a portfolio

The portfolio designations are listed below. All of them meet the conservation and renewable resource requirements of Initiative I-937. The resources in each portfolio by 2027 are given in Table 6-9.

- Portfolio 1: High Biomass and Geothermal
- Portfolio 2: High Exchange, Geothermal and Biomass
- Portfolio 3: High Wind and Geothermal
- Portfolio 4: High Exchange, Wind and Geothermal
- Portfolio 5: High Biomass, Geothermal and Wind

Performance of the Round 1 portfolios informed the construction of the Round 2 portfolios. However, the costs and other performance measures in Round 2 are not directly comparable with Round 1. As modeled within Aurora, Round 2 is essentially a different power marketplace for City Light.

More resources were "constructed" for City Light in Round 1 than in Round 2 because of a lower pace of conservation. In Round 2, there are less generating resources available to City Light in the area because of putting greater amounts of conservation in the Round 2 portfolios and having less generating resources "constructed" in nearby areas. While the relative performance of the portfolios is unaffected, the greater scarcity of resources in nearby areas and higher cost of market purchases create higher net present values of costs for Round 2. As in Round 1, all Round 2 portfolios are compared to the current City Light resource portfolio, supplemented with wholesale power purchases.

All of the Round 2 portfolios have an equal amount of conservation, hydro efficiency (Gorge Tunnel II), landfill gas, and one exchange of 50 aMW. They each feature a second exchange and, in years when needed, capacity purchases. Beyond these resource additions, resource adequacy is met with an additional exchange and combinations of these renewable resources: geothermal, wind, and biomass.

Table 6-9. Total New Resources in Round 2 Portfolios (Average Megawatts of Output in January, 2027)

Resource	1 High Biomass & Geothermal	2 High Exchange, Geothermal & Biomass	3 High Wind & Geothermal	4 High Exchange, Wind & Geothermal	5 High Biomass, Geothermal & Wind
I-937 Conservation	159	159	159	159	159
Capacity Purchase	5	15	5	0	5
Exchange 1	50	50	50	50	50
Exchange 2	55	0	55	0	55
Exchange 3	0	85	0	85	0
Gorge Tunnel II	5	5	5	5	5
Landfill Gas	21	21	21	21	21
Geothermal	125	125	125	125	125
Wind	0	0	125	100	85
Biomass	125	85	0	0	40
2027 Total	545	545	545	545	545

Portfolio 1: High Biomass & Geothermal

This portfolio features geothermal generation at 45 aMW starting in 2013, and elevating to 125 aMW by 2020. In 2018, generation from biomass is introduced at 40 aMW, and increases to 125 aMW starting in 2024. In this portfolio, geothermal and biomass contribute to the majority of the load growth, apart from conservation. Table 6-10 shows the schedule for new resource acquisition through 2027 for this portfolio.

Table 6-10. High Biomass & Geothermal (Average Megawatts in January for 2008 through 2027)

High Biomass & Geothermal

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Exchange 3	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	Total
2008	10	20	50								80
2009	22		50	55			6				134
2010	37		50	55			6				148
2011	52		50	55			9				166
2012	68		50	55			9				182
2013	84		50	55			11	45			245
2014	97		50	55			11	45			258
2015	110		50	55		5	14	45			278
2016	122		50	55		5	14	45			291
2017	135		50	55		5	16	45			306
2018	146		50	55		5	16	45		40	357
2019	149	10	50	55		5	18	45		40	373
2020	152		50	55		5	18	125		40	446
2021	153		50	55		5	21	125		40	449
2022	154		50	55		5	21	125		40	450
2023	155		50	55		5	21	125		40	451
2024	156		50	55		5	21	125		125	537
2025	157		50	55		5	21	125		125	538
2026	158		50	55		5	21	125		125	539
2027	159	5	50	55		5	21	125		125	545

Portfolio 2: High Exchange, Geothermal & Biomass

This portfolio features a small amount (10 aMW) of geothermal beginning in 2013, reflecting the fact that little geothermal is likely to be available in the near term. By 2018, the total generation from geothermal is 125 aMW, consistent with the prospect of greater availability of this resource. The portfolio also has a sizable exchange that contributes to a better match between load and resources and tends to keep costs lower. Table 6-11 shows the schedule for new resource acquisition through 2027.

Table 6-11. High Exchange, Geothermal & Biomass (Average Megawatts in January for 2008 through 2027)

High Exchange, Geothermal & Biomass

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Exchange 3	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	Total
2008	10	20	50								80
2009	22		50		55		6				134
2010	37		50		85		6				178
2011	52		50		85		9				196
2012	68		50		85		9				212
2013	84		50		85		11	10			240
2014	97		50		85		11	10			253
2015	110		50		85	5	14	10			273
2016	122		50		85	5	14	10			286
2017	135		50		85	5	16	10			301
2018	146		50		85	5	16	125			427
2019	149		50		85	5	18	125			433
2020	152		50		85	5	18	125			436
2021	153		50		85	5	21	125			439
2022	154		50		85	5	21	125			440
2023	155		50		85	5	21	125			441
2024	156		50		85	5	21	125		85	527
2025	157		50		85	5	21	125		85	528
2026	158	5	50		85	5	21	125		85	534
2027	159	15	50		85	5	21	125		85	545

Portfolio 3: High Wind & Geothermal

Table 6-12 shows the schedule for new resource acquisition through 2027 for this portfolio. Geothermal generation is introduced in 2013 at 45 aMW, which increases to 125 aMW in 2020. Wind is introduced in 2018 at 40 aMW. In this portfolio, geothermal, wind, and conservation contribute to the majority of the load growth, although conservation does not vary across portfolios.

Table 6-12: High Wind & Geothermal (Average Megawatts in January for 2008 through 2027)

High Wind & Geothermal

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Exchange 3	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	Total
2008	10	20	50								80
2009	22		50	55			6				134
2010	37		50	55			6				148
2011	52		50	55			9				166
2012	68		50	55			9				182
2013	84		50	55			11	45			245
2014	97		50	55			11	45			258
2015	110		50	55		5	14	45			278
2016	122		50	55		5	14	45			291
2017	135		50	55		5	16	45			306
2018	146		50	55		5	16	45	40		357
2019	149	10	50	55		5	18	45	40		373
2020	152		50	55		5	18	125	40		446
2021	153		50	55		5	21	125	40		449
2022	154		50	55		5	21	125	40		450
2023	155		50	55		5	21	125	40		451
2024	156		50	55		5	21	125	125		537
2025	157		50	55		5	21	125	125		538
2026	158		50	55		5	21	125	125		539
2027	159	5	50	55		5	21	125	125		545

Portfolio 4: High Exchange, Wind & Geothermal

Table 6-13 shows the schedule for new resource acquisition through 2027. Generation from geothermal begins in 2013 at 10 aMW, increasing to 125 aMW starting in 2018. The portfolio also has a sizable exchange that contributes to a better match between load and resources while keeping costs low. Wind generation is introduced in 2024 at 100 aMW, providing for additional load growth to meet demand towards the end of the planning period.

Table 6-13. High Exchange, Wind & Geothermal (Average Megawatts in January for 2008 through 2027)

High Exchange, Wind & Geothermal

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Exchange 3	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	Total
2008	10	20	50								80
2009	22		50		55		6				134
2010	37		50		85		6				178
2011	52		50		85		9				196
2012	68		50		85		9				212
2013	84		50		85		11	10			240
2014	97		50		85		11	10			253
2015	110		50		85	5	14	10			273
2016	122		50		85	5	14	10			286
2017	135		50		85	5	16	10			301
2018	146		50		85	5	16	125			427
2019	149		50		85	5	18	125			433
2020	152		50		85	5	18	125			436
2021	153		50		85	5	21	125			439
2022	154		50		85	5	21	125			440
2023	155		50		85	5	21	125			441
2024	156		50		85	5	21	125	100		542
2025	157		50		85	5	21	125	100		543
2026	158		50		85	5	21	125	100		544
2027	159		50		85	5	21	125	100		545

Portfolio 5: High Biomass, Geothermal & Wind

Portfolio 5 features geothermal, biomass, and wind generation as the main contributors to load growth. In 2013, 45 aMW of generation from geothermal begins, increasing to 125 aMW in 2020. In 2018, biomass generation begins and remains at 40 aMW, while wind generation begins in 2024 at 85 aMW and remains at that level. Table 6-14 shows the schedule for new resource acquisition through 2027.

Table 6-14. High Biomass, Geothermal & Wind (Average Megawatts in January for 2008 through 2027)

High Biomass, Geothermal & Wind

Resource (aMW)	I-937 Conservation	Capacity Purchase	Exchange 1	Exchange 2	Exchange 3	Gorge Tunnel II	Landfill Gas	Geothermal	Wind	Biomass	Total
2008	10	20	50								80
2009	22		50	55			6				134
2010	37		50	55			6				148
2011	52		50	55			9				166
2012	68		50	55			9				182
2013	84		50	55			11	45			245
2014	97		50	55			11	45			258
2015	110		50	55		5	14	45			278
2016	122		50	55		5	14	45			291
2017	135		50	55		5	16	45			306
2018	146		50	55		5	16	45		40	357
2019	149	10	50	55		5	18	45		40	373
2020	152		50	55		5	18	125		40	446
2021	153		50	55		5	21	125		40	449
2022	154		50	55		5	21	125		40	450
2023	155		50	55		5	21	125		40	451
2024	156		50	55		5	21	125	85	40	537
2025	157		50	55		5	21	125	85	40	538
2026	158		50	55		5	21	125	85	40	539
2027	159	5	50	55		5	21	125	85	40	545

Evaluation of Round 2 Portfolios

Round 2 portfolios were evaluated using the same criteria as the Round 1 portfolios: reliability, cost, risk and environmental impact. Further qualitative screens were applied based upon prudent operational strategy and the requirements of Initiative 937, as described above.

Reliability

All resource portfolios in Round 2 meet the resource adequacy target. This criterion is hard-wired into each of the resource portfolios, since each resource portfolio is specifically designed to meet the reliability criteria.

Cost

Several types of costs are considered in the IRP. Resource total costs include the capital, fixed operations and maintenance, and variable operations and maintenance costs of a resource portfolio. Each new resource portfolio is evaluated in the context of the entire portfolio, capturing the more complex interactions of the existing resources with the new resources.

Table 6-15. Resource Total Costs Net Present Value (Millions of Dollars)

Portfolio	Resource Total Costs NPV (millions)
High Geothermal, Biomass	$1,516
High Exchange, Geothermal	$1,434
High Geothermal, Wind	$1,488
High Exchange, Wind, Geothermal	$1,138
High Biomass, Geothermal, Wind	$1,501

The resources added to the resource portfolios through time are similar to an "insurance policy." They enable Seattle to have sufficient power available to deliver to customers even in years with low water. When considering costs, it is important to include the effects of short-term purchases and sales, which may help to offset the resource total cost. With the proposed 20-year resource portfolios, it is expected that short-term power sales will be much greater than short-term power purchases under average water conditions. This can be seen in Table 6-16.

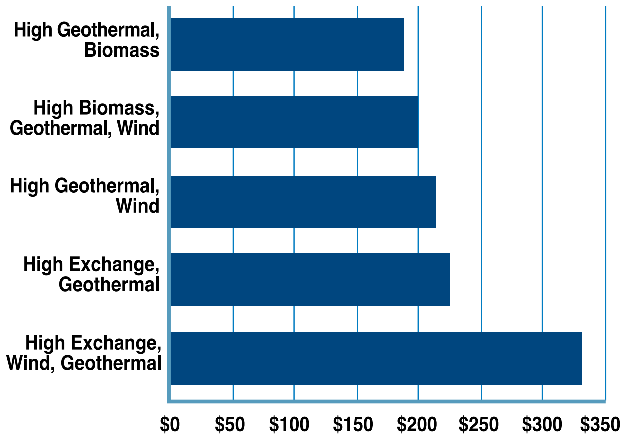
Table 6-16. Market Purchases and Sales Net Present Value (Millions of Dollars)

Market Purchases	Market Purchases	Market Sales
High Geothermal, Biomass	$210	$3,482
High Exchange, Geothermal	$236	$3,389
High Geothermal, Wind	$234	$3,454
High Exchange, Wind, Geothermal	$325	$3,077
High Biomass, Geothermal, Wind	$234	$3,466

Differences in resource total costs are most pronounced from the middle to the end of the planning period, creating most of the cost variation among portfolios. The first sizable generation resource additions occur in 2013 and 2018. The delays in the addition of new resources and the reliance upon capital-intensive renewable resources results in a more limited range of net power costs for the five Round 2 resource portfolios.

Capital costs play a very strong role in resource total costs (including emissions costs) and the economics of renewable resources, while operation and maintenance costs, which include fuel, are more often the major cost factor in fossil-fueled resources. Yet, capital costs are not the only important factor for evaluating resource portfolios for City Light. Table 6-17 shows the range of resource total costs for the Round 2 resource portfolios. Despite High Geothermal, Biomass being the portfolio with the greatest resource total cost, it is also the portfolio with the lowest overall net power cost. Its having the lowest net power costs is because of market purchases and sales. The high capacity factor of geothermal energy (95%) lowers both transmission costs and power production costs per megawatt-hour. The High Geothermal, Biomass portfolio has a comparatively low power cost, which allows it to sell into the market more frequently, creating revenues that help to offset its capital costs.

Figure 6-1. Net Power Costs (NPV in Millions of Dollars)



Another example of the importance of market purchases and sales for net power costs is found in the High Exchange, Wind, Geothermal portfolio. It has the lowest resource total cost, yet has the highest net power cost. This portfolio has the lowest amount of market sales and the highest amount of market purchases. This portfolio relies upon a larger amount of exchanges and wind than the other resource portfolios. Exchange resources are only available during a few winter months out of the year, so that exchanges cannot support power sales most of the year. The natural variability of the wind resources requires that market purchases be made frequently to fill in the periods of low wind resource production.

Risk

To measure risk for the portfolios, Net-Power-Cost-at-Risk (NPC-at-risk) was calculated. It measures the 5% worst case financial outcomes for Net Power Cost (95% of the outcomes would be better). For this risk measure, three important risk factors were varied ("shocked") to see what the impacts on net power cost would be. The risk factors shocked were hydroelectric output, electricity demand, and fuel cost. This measures the potential impacts to net power cost from varying hydro availability in different water years, recessions and high economic growth periods, and swings in natural gas and other fuel prices.

The methodology used for assessing this risk measure was to first calculate the NPC-at-risk for each of the three risk factors individually, then combined. The focus is on the combined measure, but calculating them individually gives us an approximation of the relative contribution of each risk factor to the combined risk (the combined risk is not additive). The highest risk contribution by risk factor is hydro first, followed closely by demand, then fuel costs. Hydro is an important and familiar factor in determining risk to net power costs for City Light. However, the results suggest that demand too is an important factor. Fuel costs contribute less risk because the portfolios are mainly comprised of hydropower, conservation, exchanges, and renewable resources. Of these resources, only biomass is directly affected by fuel price risk. The major source of risk from fuel in these portfolios is related to market prices.

Table 6-17. Net Power Cost at Risk (Millions of Dollars)

Portfolios	Total NPV (95%)
High Biomass, Geothermal	$2,456
High Exchange, Geothermal, Biomass	$2,473
High Wind, Geothermal	$2,476
High Exchange, Wind, Geothermal	$3,079
High Biomass, Geothermal, Wind	$2,452

Environmental Impacts of Round 2 Portfolios

The 20-year net present value calculation for each of the Round 2 portfolios included the costs of mitigating emissions of five pollutants: sulfur dioxide, nitrogen oxides, mercury, particulate matter, and carbon dioxide. All costs, except those for carbon dioxide, are estimates of the cost of pollution control equipment. Projections of the cost of emissions allowances are used for carbon dioxide. Two resources that do emit carbon dioxide, biomass and landfill gas, are not assigned any cost for carbon dioxide because the organic matter that is consumed for the production of electric power would have otherwise been released into the atmosphere through decomposition.

The emissions costs for Round 2 portfolios are close to $2 million in the 20-year net present value calculation for each portfolio. This amounts to little more than $100,000 annually for up to five million MWh.

Candidate resources for Round 2 portfolios all have extremely low emissions compared to non-renewable resources. Table 6-18 shows the total number of metric tons for each pollutant for all resources additions to City Light's current resource portfolio.

Table 6-18. Emissions from Round 2 Portfolio Resource Additions, 2008-2027 (metric tons)

Portfolio		Sulfur Dioxide	Nitrogen Oxides	Mercury	Particulate Matter	Carbon Dioxide
P1	High Biomass, Geothermal	0	1,889	0	486	0
P2	High Exchange, Geothermal, Biomass	0	1,286	0	291	0
P3	High Wind, Geothermal	0	774	0	125	0
P4	High Exchange, Wind, Geothermal	0	774	0	125	0
P5	High Biomass, Geothermal, Wind	0	1,377	0	320	0

Market purchases are the main source of carbon dioxide and sulfur dioxide for each of the portfolios, as shown in Table 6-19. Market purchases are assessed an emissions cost that is a west-wide average for all utilities and contains a high amount of coal-fired and natural gas-fired generation. City Light purchases a relatively small amount of this power in the wholesale market, primarily for load balancing. Market sales outweigh market purchase by a factor of about fifty. The market sales are mostly hydro power or renewable energy, displacing generation in the market that would pollute a great deal more. This is especially true of exports to California in the summer.

Table 6-19. Emissions from Round 2 Portfolio Market Purchases, 2008-2027 (metric tons)

Portfolio		Sulfur Dioxide	Nitrogen Oxides	Mercury	Particulate Matter	Carbon Dioxide
P1	High Biomass, Geothermal	42	349	0	133	866,552
P2	High Exchange, Geothermal, Biomass	57	471	0	177	1,168,685
P3	High Wind, Geothermal	49	415	0	139	1,034,150
P4	High Exchange, Wind, Geothermal	88	755	0	209	1,888,270
P5	High Biomass, Geothermal, Wind	46	381	0	136	949,167

Evaluating Round 2 Portfolios Across Scenarios

As described in Chapter 5, the resource portfolio evaluation for Round 2 portfolios originally involved testing them across five scenarios. They were ultimately tested in four scenarios because insufficient information was available for the Climate Change scenario to make definitive statements about the relative performance of the Round 2 portfolios, and because analysis of Plug-In Hybrid Electric Vehicles suggested little impact on SCL's system. The original six scenarios are:

- Climate Change
- High Load Growth
- Prolonged Recession
- High Renewable Resource Costs
- High Natural Gas Prices
- Plug-In Hybrid Electric Vehicles

Climate Change Scenario

Climate change is expected to alter both the seasonal demand for power and its availability. University of Washington (UW) climate research suggests that warming in the Pacific Northwest may occur at the rate of approximately one degree per decade, with greater warming occurring during the summer months, especially July and August, than in the rest of the year. Modeling of climate change for this IRP is based on work done by the Northwest Power and Conservation Council (NPCC) and the UW for the NPCC's Fifth Power Plan (2005).

City Light used the temperature changes associated with the UW/NPCC work to forecast changes in load. The combination of lower winter loads and greater winter availability of power could reduce the need for new resources to meet January loads and cause market prices to be lower in January. Hotter summer temperatures will cause greater use of air conditioning in summer. While air conditioning is not in great use by Seattle residential customers now, it is used for much of the year by large commercial buildings, a growing portion of Seattle's load. City Light has analyzed load changes on hot summer days.

Considerable concern has been raised that climate change will cause–or is already causing–greater variability in weather and increased magnitude and frequency of storms, which can affect hydro management practices and resource adequacy needs. The mountainous terrain of the Skagit watershed presents special challenges in modeling climate change impacts on demand and generation because it causes rain shadows, variability in the timing of snowmelt by elevation, and the challenge of integrating glacier models. Including changes in storm severity and frequency, flooding and glacier melting in the modeling was not possible for the 2008 IRP. Nor does the 2008 analysis include potential changes to fish protection or flood control requirements. The ability of climate models to forecast at regional levels is improving as is the ability to integrate regional forecasts with more detailed watershed models. City Light expects to have better information available for the next IRP.

Long-term exchange agreements could become less valuable in the future. City Light will need to look at changes in natural flows not only in terms of generation capability but also in combination with its commitment to maintain flows for fish and to regulate reservoir levels for recreation and flood control.

A climate change scenario was constructed using the best information presently available from the UW Climate Impacts Group and the NPCC. However, City Light analysts soon identified a critical issue: the impacts of the missing information could easily overwhelm the results of the analysis, which averaged a 1 degree centigrade temperature change per decade, resulting in lower winter loads and earlier melting of Cascade mountain snow pack. The missing information includes the impacts of climate change on North Cascade glaciers, new types of regulation of reservoirs that may be required under climate change, the possibility of changes in precipitation patterns, severe storms and flooding, and the potential need to change reservoir operations to preserve habitat for bull trout and salmon. These questions affect City Light hydro projects and those of a key supplier, the Bonneville Power Administration. City Light's Skagit River hydroelectric projects are glacier-fed, especially in the summer, so that understanding the impacts to North Cascade glaciers is critical to understanding the full range of impacts of climate change upon City Light customers. The climate change analysis helps to clarify future research priorities and focus City Light's continuing work with the UW and Lawrence Livermore National Laboratory.

The Round 2 resource portfolios are constructed entirely of conservation and renewable resources, which helps to mitigate some of the risks from climate change. Nevertheless, currently available information does not provide sufficient guidance for critically evaluating differences in the prospective renewable resource portfolios in Round 2. However, the analysis does indicate some interesting trends.

Table 6-20 Climate Change Impacts to Round 2 Portfolios – Difference from Base Case (20-Year NPV in Millions)

NPCC 5th Power Plan Regional Climate Change Assumptions Unadjusted			
	Market Purchases	Market Sales	Net Power Cost
Average of Six Round 2 Portfolios	$18	($12)	$30
NPCC 5th Power Plan Regional Climate Change Assumptions Adjusted for City Light Service Area			
Average of Six Round 2 Portfolios	$36	($82)	$118

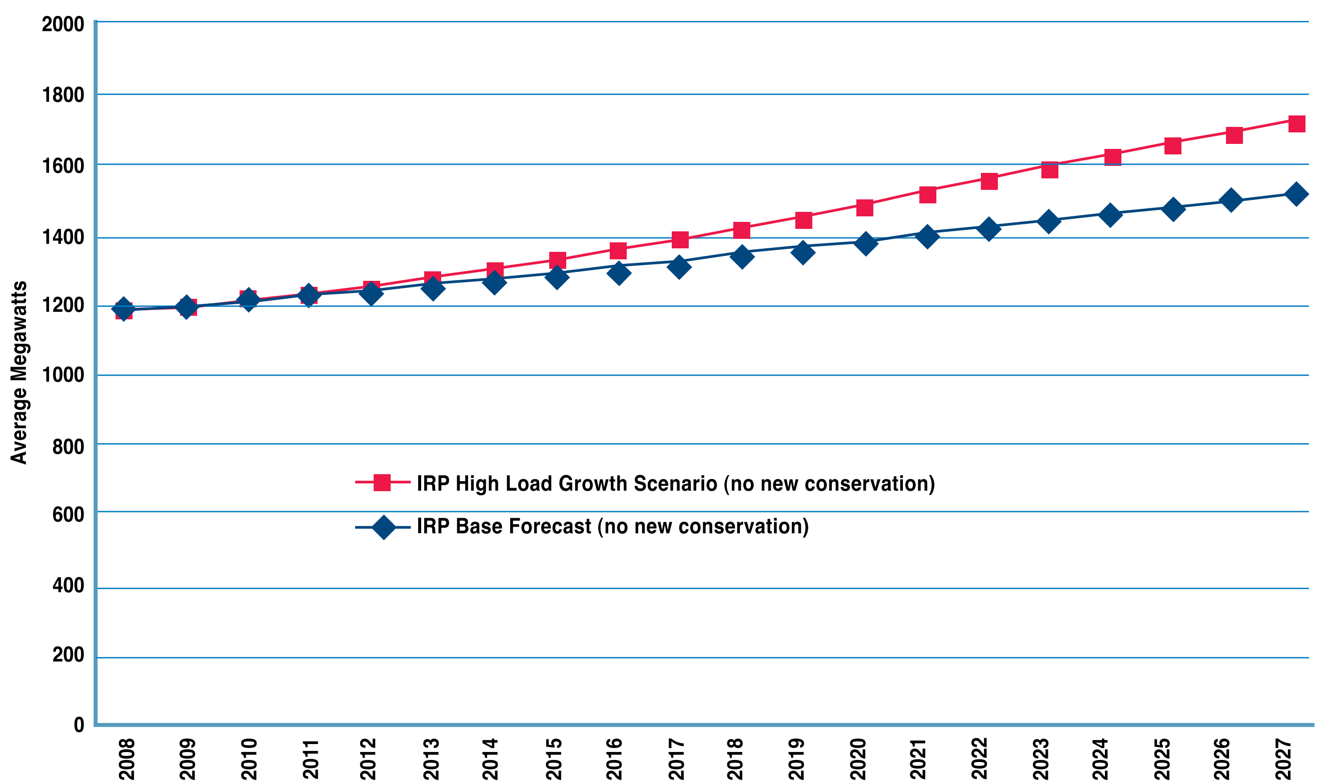
City Light modeled two different cases for climate change impacts for comparison. The first was to use the same general climate change impacts found for the Northwest in the NPCC 5th Power Plan, applying them unadjusted to City Light load and hydro resources. A second case was modeled where there is less load sensitivity to changes in temperature than the regional average. This case reflects the differences between Seattle's customer mix and its more moderate, marine-influenced climate from the regional averages.

The modeled results suggest that the moderating influence of the marine climate in the Seattle area may work against City Light with respect to net power costs. If the rest of the West has proportionately greater climate change impacts, winter loads will fall more and summer loads rise more, creating unfavorable price effects for City Light power purchases and sales. In Table 6-20, climate change increased City Light's net power costs in both cases because of increased cost of market purchases in the summer and decreased sales revenue in the winter. For the second case that is more tailored to Seattle's service area, sales declined more, purchases increased more, and net power costs rose proportionately more from the base case than the regional average. For a more detailed discussion of this analysis, see Appendix G – Climate Change in the 2008 IRP.

High Load Growth Scenario

Load growth is positive when the economy is growing, but during downturns, the load growth rate can be zero or negative for short periods. The base case assumes that load will grow in the long run and years of no or low growth will be offset by years of higher than average growth. In the long run, the base case assumes an average annual growth of about 0.8%. If in the future the base case forecast proves to be too low, there would not be enough resources to meet demand. Figure 6-2 compares the IRP high load growth forecast to the IRP base forecast.

Figure 6-2. High Load Growth Scenario



The high load growth case assumes that years of no or low load growth do not occur at all. In the high load growth scenario, every year has positive growth similar to the growth levels that occur during times of robust economic activity. The high case scenario provides information about the possible range of growth that might actually occur. In the high case scenario, a growth rate similar to the highest rates of growth for consecutive years of historical load growth is used, amounting to an average annual rate of 2.0%, after conservation. A high load growth scenario that assumes continuous positive growth for the long run can help gauge the highest potential load for a given feasible rate of growth.

The level of demand growth selected for this scenario is quite high. It is a level of demand growth for which City Light today believes there is a 95% chance that the actual level of demand growth will be lower. It surpasses the most aggressive demand case seen in the plug-in hybrid electric vehicle analysis.

The modeling results for the High Demand Growth scenario suggest a costlier outcome for supplying power than envisioned in the base case for the 2008 IRP. In this scenario, net power costs roughly triple using the level of new resources established in the IRP base case due to a growing reliance upon power being purchased in the wholesale power market.

In reality, City Light would not lock into the 2008 integrated resource plan for the remainder of the 20-year period. The plan is revised every two years, so that the resource strategy would be adjusted to recognize the higher-than-expected demand growth. The economic consequences relying so heavily on the market for long-term resource supply are thus overstated. Still, the High Demand scenario is instructive for what it suggests for future acquisition of new resources. In the early years of the scenario, demand growth exceeds the base case forecast by just 15 aMW after 4 years. This amount may not cause significant concern by itself. However, just three years later that amount grows to 48 aMW, a much more significant amount for relying upon the wholesale power market.

Relying upon the wholesale market for power supplies could cause increased costs on the order of tens of millions of dollars and potentially have implications for resource adequacy, depending upon the status of regional power supplies. It also has implications for offsetting carbon dioxide emissions for power purchased from the wholesale market, in keeping with City policy.

Despite the increased costs, the portfolios maintain the same ranking as in the IRP base case, as seen in the table below. A key lesson from this scenario is to ensure that sufficient long-term resources are available to City Light, so that it does not rely excessively on the wholesale power market.

Table 6-21. Net Power Costs – High Demand Scenario 20-Year Net Present Value in Millions of Dollars

Portfolio	Net Power Cost NPV	Rank
High Biomass, Geothermal	$624	1
High Biomass, Geothermal, Wind	$634	2
High Wind, Geothermal	$640	3
High Exchange, Geothermal	$665	4
High Exchange, Geothermal, Wind	$742	5
No Action	$803	6

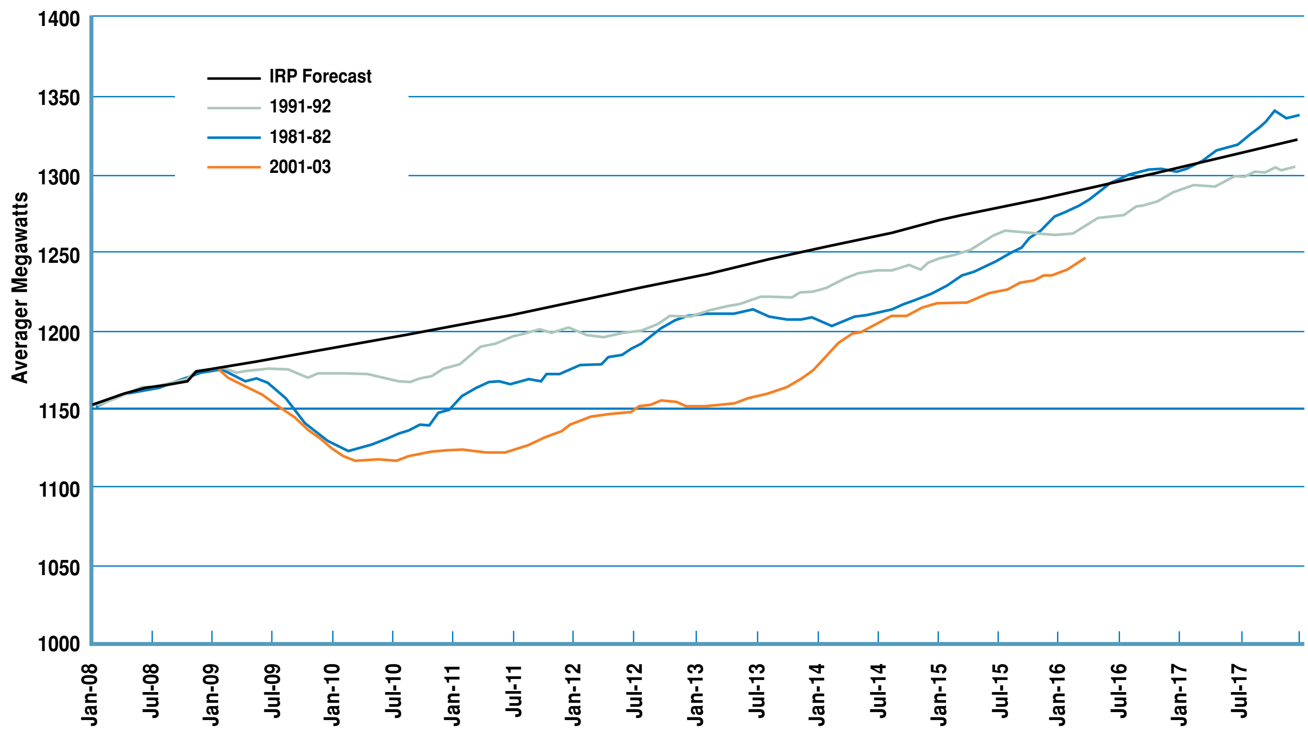
Prolonged Recession Scenario

The Pacific Northwest, along with the rest of the nation, faces a potential economic recession in the near term. While some economists believe the nation is already in recession, the Bureau of Economic Analysis has yet to make that determination. The load forecast in the base case for all portfolios for this IRP already assumes an economic slowdown for near-term years, but does not reflect a full-blown recession for City Light's service area.

The prolonged recession scenario assumes the decline in and recovery of load similar to the most recent recession. Loads declined by nearly 70 aMW in the recession after the 2000-2001 West Coast power crisis and the resulting decline in consumption by the aluminum industry; a power surplus resulted. Regional loads fell to 1990s levels even as new power plants were built to respond to the power shortages experienced in 2000-2001. The system load took about seven years to regain its previous level.

Figure 6-3 shows the IRP base forecast along with the patterns of the last three recessions. The recession of 2000-2001 (the lowest line) was modeled for this scenario.

Figure 6-3. Load Forecast and Patterns of Past Recessions



The recession scenario causes Seattle's electricity demand to drop in 2009, without recovering to pre-recession levels for five years. The prolonged recession scenario suggests significant changes in need for new resource acquisition in the first seven years. However, the implications are not uniform across the time period. In the first two years (2008-2009), winter resource needs are relatively unchanged. By the third year, winter resource needs would be reduced from the base case by 58 average megawatts and by 90 average megawatts in the fourth year of the recession. It is not until 2015 that winter resource needs have fully stabilized and have returned to a typical growth pattern. Several implications arise from this scenario. The recession did not immediately have significant impacts upon winter resource needs. It took three years for winter resource needs to decline by a sizable amount. Once the prolonged recession was over and winter electricity demand had returned to a more typical growth pattern, demand was reduced from the base case by about 56 average megawatts. In the scenario, City Light would be long in resources by that amount and have more surplus power to sell in the wholesale power market.

Within the logic in the Aurora model, having surplus resources does not necessarily lead to a bad outcome. The assumption about retail sales is that over the long run, City Light will just cover costs. However, when selling into the wholesale power market, there is sometimes an opportunity to sell power for more than marginal cost. If the prevailing market prices cover the marginal cost of production, the renewable generating units will be operated. In the recession scenario, City Light is assumed to acquire resources at a pace faster than ultimately needed because of unexpectedly low demand. The resulting surplus power could be sold in the market. The increased sales and wholesale revenues in the scenario lead to substantially lower net power costs.

Table 6-22. Net Power Costs – Prolonged Recession Scenario 20-Year Net Present Value in Millions of Dollars

Portfolio	Net Power Cost NPV	Rank
High Biomass, Geothermal	($175)	1
High Biomass, Geothermal, Wind	($167)	2
High Wind, Geothermal	($161)	3
High Exchange, Geothermal	($137)	4
High Exchange, Geothermal, Wind	($74)	5
No Action	($22)	6

The net power cost information in this scenario should not be given much credence because of the limited scope of the scenario design. The scenario was designed to evaluate the impact of a severe recession on resource needs as requested. It does not consider important factors that could affect financial outcomes. For example, it does not consider the financial impacts of lost retail load. It does not consider that after the first five years, City Light would reduce future resource acquisition plans to reflect the lower-than-expected demand growth and lower resource needs. The key risk of acquiring a sizable amount of surplus resources, that market prices may not cover the new resource costs, is also unaddressed within the scenario. Rather, this scenario was designed foremost to evaluate the impacts of a recession on the need for new resources.

High Renewable Resource Costs Scenario

Recent years have seen increases in the cost of wind projects. Much of the increased cost is due to higher priced commodities such as steel and cement. The prices of commodities are influenced by international markets, and at times by the actions of speculators or entities that periodically gain market power. Another factor that could affect future prices of renewable resources is disequilibrium between the supply and demand for renewable resources. Utilities seeking to meet state mandates for prescribed levels of renewable resources will be forced to bid against each other for possibly scarce resources, driving up prices to utilities and their ratepayers. This scenario will test the performance of each of the Round 2 portfolios against this eventuality.

The high renewable resource cost scenario is constructed so that renewable resource costs continue on a similar growth path that they have followed for the last five years. For example, growth in wind turbine costs and a declining value for the US dollar have caused the cost of wind to grow by more than 70% since 2002, or an average growth rate of about 9.2% per year. In this scenario, renewable resources maintain their relative cost differences, but as a group they are growing at an average of 7.3% per year in nominal terms. The costs peak about 2020 and then very slowly begin to decline. This simple scenario underscores the impacts of continued growth of commodity prices such as steel, copper, aluminum and concrete. It also suggests the risk of a growing scarcity of renewable resources relative to non-renewable resources as many utilities simultaneously pursue renewable resources to meet state renewable portfolio standards. One result of this scenario is that those portfolios with proportionately higher capital costs tend to perform the worst. The cost of power from the new resources reaches the point where it begins to be priced out of the wholesale market. The worst performing portfolios have lower sales and higher purchases. The model will purchase power from the wholesale market, rather than operate owned resources if the market price is lower than generation costs. In this scenario, the cost of non-renewable resources, even with the assumed regulatory requirement for purchase of CO2 emissions allowances, becomes increasingly competitive throughout the 20-year period relative to growing cost of renewable resources.

Table 6-23. Net Power Costs – High Renewables Cost Scenario 20-Year Net Present Value in Millions of Dollars

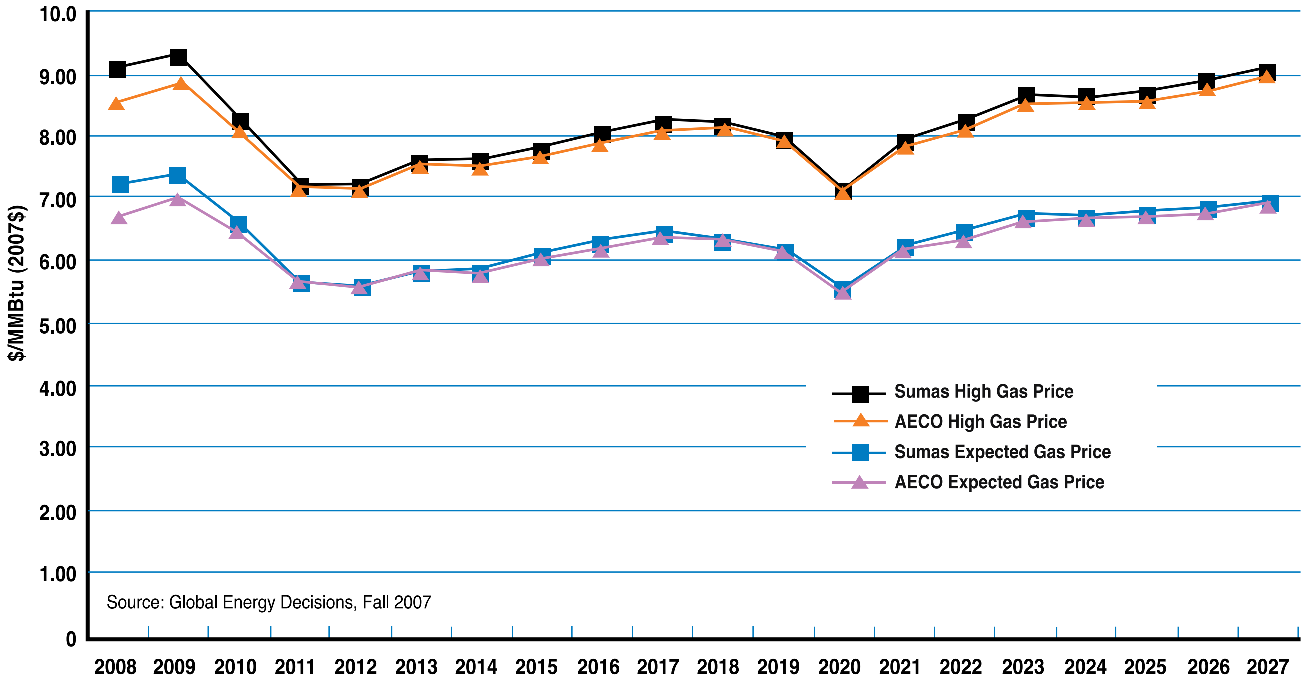
Portfolio	Net Power Cost NPV	Rank
High Biomass, Geothermal	$298	1
High Exchange, Geothermal	$326	2
High Wind, Geothermal	$327	3
High Exchange, Geothermal, Wind	$349	4
No Action	$453	5
High Biomass, Geothermal, Wind	$633	6

High Natural Gas Price Scenario

The natural gas prices used in the modeling of the portfolios in the High Natural Gas Price scenario are taken from the Ventyx (formerly Global Energy Decision's) Fall 2007 baseline forecast. Much uncertainty exists around the expected natural gas price forecast. Consequently, resource portfolios which include combined cycle turbines face substantial cost volatility since gas prices dictate the bulk of operating costs. Wholesale electricity prices are strongly correlated with natural gas prices, since gas turbines are usually the marginal generating unit. Natural gas prices will affect the amount of wholesale revenue City Light receives from selling its surplus power on the market. To capture some of this uncertainty, a scenario is run to test the sensitivity of portfolio costs under high natural gas prices.

Ventyx performed a stochastic analysis of long-term Henry Hub gas prices to develop a probability distribution of expected prices. Prices at Henry Hub are often the basis for the forecast of prices at other market centers, such as AECO and Sumas, the difference being the price of transportation. The 75th percentile of this distribution is its high gas price scenario. Figure 6-4 shows both the expected and the high average annual gas prices at AECO and Sumas. A weighted average of the high prices at these two centers is used for the high natural gas price scenario. In reality, 2008 natural gas prices reached the upper end of the distribution forecasted by GED in 2007 and have since declined. Price "excursions" have been a common feature in natural gas markets since power production became a major end-use for natural gas.

Figure 6-4. Forecast of Natural Gas Prices



In the high natural gas price scenario, little or no downside risk is expected from the Round 2 portfolios. While this scenario could be serious trouble for many electric utilities, it would not be for City Light. City Light's existing resources are primarily hydro and are not directly affected by high natural gas prices. All the proposed resources are either conservation or renewable resources, which are also not directly affected by high natural gas prices. Natural gas is typically the price-setting resource in the western wholesale power market during most hours. In a regional market environment where natural gas prices have risen substantially, market prices for electricity are also expected to rise substantially. With an average water year, City Light would have much more power available to sell in the western wholesale power market than it would need to purchase. This means that with higher wholesale power prices, City Light's wholesale power revenues would be higher. Using a high natural gas price forecast from Ventyx, this expectation was confirmed in the modeling results. In addition, the relative performance of the portfolios is the same as the base case.

Table 6-24. Net Power Costs – High Natural Gas Price Scenario 20-Year Net Present Value in Millions of Dollars

Portfolio	Net Power Cost NPV	Rank
High Biomass, Geothermal	($566)	1
High Biomass, Geothermal, Wind	($553)	2
High Wind, Geothermal	($544)	3
High Exchange, Geothermal	($507)	4
High Exchange, Geothermal, Wind	($356)	5
No Action	($228)	6

Plug-In Hybrid Electric Vehicle Scenario

Plug-in hybrid electric vehicles (PHEVs) are similar to conventional hybrid electric vehicles but use a larger battery and a plug-in charger which enables electricity from the grid to replace part of the gasoline.

The economic incentive for drivers to use a PHEV is the comparatively low cost of fuel, especially as the cost of oil continues to rise. The electric equivalent of the "drive energy" in a gallon of gasoline delivering 25-30 miles in a typical midsized car is about 9-10 kWh, assuming a vehicle efficiency of 2.9 mile/kWh. A study by the Electric Power Research Institute (EPRI) found a significant potential market for PHEVs, depending on vehicle cost and the future cost of gasoline.

City Light used assumptions from a July 2007 study that EPRI and the Natural Resource Defense Council (NRDC) jointly conducted on PHEVs to evaluate electricity use implications for City Light.

The impact of PHEVs on City Light system load depends upon the ultimate technology used for the PHEVs, consumers' rate of adoption and customer charging patterns. PHEV proponents point out that the batteries could be charged during off-peak hours, when base load generation (primarily coal and nuclear plants) is cheap and available. This argument is strongest for parts of the country that have such surplus power, but less compelling in the Pacific Northwest and with City Light because of the storage capability of much of hydro generation. Figure 6-5 shows the charging pattern used for the EPRI/NRDC analysis, which assumed an incentive for off-peak charging. Figure 6-6 shows EPRI/NRDC market share assumptions.

Figure 6-5. PHEV Charging Pattern per EPRI/NRDC

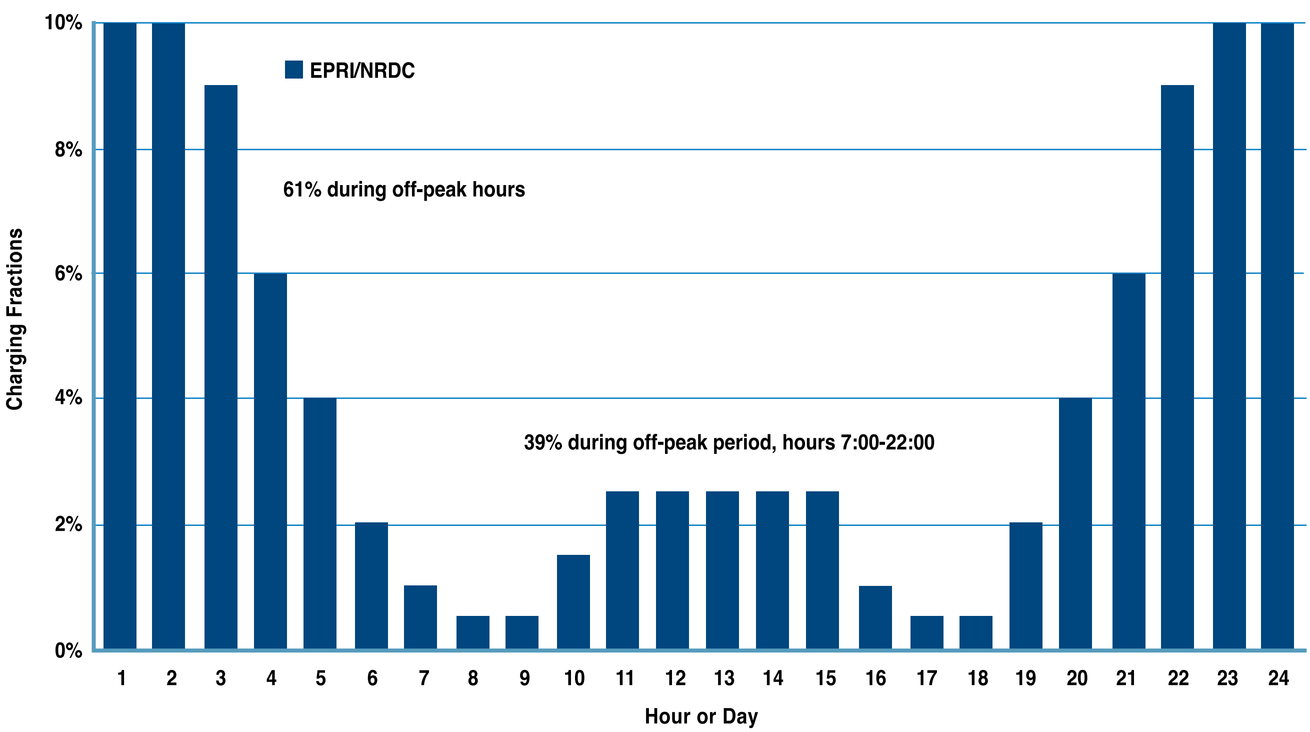
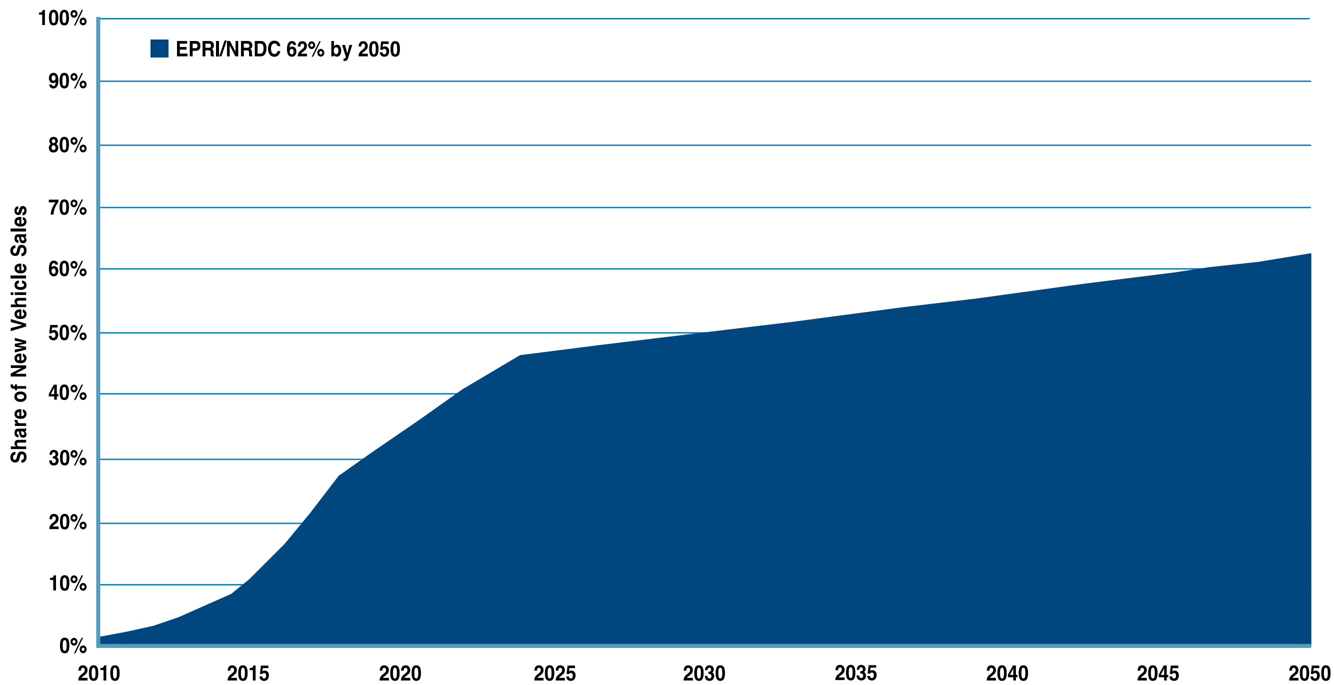


Figure 6-6. EPRI/NRDC Market Share Assumptions



There are two PHEV scenarios for the 2008 IRP. The first, base case, largely relies upon assumptions developed by EPRI/NRDC. The second scenario, or aggressive case, has more aggressive assumptions about 1) market penetration, 2) charging during the peak period, and 3) annual consumption per vehicle, and tests the high end of the range of all three assumptions simultaneously.

Assumptions common to both PHEV scenarios:

1. Commercial availability by 2010.
2. PHEVs with a 40-mile range per charge (highest range anticipated by EPRI).
3. Rate of new vehicle registrations per Washington household average of 10.6%.
4. Replacement rate for PHEVs of 100%.

Table 6-25 below compares the assumptions in the base and aggressive cases for PHEVs. While the base case is representative of an "expected value," the aggressive case is representative of an extreme, establishing what is seen as the outer boundary of potential outcomes,

Table 6-25. PHEV Electricity Demand for Battery Charging, Base and Aggressive Cases

Case	Market Penetration	By Year	Annual Battery Charging / PHEV (kilowatt-hours)	Percent of Charging On-Peak	On-Peak Demand (aMW)	Year 2027 Demand (aMW)
Base	62%	2050	2,477	39%	21	55
Aggressive	80%	2030	4,745	49%	67	140

The results of this analysis are highly sensitive to the pace of technological change, the rate of adoption of PHEVs by consumers, and the timing of battery charging. However, the results of the two cases suggest two general conclusions:

1. The impacts of PHEV electricity demand are likely to be manageable for City Light, provided that the technology continues to be monitored and adequate resources are acquired ahead of time.
2. Influencing the timing of charging PHEVs to off-peak hours can greatly reduce the amount and costs of new power resource requirements.

Scenarios Summary

These scenarios help to identify the degree of risk that underlies the 2008 IRP resource portfolios, especially when viewed in combination with other risk measures. While the relative risk seems similar by portfolio, the greatest risks identified in the scenarios were: 1) having insufficient resources; 2) having the growth in costs for renewable resources outpace the growth in costs for fossil fuel resources, even when including a cost for carbon dioxide emissions; 3) having rapid growth in load for recharging PHEVs during peak demand hours; and 4) the potential for disproportionate costs from climate change compared to the region.

The degree of risk of "having insufficient resources" is greatly dependent upon the state of the regional wholesale power market for both reliability and net power cost. It also has implications for compliance with Washington Initiative 937. Having the unexpectedly high demand growth in the high growth scenario would lead to non-compliance with Initiative 937 for one or more years and up to a $26 million fine per year ($50 per megawatt-hour escalated for inflation). This would suggest that acquiring renewable resources earlier may be advantageous for City Light's customers.

City Light does not subscribe to the idea that commodity prices will continue to rise unabated at the same pace for the next 20 years as they do in the high renewable resource cost scenario. There is less certainty about the potential risk for scarcity of renewable resources. Many utilities are beginning to investigate the supply of renewable resources, given the renewable portfolio standards adopted by many states. In time, economies of scale and innovations in both conservation and renewable resource technologies may eventually overwhelm the commodity-driven price escalation seen in this decade.

The main conclusion that can be drawn from the scenario for PHEVs is that it is very important to try to influence the recharging of PHEVs to occur in the off-peak hours. Even a relatively high rate of growth in sales for PHEVs could be accommodated (with recharging in the off-peak) with a moderate need to acquire new resources (21 aMW). However, the aggressive case, where a sizable amount of recharging occurs during the daytime, results in the need to acquire nearly 70 aMW of additional resources (over 23 years) to serve increased load from PHEVs.

The analysis of climate change is preliminary and has substantial missing information. While City Light does not consider this analysis in any way conclusive, it does indicate a risk that climate change could have previously unanticipated negative impacts to net power costs based upon relative changes in seasonal demand and prices. Preparing for climate change could include evaluating strategies to reshape seasonal resources to shift more power production and resource availability into the summer as climate change progresses. Seasonal shaping of City Light resources should and will be re-evaluated on an ongoing basis as part of integrated resource planning. However, if existing forecasts of climate change are reasonably accurate, having sufficient winter resources will continue to be the main focus of resource adequacy concerns for many years to come.

Finally, the scenarios serve to demonstrate the durability of the net power cost results of the Round 2 portfolio rankings under widely different conditions than those envisioned in the base case forecast.

The Recommended Resource Portfolio

The recommended resource portfolio, P5: High Biomass, Geothermal, and Wind, continued to perform well within the scenarios. It is the best performing in risk measures, a close second best in net power cost, and, like the other Round 2 portfolios, has low direct emissions costs. It targets the widest range of renewable resources of the Round 2 portfolios, increasing the likelihood of success for acquiring renewable energy resources in a highly competitive market. With an increased reliance upon conservation, it is comparatively low cost and has low environmental impacts. It meets the requirements of I-937 and advances the Mayor's agenda for Climate Action Now.

Figure 6-7. Recommended Portfolio (Average Megawatts in January)