Integrated Resource Plan

Final Environmental Impact Statement

August 2012

Seattle City Light

FACT SHEET

Project Title: Seattle City Light Integrated Resource Plan

Proposed Action: Seattle City Light has prepared an Integrated Resource Plan (IRP) to determine strategies for the type, amount, and timing of new resource acquisitions over a time period between 2012 and 2031. Potential resources options include generation options, contract and market purchases, and conservation.

Location: The Integrated Resource Plan is not site specific, and evaluates resources that could be developed in the Pacific Northwest (Washington, Oregon, Idaho, and western Montana) and wholesale electricity markets in the western region.

Alternatives: A number of alternative resource portfolios that would satisfy City Light's future energy needs were evaluated in the EIS. Each alternative consists of different combinations of individual resources. The four alternatives are: No Action (Rely on the Market), Renewables: Base Conservation, Renewables: High Conservation and Wind and Gas. Seattle City Light has selected the Renewables: Base Conservation Plan as the preferred alternative.

Proponent and Lead Agency: Seattle City Light

Responsible Official: Jorge Carrasco, Superintendent, Seattle City Light

Required Approvals: Adoption of the Integrated Resource Plan by the Mayor and Seattle City Council. No licenses or permits are required for the City Council to adopt the IRP. Development of new energy resources could require specific permits or approvals. Permitting would be considered in any project-specific environmental review.

Authors and Principal Contributors to this EIS
This Integrated Resource Plan Final Environmental Impact Statement has been prepared by many staff from Seattle City Light's Power Supply and Environmental Affairs Business Unit, with Corinne Grande serving as project manager. Research and analysis associated with this EIS were also provided by Hart Crowser.

Date of Final EIS Issuance: **August 17, 2012**

The Determination of Significance and Scoping Notice were published on February 23, 2012, and the Draft EIS was issued on July 10, 2012.

The Draft EIS and Final EIS, information about the IRP, and SCL recommendations are available at: www.seattle.gov/light/news/issues/irp, at the Seattle Public Library Downtown Branch (1000 Fourth Avenue, Seattle, WA), at the Seattle City Light Visitor's Center (700 Avenue, 32nd Floor, Seattle, WA 98104), or by calling (206) 684-3270.

Appeals of the adequacy of the FEIS are governed by Seattle Municipal Code 25.05.680. Copies of this code provision are available from the Seattle City Clerk. To be considered, a notice of appeal must be received by the Office of the Hearing Examiner no later than August 31, 2012. Such notice may be sent by mail to: City of Seattle Hearing Examiner, P.O. Box 94729, Seattle, WA 98124-4729, or by other delivery to: 700 Fifth Avenue, Suite 4000, Seattle, WA 98104.

Nature and Date of Final Action:
The IRP will be submitted to the Washington State Department of Commerce at the beginning of September, 2012.

Subsequent Environmental Review: Development of individual energy resources by City Light would require project-specific environmental review.

Location of Background Data: Seattle City Light, Environmental Affairs Division
700 Fifth Avenue, Suite 3300
Seattle, WA 98104

Integrated Resource Plan
Final Environmental Impact Statement
TABLE OF CONTENTS

1 EXECUTIVE SUMMARY 1-1

1.1 PROPONENT/LEAD AGENCY/PROJECT LOCATION 1-1
1.2 PROJECT OVERVIEW 1-1
1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION 1-2
1.3.1 Load Forecasts 1-2
1.3.2 Seattle City Light's Existing Resources 1-2
1.3.3 Resource Adequacy and Need 1-3
1.4 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES 1-3
1.4.1 Resources 1-3
1.4.2 Alternative Portfolios 1-4
1.4.2.1 Specification of Portfolios 1-4
1.4.2.2 Evaluation of Portfolios 1-6
1.5 SUMMARY OF IMPACTS AND MITIGATION 1-6
1.5.1 Impact Evaluation 1-6
1.5.2 Mitigating Measures 1-10
1.6 UNAVOIDABLE SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACTS 1-10
1.7 NEXT STEPS 1-12

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES 2-1

2.1 NAME OF THE PROPOSAL 2-1
2.2 PROPONENT AND LEAD AGENCY 2-1
2.3 LOCATION 2-1
2.4 OBJECTIVES OF THE PROPOSED ACTION 2-1
2.4.1 Need for and Purpose of an Integrated Resource Plan 2-1
2.4.1.1 Overview 2-1
2.4.1.2 Seattle City Light Load (Demand for Electricity) 2012-2031 2-2
2.4.1.3 Seattle City Light Existing Energy Resource Portfolio, 2012-2031 2-3
2.4.1.4 Load Forecast vs. Existing Energy Resources 2-8
2.4.2 Policy Context for the Integrated Resource Plan 2-9
2.4.2.1 Internal Policies 2-9
2.4.2.2 State and Federal Laws and External Guidelines 2-15
2.5 DEVELOPMENT OF ALTERNATIVES 2-20
2.5.1 Determination of Resource Need During the 2012-2031 Planning Period 2-20
2.5.2 Formulation of Portfolios 2-21
2.5.2.1 Reference Case and Futures—Model Inputs and Assumptions 2-21
2.5.2.2 The Model 2-22
2.6 DESCRIPTION OF ALTERNATIVES 2-23
2.6.1 Objectives 2-23
2.7 PORTFOLIO EVALUATION 2-25
2.7.1 Portfolio Evaluation Criteria 2-25
2.7.2 Portfolio Evaluation Results 2-26
2.7.3 Portfolio Descriptions 2-27
2.7.3.1 Renewables: Base Conservation 2-27
2.7.3.2 Renewables: Higher Conservation 2-27
2.7.3.3 Wind and Gas 2-28

3 IMPACTS OF THE ALTERNATIVES, MITIGATING MEASURES, AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS **3-1**

3.1 INTRODUCTION 3-1
3.2 SOILS AND GEOLOGY 3-5
3.2.1 Impacts of the Alternatives *3-5*
3.2.2 Mitigation *3-6*
3.3 AIR QUALITY AND CLIMATE IMPACTS 3-6
3.3.1 Impacts of the Alternatives *3-6*
3.3.1.1 Emission Rates 3-7
3.3.1.2 Emission Control Equipment - Assumptions for Each Resource 3-7
3.3.1.3 Energy Output in the Portfolios 3-9
3.3.1.4 Air Emissions from the Portfolios 3-10
3.3.2 Mitigation *3-12*
3.3.2.1 Emissions Control Mitigation 3-12
3.3.2.2 Greenhouse Gas Mitigation Requirements 3-13
3.4 SURFACE AND GROUNDWATER 3-14
3.4.1 Impacts of the Alternatives *3-14*
3.4.2 Mitigation *3-16*
3.5 PLANTS AND ANIMALS 3-16
3.5.1 Impacts of the Alternatives *3-16*
3.5.2 Mitigation *3-17*
3.6 ENERGY AND NATURAL RESOURCES 3-18
3.6.1 Impacts of the Alternatives *3-18*
3.6.2 Mitigation *3-19*
3.7 ENVIRONMENTAL HEALTH 3-20
3.7.1 Impacts of the Alternatives *3-20*
3.7.2 Mitigation *3-20*
3.8 LAND USE 3-21
3.8.1 Impacts of the Alternatives *3-21*
3.8.2 Mitigation *3-22*
3.9 AESTHETICS AND RECREATION 3-22
3.9.1 Impacts of the Alternatives *3-22*
3.9.2 Mitigation *3-23*
3.10 HISTORIC AND CULTURAL RESOURCES 3-23
3.10.1 Impacts of the Alternatives *3-23*
3.10.2 Mitigation *3-24*
3.11 EMPLOYMENT 3-25
3.11.1 Impacts of the Alternatives *3-25*
3.11.2 Mitigation *3-26*

4 PUBLIC COMMENT ON THE DRAFT EIS AND RESPONSES *4-1*

List of Tables

Table 1-1. IRP Resource Options 1-4
Table 1-2. Total New Resources by Portfolio 1-5
Table 1-3. Portfolio Objectives and Evaluation Criteria 1-6
Table 1-4. Summary of Resource Impacts 1-8
Table 1-5. Summary of Portfolio Impacts 1-9
Table 2-1. Seattle City Light Generation and Contract Energy (aMW) Actual Output Years 2006–2011 . 2-8
Table 2-2. Resource Options 2-21
Table 2-3. Total New Resources by Portfolio (Cumulative Average Megawatts in 2031) 2-24
Table 2-4. Portfolio Evaluation Criteria 2-25
Table 2-5. Renewables: Base Conservation 2-27
Table 2-6. Renewables: Higher Conservation 2-28
Table 2-7. Wind and Gas 2-28
Table 3-1. Resource Additions to the Alternative Portfolios 3-1
Table 3-2. 20-Year Total Energy in Each Portfolio (Average Megawatts) 3-2
Table 3-3. Summary of Portfolio Impacts 3-4
Table 3-4. Impacts on Geology and Soils 3-5
Table 3-5. Emission Rate Assumptions for Air Impact Calculations 3-7
Table 3-6. Assumed Emission Control Equipment for Resources 3-8
Table 3-7. Air Emissions per Unit of Electricity, by Generation Type 3-9
Table 3-8. 20-Year Total Energy in Each Portfolio (Average Megawatts) 3-10
Table 3-9. 20-Year Air Emissions for Each Portfolio – New Generation Only 3-11
Table 3-10. 20-Year Air Emissions in Portfolios - Market Purchases Only 3-11
Table 3-11. Impacts on Air Quality Summary 3-12
Table 3-12. Water Use for Energy Resources (Gallons/MWH) 3-15
Table 3-13. Impacts on surface and Groundwater 3-15
Table 3-14. Impacts on Plants and Animals 3-17
Table 3-15. Fuel Use Rate by Resource 3-18
Table 3-16. Impacts on Energy and Natural Resources 3-19
Table 3-17. Impacts on Environmental Health 3-20
Table 3-18. Impacts on Land Use 3-21
Table 3-19. Impacts on Aesthetics and Recreation 3-23
Table 3-20. Impacts on Historic and Cultural Resources 3-24
Table 3-21. Impacts on Employment 3-26

List of Figures

Figure 1-1. System Annual Energy Load and Peak Load History and Forecast 1-2
Figure 2-1. System Annual Energy Load and Peak Load History and Forecast 2-3
Figure 2-2. City Light's Generating Resources 2-5
Figure 2-3. 2010 Sources of Power 2-7

DISTRIBUTION LIST

APPENDICES

A. Glossary
B. Seattle City Light Environmental Policy Statement
C. Environmental Analysis of Resources

1 EXECUTIVE SUMMARY

This document is the Final Environmental Impact Statement (FEIS) for Seattle City Light's 2012 Integrated Resource Plan (IRP). Due to the limited number of public comments (described, with responses, in Chapter 4) and limited number of internal review edits to the Draft Environmental Impact Statement (DEIS) that was issued on July 10, 2012, the FEIS is simply the DEIS with revisions reflecting public and internal comments.

1.1 Proponent/Lead Agency/Project Location

Seattle City Light (SCL) proposes an Integrated Resource Plan that evaluates alternatives for meeting electrical demand over a 20-year period. The proposed action is not site-specific, though only energy resources that can be acquired or developed within the Pacific Northwest (Washington, Oregon, Idaho, and western Montana) are included. The one exception is the Gorge Second Tunnel, a Hydro Efficiency Improvement, which is site-specific.

1.2 Project Overview

Seattle City Light (City Light) is a municipal electric utility serving Seattle and areas to the north and south. It owns and operates electricity generating, transmission, and distribution facilities and serves over 400,000 metered customers.

City Light proposes an Integrated Resource Plan (IRP) covering the amount and timing of new energy resource acquisitions needed from 2012 to 2031. For this analysis, we evaluated three Alternatives (combinations of resources) that could meet anticipated future needs and No Action. Resources encompass both electricity generation and conservation measures. Washington State law requires that City Light perform a detailed and consistent analysis of a wide range of commercially available resources. The proposed IRP was presented to the Seattle Mayor and City Council in July 2012.

The general steps to create the IRP are:

- Describe existing City Light resources;
- Forecast demand for electricity through 2031;
- Determine when additional resources will be needed and how much resource, taking into account variable conditions and reliability criteria;
- Develop alternative "resource portfolios" or combinations of resources and measures to meet customer's needs;
- Evaluate and compare alternatives based on cost, risk, reliability, and environmental impacts; and
- Assess resource portfolios for other alternatives considering different assumptions about future market conditions.

1.3 Purpose and Need for the Proposed Action

1.3.1 Load Forecasts

Annual system energy load (adjusted for weather) reached a high of 1,154 average megawatts (aMW) in 2008 but fell by 2.6 percent to 1,124 aMW in 2010 during the Great Recession. The local economy has rebounded slowly and so has load. System load in 2011 was 1,134 aMW—10 megawatts more than in 2010, but still 20 aMW less than in 2008. Load is forecast to grow at an average annual rate of 0.8 percent through 2031. Although there will be some years in which annual energy load will not grow, the historical growth trend is expected to continue into the future. Figure 1-1 shows load history from 1985 through 2011 and the annual energy load forecast through 2031.

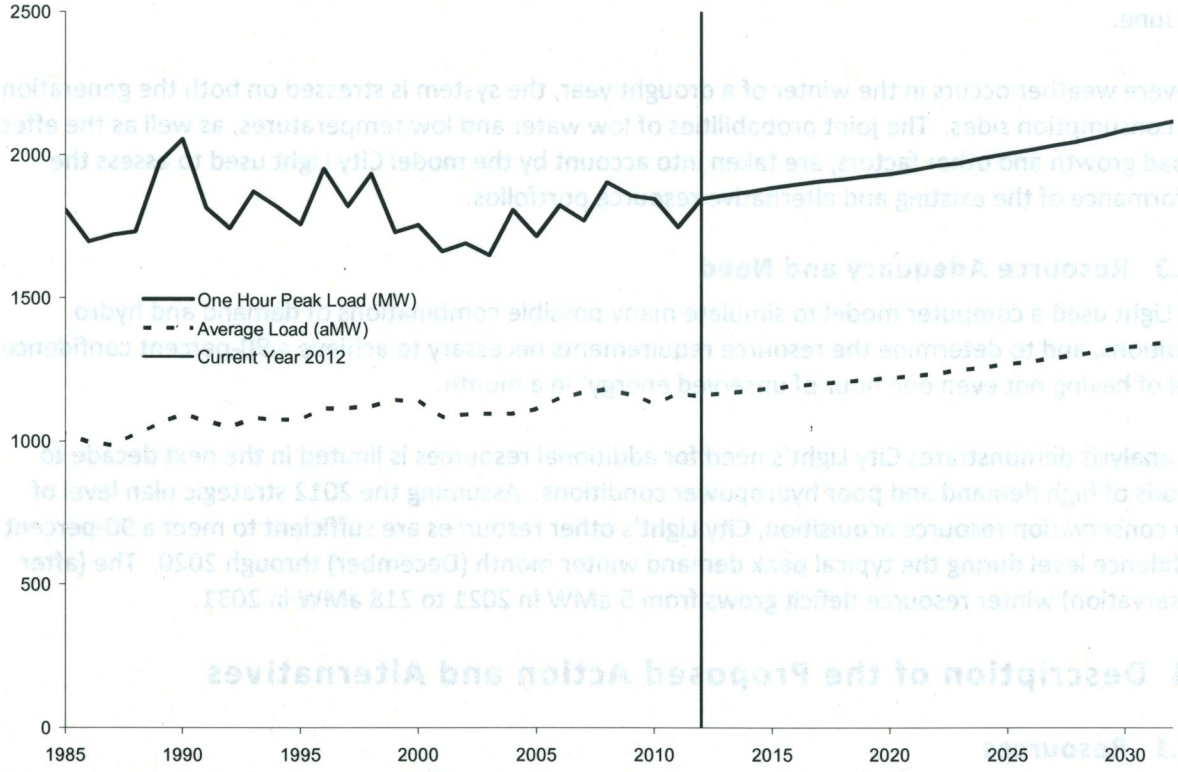

Figure 1-1. System Annual Energy Load and Peak Load History and Forecast

1.3.2 Seattle City Light's Existing Resources

City Light's existing resources include several hydroelectric projects it owns, and purchase contracts with the Bonneville Power Administration (BPA) and several other utilities. The resource portfolio also includes energy savings from conservation resources that City Light and its customers have already implemented.

The resources City Light currently relies on are hydroelectric power (88 percent), conservation, wind (2 percent), nuclear through its contract with BPA (6 percent), biomass and a small amount of other

resources through market transactions such as coal, natural gas, and petroleum.[1] Nearly one-half of City Light's electricity comes from its own hydroelectric resources.

In planning for new resources, the IRP compared the forecasted differences between future load and existing resources that City Light owns or has contracts for over the planning period 2012 to 2031. Expected annual generation is sufficient to meet forecasted annual energy load through the planning period. However, two factors may cause actual generation from existing resources to be less than energy load.

First, actual generation can be much less than expected, depending on the amount and timing of precipitation in the watersheds that City Light primarily relies upon for hydropower.
Second, the monthly profiles for loads and generation are not the same. For example, energy loads reach their highest levels during the winter months, while power generation is usually highest in May and June.

If severe weather occurs in the winter of a drought year, the system is stressed on both the generation and consumption sides. The joint probabilities of low water and low temperatures, as well as the effects of load growth and other factors, are taken into account by the model City Light used to assess the performance of the existing and alternative resource portfolios.

1.3.3 Resource Adequacy and Need

City Light used a computer model to simulate many possible combinations of demand and hydro conditions, and to determine the resource requirements necessary to achieve a 90-percent confidence level of having not even one hour of unserved energy[2] in a month.

The analysis demonstrates City Light's need for additional resources is limited in the next decade to periods of high demand and poor hydropower conditions. Assuming the 2012 strategic plan level of new conservation resource acquisition, City Light's other resources are sufficient to meet a 90-percent confidence level during the typical peak demand winter month (December) through 2020. The (after conservation) winter resource deficit grows from 5 aMW in 2021 to 218 aMW in 2031.

1.4 Description of the Proposed Action and Alternatives

1.4.1 Resources

Based on future conditions that are considered most likely, referred to in the IRP as the Reference Case, it is anticipated that most growth in electric power resources in the Pacific Northwest will come from natural gas-fired generators. Hydro and nuclear generating capacity is forecasted to remain relatively constant in total. A number of coal-fired facilities are scheduled to be retired over the planning period. Renewable energy sources will see significant growth, adding over 29,000 MW of generation (non-dependable) capacity by 2031.

[1] 2010 SCL fuel mix. Available from: http://www.seattle.gov/light/fuelmix/
[2] Unserved energy measures the expected amount of energy (in megawatt-hours) not being served per hour.

The resources that City Light considered in its evaluation are listed in Table 1-1 and fully described in Chapter 2.

Table 1-1. IRP Resource Options

Conservation
Landfill Gas
Hydro Efficiency Improvements
Geothermal
Biomass
Wind
Solar Energy
Combined Cycle Combustion Turbine (CCCT)
The Wholesale Power Market

1.4.2 Alternative Portfolios

1.4.2.1 Specification of Portfolios

The Proposed Action covered in this EIS is adoption of an Integrated Resource Plan containing City Light's long-term strategy (types of resources, amounts, and timing) for meeting electrical load over a 20-year period. Once electricity needs were defined, City Light developed a number of possible combinations of new resource additions that could meet the need. These combinations are called "portfolios." Nine portfolios were developed and the three that performed best on a combination of criteria including cost, risk and City policy objectives were selected for further analysis.

Three key objectives were considered in constructing the resource portfolios:

1. Develop a wide range of resource portfolios, including those containing predominantly renewable resources, those containing predominantly non-renewable resources, and those with a mixture of renewable and non-renewable resources.
2. Ensure sufficient supplies of generation each month during the 20-year period to avoid unserved energy needs.
3. Use a mix of resources believed to be commercially available to Seattle City Light and resources specifically recommended for inclusion in the portfolios through the public input process.

Alternative resource portfolios that would satisfy City Light's future energy needs were formulated. Each portfolio, consisting of different combinations of individual resources, represents an alternative "theme." Evaluation criteria covering cost minimization, risk management, reliability, and minimization of environmental impacts (air emissions) were established for the portfolios, and each was analyzed to determine how well they would perform under different future conditions. City Light used a computer model, Aurora xmp, to evaluate the performance of each portfolio. Assumptions about fuel and electricity prices, electricity supply and demand, and environmental regulations were varied.

The EIS uses the baseline assumptions about these variables (compiled as the Reference Case). The nine alternative portfolios are listed below. The No Action alternative was evaluated for analysis purposes only, but it does not meet reliability criteria.

1. No Action – Rely on the Market (Does not meet reliability criteria)
2. Renewables: Base Conservation
3. Renewables: Lower Conservation
4. Renewables: Higher Conservation
5. Wind and Gas
6. Mixed Resources
7. Renewables: No Waste Wood Biomass
8. Natural Gas
9. Renewables: Constant Rate Conservation

The three portfolios chosen for further analysis in the IRP are 2) Renewables: Base Conservation, 4) Renewables: Higher Conservation and 5) Wind and Gas. These three and the No Action (Rely on Market) will be evaluated as Alternatives in this EIS.

The total conservation acquired by 2031 varies little across portfolios, since it is driven by the amount of cost-effective potential. However, the pace that the conservation is acquired does vary over the 20-year period and affects portfolio performance on financial, risk, and environmental measures. It also influences the timing and amounts of more expensive resources that must be acquired.

Table 1-2 depicts the total new resources acquired in each of the nine resource portfolios between 2012 and 2031.

Table 1-2. Total New Resources by Portfolio (Cumulative Average Megawatts in 2031)

Resource	Resource Portfolio							
	2 Renewables: Base Conservation	3 Renewables: Lower Conservation	4 Renewables: Higher Conservation	5 Wind and Gas	6 Mixed Resources	7 Renewables: No Waste Wood Biomass	8 Natural Gas	9 Renewables: Constant Rate Conservation
Conservation	237	206	237	237	237	237	237	237
Landfill gas	8	8	8		8	8		8
Hydro Efficiency	5	5	5		5	5		5
Geothermal	20	20	20		20	20		20
Biomass	40	40	40		20			40
Wind	125	125	125	125	35	125		125
Solar Thermal					80	10		
Solar PV	20	50	20			50		20
CCCT				93	50		220	
RECs							34	

With the exception of the Portfolio 6 (Mixed Resources), the eight portfolios were designed using a linear program to help determine which resources are added and when. This included estimating the total amounts of cost-effective energy resources that may be accessible to City Light given transmission and resource availability constraints. And, based upon different resource strategies, some resources were further constrained in the linear program, such as the portfolio that tests a strategy of not including waste wood biomass, or portfolios that test different conservation acquisition strategies.

Five of eight portfolios were eliminated from further consideration based upon their performance in computer simulations and consistency with City policy. The remaining three portfolios and No Action – Rely on Market are analyzed in this EIS. Seattle City Light has selected the Renewables: Base Conservation Plan as the preferred alternative.

1.4.2.2 Evaluation of Portfolios

After each energy resource portfolio is modeled, the portfolios are evaluated in comparison to each other. A series of calculations are completed for measuring cost, environmental impact, risk, and reliability. These criteria were selected to evaluate the relative performance of the resource portfolios being studied. The portfolio evaluation criteria are shown in Table 1-3.

Table 1-3. Portfolio Objectives and Evaluation Criteria

Portfolio Evaluation Criteria	Criteria Measures
Minimize costs to customers	20-year net present value of portfolio costs
Manage risks	Volatility of portfolio costs
Provide reliable service	Occurrence of unserved customer energy need
Minimize environmental impacts	Level of pollutant emissions including CO_2, SO_2, NOx, Mercury, and particulates
Meet City Policies	City Council Resolutions, including #30144

In terms of net present value of net power costs (revenues net of costs) and risk, the top-performing four portfolios are:

- Natural Gas
- Wind and Gas
- Renewables: Higher conservation
- Renewables: Base conservation

When the Natural Gas portfolio was dropped from further consideration due to inconsistency with Council Resolution 30144 and high levels of air emissions, the top three portfolios became:

- Wind and Gas
- Renewables: Higher conservation
- Renewables: Base conservation

These three portfolios and the No Action Alternative are analyzed in this EIS.

1.5 Summary of Impacts and Mitigation

1.5.1 Impact Evaluation

The environmental impacts analysis draws upon assessments of individual energy resources presented in Appendix C. Appendix C begins with a general description of each energy resource and then describes the impacts and mitigation measures for ten elements of the environment. The ten elements of the environment are: (1) Soils and Geology, (2) Air Quality, (3) Surface and Groundwater, (4) Plants and Animals, (5) Energy and Natural Resources, (6) Environmental Health, (7) Land Use, (8) Aesthetics and Recreation, (9) Historic and Cultural Resources, and (10) Employment.

Each element of the environment section concludes with a table that summarizes the potential level of construction and operation impacts for each resource. The assigned impact level is based on a scale of three levels: potential for low, moderate, or high impact. The assigned value reflects a judgment about the severity of an impact, with the level of severity determined by considering the magnitude, extent, duration, and probability of an impact.

The evaluation of air quality impacts is more extensive than for the other elements of the environment. This is because air pollutant emissions are important in evaluating the impacts of generating resources, and because emissions are easier to quantify without having site-specific information about a resource location.

The impact evaluations for the individual energy resources and for the resource portfolios are summarized in Table 1-4 and Table 1-5, respectively. The evaluation results are presented for each element of the environment separately for construction and operation. The level of impact for each resource is a building block for analyzing the environmental impacts of the portfolios (combination of resources) described in Chapter 3 of this Environmental Impact Statement (EIS). There are often a range of environmental impacts that may occur from the construction and operation of energy resources. Because this analysis is not site specific (with the exception of the Gorge Second Tunnel), there is uncertainty about many factors that influence impacts, including the geographic location of the facility, types and effectiveness of mitigation, site conditions, fuel extraction operations, methods of waste disposal, etc. Where a range of potential impacts has been identified, the highest impact level is depicted in the summary table.

For example, the impact level on aesthetics and recreation from transmission towers was determined to range from low to high; the "high" impact level is shown in the summary table. For this example, there is a range of aesthetic impacts because this is a programmatic environmental impact statement, and the actual impact will depend on the specific site developed, the surrounding views, and the number and type of exposed viewers and their sensitivity to landscape changes.

Table 1-4. Summary of Resource Impacts

Elements of the Environment	Energy Resources										
	Conservation	Landfill Gas	Gorge 2nd Tunnel	Geothermal	Biomass (Cogen)	Wind	Solar Energy (Utility-Scale)	Natural Gas (CCCT)	RECs	Market Transactions	Transmission
Soils and Geology											
Construction	L	L	M	M	L	M	H	M	L - H	L	M
Operation	L	L	L	M	L	L	L	H	L - M	H	L
Air Quality											
Construction(NOx, SOx, PM, Hg)	L	L	L	L	L	L	L	L	L	L	L
Operation(NOx, SOx, PM, Hg)	L	L	L	L	M	L	L	M	L-M	M	L
Construction (CO2)	L	L	L	L	L	L	L	L	L	L	L
Operation (CO2)	L	L	L	L	L	L	L	H	L	H	L
Surface and Groundwater											
Construction	L	L	L	L	L	L	L	L	L	L	M
Operation	L	L	L	M	M	L	M	H	L-M	H	M
Plants and Animals											
Construction	L	L	L	H	L	M	M	M	L-H	L	M
Operation	L	L	L	L	L	M	M	M	L-M	M	M
Energy and Natural Resources											
Construction	L	L	L	L	L	L	L	L	L	L	L
Operation	+L	+L	+L	+L	+L	+L	+L	H	+L	H	M
Environmental Health											
Construction	L	L	L	M	M	M	L	M	L-M	L	H
Operation	L	L	L	M	M	M	L	M	L-M	M	M
Land Use											
Construction	L	L	L	M	M	M	M	M	L-M	L	M
Operation	L	L	L	M	L	M	M	M	L-M	M	H
Aesthetics and Recreation											
Construction	L	L	M	M	M	M	M	M	L-M	L	M
Operation	L	L	L	M	M	H	H	M	L-H	M	H
Historic and Cultural Resources											
Construction	L	L	L	M	M	M	M	M	L-M	L	M
Operation	L	L	L	L	L	H	H	M	L-M	M	H
Employment											
Construction	+H	+L	+L	+L	+L	+L	+H	+L	+L-+H	+L	+L
Operation	+L	+H	+L	+M	+M	+L	+M	+L	+L-+H	+L	+L

LEGEND

L	Low Impact		M	Moderate Impact		H	High Impact		+L, +M, +H	Positive Impact

Table 1-5. Summary of Portfolio Impacts

Elements of the Environment	1. Rely on Market	2. Renewables: Base Conservation	4. Renewables: Higher Conservation	5. Wind and Gas
Soils and Geology				
Construction	L	M	M	M
Operation		L	L	H
Air Quality				
Construction(NOx, SOx, PM, Hg)	L	L	L	L
Operation(NOx, SOx, PM, Hg)	M	M	M	M
Construction (CO2)	L	L	L	L
Operation (CO2)	H	M	M	H
Surface and Groundwater				
Construction	L	L	L	L
Operation	H	L	L	H
Plants and Animals				
Construction	L	M	M	M
Operation	M	M	M	M
Energy and Natural Resources				
Construction	L	L	L	L
Operation	H	L	L	M
Environmental Health				
Construction	L	M	M	M
Operation	M	M	M	M
Land Use				
Construction	L	M	M	M
Operation	M	M	M	M
Aesthetics and Recreation				
Construction	L	M	M	M
Operation	M	M	M	M
Historic and Cultural Resources				
Construction	L	M	M	M
Operation	M	M	M	M
Employment				
Construction	+L	+M	+M	+M
Operation	+L	+L	+L	+L

LEGEND

L	Low Impact	M	Moderate Impact	H	High Impact	+L, +M, +H	Positive Impact

In general, the highest levels of potential impact are associated with market transactions, natural gas combined-cycle combustion turbines (CCCT), transmission and, to a lesser extent, utility-scale photovoltaic systems, biomass, and wind resources. Conservation, hydro efficiency improvements at an existing SCL hydro facility (Gorge Tunnel), and landfill gas resources are expected to have the fewest environmental impacts. Overall, the following resources could potentially cause significant impacts:

- Gas turbines—operating a gas turbine emits carbon dioxide, which contributes to climate change. Additionally, ongoing fuel extraction could potentially affect several elements of the environment including soils, geology, and groundwater.
- Market transactions—the analysis assumes market transaction resources would be used that would have high levels of air emissions and fuel extraction impacts similar to gas turbine resources.

- Transmission—impacts on environmental health, land use, and aesthetics and recreation could be high.
- Solar Energy—utility-scale photovoltaic projects use a large amount of land, which requires the permanent displacement of existing uses within the project area.
- Biomass—impacts would likely be moderate if mill waste and/or unused forest by-products are used as fuel. Control technology would be used to substantially reduce the particulate emissions and mitigate air quality impacts.
- Wind—potential high aesthetic impacts and possible effects on birds and bats.

The impact evaluations for the No Action and top three alternative portfolios (shown in Table 1-5) combine the impact evaluation results and the amount of power generated by the individual energy resources to determine the overall portfolio impact. Portfolio 5 (Wind and Gas), which uses combined-cycle combustion turbines, would cause higher impacts on air quality because of carbon dioxide emissions, which contribute to climate change. The Wind and Gas portfolio would also cause significant impacts on energy and natural resources because the portfolio uses non-renewable fuel resources to produce electricity, thereby contributing to the depletion of known fuel reserves. Also, this portfolio would have impacts on soil and water resulting from natural gas fuel extraction.

Portfolio 2 (Renewables: Base Conservation) and Portfolio 4 (Renewables: Higher Conservation) have nearly identical impacts because the two portfolios comprise the same resources in similar amounts. In general, the Renewables: Base Conservation and the Renewables: Higher Conservation portfolios have a low to moderate impact on air quality and low, potentially positive, impact on energy and natural resources. The impact on other elements of the environment (e.g., plants and animals, land use and aesthetics, and recreation) is expected to be moderate.

Site-specific projects and their associated impacts would need to be evaluated in order to further distinguish the environmental impacts associated with each portfolio.

1.5.2 Mitigating Measures

Mitigating measures will be considered in energy development decisions as appropriate. Some measures are required under governmental regulations; some may become part of specific development proposals, and some may be optional. Mitigation is described in detail in Appendix C and Chapter 3.

1.6 Unavoidable Significant Adverse Environmental Impacts

An unavoidable impact is a significant impact that cannot be mitigated.

Since resource locations and facility designs have not been determined as part of the IRP, there is considerable uncertainty associated with identifying impacts that are both significant and unavoidable. Site locations and characteristics, energy generation technology, and mitigation designed to address specific impacts are unknown. This section makes general conclusions based upon available information.

Generally, there are no unavoidable significant adverse impacts expected to be associated with conservation and Gorge Second Tunnel.

All new generation facilities are likely to have unavoidable adverse impacts, depending on the resources including:

- Displacement of land uses
- Temporary soil disturbance
- Water resource quantity and quality
- Permanent loss of vegetation and wildlife habitat
- Visual, aesthetic, and/or recreation resources

In addition, fossil-fueled electricity generation facilities would likely have unavoidable adverse impacts for:

- Emissions of air pollutants
- Emission of greenhouse gases, contributing to climate change
- Consumption of water for cooling and other purposes
- Discharge of waste heat to the environment

Whether the impacts would rise to a level of being significant even with mitigation is difficult to determine without site-specific information.

For resources such as wind and geothermal that are sited according to the location and availability of the primary energy source, there is a greater possibility of the following significant unavoidable adverse impacts:

- Permanent loss of vegetation and wildlife habitat
- Visual, aesthetic, and/or recreation resources

Unavoidable adverse impacts on air quality will result from all the portfolios, but will have different magnitudes, duration, and extent. See section 3.3.1 for a detailed description of air emissions from each portfolio.

Carbon dioxide emissions contribute to climate change on a global level, and its impacts are not confined to the area in which it is emitted. Carbon dioxide has a long lifetime in the atmosphere. Since there are currently no commercially available capture and control technologies for carbon dioxide, there is no feasible option for avoiding these emissions for a thermal power plant. City Light has committed to obtaining offsets for any unavoidable greenhouse gas emissions.

Nitrogen oxide emissions will occur in portfolios with electricity created through combustion of fuel, including fuel from sources that are considered renewable such as biomass. The impact of nitrogen oxide (NO_X) emissions can be significant, depending on the existing air quality and the presence of other pollution sources in the vicinity. Other emission sources play a role because one of the ways NO_X affects air quality is through combining with other air pollutants and forming ground level ozone (smog). Therefore, the extent to which unavoidable impacts occur depends on location and nearby activities. Generally, NO_X emissions have impacts on both local air quality and at locations far from the site, as they can be transported long distances through wind movement. In addition, NO_X contributes to acidification

of precipitation and water bodies, and the subsequent damage to wildlife, vegetation, and the built environment.

Particulates can be efficiently, but not completely, controlled in many power plants. The remaining particulate emissions often affect the area around the plant the most, because their mass causes them to fall out of the air near the plant. However, smaller particulates could be transported longer distances.

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 Name of the Proposal

The proposed action is the adoption of an Integrated Resource Plan.

2.2 Proponent and Lead Agency

Seattle City Light

2.3 Location

The proposed action is not site-specific. The Integrated Resource Plan evaluates resources at potential locations throughout the Pacific Northwest (Washington, Oregon, Idaho, and western Montana).

2.4 Objectives of the Proposed Action

2.4.1 Need for and Purpose of an Integrated Resource Plan

2.4.1.1 Overview

Seattle City Light (City Light) is the municipal electric utility for the City of Seattle and surrounding areas. It owns and operates electricity generation, transmission, and distribution facilities, and serves approximately 408,000 metered customers.[3] City Light is preparing an Integrated Resource Plan (IRP) whose overall objective is to determine strategies for the type, amount, and timing of new energy resource acquisitions between 2012 and 2031. Resources are the methods by which City Light plans to meet its electricity needs, and encompass electricity generation options and conservation. The purpose of this Environmental Impact Statement (EIS) is to evaluate and disclose the potential environmental impacts of implementing the IRP.

This Need and Purpose section (Section 2.4.1) provides background on the IRP planning process and the context for how City Light evaluates its energy resource choices and their environmental impacts. In this section, the existing conditions and forecasts for the future of City Light's electricity resources and demand for electricity (load) are described, followed by a brief description of existing City Light electricity generation resources. Then, the measure for having enough electricity to meet load under a variety of conditions, called resource adequacy, is defined. Next, since energy resource planning also must consider factors beyond supply and demand, there is a section describing the policies, both internal and external to the City of Seattle and City Light, which influence the resource choices City Light makes.

Once this background has been established, Section 2.5, Development of Alternatives provides further detail on the quantity of resources that may need to be acquired and their acquisition time frame. The section also describes the potential resource types that are being evaluated, and the analytical process

[3] SCL Fingertip Facts, January 2012, pg 13, http://www.cityofseattle.net/light/AboutUs/CustomerGuide/docs/fingertipfacts.pdf

used to evaluate resource options, including a description of the computer model and inputs and assumptions used in the analysis. It also describes the potential range of future conditions for fuel and electricity prices in the wholesale market and resource performance.

Section 2.6, Description of Alternatives, describes the combinations of resources, called "portfolios" or "plans," which are the alternatives evaluated in this EIS. The resources contained in each portfolio are described along with the megawatts of resource capacity that each would add to City Light's existing energy resources. Finally, Section 2.7, Portfolio Evaluation, describes the relative performance of the alternative portfolios against the evaluation criteria.

2.4.1.2 Seattle City Light Load (Demand for Electricity) 2012-2031

Seattle City Light's service area covers about 131 square miles and includes all of the City of Seattle, plus all or part of several political entities to the north and south of the City limits. These entities include the cities of Shoreline, Lake Forest Park, Mountlake Terrace, Tukwila, SeaTac, Burien, Renton, Normandy Park, and parts of unincorporated King County.

Load growth is driven primarily by increases in employment and residential density. The City's Comprehensive Plan and the State's Growth Management Act both direct higher development density in urban areas. Multifamily housing construction is strong in City Light's service area. Although employment for King County is 4 percent less than its level in 2008, economic forecasters expect employment to reach pre-recession levels by the end of 2013.

Residential load accounts for about 34 percent of service area retail sales, with industrial load at about 11 percent, and commercial/government load about 55 percent. The commercial sector is growing the fastest. System load peaks in the winter, primarily due to residential heating loads, with power consumption peaking in early evening and early morning. There is a secondary peak in late afternoon during the July-August period caused by commercial-sector air conditioning systems.

Annual system energy load (adjusted for weather) reached a high of 1,154 average megawatts (aMW) in 2008 but fell by 2.6 percent to 1,124 aMW in 2010 during the Great Recession. The local economy has rebounded slowly and so has load. System load in 2011 was 1,134 aMW—10 megawatts more than in 2010, but still 20 aMW less than in 2008. Load is forecasted to grow at an average annual rate of 0.8 percent through 2031. Although there will be some years in which annual energy load growth will not be positive, the historical growth trend is expected to continue into the future. Figure 2-1 shows load history from 1985 through 2011 and the annual energy load forecast through 2031.

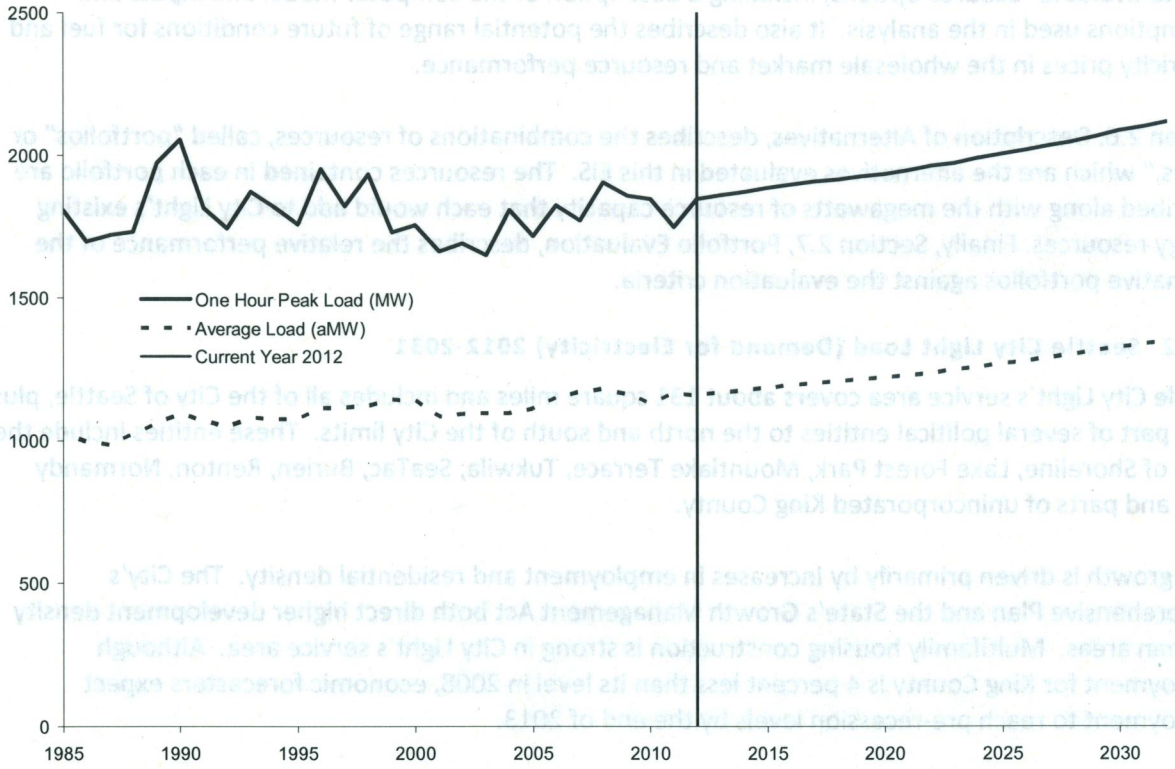

Figure 2-1. System Annual Energy Load and Peak Load History and Forecast

2.4.1.3 Seattle City Light Existing Energy Resource Portfolio, 2012-2031

City Light's energy resource portfolio consists of several SCL-owned hydroelectric projects and purchase contracts with the Bonneville Power Administration (BPA) and several other utilities. The energy resource portfolio also includes energy savings from conservation resources that City Light and its customers have already implemented.

Conservation Programs

Since 1977, City Light has delivered a comprehensive menu of energy efficiency services and programs to serve the energy efficiency needs of City Light customers in all sectors. These programs have provided a wide variety of financial incentives and technical assistance to encourage customers, for example, to insulate their homes, install energy efficient water heaters, or install energy efficient lights and HVAC equipment in commercial and industrial establishments. In 2011, the Conservation Resources Division secured 12.3 aMW of energy savings from the installation of conservation measures; this is enough electricity to power 12,600 Seattle homes for one year. Energy efficiency measures installed under past City Light conservation programs are still delivering energy savings; the program reduced City Light's load by 126 aMW—enough to power almost 130,000 Seattle homes for one year.

Generating Resources Owned By City Light

Boundary Project. The Boundary Project is a hydroelectric generating facility located on the Pend Oreille River in northeastern Washington. It is City Light's largest energy resource and has a peaking capability of 1,055 MW and average generation of about 400 aMW annually. It is a "run-of-the-river" project and is affected by other projects in the river basin. Since this project is located in the Columbia River Basin, it is also subject to the flow regulations established in the Biological Opinion issued by the National Marine Fisheries Service for the protection of fish populations. Like almost all non-federal hydroelectric projects, it is licensed by the Federal Energy Regulatory Commission (FERC). City Light is currently in the process of obtaining a new FERC license. Under the current license, part of the Boundary Project output is provided to Pend Oreille County Public Utility District (PUD) No. 1 to meet its load growth and in compensation for the Boundary Project's encroachment on their Box Canyon Dam. Energy from Boundary is delivered to consumers over Bonneville Power Administration's (BPA) transmission grid.

Skagit Project. The Skagit Project includes three large hydroelectric projects owned by Seattle City Light: Ross, Diablo, and Gorge. They are all located on the Skagit River, about 80 miles northeast of Seattle, and the three projects operate as a single system. Ross has a major water reservoir, and water released from Ross flows to Diablo and Gorge. The combined one-hour peak capability is 690 MW. The license for these projects was renewed in 1995 and will be in effect for 30 years. City Light has committed to mitigating measures for fisheries, wildlife, erosion control, archaeology, historical preservation, tribal cultural resources, recreation, visual quality, and environmental education. This project was certified as a Low Impact Hydropower facility by the Low Impact Hydropower Institute in 2003. Electricity from the Skagit Project is transmitted to Seattle over transmission lines owned by City Light.

South Fork of the Tolt Project. This small hydroelectric project, located in north central King County on the south fork of the Tolt River, went into commercial operation in 1995. This facility uses surplus water from an existing reservoir constructed for the City of Seattle's water supply. Its one-hour peak capability is less than 17 MW and annual average generation is about 6 aMW. Power is transmitted by Puget Sound Energy.

Newhalem Project. This small hydroelectric project is located on Newhalem Creek, a tributary of the Skagit River. It was built in 1921 to provide power for construction of the Skagit Project. During an average water year, this project produces slightly more than 1 aMW per month, but during late summer and early fall, it produces less than 0.5 aMW per month. In 1970, the Newhalem project was modernized and now operates under a FERC license that will expire in 2027. Power is delivered through transmission lines owned by City Light.

Cedar Falls Project. The Cedar Falls Project was built in 1905 on the Cedar River, about 30 miles southeast of Seattle. This is City Light's oldest generating resource; it was constructed by Seattle's Water Department, which retains priority rights to the water. Maximum output of this project is 30 MW. Cedar Falls was constructed before adoption of the Federal Power Act of 1920 and, therefore, does not need a FERC license to operate. Power is transmitted by Puget Sound Energy.

Source: SCL 2010 Integrated Resource Plan

Figure 2-2. City Light's Generating Resources

Power Purchase Contracts

Bonneville Power Administration. City Light's largest power purchase contract is with Bonneville Power Administration (BPA). The contract allows the utility to receive power from 29 hydroelectric projects, one nuclear plant, renewable projects, and market power in the Pacific Northwest. Energy is delivered through BPA's transmission grid. A Block and Slice Power Sales Agreement with Bonneville provides for power purchases by SCL. Through the Block product, power is delivered to the utility in monthly amounts (blocks) shaped to the utility's monthly net requirement, which is defined as the difference between SCL's projected monthly load and its non-BPA resources available to serve that load under critical water conditions. The Slice product provides SCL with a fixed percentage of the actual output of the Federal System. The Block energy shape during each year is largest during Seattle's heavy winter load months and smallest during the heavy spring snowmelt runoff months. Power available under the Slice product varies with water conditions, federal generating capabilities, and fish and wildlife protection and restoration requirements.

High Ross Agreement. City Light originally planned the Skagit hydroelectric projects to be constructed in stages. In order to fulfill that vision, in the early 1980s City Light intended to raise the height of its Ross Dam. Raising the dam would have increased the area of the reservoir, and increased inundation of land in Canada. The Canadian Province of British Columbia and City of Seattle entered into negotiations over the proposal to raise the dam and its consequences in Canada, and as a result, the 80-year High Ross Treaty was signed in 1986. The agreement provided that City Light would abandon its plans and instead would purchase power from the British Columbia Power Exchange. Under the agreement, power would be delivered and priced to mimic the generation (36 aMW) and costs that the High Ross Dam would have produced. The output received from this contract has a relatively high cost through 2020. After that, the cost will drastically decrease to a few dollars per MWh because the portion of costs equal to the cost of servicing the debt that would have been issued to build the High Ross Dam will end. Power is delivered over BPA transmission lines.

Lucky Peak Project. Lucky Peak, another hydroelectric project, was built by several irrigation districts in the mid-1980s near Boise, Idaho. In an average water year, it produces about 39 aMW. Power operations started in 1988 under a FERC license that ends in 2030. Power generation is secondary to the project's irrigation purpose, and most of the power output is available only in the summer months. Project costs were reduced when the outstanding long-term bonds were refinanced in early 2002. The power from this project is transmitted over facilities owned by Idaho Power and BPA.

Priest Rapids Project. The Priest Rapids hydroelectric project is owned and operated by Grant County PUD. The project consists of the Priest Rapids Development and the Wanapum Development on the Columbia River, upriver from the Hanford Reservation. City Light purchases power from this project under an agreement executed with Grant County PUD in 2002. Effective November 1, 2005, 70 percent of the Priest Rapids Project output was allocated to Grant County PUD. Seattle City Light is entitled to a share of the difference between the allocation to Grant County PUD and Grant County PUD's load requirements. As Grant County PUD's load grows, the amount of power available to City Light will decrease. City Light's share came solely from the Priest Rapids Development from November 1, 2005, through October 31, 2009. Effective November 1, 2009, City Light's share comes from both the Priest Rapids Development and the Wanapum Development. The term of the contracts runs through the end of the new FERC license period.

Grand Coulee Project Hydroelectric Authority (GCPHA). City Light has 40-year contracts to buy half of the output from five hydroelectric projects built by irrigation districts in the Columbia River Basin. The City of Tacoma buys the remainder of the output from the projects. The contracts expire over the period 2022-27. Electricity is generated mainly in the summer months and is delivered by local entities and BPA. Annually, City Light receives about 27 aMW from this contract. However, during an average water year, none is received during the winter months, and the amount received from spring until fall can vary from 20 aMW to nearly 60 aMW per month.

Stateline Wind Project. City Light has an agreement with J.P. Morgan Global Commodities to purchase wind energy and associated environmental attributes (Renewable Energy Credits) from the Stateline Wind Project located in Walla Walla County, Washington, and Umatilla County, Oregon. Project capacity is 175 MW. Energy delivered under the contract is expected to average about 26 percent of capacity, or about 45.5 aMW.

Exchange with Northern California Power Agency (NCPA). An exchange agreement with NCPA provides for City Light to deliver 60 MW of capacity and 90,580 MWh of energy to NCPA in the summer. In return, NCPA delivers 46 MW of capacity and 108,696 MWh of energy to City Light in the winter. Deliveries to NCPA started in 1995 and will continue until the agreement is terminated. Either party has the right to terminate the agreement after May 31, 2014.

In summary, Seattle City Light supplies power from a portfolio of sources that include self-generated assets and purchased power. Nearly half of City Light's electricity comes from its own hydroelectric resources. Figure 2-3 shows the 2010 sources of power.

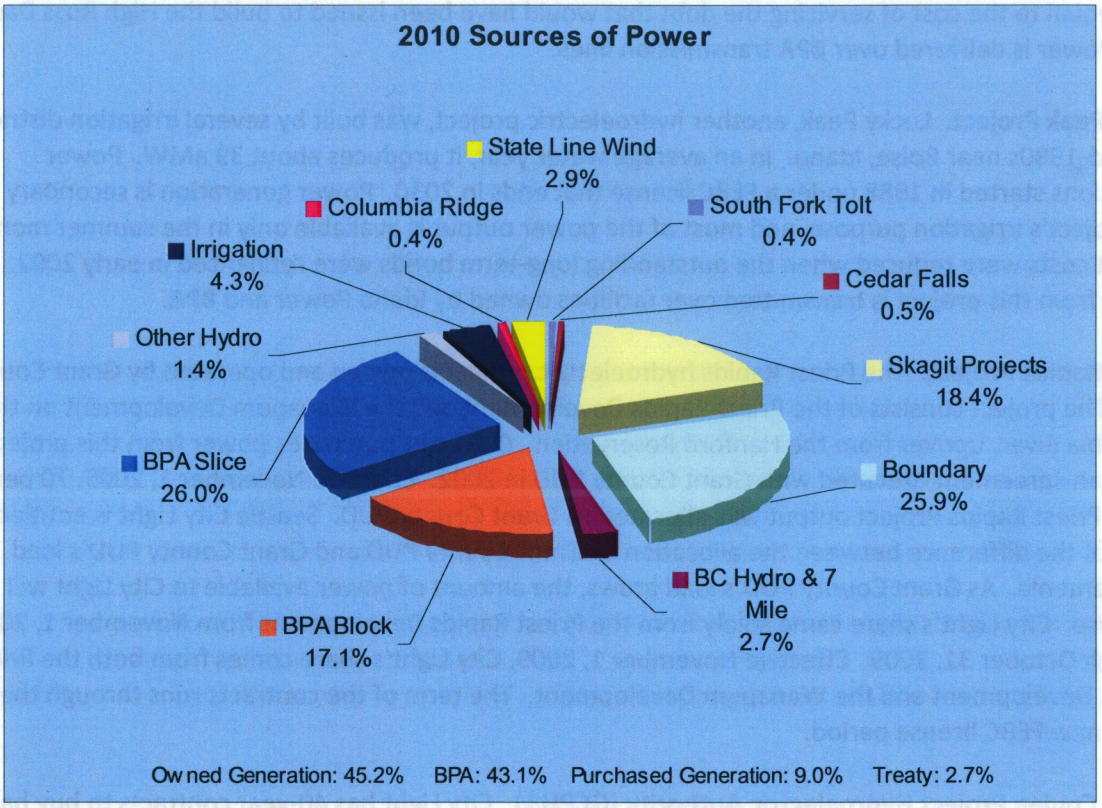

Figure 2-3. 2010 Sources of Power

Table 2-1 shows the amount of power generated by the projects owned by Seattle City Light and power purchased by the utility over the years 2006 through 2011.

Table 2-1. Seattle City Light Generation and Contract Energy (aMW) Actual Output Years 2006–2011

POWER GENERATED ANNUALLY in aMW	2006	2007	2008	2009	2010	2011
SCL-OWNED GENERATION:						
South Fork Tolt	6.1	6.4	6.5	5.8	6.2	5.7
Cedar Falls	8.6	7.6	9.8	8.7	7.5	12.6
Newhalem	1.0	0.6	0.2	0.3	0.5	0.2
Gorge	99.6	122.9	104.4	95.9	99.5	124.9
Diablo	85.1	95.3	86.1	78.9	82.2	105.1
Ross	73.2	98.1	75.0	71.0	74.0	99.4
Boundary	493.1	414.6	435.1	410.3	359.1	513.6
TOTAL OWNED GENERATION	766.7	745.5	717.1	671.0	628.9	861.5
PURCHASE CONTRACTS:						
Bonneville Power Administration Block	174.4	242.2	239.0	237.6	237.3	247.6
Bonneville Power Administration Slice	451.1	411.3	412.1	379.4	361.1	461.9
Grant County PUD (Priest Rapids)	2.8	2.9	2.6	3.8	19.2	3.7
Grand Coulee Project Hydroelectric Authority	27.6	29.1	29.6	29.7	27.5	27.1
Lucky Peak	46.5	31.2	35.4	36.9	32.6	44.4
Klamath Falls (contract expired in 2006)	11.4					
B.C. Hydro (High Ross)	36.1	35.8	35.3	35.7	35.1	35.8
B.C. Hydro (Boundary Encroachment)	2.6	1.9	1.9	1.7	1.8	2.0
Stateline Wind	43.9	44.0	49.2	40.2	39.8	47.2
Columbia Ridge				0.2	5.8	5.7
TOTAL PURCHASE CONTRACTS	796.4	798.4	805.1	765.2	760.3	875.5

2.4.1.4 Load Forecast vs. Existing Energy Resources

In planning for new energy resources, the IRP compared the forecasted differences between future load and existing resources that City Light owns or has contracts for over the planning period 2012 to 2031. Expected generation on an annual basis is sufficient to meet forecasted annual energy load through the planning period. However, two factors may cause actual generation from existing resources to be less than energy load.

First, actual generation can be much less than expected, depending on the amount of precipitation in the dam watersheds that City Light primarily relies upon, as well as other variables that affect generation. City Light's IRP analysis considered the amount of variation in precipitation, as well as other variables that affect generation, when assessing the suitability of possible additions to the utility's energy resource portfolio. This analytical process is described in more detail in Section 2.5,

Development of Alternatives. Second, the monthly profiles for loads and generation are not the same. For example, energy loads reach their highest levels during the winter months, while power generation is usually highest in May and June.

If severe weather occurs during the winter of a drought year, the system can be stressed from both the generation and consumption sides. The joint probabilities of low water and low temperatures, as well as the effects of load growth and other factors, are taken into account by the model City Light is using to assess the performance of the existing and alternative energy resource portfolios.

2.4.2 Policy Context for the Integrated Resource Plan

The 2001 power crisis in the West underscored the dangers of relying on the short-term wholesale power market for new resource needs. The Seattle City Council directed City Light to reinstitute long-term resource planning, which was implemented in 2006.

City Light's actions, including resource decisions, are determined within a policy framework. This framework includes both internal policies that are established by the utility and its policy makers (the Seattle Mayor and City Council) and state and federal laws. In addition, there are guidelines and best industry practices that are promulgated by industry organizations and agencies such as Public Utility Commissions that can be helpful in developing an IRP. This section describes the policies, laws, and guidelines that have the most impact on City Light's IRP process.

2.4.2.1 Internal Policies

Cost

It is City Light's policy to spend ratepayers' funds prudently and to make wise energy resource investment decisions to meet its customers' needs for electricity at reasonable cost. Producing and delivering low-cost power is part of City Light's mission, as described in the Vision, Mission, and Values Statement (see Appendix B). Recent City Council resolutions help guide City Light's approach to resource acquisition. Resolution 30685, passed in 2004, gives direction to City Light to consider long-term costs and objectives, stabilize rates over time, and to set rates to encourage conservation (one resource type considered in the IRP). Further, the Resolution states, "Electric utility rates should be sufficient to meet the City Light Department's revenue requirements, while charging the lowest possible cost to the ratepayer over the long run."

Purchasing and contracting for energy is more than half of the entire cost of serving customers, whether it is the cost of building, owning and operating a plant, or the cost of purchasing electricity through a contract. So keeping energy costs low is an important part of keeping overall costs to ratepayers low.

The Seattle City Council sets rates and policies for City Light. Periodically, the Mayor proposes new City Light rates that reflect the anticipated future cost to operate the utility, including the cost of new sources of power. The Council reviews the proposal and has final approval authority.

In the context of the IRP, the term "cost" is not the same as costs used for setting rates, although the two are closely linked. Cost, as used in the IRP, means only the cost that City Light will face to cover the fixed and variable cost of obtaining energy resources. Other costs that the utility may face to maintain its distribution system, pay taxes, or run the business are among the costs that go into rates, but are not considered here.

Calculating the cost of specific resources in the IRP does not include determining whether City Light should build and own a resource rather than contracting to buy the output of that resource. It is expected that the long-run costs of ownership versus contracting will be similar. With some exceptions, the determination will be made at the time that City Light is ready to acquire a resource and has received cost information for both approaches through competitive bidding. The exceptions are those energy resources that are, by definition, based on contracting for energy rather than building and owning the plant, such as capacity contracts, exchanges, and the short-term market (resources that will be described in detail in later sections).

Seattle City Light's long-term resource position and aggressive acquisition of conservation has made it not cost-effective for the utility to maintain the staffing and capabilities to develop, design, and construct new generating resources. It is expected that future new generating resources will be acquired by contract, as they have been since the 1960s. Since new generating resources are analyzed as contracts, they are directly comparable to each other within the IRP.

Costs in the IRP will be evaluated over the entire resource portfolio. For example, a higher cost resource could be included in small amounts in a portfolio, and that small addition could help City Light avoid investment in a much larger resource, which may have lower per unit of energy costs, but higher overall costs. It is necessary to evaluate resources in an *integrated* way to identify these resource combinations.

Environment

The City of Seattle and Seattle City Light have environmental policies that guide the resource planning and acquisition process. These policies include specific and general direction about how to protect natural resources and minimize impacts while serving the electricity needs of Seattle. Seattle City Light's Environmental Policy Statement is attached in Appendix B. It specifically calls for City Light to avoid, minimize, or mitigate impacts to the ecosystems that it affects, and to incorporate environmental costs, risks, and impacts when making decisions. City Light's Vision, Mission, and Values Statement reaffirms that minimizing environmental impacts and enhancing, protecting, and preserving the environment are key parts of City Light's goals. In addition, City Light has a policy to minimize impacts on fish and wildlife in operating resources, and to operate its hydroelectric facilities to meet or exceed applicable laws and license requirements. The potential to minimize and mitigate impacts of operating resources is a consideration in evaluating specific energy resource opportunities.

Conservation and Renewable Energy. Through a variety of City resolutions and ordinances passed over three decades ago, conservation was established as the first-choice resource to meet City Light's energy requirements. Since that time, the City has repeatedly affirmed the commitment to energy efficiency as its priority energy resource through additional ordinances and resolutions. Energy-efficiency measures installed under past City Light conservation programs are still delivering energy savings; the program reduced City Light's load by 126 aMW—enough to power almost 130,000 Seattle homes for one year.

The City of Seattle passed the 2000 Earth Day Resolution, which directed City Light to meet load growth with conservation and renewable energy as a strategy to avoid greenhouse gas emissions (see Climate Change section below). Toward that goal, in the last five years City Light has nearly doubled its annual energy savings goal to 14 aMW, while also purchasing 175 MW of capacity from the Stateline Wind plant.

Climate Change. In 1992, the Seattle City Council identified climate change as an environmental priority for the City of Seattle. City Light has a long history of initiatives and programs that help to reduce or mitigate greenhouse gas emissions that cause global warming. The utility started operating a comprehensive conservation program in 1977. In 1995, City Light joined the Climate Challenge, a U.S. Department of Energy voluntary program. Through the latter program, City Light reported projects that reduce or sequester greenhouse gas emissions such as conservation, efficient electricity production, and tree planting.

The City of Seattle's Earth Day Resolution directed City Light to meet load growth with cost-effective conservation and renewable resources, and to mitigate for greenhouse gas emissions from any fossil fuel use. It also set a long-term goal of "Net Zero" greenhouse gas emissions, which Seattle City Light achieved in 2005. This commitment is to be met every year. In July 2001, the Greenhouse Gas Mitigation Strategy Resolution was passed, setting standards for calculating greenhouse gas emissions and mitigation projects. Greenhouse gas emissions come from City Light facility operations, some power purchase contracts, power market transactions, the operation of vehicles, natural gas used to heat facilities, and SF_6 (sulfur hexafluoride) leakage.

Under its greenhouse gas neutral program, City Light estimates utility emissions each year, and then purchases offsets for those emissions that cannot be eliminated. The emission and offsets are balanced at the end of the year. Offsets are the result of actions that avoid, reduce, or sequester greenhouse gas. There are currently no federal or Washington state laws dictating how offsets are defined, created, and sold. However, several organizations have established protocols for creating, monitoring, and verifying offsets.[4] The state of California has a cap and trade program for greenhouse gas emissions that allows the use of offsets. This program is implemented by the California Air Resources Board.[5]

In the IRP analysis, the amount of greenhouse gas emissions of various resources and portfolios has been calculated. The cost of offsetting those emissions will be calculated based on a range of potential mitigation costs that City Light would pay under its Council mandate, or that might be imposed through greenhouse gas regulation or taxes.

In addition to City Light's commitment to greenhouse gas mitigation, the City of Seattle has also committed to achieving reductions in greenhouse gas emissions and is considering the possibility of reaching greenhouse gas neutrality for Seattle. The City's Climate Action Plan process grew out of the City's original goal of reaching the Kyoto Protocol emission reduction for the United States: a 7 percent reduction in greenhouse gas emissions compared to 1990 levels, to be achieved by the year 2012. To develop guidelines for meeting the goal, the Mayor appointed the Green Ribbon Commission on Climate Protection in 2005.

The original Commission, which included 18 leaders from Seattle's business, labor, non-profit, government, and academic communities, was specifically charged with developing local solutions to global climate disruption and a Climate Action Plan. The Climate Action Plan, completed in 2006, directed City Light to maintain its goal of meeting load growth with conservation and renewable resources, and to offset all greenhouse gas emissions. The Plan also identified other actions, including efficient use of natural gas and coordination between the gas and electric utilities serving Seattle to

[4] These programs include the Climate Action Reserve, the Verified Carbon Standard, and the American Carbon Registry

[5] California Air Resources Board, http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

deliver efficient services. Progress reports to the Climate Action Plan were issued annually from 2007 through 2010. In 2011, a report commissioned by the City was published: "Getting to Zero: A Pathway to a Carbon Neutral Seattle." This report assumes that City Light will continue to reach greenhouse gas neutrality and that electricity conservation efforts will be necessary. The City's work is ongoing in 2012 to update the Plan.[6]

Risk

Current practices in integrated resource planning focus increased emphasis on identifying and analyzing sources of risk. Different forms of risk are evaluated in the IRP; some risks are evaluated quantitatively, and some risks are evaluated qualitatively. Risks that can be quantified include:

- Variations in demand for electricity (City Light's load) caused by 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;
- Prices for electricity on the wholesale market;
- Cost of fuel such as natural gas; and
- Potential cost of complying with environmental regulations, particularly with respect to air emissions.

Evaluating these risks does not guarantee that they can be determined exactly. Instead, the evaluation defines a range of possible risk, and the range of associated cost.

Other types of risk can be more difficult, and sometimes 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.

One of the most significant types of risk that City Light deals with is the risk of purchasing and selling electricity in the wholesale power market. These transactions involve hundreds of millions of dollars annually, and the magnitude of wholesale revenues and purchases can swing significantly from year to year. City Light participates in the market to buy electricity when its own resources are not sufficient to meet demand, which occurs at some times of year under dry hydro conditions. In addition, City Light can use the energy storage capability at its hydro projects to purchase low-priced energy on the market and store water for use later when prices are higher. Currently, City Light sells much more electricity into the market on an annual basis than it purchases because of an energy surplus.

The risk of buying and selling on the market has two important aspects. One is the risk that City Light will have to buy power when it is expensive, and that if it had made different decisions about resources to add to its portfolio, it might have been able to avoid that higher cost. The second is that City Light will have to sell surplus power at lower than expected prices, leading to lower than expected revenues. The likelihood of facing either of these risks are difficult to predict, since City Light's hydro output varies so dramatically from year to year, and there are so many factors that determine demand and market prices.

[6] http://www.seattle.gov/environment/climate_plan.htm

A strategy City Light has used to avoid selling power at a low market price is to enter into agreements to sell energy for delivery at some future date (up to 18 months out) at a set price. This eliminates the uncertainty about the price City Light will receive, but it has its own set of risks. The greatest risk is that City Light will not have enough power to deliver as agreed because of dry hydro conditions, and will have to purchase power on the market to meet the obligation. Often, during times of low hydro production, the entire region is short on energy and subsequently, market prices are high. Therefore, City Light may have to buy power in the market at a price that is higher than it will receive for providing it under the contract.

Because of the risks of being short or long on resources, and because of the strategies used to deal with surplus and deficit energy, City Light, the Mayor, and City Council have been working to establish policies to manage that 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. The IRP will not provide "the answer," but will show how certain portfolios can result in more or less risk, and illustrate the options.

There are three stages in managing the risk of buying and selling electricity in the market. The first, planning a low-risk energy resource portfolio, is one of the primary goals of the IRP process. This goal is reached by evaluating the portfolios under a number of different combinations of future conditions, such as City Light's demand for electricity, the cost of market power, the cost of natural gas and other fuels, and environmental regulations. In effect, the IRP process attempts to test the portfolios against a range of conditions that might occur in the future.

The second stage involves implementing the long-term resource strategy developed in the IRP. This stage includes acquiring new energy resources. It may also involve entering into long-term transactions designed to improve the overall balance of loads and resources in the utility's portfolio.

The third stage of managing risk in the portfolio is to minimize risk on an ongoing basis. Resource portfolios will change over the years, and their output and performance can change daily or even hourly. This presents a significant challenge to utility operators who must make sure that City Light has enough electricity to meet demand at all times and understand the financial impacts of changing market conditions.

Reliability

It is generally accepted that electricity is a necessary part of modern life, and is critical to health, safety, and economic security. Consequently, providing reliable service is a critical mission for City Light. Producing and delivering reliable power is one of City Light's missions, as defined in the Vision, Mission, and Values Statement. Failure to provide reliable power has serious, immediate consequences, and City Light has practices and procedures to ensure that it is able to provide power or restore power quickly in case of events beyond its control.

Reliability, generally, means that when customers want to use electricity, that electricity is available. There are three principal requirements in making sure that power is available:

- There must be enough power generated to meet the demand.
- There must be sufficient transmission infrastructure, and that infrastructure must be functioning properly, to bring the power to City Light's service territory.
- There must be sufficient distribution infrastructure, and it must be functioning properly, to bring the power from the transmission system to the customer's location.

City Light is part of a very large electrical system that extends north to Canada, south to Mexico, and west to the Rockies. There are many generating plants and thousands of miles of transmission lines throughout this area, and hundreds of miles of distribution lines in City Light's service territory. It is a complex process for the various organizations and people to keep this infrastructure operating so that electricity is available to everyone at all times.

IRPs have traditionally focused on meeting a high standard of reliability for power supply and do not address reliability for transmission and distribution. The availability of electric transmission is considered an important aspect of power supply, and is, therefore, evaluated for any potential new resource. Issues such as transmission availability and the likelihood and cost of building new transmission are considered.

The distribution aspects of reliability are not considered quantitatively in the IRP, with one exception. Energy savings from conservation programs are assumed to have benefit in deferring investment in new distribution infrastructure. For purposes of quantifying those benefits in the IRP, the cost of all energy efficiency measures assessed in the IRP was reduced.

In general, the reliability of power supply depends on several factors:

- Adequacy of generating capacity to meet demand;
- Adequacy of fuel (water, natural gas, etc.) to create the energy needed; and
- 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 (see Section 2.4.2, Development of Alternatives, for more discussion). The PRN analysis is an important step in determining the types of resources, in what combinations, and at what point in time they would be needed to meet a reliability standard. In the PRN evaluation, City Light compared energy demand to the energy available from its owned and contracted resources, and a limited amount of market electricity. Many possible combinations of hydropower outputs (a critical issue given City Light's dependence on hydropower) and load were considered for each year over the 20-year planning period.

The first step in guaranteeing reliability is to ensure adequate generation of electricity. In addition to the price risk associated with selling or buying electricity in the wholesale market, there is also a risk for any type of generating resource whose output will not be available or predictable.

Each type of resource has its own set of uncertainties:

- Hydropower depends on precipitation, snowmelt, and even the variations in the migration and spawning cycles of fish in the river.
- Wind farms are able to produce electricity only when the wind blows.
- Natural gas plants also face fuel supply issues, particularly in high-demand periods. These plants can also experience unplanned outages that bring their output to zero.

In summary, the IRP process must consider the City of Seattle and City Light's internal policies related to costs and cost standards, environmental obligations, customer preferences, risks associated with generating vs. buying/selling electricity and the market, and reliability of generating and conveying electricity to meet customers needs at all times.

2.4.2.2 State and Federal Laws and External Guidelines

Washington State Integrated Resource Planning Requirement

In 2006, the Washington State Legislature passed a law that requires all large consumer-owned utilities that are not full-requirements customers of BPA to prepare a detailed IRP. Further, it encourages the governing body of a consumer-owned utility to promote public participation when developing the plan. Seattle City Light must comply with this law. An IRP must describe the mix of generating resources and conservation and efficiency resources that will meet current and projected needs at the lowest reasonable cost to the utility and its ratepayers. The plans must contain a number of elements, including:

- Demand forecasts for at least the next 10 years.
- Assessments of commercially available conservation and efficiency resources.
- Assessments of commercially available utility-scale renewable and nonrenewable generating technologies.
- Comparative evaluations of renewable and nonrenewable generating resources.
- Demand forecasts and resource evaluations must be integrated into a long-range assessment describing the mix of supply-side generating resources and conservation and efficiency resources.
- A short-term plan identifying the specific actions to be taken by the utility consistent with the long-range integrated resource plan.

City Light must submit its updated plans to the Washington State Department of Commerce every two years after the initial reporting date of September 1, 2008.

Regional Power Supply Planning Efforts

The Northwest Power Planning and Conservation Council (NWPPC) has worked with regional utilities and the Bonneville Power Administration to develop a regional standard for power supply availability to use for guidance in long-term resource planning. The NWPPC Council adopted this standard for its own planning process and recommended that other entities in the region incorporate it into their planning efforts.

The regional standard is not intended to be mandatory, but rather a gauge used to assess whether the Northwest power supply is adequate to meet load requirements under most circumstances, which is a minimum threshold for resource acquisition. However, the NWPPC Council encourages utility planners to think beyond this minimum and consider strategies that also protect against potentially bad economic outcomes. As new information becomes available, underlying assumptions for this regional energy standard will be updated. The intent is for this process to be dynamic, and the NWPPC Council recommends that an assessment of the region's resource adequacy be made at least once per year.

The regional standard is addresses the unique characteristics of the Pacific Northwest including the region's winter peak loads (compared to summer peak loads across most of the West) and the region's heavy dependence on hydroelectric generation.

Transmission Adequacy Standards

BPA owns over 75 percent of the transmission infrastructure in the Pacific Northwest. In late 2004, BPA began developing transmission adequacy standards in order to determine how much transmission it needs, the solutions to be deployed, and the criteria to guide prudent investment decisions consistent with its obligations. Because of the interconnected nature of the electric grid, transmission adequacy standards would be most effective if the standards were applied across all transmission in the Northwest. If this cannot be achieved, a BPA standard must be developed with input from all stakeholders. Thus, BPA engaged regional stakeholders in its effort to develop those standards that would apply to the federal transmission system. Transmission Adequacy Standards are proceeding through the auspices of the Transmission Adequacy Work Group of the Northwest Power Pool's Northwest Transmission Assessment Committee.

Bonneville Power Administration

City Light purchases approximately 44 percent of its power supply from BPA, the power-marketing agency for electricity generated from the projects owned and operated by the U.S. Army Corp of Engineers and the Bureau of Reclamation. Decisions by the President, Congress, the Department of Energy (DOE), and others affect the marketing of this power and can have a significant impact on City Light's resource portfolio cost, risk, and reliability. For purposes of the IRP, City Light assumes that BPA will continue to sell it the same amount of power it currently receives under its 2011 block and slice contract, at cost-based rates. City Light is a transmission-dependent utility that relies heavily on purchases of significant amounts of transmission from BPA to transfer power from City Light's remote generating resources to its load.

BPA allocates the output of the Federal Columbia River Power System (FCRPS) to its Northwest customers and the rate will reflect the costs of the FCRPS. To the extent that publicly owned utilities need more resources than are allocated to them from the FCRPS, they will have to either acquire additional new resources themselves, or contract with BPA to do that for them and then reimburse BPA for the costs of those additional resources

Washington State Renewable Portfolio Standard Initiative

Initiative 937, the Energy Independence Act, mandates certain utilities in Washington State, including City Light, acquire renewable resources for meeting their load. It also requires that these utilities

evaluate the potential for cost-effective conservation in their service territories, and establish and make public an acquisition target for conservation. The renewable resource portfolio requirements in the initiative increase over time: at least 3 percent of a utility's load by January 1, 2012; 9 percent by 2016; and 15 percent by 2020. This requirement can also be met by using Renewable Energy Credits (RECs), also called green tags. There is a financial penalty for failing to meet the requirement. Existing hydropower generation is not counted toward the target. Stateline Wind, at approximately 3 percent of current load, and efficiency upgrades resulting in additional power output at City Light hydropower plants (completed after March 31, 1999), are eligible resources for meeting the target.

Environmental Regulations

At the federal level, recent EPA regulations (the Cross State Air Pollution Rule and the Mercury and Air Toxics Standards) will set tighter limits for emissions of common air pollutants from power plants: oxides of sulfur and nitrogen, mercury, and hazardous and toxic air pollutants. Other regulations will further limit emissions of particulate matter. These regulations may become more restrictive during the planning period, and states may set their own more restrictive standards as well. Meeting these limits can be a significant technical challenge, as well as a significant additional cost, for power plants that burn fossil fuel.

Also significant for the electric utility industry, in response to 2008 legislation, the EPA has issued a regulation requiring that sources of greenhouse gas emissions, including power plants, report those emissions.[7] According to the EPA's Frequently Asked Questions web page, "In general, the rule calls for fossil fuel suppliers and industrial gas suppliers, manufacturers of vehicles and engines outside of the light-duty sector, and certain downstream facilities that emit greenhouse gases (primarily large facilities emitting 25,000 metric tons of carbon dioxide equivalent (metric tons CO_2e) or more of GHG (greenhouse gas) emissions per year) to submit annual reports to EPA." There is an exception for sources that the EPA calls "biogenic fuels," which includes wood biomass for electricity production. The EPA had treated these emissions as being "net zero," because of the closed loop carbon cycle in the uptake of carbon by the wood fuel source and eventual regrowth and recapture of carbon in that fuel source. In July 2011, the EPA exempted biogenic fuels form the reporting requirement.

Questions have been raised about this approach and EPA has agreed to reevaluate biogenic carbon dioxide emissions and stated that it will make a determination about whether and how these sources should be included in the Reporting Program sometime in 2014. For this EIS, a framework for addressing this issue was developed and three different possible emission rates for biomass were evaluated.

In March 2012, EPA proposed a New Source Performance Standard under the Clean Air Act, called the Carbon Pollution Standard for New Power Plants[8]. This regulation was the result of EPA's decision in 2009 that greenhouse gas emissions endangered human health, following a U.S. Supreme Court ruling that EPA had the authority to regulate these emissions. The proposal would not apply to plants that are currently operating or those that are newly permitted and begin construction within 12 months of the proposal. The standard would apply only to new fossil-fueled (not biomass) power plants larger than 25 MW. The standard would require new plants to meet an emission limits of 1,000 pounds of carbon

[7] http://www.epa.gov/climatechange/emissions/ghgrulemaking.html
[8] http://www.epa.gov/climatechange/emissions/ghgrulemaking.html and http://epa.gov/carbonpollutionstandard/pdfs/20120327factsheet.pdf

dioxide (CO_2) per MWh of electricity produced. EPA states that most new natural gas combined cycle combustion turbines would meet the standard and that 95 percent of these types of plants built since 2005 meet the standard. EPA also says that new coal plants would be allowed to use technologies such as carbon capture and storage/sequestration. However, those technologies are not currently commercially available, and there is uncertainty about when these technologies might be available, and what the cost and effectiveness of controlling CO_2 long-term would be.

Washington state is a member of the Western Climate Initiative, but legislation has not been passed that would bind the state to the emission limits set forth in that Initiative. The only state that has legislated limits on greenhouse gas emissions is California. The Regional Greenhouse Gas Initiative resulted in a cap and trade program that has been imposed on power plants in northeastern states. Due to the economic downturn, prices for CO_2 emissions allowances have been low and power plants have been able to meet those limits. Washington and Oregon have laws that require new power plants that burn fossil fuel to mitigate portions of their greenhouse gas emissions. A Washington state law prohibits electric utilities from purchasing power from plants that emit more than 1,100 pounds of carbon dioxide per megawatt-hour for longer than a five-year term.

Federal Clean Water Act regulations are also becoming more stringent. Power plants that use water for cooling could be affected by these changing regulations, as restrictions increase on removing water from, and discharging cooling water into, surface and groundwater sources. These restrictions are often related to protecting habitat for fish and wildlife, as well as protection of human health.

Coal plants also face new EPA regulations on the storage and disposal of coal ash[9]. In 2010, the EPA proposed regulating Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) for the first time. These regulations could limit disposal alternatives for CCRs and increase disposal costs.

The Endangered Species Act (ESA) can affect the potential to site new power plants and transmission facilities. Currently, hydropower operations are often regulated because of their potential impacts on ESA-listed fish species. As new species are listed, and as new information about hydropower operations' effects on those species becomes available, the operational rules may change. Consequently, this could change both the amount and the timing of hydropower output. This issue is extremely important to City Light given its reliance on both its own hydropower facilities and on the Bonneville Power Administration's supply.

Under current conditions, it is very unlikely that new coal plants will be built in the western states serving City Light load. The states of Washington[10], Oregon[11], and California[12] have regulations that effectively prohibit new coal plants or render them uneconomical by imposing CO_2 emission limits and costs. In fact, owners of the only coal plants in the states of Washington and Oregon, the Centralia and Boardman plants, have announced that they will close those plants by 2025.

---

[9] EPA Coal Combustion Residuals, http://www.epa.gov/wastes/nonhaz/industrial/special/fossil/ccr-rule/index.htm
[10] Washington CO2 Mitigation and Emission Performance Standards for Greenhouse Gases, Chapter 463-80 WAC Carbon Dioxide Mitigation for Thermal Electric Generating Facilities and Chapter 463-85 WAC Greenhouse Gases Emissions Performance Standard and Sequestration Plans and Programs for Baseload Electric Generating Facilities
[11] Oregon Energy Facility Siting Council, Carbon Dioxide Emission Standard, http://www.oregon.gov/ENERGY/SITING/standards.shtml#Carbon_Dioxide_Emissions
[12] California Global Warming Solutions Act, AB32, http://www.arb.ca.gov/cc/ab32/ab32.htm

Renewable electricity sources will likely be developed to fulfill renewable portfolio standards in the western states, with California leading the demand with a requirement of 33 percent renewable sources[13] supplied to retail electricity customers by 2020. The environmental attributes, also called Renewable Energy Credits (RECs), and the rights to claim those attributes, will be sold as a separate commodity, with or without the electricity. Therefore, purchasers of market electricity generated at a renewable power plant, but lacking the associated environmental attributes, cannot claim the renewable/environmental attributes.

Northwest Power and Conservation Council 6th Power Plan

The Northwest Power and Conservation Council (NWPCC) is a public agency created by the Pacific Northwest Electric Power Planning and Conservation Act of 1980.

The agency has responsibility to develop a regional power plan and to implement fish and wildlife programs. Its three major functions are:

1. Develop a 20-year electric power plan that will guarantee adequate and reliable energy at the lowest economic and environmental cost to the Northwest
2. Develop a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin
3. Educate and involve the public in the Council's decision-making processes.

The NWPCC's Sixth Power Plan (February 2010) forecasts a surplus of power for the next few years. A power surplus resulted when loads declined due to the recession of 2008–2009. The Plan recommends that the region aggressively pursue conservation programs and lay the groundwork for building renewable generation required to meet state renewable portfolio standards and natural gas-fired generation that will be needed later in the 20-year planning period.

[13] California Senate Bill SBX1-2, http://www.energy.ca.gov/renewables/index.html

2.5 Development of Alternatives

This section summarizes the process used to develop alternatives. Alternatives were formulated by first determining energy resource needs during the planning period. Once needs were defined, City Light created a number of possible combinations of new resource additions that could meet that need. These combinations are called "portfolios." The portfolios were tested against a wide range of future business environments that reflected variability in hydro conditions, fuel prices, and demand for electricity. One of the business environments is a baseline forecast called the Reference Case. City Light employed a power market model, *Aurora xmp*, to evaluate each of the portfolios. Each portfolio except Mixed Resources was designed with a linear optimization. Given the resources it contained, each portfolio was dispatched to most efficiently meet the demand it faces. The portfolio results were then compared to City Light's key objectives, or criteria, for evaluating portfolios to create a portfolio scorecard. The key criteria are cost, environmental impact, risk, and reliability.

2.5.1 Determination of Resource Need during the 2012-2031 Planning Period

As discussed in Section 2.4.1.4, Load Forecast vs. Existing Resources, City Light considered a wide range of potential future conditions to determine its needs for new electricity supply. The probabilistic resource adequacy evaluation was based on the objective that the utility provide sufficient resources to meet customer needs under a wide range of conditions that can affect both supply and demand for electricity.

Resource needs can consist of both *Energy* and *Capacity* needs. Having sufficient energy means there are available electric resources to meet customer needs across an extended period such as a month, a season or a year. Capacity refers to the sufficiency of electric resources available to meet customer needs during a much shorter period such as a peak hour or day, including when temperatures are colder than normal. Power supplies and demand-side resources are included in both adequacy measures.

To address energy resource adequacy for its 2012 IRP, City Light evaluated the probability that all of the energy needs of its customers will be met. This approach identifies a threshold specifying the amounts and timing of new resources that must be added by City Light to meet all customer energy needs with a given probability. Alternative portfolios that include the new resources were defined and then evaluated using computer-based modeling tools that quantify performance with respect to cost, risk, and environmental objectives (air emissions). Further details about the process used for the first round of portfolio analysis for City Light's 2012 IRP are described in Section 2.5.2 Formulation of Portfolios.

The specific energy measure that was selected for the portfolio analysis for the 2012 IRP is at the 90 percent probability level, less 300 megawatts. The 300 megawatts represents the operational flexibilities that City Light is expected to have even under the most challenging conditions. With this measure, there would be "a 90-percent confidence of having no unserved energy from City Light's own resources in a month."

City Light used a computer model (described in more detail below) to simulate many possible combinations of demand and hydro conditions, and to determine the resource requirements necessary to achieve a 90-percent confidence level of having not even one hour of unserved energy in a month.

The analysis demonstrates City Light's need for additional resources are limited in the next decade to periods of high demand and poor hydropower conditions. Assuming the 2012 strategic plan level of

new conservation resource acquisition, City Light's other resources are sufficient to meet a 90-percent confidence level during the typical peak demand winter month (December) through 2020. The (after conservation) winter resource need grows from 5 aMW in 2021 to 218 aMW in 2031.

2.5.2 Formulation of Portfolios

Once the resource need was defined, City Light created a number of possible combinations of new resource additions to meet that need over the 2012-2031 planning period. These combinations are called "portfolios." The resources that City Light chose from are listed in Table 2-2. These resources and their environmental impacts are described in Appendix C. The portfolios are described in more detail in Section 2.6, Description of Alternatives.

Table 2-2. Resource Options

Conservation
Landfill Gas
Hydro Efficiency Improvements
Geothermal
Biomass
Wind
Solar Energy
Combined Cycle Combustion Turbine (CCCT)
The Wholesale Power Market

2.5.2.1 Reference Case and Futures—Model Inputs and Assumptions

All forecasts of fuel prices over the 20-year planning period have been supplied by Ventyx, Inc. City Light used the baseline forecast, called the Reference Case, to plan for a future electric business environment in which the resource portfolios are most likely to operate. It also analyzed the resource portfolios using a broad range of potential alternate futures. These futures are used in the study in explicit recognition that the business environment for Seattle City Light could vary substantially over the next 20 years, depending upon future political, economic, regulatory, and environmental trends. Each future has an associated set of forecasts for energy supply, demand, and prices for the Pacific Northwest. Specifically, the forecasts include natural gas, regional supplies of power resources by generation type, load-resource balance, expected demand growth in the Pacific Northwest, and spot market prices at key market hubs for wholesale power transactions in the West.

While the focus of City Light's resource planning is the Pacific Northwest, price forecasts for power are driven by the western wholesale power market in which City Light conducts power transactions. This West-wide power market is commonly influenced by such diverse factors as hot temperatures in Southern California, transmission constraints at Palo Verde in the Desert Southwest, precipitation levels in the Pacific Northwest, coal plant outages in Montana and Utah, and power exports from British Columbia, Canada.

Forecasts used in the Reference Case are described in the sections that follow.

Fuel Prices

The following provides an overview of the fuel price forecasts being used in the IRP:

Natural Gas. The market for natural gas in the Pacific Northwest is heavily influenced by national market trends because of the national, interconnected network of natural gas pipelines. Natural gas-fired generation plays a key role in the West because it is usually the last generating unit to be dispatched (known as the "marginal unit"). The cost of dispatching the marginal unit often sets the short-term power price in the western wholesale power market. Thus, even though City Light does not own or contract for natural gas-fired generation, the price of natural gas will continue to be an important factor in determining City Light's wholesale power costs and revenues.

In the Reference Case, future natural gas prices grow slowly and range from an annual average of $4.31 per MMBtu (million Btu) in 2012 to $7.82 per MMBtu in 2031 (2010 dollars). The forecasted moderate growth in natural gas prices is likely to result in continued growth in the use of natural gas-fired turbines. Natural gas-fired turbines also have a strong impact on prices and emissions rates of the western wholesale spot market

Northwest Supply and Demand for Electricity

The interconnected, high-voltage electric transmission system physically defines the wholesale market for electricity in the West (generally the 11 western states, two Canadian provinces, and Baja, Mexico). In 2012, parts of the West have surplus generating capacity, including the Pacific Northwest. Demand in the West (Western Electric Coordinating Council) is forecast by Ventyx to grow at an average of 1.3 percent annually, a significantly faster rate than forecast for the City of Seattle. Despite the higher western growth rate, the Ventyx Reference Case forecast estimates that the Pacific Northwest will have more than adequate reserves for the next decade under average conditions.

Based on future conditions that are considered most likely, referred to in the IRP as the Reference Case, it is anticipated that most growth in electric power resources in the Pacific Northwest will come from natural gas-fired generators. Hydro and nuclear generating capacity is forecasted to remain relatively constant in total. A number of coal-fired facilities are scheduled to be retired over the planning period. Renewable energy sources also see significant growth, adding over 29,000 MW of generation (non-dependable) capacity by 2031.

2.5.2.2 The Model

The model, *Aurora xmp*, incorporates a complete description of the resources available, the prices of fuel and power, and the load. It simulates the dispatch (operation) of the resources available to it to meet the demand it faces each hour of the year at the lowest possible cost. If it runs out of resources before meeting demand, or if wholesale market power is cheaper than the cost of dispatching resources in the portfolio, then it will purchase from the market. The model also dispatches energy resources to sell into the wholesale market when it is profitable. This use of a resource helps to reduce the overall cost of having it in the portfolio. Note that the costs associated with the Reference Case assumption of future carbon dioxide emissions are included in the dispatch decision.

As the model dispatches resources, it keeps track of the cost of operating the resources, quantifies a variety of air emissions and the hours of load not served, among a host of other data. These data are

used for the evaluation criteria noted earlier. The model also considers uncertainty about the future such as uncertainty about future prices for fuel and power, customer demand, and the availability and variability of water for hydro generation. The model can produce random draws (or selections from all possible values) of fuel and power prices, generation, and load that can constrain it in several ways. First, there are relationships between power prices and fuel prices. For example, higher fuel prices will lead to higher power prices, and fuel prices themselves often move in tandem. Second, because of the size of the hydro system in the Northwest, during the snowmelt runoff period (April to June), wholesale market prices for power are often depressed as the hydro system displaces fossil fuel generation in the region. The effect is relatively short-lived, but it is important.

These correlations among the variables in the model must be accounted for when making a random draw. For example, a draw including hydro conditions in Eastern Washington at the Pend Oreille River (Boundary dam) should have a strong correlation to the hydro conditions on the upper Columbia River (a series of federal hydro generation facilities) and a lesser correlation to Western Washington hydro conditions on the Skagit River (Ross, Diablo, and Gorge dams).

For each hour analyzed, the model generates a draw of correlated values for the hydro, demand, and fuel price, and dispatches the resources as described earlier. It repeats the random draw-dispatch process many times, producing a distribution for each output. Those distributions reflect the underlying distributions and correlations for prices and other variables.

2.6 Description of Alternatives

Integrated resource planning commonly involves examining a wide range of alternative resources. Washington State law requires that City Light "perform a detailed and consistent analysis of a wide range of commercially available resources."

The Proposed Action covered in this EIS is adoption of an Integrated Resource Plan containing City Light's long-term strategy (types of resources, amounts, and timing) for meeting electrical load over a 20-year period. Once electricity needs were defined, City Light developed a number of possible combinations of new resource additions (portfolios) that could meet the need. These were then reduced to three portfolios that performed the best. Seattle City Light has selected the Renewables: Base Conservation Plan as the preferred alternative.

2.6.1 Objectives

Three key objectives were considered in constructing the resource portfolios:

1. Develop a wide range of resource portfolios, including those containing predominantly renewable resources, those containing predominantly non-renewable resources, and those with a mixture of renewable and non-renewable resources.
2. Ensure sufficient supplies of generation each month during the 20-year period to avoid unserved energy needs.
3. Use a mix of resources believed to be commercially available to Seattle City Light and resources specifically recommended for inclusion in the portfolios through the public input process.

Alternative resource portfolios that would satisfy City Light's future energy needs were formulated. Evaluation criteria covering cost minimization, risk management, reliability, and minimization of

environmental impacts (air emissions) were established for the portfolios, and each was analyzed with a computer model to determine how well they would perform under different future conditions. Assumptions about fuel and electricity prices, electricity supply and demand, and environmental regulations were varied. The EIS uses the baseline assumptions about these variables (compiled as the Reference Case). The nine alternative portfolios are listed below. The No Action alternative was evaluated for analysis purposes only, but it does not meet reliability criteria.

1. No Action – Rely on the Market (Does not meet reliability criteria)
2. Renewables: Base Conservation
3. Renewables: Lower Conservation
4. Renewables: Higher Conservation
5. Wind and Gas
6. Mixed Resources
7. Renewables: No Waste Wood Biomass
8. Natural Gas
9. Renewables: Constant Rate Conservation

The total conservation acquired by 2031 varies little across portfolios, since it is driven by the amount of cost-effective potential. However, the pace that the conservation is acquired does vary over the 20-year period and affects portfolio performance on financial, risk, and environmental measures. It also affects the timing and amounts of more expensive resources that must be acquired. Table 2-3 depicts the total new resources acquired in each of the resource portfolios between 2012 and 2031.[14]

Table 2-3. Total New Resources by Portfolio (Cumulative Average Megawatts in 2031)

Resource	Resource Portfolio							
	2 Renewables: Base Conservation	3 Renewables: Lower Conservation	4 Renewables: Higher Conservation	5 Wind and Gas	6 Mixed Resources	7 Renewables: No Waste Wood Biomass	8 Natural Gas	9 Renewables: Constant Rate Conservation
Conservation	237	206	237	237	237	237	237	237
Landfill gas	8	8	8		8	8		8
Hydro Efficiency	5	5	5		5	5		5
Geothermal	20	20	20		20	20		20
Biomass	40	40	40		20			40
Wind	125	125	125	125	35	125		125
Solar Thermal					80	10		
Solar PV	20	50	20			50		20
CCCT				93	50		220	
RECs							34	

With the exception of the Mixed Resource portfolio, the eight portfolios were designed using a linear optimization to help determine which resources are added and when. This included estimating the total

[14] The totals in Table 2-3 are for the year 2031. Please note that the totals may vary among portfolios because they represent generation capacity vs. energy actually produced. For example, because of the lesser reliability of wind energy, a greater generation capacity is required to produce an amount of electricity equal to that produced by another resource with higher reliability.

amounts of cost-effective energy resources that may be accessible to City Light given transmission and resource availability constraints. And, based upon different resource strategies, some resources were further constrained in the linear optimization, such as the portfolio that tests a strategy of not including waste wood biomass, or portfolios that test different conservation acquisition strategies.

Five of eight portfolios were eliminated from further consideration based upon their performance in computer simulations and consistency with City policy. The remaining three portfolios and the No Action (Rely on Market) are analyzed as Alternatives in this EIS and will be further evaluated based on this analysis and comments received. With the input of the IRP Stakeholders, City Light has identified a Preferred Alternative: Renewables: Base Conservation.

2.7 Portfolio Evaluation

2.7.1 Portfolio Evaluation Criteria

After each resource portfolio was modeled, the portfolios were evaluated in comparison to each other. A series of calculations are completed for measures of cost, environmental impact (air emissions), risk, and reliability. These criteria were selected for evaluating the relative performance of the resource portfolios being studied. All costs and revenues are expressed in real dollars, as a net present value using a 3 percent discount rate. The portfolio evaluation criteria are shown in Table 2-4.

Table 2-4. Portfolio Evaluation Criteria

Portfolio Evaluation Criteria	Criteria Measures
Minimize costs to customers	20-year net present value of portfolio costs
Manage risks	Volatility of portfolio costs
Provide reliable service	Occurrence of unserved customer energy need
Minimize environmental impacts	Level of environmental impacts including monetized values for pollutant emissions including CO_2, SO_2, NOx, Mercury
Meet City Policies	City Council Resolutions, including #30144

Cost

Fixed costs are evaluated in the form of capital costs for generation plants and electric transmission expansions or upgrades. Variable costs include fuel, plant start-up costs, variable operations and maintenance (O&M), and carbon dioxide offset costs. Carbon dioxide offset costs are internalized in the analysis because of the City's policy on greenhouse gas emissions.

Environmental Impact

Air Emissions. Air emissions was the only environmental factor explicitly included in the modeling and analysis of portfolios because of its importance and because it can be quantified without specific siting information. For each generating resource portfolio, total emissions into the air of carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen oxides (NOx), mercury (Hg), and particulates (PM) are estimated over the 20-year period. A monetary cost based on the estimated cost of regulation is applied to the emissions to facilitate evaluating the cost of complying with potential environmental regulations in the future. The compliance costs of each portfolio are tabulated by year and expressed as a net present value. The total

costs of emissions are varied in the alternative futures to gain a sense of the how well the portfolios perform under different regulatory scenarios. These costs are included in the cost evaluations described above.

There are several methods to determine the societal costs of environmental impacts such as air emissions. In addition to the internalized cost comparisons described above, the emissions for each resource portfolio are calculated. In this case, control costs are used as a proxy for the net environmental damage from air pollutants of each portfolio.

Other Environmental Impacts. The three portfolios that preformed best in the model analysis: Renewables-Base Conservation, Renewables-Higher Conservation, and Wind and Gas, are analyzed in this EIS for impacts to several environmental elements. These include land use, surface and groundwater, soils and geology, plants and animals, employment, aesthetics and recreation, environmental health, and cultural and history. Each portfolio was assessed for the level of impact in each element and ranked high, moderate, or low for that element.

Risk

Risk is measured for the costs of the resource portfolios, including the impacts of net market purchases and sales. Varying fuel prices and the extent and frequency of plant operations affect variable costs. Net revenues from market purchases and sales are influenced by the extent of surplus generation and the spot market price. Initially, a mean absolute deviation is calculated for each portfolio. In the more detailed evaluation of the final three portfolios, a stochastic risk analysis is conducted.

Reliability

Reliability is factored into the analysis early in the process. Each portfolio is constructed to meet all loads and water conditions with 90-percent confidence level (less 300 megawatts) for December hourly loads. As constructed, the portfolios produce little or no unserved energy and produce no meaningful differences among the portfolios that, by definition, provide a high degree of reliability. Another, less direct measure of reliability is the net market purchases and sales. Portfolios that rely more heavily on market purchases may be less reliable. However, in all resource portfolios, Seattle City Light would continue to be a large net seller through this decade.

2.7.2 Portfolio Evaluation Results

After each energy resource portfolio is modeled, the portfolios are evaluated in comparison to each other. A series of calculations are completed for measuring cost, environmental impact (air emissions), risk, and reliability. These criteria were selected to evaluate the relative performance of the resource portfolios being studied. .

The top four portfolios performing in terms of net present value of net power costs (revenues net of costs) and risk are:

- Natural Gas
- Wind and Gas
- Renewables: Higher conservation
- Renewables: Base conservation

When the Natural Gas portfolio was dropped from further consideration due to inconsistency with Council Resolution 30144 and high levels of air emissions, the top three portfolios became:

- Wind and Gas
- Renewables: Higher conservation
- Renewables: Base conservation

These three portfolios and the No Action Alternative are analyzed in this EIS.

2.7.3 Portfolio Descriptions

A brief description of each of the three portfolios remaining after preliminary analysis follows.

2.7.3.1 Renewables: Base Conservation

As its name implies, the renewables portfolio contains many renewable resources. These renewable resources are believed to be available by expanding existing contractual relationships or by establishing new ones. It contains the base case conservation plan, as described in and consistent with the Draft Seattle City Light Strategic Plan. This portfolio of resources continues an aggressive accelerated conservation strategy, first identified and tested in the 2008 Integrated Resource Plan. Emissions in the portfolio are assumed to occur from two of the seven resources: biomass and landfill gas. For the base case analysis, the biomass and landfill gas resources are treated as greenhouse gas neutral, as they are under Washington State law. However, a framework was developed to look at CO2 emissions from biomass under different assumptions for the importance of timing of sequestration, potential alternative fates for the fuel, and the rate of decomposition and sequestration.

Table 2-5. Renewables: Base Conservation

(Average Megawatts of Energy, 2012 through 2031)

P2: Renewables - Base Cons.	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
- Conservation	14	27	41	55	69	83	97	111	125	139	153	167	181	194	205	213	220	227	233	237
- Landfill Gas									8	8	8	8	8	8	8	8	8	8	8	8
- Hydro Efficiency												5	5	5	5	5	5	5	5	5
- Geothermal																				20
- Wind							10					20	90	100	125	125	125	125	125	125
- Wind 2																	15			
- Solar PV																				20
- CCT																				
- RECs (aMW)						3				7										

2.7.3.2 Renewables: Higher Conservation

The Renewables: Higher Conservation portfolio tests an even more aggressive conservation plan than the Base Case. Like all but the Constant Rate conservation plan, this plan accelerates the acquisition of

known cost-effective conservation into the early years. This means that City Light would effectively run out of most known cost-effective conservation opportunities before the 20-year planning period is over. Looking back through over 30 years of conservation experience, technological improvements have continuously resulted in the expansion of new conservation opportunities, despite the difficulty of predicting them. This leads City Light to believe that new opportunities will arise and that it can be a sound strategy to try to exhaust cost-effective conservation opportunities as fast as it can. Table 2-6 depicts new resources to be acquired for Renewables: Higher Conservation between 2012 and 2031.

Table 2-6. Renewables: Higher Conservation

(Average Megawatts of Energy, 2012 through 2031)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
- Conservation	14	29	45	61	77	93	109	125	141	157	173	182	191	199	207	214	221	227	232	237
- Landfill Gas											8	8	8	8	8	8	8	8	8	8
- Hydro Efficiency												5	5	5	5	5	5	5	5	5
- Geothermal																	10	10	10	20
- Waste Wood Biomass											10	40	40	40	40	40	40	40	40	40
- Wind													75	95	115	115	125	125	125	125
- Solar PV																				20
- CCT																				
- RECs (aMW)										13										

2.7.3.3 Wind and Gas

The Wind and Gas portfolio is a straightforward portfolio with Base Case conservation, and contracts for wind and the output of a natural gas combined-cycle turbine. Wind enters the portfolio in 2022, while the first natural gas generation enters in 2024. By the end of the planning period, there is about 34 percent more wind generation than natural gas generation. New conservation is the largest single resource, at more than 2.5 times the amount of natural gas generation.

Table 2-7. Wind and Gas

(Average Megawatts of Energy, 2012 through 2031)

Wind & Gas	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
- Conservation	14	27	41	55	69	83	97	111	125	139	153	167	181	194	205	213	220	227	233	237
- Landfill Gas																				
- Hydro Efficiency																				
- Geothermal																				
- Waste Wood Biomass																				
- Wind											35	70	70	70	90	90	100	100	100	125
- Solar Thermal																				
- Solar PV																				
- Natural Gas C.C. Turbine							10			5			75	90	90	90	90	90	90	93
- RECs (aMW)										15										

3 IMPACTS OF THE ALTERNATIVES, MITIGATING MEASURES, AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

3.1 Introduction

Chapter 2 includes a description of Seattle City Light's load projections, existing resources, and the adequacy of these resources to fulfill the load. With the conclusion that additional resources are needed, Chapter 2 then provides the policy context for resource planning and outlines the process SCL undertook to develop alternatives. This process involved formulating multiple alternative resource portfolios, any of which would satisfy SCL energy needs during the planning period. Each portfolio consists of different combinations of individual resources. Evaluation criteria covering cost minimization, risk management, reliability, and minimization of environmental impacts (air emissions) were applied to the portfolios, and each was subjected to rigorous analysis to determine how well they would perform.

The analysis tested the portfolios against a wide range of future business environments that reflected variability in hydro conditions, fuel prices, and demand for electricity. The eight were reduced to the three best performing portfolios. The EIS evaluates these three portfolios, listed below, and the No Action portfolio (Rely on the Market) for their environmental impacts. The alternative portfolios evaluated in this EIS use the baseline forecast (called Reference Case) assumptions about future conditions. This chapter describes the environmental impacts of implementing each of the four alternative portfolios. The portfolios are:

1. No Action – Rely on the Market
2. Renewables: Base Conservation
4. Renewables: Higher Conservation
5. Wind & Gas

Seattle City Light has selected the Renewables: Base Conservation Plan as the preferred alternative. A detailed description of the portfolios is in Chapter 2. The individual resources that make up these portfolios are shown below Table 3-1.

Table 3-1. Resource Additions to the Alternative Portfolios

Portfolio	Resource Additions
1 - No Action - Rely on Market	Market Purchase and Sales Only
2 – Renewables – Base Conservation	Conservation, Landfill Gas, Hydro Efficiency (Gorge Tunnel), Geothermal, Biomass (Cogen), Wind, Solar Energy, RECs, Market Purchases and Sales
4 – Renewables: Higher Conservation	Conservation, Landfill Gas, Hydro Efficiency (Gorge Tunnel), Geothermal, Biomass (Cogen), Wind, Solar Energy, RECs, Market Purchases and Sales
5 – Wind & Gas	Conservation, Wind, Natural Gas (CCCT), RECs, Market Purchases and Sales

The various combinations of resources in the four portfolios are shown in Table 3-2. This table depicts the aggregate resources that would be used over a 20-year period to fulfill SCL's electricity needs, by portfolio. For example, Portfolio 5 (Wind & Gas) would consist of 237 aMW of new conservation measures, 851 aMW of new wind resources, 723 aMW of new natural gas combined-cycle combustion turbine (CCCT) resources, 817 aMW purchased from other utilities, and 6,836 aMW sold to other utilities.

Table 3-2. 20-Year Total Energy in Each Portfolio (Average Megawatts)

	Portfolios			
	1	2	4	5
Resources	Rely on Market	Renewables: Base Conservation	Renewables: Highest Conservation	Wind & Gas
Conservation	0	237	237	237
Landfill Gas	0	97	81	0
Hydro Efficiency (Gorge Tunnel)	0	45	45	0
Geothermal	0	20	51	0
Biomass (Cogen)	0	386	367	0
Wind	0	984	900	851
Solar Energy	0	20	20	0
Natural Gas (CCCT)	0	0	0	723
RECs	0	10	13	15
Market Purchases	817	477	474	494
Market Sales	5,493	6,836	6,824	6,736

The portfolio impact evaluations in this chapter draw upon assessments of individual resources presented in Appendix C. Appendix C begins with a general description of each resource and then describes the impacts and mitigation measures for ten elements of the environment. The ten elements of the environment are: (1) Soils and Geology, (2) Air Quality (includes climate impacts as a separate evaluation), (3) Surface and Groundwater, (4) Plants and Animals, (5) Energy and Natural Resources, (6) Environmental Health, (7) Land Use, (8) Aesthetics and Recreation (9) Historic and Cultural Resources and (10) Employment.

Each element of the environment section in Appendix C describes the range of potential impacts and mitigation measures and concludes with a table that summarizes the potential level of construction and operation impacts for each resource. The impact evaluations for the resources are also summarized in Table 3-3. The level of impact for each individual resource is a building block for the analysis of the environmental impacts of the portfolios (combination of resources) described in this chapter.

The assigned impact level for both resources and portfolios assumes compliance with federal and state laws and implementation of, at the minimum, industry standard mitigation measures. In cases where City Light is committed to more stringent standards, this is indicated in the text. The impact level is based on a scale of three levels: potential for low, moderate, or high impact. The assigned value reflects a judgment about the severity of an impact, with the level of severity determined by considering the magnitude, extent, duration, and probability of an impact. Impacts shown with a "+" reflect positive impacts; "+L" indicates that the positive impacts are low and "+M" indicates they are moderately positive. Further, impacts are shown separately for construction and operation. Generally, construction

impacts tend to be relatively short term and operational impacts of longer-term duration and greater magnitude

In addition, there is often a range of environmental impacts that may occur from the construction and operation of energy resources. This is because there is uncertainty about many factors that influence impacts, including the geographic location of the facility, types, and effectiveness of mitigation, site conditions, fuel extraction operations, methods of waste disposal, etc. Where a range of potential impacts has been identified, the highest level is depicted in the summary table. For example, the level of impact on aesthetics and recreation from transmission towers was determined to range from low to high; the "high" level of impacts is shown in the summary table. In this case, there is a range of aesthetic impacts because this is a programmatic environmental impact statement (EIS) and the actual impact will depend on the specific site developed, the surrounding views, and the number and type of exposed viewers and their sensitivity to landscape changes.

This chapter summarizes the environmental impacts of the four alternative portfolios. Similar to Appendix C, this chapter is organized around elements of the environment, with impact conclusions presented for each portfolio. The impact evaluations for the four alternative portfolios uses a weighted average approach that combines the impact result (e.g. L, M, or H) and the cumulative amount of power (e.g. 10 aMW, 20 aMW or 900 aMW) for the individual resources to determine the overall impact resulting from the combination of multiple resources for each element of the environment.

Table 3-3. Summary of Portfolio Impacts

Elements of the Environment	1. Rely on Market	2. Renewables: Base Conservation	4. Renewables: Higher Conservation	5. Wind and Gas
Soils and Geology				
Construction	L	M	M	M
Operation	L	L	L	H
Air Quality				
Construction(NOx, SOx, PM, Hg)	L	L	L	L
Operation(NOx, SOx, PM, Hg)	M	M	M	M
Construction (CO2)	L	L	L	L
Operation (CO2)	H	M	M	H
Surface and Groundwater				
Construction	L	L	L	L
Operation	H	L	L	H
Plants and Animals				
Construction	L	M	M	M
Operation	M	M	M	M
Energy and Natural Resources				
Construction	L	L	L	L
Operation	H	L	L	M
Environmental Health				
Construction	L	M	M	M
Operation	M	M	M	M
Land Use				
Construction	L	M	M	M
Operation	M	M	M	M
Aesthetics and Recreation				
Construction	L	M	M	M
Operation	M	M	M	M
Historic and Cultural Resources				
Construction	L	M	M	M
Operation	M	M	M	M
Employment				
Construction	+L	+M	+M	+M
Operation	+L	+L	+L	+L

LEGEND

L	Low Impact	M	Moderate Impact	H	High Impact	+L, +M, +H	Positive Impact

3.2 Soils and Geology

3.2.1 Impacts of the Alternatives

A variety of land-disturbing activities could occur depending upon the type of energy project and the location of the site. During construction, clearing and grading to build access roads, construction pads for plant facilities, waste disposal areas, and other plant components; excavations for utilities and foundations; and blasting to achieve desired grades could trigger erosion, soil compaction, fugitive dust, and geologic hazards such as landslides. Similar risks would be involved during operation in some cases. Depending on the fuel source, some biomass plants may require clearing of logging residues. Natural gas extraction involves drilling, operating heavy equipment, and other activities that could adversely affect soils and geologic features.

The levels of impact on Soils and Geology attributable to the alternative portfolios for both construction and operation are summarized in Table 3-4. The levels of impact for the individual resources in each portfolio are detailed in Appendix C. Overall, during construction potential impacts would range from low for Portfolio 1 (Rely on the Market - No Action) to moderate for Portfolios 2, 4, and 5. The latter evaluations reflect the greater ground-disturbing activities that would occur from the construction of resources such as the Gorge Second Tunnel, geothermal, and solar projects. The extent of each portfolio's impact cannot be fully determined until specific development sites for all resources are known.

Table 3-4. Impacts on Geology and Soils

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	M	M	M
Operation	H	L	L	H

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

Operational impacts would be high for Portfolio 1 (Rely on the Market – No Action) and for Portfolio 5 (Wind and Gas) due to the high geological impact of natural gas extraction and the potential for hydraulic fracturing. Hydraulic fracturing is a technique in which water, chemicals, and sand are pumped into a well to unlock the hydrocarbons trapped in shale formations by opening cracks or fractures in the rock and allowing natural gas to flow from the shale into the well . Operational impacts of the Portfolio 2 and 4 would likely be low because of the significant contribution of individual resources that have a low impact (landfill gas, Gorge Second Tunnel, and wind).

3.2.2 Mitigation

Potential mitigating measures for soils and geology include the following:

- Implement planning and design measures to avoid areas of sensitive soil, streams, wetlands, and geologic hazards.
- Retain vegetative buffers where possible to prevent sediment from reaching streams.
- Minimize the footprint of the operations area and the extent of ground disturbance required through careful project planning and by using existing roads to the extent possible. Locate new access roads to follow the local topography, and minimize hillside cuts.
- Identify and avoid unstable slopes and other geologic hazards, and avoid creating excessive slopes during construction; use special construction techniques where applicable.
- Obtain clearing and grading permits required by local jurisdictions for soil and vegetation disturbance and comply with permit requirements.
- Schedule construction during the dry season to the extent possible when stream flow, rainfall, and runoff are low, to minimize erosion, sedimentation, and soil compaction.
- Cover and stabilize exposed areas consistent with applicable standards, salvage removed topsoil and revegetate disturbed areas with native seed as soon as possible.
- Develop and implement a stormwater management system to control runoff, erosion, and sedimentation during construction, including use of a stormwater pollution prevention plan (SWPPP) and best management practices (BMPs) during construction. BMPs may include using straw, silt fences, and water detention ponds.
- Implement a spill prevention control and countermeasure plan (SPCC) that would minimize groundwater impacts.

3.3 Air Quality and Climate Impacts

3.3.1 Impacts of the Alternatives

The evaluation of air quality impacts includes estimates of quantities of air pollutants, whereas for most of the other elements of the environment the analysis is primarily qualitative. This EIS does not attempt to estimate the specific impacts of specific plants. The processes for evaluating the potential emissions and their impact on air quality are extremely complex, and are very specific to the geographic and climatic conditions at the plant site as well as the plant design and operation patterns. Therefore, it is impossible to know precisely how a generalized power plant would affect air quality. However, it is possible to make some general assumptions about major types of generating plants and the type of control equipment that would likely be required, and the residual level of emissions that exist even when control equipment has been installed.

Impacts associated with capacity are related to the construction of the plants, and occur whether the plant is operated or not. Air impacts of construction tend to be low and of a short duration as they are primarily due to construction activity that disturbs soil and creates dust and to construction vehicle emissions. Air impacts associated with operation of power plants are much greater, especially for fossil fuel generation or plants that burn fuel such as biomass. The emission rates have been quantified for five pollutants: carbon dioxide (CO_2), oxides of nitrogen (NO_X), oxides of sulfur (SO_X), mercury (HG), and particulates (PM).

3.3.1.1 Emission Rates

Emission rates are the amount of pollutant emitted per unit of fuel used or per unit of electricity produced. Air emissions impacts resulting from electricity production will vary widely among the resource types. Table 3-5 shows categories of resources having air emissions that are used in the portfolios.

Table 3-5. Emission Rate Assumptions for Air Impact Calculations

Category	Description	Resources	Emission Rate
Generating Resources	New generating plants that would serve new SCL load over the planning period.	Landfill Gas Biomass - (wood) CCCT - (natural gas)	Rates are specific to each resource - See Table 3-7
Market Transactions (Sales and Purchases of Existing Resources)	Energy purchased from the wholesale power market.	Analysis assumes a mixture of older natural gas combustion turbines and small amount of coal under certain market conditions.	Market Emission rate – See Table 3-7

Once the emission rate for each resource is established, it is multiplied by the amount of energy produced by that resource in each portfolio to determine the total emissions. This is done for each of the five emission categories (CO_2, NO_X, SO_X, HG, and PM) in each portfolio. The general calculation is:

Emissions[15] (pounds) = Emission Rate (pounds/MWh[16]) x Electricity Produced (MWh)

Generating resources are new power plants that are built to meet load. The emission rates of generating resources are based on best knowledge about technology available today. It does not reflect potential changes in efficiency or control technology.

Market purchases of existing resources provide a specified amount of energy for a specified time at a specified price. For analysis purposes, the important characteristic of these market purchases is that they would be supplied by existing power plants. To estimate the net air quality impact of using these resources, it is assumed that the emissions are primarily from natural gas plants that serve incremental increases in electricity demand in the market, also referred to as the marginal resource. See Appendix C for additional information about these resources and the assumptions about City Light's market transactions.

3.3.1.2 Emission Control Equipment - Assumptions for Each Resource

The developer of any proposed new power plant is required under the federal Clean Air Act to evaluate the plant's potential to emit air pollutants during operation. Plants that could emit quantities of air pollutants above an amount set by law, or that could increase air pollution near the plant above the

[15] Generally, pounds have been converted into tons (1 ton = 2,000 pounds).
[16] MWh = megawatt hour

National Ambient Air Quality Standard (NAAQS - levels considered safe for public health), will be required to install pollution control equipment or limit operation.

The processes for evaluating the potential emissions of conventional pollutants and their impact on air quality are extremely complex, and are very specific to the geographic and climatic conditions at the plant site as well as the plant design and operation patterns. Because it is programmatic rather than site-specific, the analysis in this EIS evaluates the general impacts of the quantity of emissions produced in each portfolio.

This EIS does not attempt to estimate the specific impacts of specific plants. However, it is possible to make some general assumptions about major types of generating plants and the type of control equipment that would likely be required. For combined cycle combustion turbines, for example, the pollution controls include equipment to remove oxides of nitrogen. Some power plants that do not emit pollutants, such as wind power, or plants that are small and use low amounts of fuel, would not be required to install air pollution controls or limit operations to reduce air emissions.

No controls were assumed for capturing CO_2. While CO_2 capture has been proposed for plants using fossil fuels, at this time the technology is still in the research and development stage, and was not included in the assumptions for emission control equipment.

Table 3-6 shows the pollution control equipment that was assumed in the new generating resources included in the portfolios. Each of the control technologies listed in Table 3-6 has costs for both the equipment capital and its operation and maintenance. Pollution controls can reduce the efficiency of plants somewhat, and often require the use of a small amount of the plant's power output to operate.

Table 3-6. Assumed Emission Control Equipment for Resources

Landfill Gas	None - generally emissions are below regulatory threshold
Gorge Second Tunnel (Hydro Efficiency)	None - no emissions
Geothermal	None - no emissions
Biomass: Cogeneration	Electrostatic precipitators or fabric filters (control particulates) Selective Non-Catalytic Reduction (control oxides of nitrogen)
Wind	None - no emissions
Solar Energy	None - no emissions
Natural Gas CCCT	Selective Catalytic Reduction (control oxides of nitrogen)

The emissions rates for the resources listed in Table 3-7 represent the emissions that would still occur, even though emission control equipment is assumed to be used. Even though many pollution control devices can control up to 90 percent or more of a pollutant in the combustion exhaust, there will be residual emissions.

Table 3-7. Air Emissions per Unit of Electricity, by Generation Type

	SOx lbs/MWh	NOx lbs/MWh	Mercury lbs/MWh	Particulates lbs/MWh	CO_2 lbs/MWh
Conservation	0	0	0	0	0
Landfill Gas	0	0	0	0	0
Gorge Second Tunnel	0	0	0	0	0
Geothermal	0	0	0	0	0
Biomass: Cogen	0.4265	2.2178	0	0.3412	0[17]
Wind	0	0	0	0	0
Solar Energy	0	0	0	0	0
Natural Gas CCCT	0.00432	0.216	0	0.00504	857
RECs	Varies depending upon technologies used for RECs, as shown in this table.				
Market Transactions	0.0101	0.303	1.9×10^{-6}	0.04	870

3.3.1.3 Energy Output in the Portfolios

Each portfolio has a different combination of resources, and not all resources were used in all portfolios. Conservation is assumed in all the portfolios except Rely on Market. The energy output from new generation resources varies widely across the portfolios. Some resources such as Solar, Geothermal, and Landfill Gas contribute only small amounts to the portfolio's 20-year total energy. In Portfolio 2 and 4, Solar contributes about 1 percent of the total generation while geothermal contributes between 1 and 3 percent and Landfill gas about 5 percent of total generation. The generating resources that provide the most energy in the portfolios in which they are included are Wind, Combined-Cycle Combustion Turbines (CCCTs) and Biomass: Cogen. Wind power contributes over 50 percent of the energy in the Renewables: Base Conservation and the Renewables: Highest Conservation portfolios. In Portfolio 5, wind and gas resources contribute approximately 47 and 40 percent of the energy, respectively.

[17] SCL evaluated a range of potential emission rates to represent different assumptions concerning the importance of the timing of sequestration and alternative fates of the fuel: 0, 280, and 640 lbs CO_2 per MWh. See Appendix C for more information

Table 3-8 shows the 20-year total energy produced by each resource type in each portfolio, in units of average megawatts (aMW).

Table 3-8. 20-Year Total Energy in Each Portfolio (Average Megawatts)

	Portfolios			
	1	2	4	5
Resources	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Conservation	0	237	237	237
Landfill Gas	0	97	81	0
Gorge Second Tunnel (Hydro Efficiency)	0	45	45	0
Geothermal	0	20	51	0
Biomass (Cogen)	0	386	367	0
Wind	0	984	900	851
Solar Energy	0	20	20	0
Natural Gas (CCCT)	0	0	0	723
RECs	0	10	13	15
Market Purchases	817	477	474	494
Market Sales	5,493	6,836	6,824	6,736

Market Sales and Purchases accounted for a significant amount of energy in each portfolio. Purchases were actually much smaller than sales because the need to acquire resources to meet winter demand (see section on resource adequacy in Chapter 2) causes City Light to be surplus the rest of the year. The model used in the IRP is designed to operate resources not needed to meet load for sale in the market when it is profitable to do so, that is, when the price received for the energy is greater than the run cost of the resource in question. The computer model results shown in Table 3-8 for Market Purchases and Market Sales indicate that this was usually the case and City Light's new portfolios were generally able to displace the marginal resource in the market. The environmental implications of this are important because the new resources are assumed to produce lower emissions than the marginal resource, resulting in a net environmental gain from operation.

The environmental gain from displacing the marginal resource will only be realized if the resources acquired by City Light continue to have lower emission rates than the marginal resource in the market. If the resources operated to serve the market changes and the marginal resource then has emissions closer to those produced by resources in the portfolios, the environmental benefit of the portfolio would be reduced.

3.3.1.4 Air Emissions from the Portfolios

Air emissions from electricity produced in each portfolio are listed in Table 3-9 and 3-10. The numbers are the 20-year totals, in tons. The emissions are broken out into two tables, one for each of the categories described above: New Generation and Market Purchases.

Referring back to the table showing the 20-year total energy in each portfolio, Table 3-8, and the table of emission rates for each of the resource categories within the portfolios, Table 3-7, is useful in understanding the emission data. The actual energy produced (or displaced in the case of existing

resources), multiplied by the emission rates, is what determines the actual 20-year emissions. While the construction of each resource in the portfolios does contribute to the air impacts, the construction impacts are much smaller in magnitude and shorter in duration than operational impacts and are not included in the tables.

Table 3-9 shows the air emissions from specific new generation plant technologies (biomass, CCCT). In the Rely on the Market - No Action portfolio, City Light assumes that it does not acquire any new resources, but instead relies entirely on existing resources and contracts, and buys any additional electricity needed to meet load on the wholesale power market, so new generation emissions for Rely on Market are zero. Portfolio 2 (Renewables: Base Conservation) emits zero CO_2, and its NO_x and particulate (PM) emissions are low; these emissions are due to the biomass wood, landfill gas plants, and RECs in the portfolio. Portfolio 4 (Renewables: Higher Conservation) also emits zero CO_2, and its NO_x and particulate (PM) emissions are slightly less than Portfolio 2 emissions. Portfolio 5 (Wind and Gas) emits CO_2, NO_x, SO_x and PM. Although this portfolio emits CO_2, the NO_x, and PM emissions are less than Portfolio 2 and 4 because biomass and landfill gas are not used in the portfolio.
Table 3-10 shows emissions for the Market Purchases category over the 20-year period.

Table 3-9. 20-Year Air Emissions for Each Portfolio – New Generation Only

Portfolio	CO_2 (tons)	NO_X (tons)	SO_X (tons)	HG (tons)	PM (tons)
1. Rely on Market	0	0	0	0	0
2. Renewables: Base Conservation	0[1]	3,847	740	0	592
4. Renewables: Higher Conservation	0[2]	3,691	710	0	568
5. Wind & Gas	2,713,896	830	42	0	38

Table 3-10. 20-Year Air Emissions in Portfolios - Market Purchases Only

Portfolio	CO2 (tons)	NOX (tons)	SOX (tons)	HG (tons)	PM (tons)
1. Rely on Market	3,113,260	1,084	36	0.0068	143
2. Renewables: Base Conservation	1,817,656	633	21	0.0040	84
4. Renewables: Higher Conservation	1,806,224	629	21	0.0039	83
5. Wind & Gas	1,882,436	656	22	0.0041	87

Air Quality impacts are summarized in Table 3-11.

Table 3-11. Impacts on Air Quality Summary

		Portfolios			
		1	2	4	5
		Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
NOx, SOx, PM, Hg	Construction	L	L	L	L
	Operation	M	M	M	M
CO_2	Construction	L	L	L	L
	Operation	H	M	M	H

L	= Low Impact	M	= Moderate Impact	H	=High Impact

3.3.2 Mitigation

3.3.2.1 Emissions Control Mitigation

Air emissions from new and existing power plants are regulated under the federal Clean Air Act. For individual plants, these regulations are often implemented by state air agencies that have been given authority by the US Environmental Protection Agency. The state agencies translate the Clean Air Act regulations into specific permit requirements and emission standards for power plants. These regulations serve to reduce some air emissions and are subject to change, usually toward more restrictive emissions regulations, as new information about the impacts of emissions on human and environmental health becomes available, and as new control technologies are developed.

There are two general categories of air pollutant regulations: those that apply to specific generation facilities and those that apply to the entire power generation industry.

The regulations that apply to specific power plants include requirements for Best Available Control Technology (BACT) on new plants, which means that any new plant is required to install air pollution control equipment that is commercially available and economically feasible. Not all new power plants are required to apply BACT for all pollutants. The technologies that are considered BACT change as technology changes and through federal legislation and agency rulemaking. Power plants are also required to show that they will not exceed the National Ambient Air Quality Standards (NAAQS) for any air pollutant. These standards are usually defined in parts per unit of volume of air of the pollutant, and are measured for varying periods such as hourly, daily, and annually. Before a new plant that is included under these regulations can receive an operating permit from the local air quality agency, it must do computer modeling to show that the NAAQS will not be exceeded. Factors that are site specific such as the presence of other sources of air pollutants, climate, meteorology, topography, and proximity to

population centers and protected natural areas can have a significant impact on whether a plant can show that it will comply with NAAQS. Plants are also required to monitor emissions during operation to show they remain in compliance.

Regulations that apply to the power generation industry as a whole include the Acid Rain Reduction program, the Cross State Air Pollution Rule, and other EPA regulations. The Acid Rain program is commonly called the SOx trading program, and was designed as a cap and trade system. Emissions from the entire industry were capped, and then reduced over time. Power plants were given allowances; if they exceeded their emission allowances, they were able to purchase allowances from other plants that were able to emit less than they were permitted to do. The recent EPA Cross State Air Pollution Rule, which limits emissions of SOx and NOx, applies to power plants that are located in the Midwest and eastern part of the United States, and the Mercury and Toxics Standard applies to coal and oil-fired plants throughout the country.

Some mitigating measures reduce air emissions, but may have their own negative environmental impacts. NOx controls with selective catalytic reduction (SCR) uses ammonia. There are risks associated with ammonia including harm to human, animal, and environmental health if it is released during transportation and storage. Also, some ammonia is released from control equipment, but these releases are often limited by permit requirements.

3.3.2.2 Greenhouse Gas Mitigation Requirements

The EPA proposed the Carbon Pollution Standard for New Power Plants in March of 2012. This regulation, a part of the New Source Performance Standard of the Clean Air Act, would set a limit on the carbon dioxide (CO2) emission rate from new power plants of 1,000 pounds CO2 per MWh. It would not apply to biomass/biogas plants or to natural gas simple cycle combustion turbines.

Several states, including Washington and Oregon, have greenhouse gas performance standards for Northwest power plants, and California has a cap and trade program for greenhouse gas emissions that includes emissions from power plants.

Seattle City Light has a specific obligation to evaluate and mitigate the greenhouse gas impacts of its operations, including electricity resource decisions. The policy, established by the Seattle City Council and Mayor, is described in the Internal Policy section of Chapter 2. Specifically, City Light is to avoid emissions of greenhouse gas to the extent possible, through energy conservation and renewable resource acquisition, then to purchase greenhouse gas offsets to cover any emissions that result from energy purchased from resources that emit CO_2. Current cost estimates for high quality, verifiable greenhouse gas offsets range widely depending on a number of factors.

A greenhouse gas offset directly avoids, displaces, or sequesters greenhouse gas emissions. Offset projects must be evaluated carefully to determine that they will actually produce the intended results, and that they will be monitored, and that the offsets are verified by a third party. Examples of offset projects include capture and destruction of methane from dairies and landfills. There are many types of potential offset projects, and many organizations are attempting to create standards for the definition, accounting, and certification of offsets. In considering offset projects, City Light will continue to seek high-quality offsets at the lowest available price.

3.4 Surface and Groundwater

3.4.1 Impacts of the Alternatives

Construction of energy facilities can affect surface and groundwater quantity and quality in several ways. Construction can affect water resources through alteration of surface and groundwater flow patterns, discharges to existing water sources, and consumption of water during the construction process. Surface disturbance of a project area for construction of roads, building sites, and other facilities can alter the surface drainage patterns and create areas of impervious surfaces, leading to greater levels of runoff. If uncontrolled, runoff from disturbed areas can produce temporary increases in soil erosion, resulting in elevated turbidity in runoff water and sedimentation in stream channels. Grading and excavation activities and extraction of geologic materials for use in construction can also change groundwater flow patterns, and result in discharges to groundwater. National Pollution Discharge Elimination System (NPDES) permit conditions require development and implementation of a surface water pollution prevention plan (SWPPP), which will in turn require a variety of best management practices (BMPs) to minimize erosion and control runoff and sedimentation. Construction also typically involves water consumption for several activities, including dust suppression, vehicle washing, concrete mixing, and potable water supply for the construction crew.

During operation, electricity generation can affect surface and groundwater in many phases of its life cycle. Extraction of fuels such as natural gas can affect both ground and surface water due to drilling and from waste products from fuel processing. If the generation source is based on fuel combustion, water is often used as both a carrier of combustion energy to a turbine for conversion into electricity, and for cooling the plant. Ground or surface water sources are needed for these functions. Water use per MWh for the various energy resources considered in the IRP analysis is depicted in Table 3-12.

The data is from an NREL report (2011). The report notes "water withdrawal and consumption factors vary greatly across and within fuel technologies." Additionally, "federal datasets on water use in power plants have numerous gaps and methodological inconsistencies." Actual water use will depend on many factors, and mitigation measures listed at the end of this section should be considered when evaluating specific power plants. In the report "withdrawal" refers to the amount of water removed from a groundwater source or diverted for a surface water source, and "consumption" refers to water that is evaporated, transpired, or removed from the immediate water environment.

The numbers in Table 3-12 are meant to provide a general range only.

Table 3-12. Water Use for Energy Resources (Gallons/MWh)

Energy Resource	NREL (March 2011) (Consumption)	NREL(March 2011) (Withdrawal)
CCCT (once-through)	20-100	7,500 – 20,000
CCCT (recirculate)	130-300	150-283
CCCT (dry)	0-4	0-4
Wind	~1	Not Available
Geothermal (Binary)	0-3,963	Not Available
BioPower (Steam - Tower)	480-965	500-1,460
BioPower (Steam – once-through)	300	20,000-50,000
BioPower (Steam – dry)	35	Not Available
Solar PV	0-33	Not Available

Thermal resources are the most water-intensive. Recirculating water rather than using the water only once considerably reduces the amount of water that has to be withdrawn from a surface or ground source. There is a cost, however. More water is lost to evaporation in recirculation systems compared to once-through systems, resulting in less water being returned to the source. In addition, more chemicals such as chlorine and biocides are used in recirculation systems and these chemicals eventually leave the cooling system and have to be disposed of.

In addition, wastewater is often produced, sometimes containing chemicals added at the generation facility and with a higher temperature that the intake water. If the wastewater is discharged into surface or ground water bodies, this chemical and thermal pollution can be transferred to those water bodies.

Construction and operation impacts on surface and groundwater attributable to the alternative portfolios are shown in Table 3-13. Although considerable potential exists for impacts during construction, the requirements for mitigation are likely to minimize those impacts. As a result, construction impacts are anticipated to be low for all portfolios.

Table 3-13. Impacts on Surface and Groundwater

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	L	L	L
Operation	H	L	L	H

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

During operation, it is expected that impacts would be low for the renewables portfolios. This is partly due to these portfolios including large quantities of wind power, which is likely to have a low impact on

surface and groundwater. Operational impacts of Portfolios 1 and 5 (Rely on Market and Wind & Gas) could be high due to wholesale market purchases that include natural gas and under certain market conditions can also contain small amounts of coal-fired power generation. Coal fired generation has impacts during mining, transport, handling, and water use for steam generation and cooling. Natural gas-fired generation also has impacts related to fuel extraction activities.

3.4.2 Mitigation

Potential mitigating measures for surface and groundwater include the following:

- Use a recirculating system for cooling to reduce water requirements.
- Use treated wastewater for cooling, where available and appropriate for the type of technology in use.
- Develop temporary and permanent stormwater management systems that incorporate BMPs for pollution prevention.
- Characterize the surface and groundwater hydrology prior to construction, develop an understanding of discharge and recharge relationships, and avoid creating new hydrologic connections through grading and related activities.
- Monitor water quantity and quality conditions if construction activity is to occur near aquifer recharge areas.
- Implement BMPs for use, handling, and storage of fuels, pesticides and other hazardous materials during both construction and operation.
- Implement a groundwater-monitoring plan if groundwater withdrawals and discharges are planned.
- Develop and implement a spill prevention control and countermeasure plan (SPCC).
- Manage all maintenance/cleaning wash water with appropriate BMPs for pollution prevention.

3.5 Plants and Animals

3.5.1 Impacts of the Alternatives

A broad range of impacts on plants and animals could occur during construction and/or operation of energy facilities; the type and severity of impact would depend upon the nature of the energy resource and location. Due to the wide variety of species that could be involved, impacts on federally and state-listed species would be addressed at a project-specific level. Direct effects during construction commonly include removal of vegetation and the habitat it provides for wildlife, and mortality or injury to animal species that inhabit a site at the time of construction. Impacts could potentially be substantial for facilities that occupy large sites, such as a solar photovoltaic projects. Construction requires clearing existing vegetation around areas to be occupied by roads, plant facilities, fuel storage, substations, and other project facilities. These areas represent a permanent loss of vegetation and habitat on a previously undeveloped site. Mobile species present on a project site are likely to be displaced during construction, while those that are less mobile can be killed or injured because of construction activity within the area of disturbance.

Indirect effects during construction can stem from a number of disturbance mechanisms that can interfere with normal animal behaviors or introduce adverse changes to their habitat. Remaining vegetation and habitat quality for wildlife can be diminished indirectly through dust generated by construction, erosion and runoff, and increased opportunities for invasive species. Similarly, aquatic

habitat can be degraded by runoff, dust, and exposure to contaminants through spills. Noise, the presence of humans and vehicles, and similar aspects of construction activity can disrupt the breeding, nesting, or rearing of species or modify the behavior of wildlife remaining on the site and in adjacent areas.

Impacts during operation would occur for resources that permanently remove vegetation and the habitat it provides for wildlife. Additional operation impacts would occur for energy resources where fuel extraction would require additional disturbance of habitats (e.g., natural gas extraction, clearing of forest residues for biomass facilities). There are also potential impacts on birds and bats from operation of wind turbines.

Impact levels for plants and animals are depicted in Table 3-14. With the exception of Portfolio 1 (Rely on the Market - No Action), the other portfolios would result in moderate impacts during construction. The moderate impact level assumes industry standard mitigation measures for wind, solar and the other resources.

Table 3-14. Impacts on Plants and Animals

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	M	M	M
Operation	M	M	M	M

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

During operation, all of the portfolios could have a moderate impact on plants and animals due to the continuing potential disturbance of habitats and species. The ongoing disturbance is a result of fuel extraction activities, generating facility operating noise, vehicle traffic, etc. Portfolio 1 (Rely on the Market - No Action) and 5 (Wind and Gas) include natural gas as a fuel resource, which would require disturbance of habitats for fuel extraction activities.

3.5.2 Mitigation

Potential mitigating measures for Plants and Animals include the following:

- Conduct pre- and post-development studies of plant and animal resources.
- Avoid siting facilities in areas that support unique or sensitive plants or wildlife habitat. Site facilities to avoid migration routes or other sensitive areas where plants and animals could experience significant impacts.
- Where possible, use existing roads and disturbed areas for project development, and minimize the area disturbed for project construction.
- Design necessary stream crossings to minimize disturbance and maintain aquatic habitat conditions.
- Develop and implement a restoration plan to restore disturbed plant and animal habitat.
- Purchase or set aside land to replace habitat lost through project development.
- Implement measures to minimize establishment of invasive species.

- Landscape site buffer areas with native plant species.
- Establish a monitoring program to assess impacts on the area's plants and animal species.
- Time construction to avoid sensitive periods for species of concern.
- Properly manage garbage and waste disposal on project sites.
- Minimize lighting and avoid steadily burning lights.

3.6 Energy and Natural Resources

3.6.1 Impacts of the Alternatives

The impact on energy resources varies widely with generation technology. Electricity generation that uses fossil fuels such as natural gas or coal deplete those non-renewable fuel resources, resulting in a high impact to energy resources. Electricity generation using renewable fuels, such as wind and solar power, are generally considered to have negligible to no impact on energy resources, and have the positive impact of reducing the need to consume fossil fuel. Some fuels, such as biomass, are sometimes considered renewable if they come from sources that are replaced (such as wood waste). Within those generation types there are a variety of plant designs with different efficiencies in fuel use. The range of heat rates for resources considered in the IRP are shown in Table 3-15.

Table 3-15. Fuel Use Rate by Resource

Resource	Fuel	Heat Rate Ranges (Btu/kWh)
Conservation	None	N/A
Landfill Gas	Methane (landfill gas)	8,940 to 13,648
Gorge Second Tunnel	Water	N/A
Geothermal	Water	N/A
Biomass	Wood	13,500 to 19,300 to
Wind	Wind	N/A
Solar Energy	Sun	N/A
Gas – CCCT	Natural Gas	6,333 to 7,050
RECs	Wind, Biomass, or Landfill Gas	Varies By Fuel
Market Transactions	Primarily natural gas/some coal under certain market conditions	Slightly greater than Gas CCCT

Table 3-16 summarizes the level of impacts on energy and natural resources that are expected to occur for the alternative portfolios. During construction, all the portfolios would likely have a low level of impact during construction. All the portfolios would require a range of energy and natural resources including fossil fuels for construction equipment, water for dust mitigation, geological material for building access roads, etc. These impacts would be temporary and the amount of natural resources used would likely be small in comparison to the total amount available.

Table 3-16. Impacts on Energy and Natural Resources

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	L	L	L
Operation	H	L+	L+	M

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

Portfolio 1 (Rely on the Market - No Action) would have the highest level of impact during operation because it relies on market purchases made in the wholesale electricity market. Purchases from the wholesale power market are assumed to reflect the marginal resource, which is usually a combustion turbine. This analysis assumes that in the near-term planning period, this resource is a natural gas combustion turbine with a small amount of coal power production and that the natural gas and coal plants on the margin (i.e., most likely to be turned on or off as the demand for electricity is added or dropped) will generally be older, less efficient plants. Because both natural gas and coal-fired resources use a non-renewable fuel and the plants are likely to be less efficient, Portfolio 1 would have a high impact on energy and natural resources.

The Wind and Gas plan (Portfolio 5) uses a combination of non-renewable resources (natural gas fuel) and renewable resources (wind) and is likely to have a moderate impact. The Renewables: Base Conservation and Renewables: Higher Conservation (Portfolio 2 and 4) predominantly rely on renewable resources to meet demand and, therefore, would have a low impact to energy and natural resources. Both Portfolio 2 and 4 include a biomass cogeneration facility, which is considered to have a low impact on natural resources because City Light anticipates the fuel source to be from unused forest by-products, such as mill residuals and non-merchantable debris that is removed for timber management or ecological restoration efforts.

3.6.2 Mitigation

Potential mitigating measures for energy and natural resources include the following:

- Use conservation to reduce the need for new resources.
- Use high efficiency technologies, regardless of fuel, which reduce the impacts to the energy resource, either directly by avoiding use of that resource in the plant or by producing more electricity from renewable sources, thus avoiding the use of a non-renewable source.
- For facilities that require transmission improvements, design new lines for higher voltages to reduce energy losses.

3.7 Environmental Health

3.7.1 Impacts of the Alternatives

Construction of energy facilities would affect environmental health concerns regarding the occupational safety for workers, audible noise, and use and disposal of hazardous materials. Adherence to occupational health and safety plans and regulations, confining work to normal daytime hours, and safe handling practices for hazardous materials would reduce the level of such impacts, and overall impacts of the portfolios is anticipated to be low to moderate. A low construction impact would occur with Portfolio 1 (Rely on the Market - No Action) because it is unlikely that new resources would be built to meet the increased City Light demand. Portfolios 2, 4, and 5 include new resources, and have the potential to have moderate impacts.

During operation of energy facilities, in addition to possible air quality health impacts as described in Section 3.3, other environmental health issues include operating noise, exposure to EMFs and occupational safety hazards that workers are exposed to by routine maintenance of turbines, generators, electric systems, and other energy resource infrastructure. The source of noise is discussed in the relevant resource section and the risks associated with exposure to EMFs are detailed in the transmission section of Appendix C.

All the portfolios have the potential to cause moderate impacts during operation because of environmental heath issues such as operating noise and occupational safety hazards that workers are exposed to by routine maintenance of turbines, generators, electric systems, and other energy resource infrastructure. Table 3-17 summarizes impacts on environmental health.

Table 3-17. Impacts on Environmental Health

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	M	M	M
Operation	M	M	M	M

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

3.7.2 Mitigation

Potential mitigating measures for environmental health include the following:

- Restrict construction activities to daylight hours if there are potential receptors nearby.
- Lay out plant facilities so that noise standards are not exceeded at the site boundary. If necessary, construct noise barriers, insulate buildings that house turbines and generators, install and use noise control devices in the stacks, or implement other mitigation measures to comply with state and local noise regulations.
- Ensure adherence to all applicable occupational safety regulations and standards and project health and safety plans in construction and operation.

- Establish safety zones and setbacks to prevent public exposure to potential safety hazards during both construction and operation.
- Secure construction sites at night.
- Analyze and evaluate operating noise conditions during project planning and design to ensure compliance with applicable community noise standards.
- Consider implementing a noise complaint and investigation program for the project duration period.
- Use up-to-date low field designs to minimize EMFs and induced currents.
- Transfer construction and operation wastes to appropriate facilities for recycling, treatment, processing, or disposal.
- Restrict nighttime operation of the power plant if sensitive land uses are nearby.

3.8 Land Use

3.8.1 Impacts of the Alternatives

Land use impacts vary widely with location, type of energy facility, and land requirements. Sites that are already used for commercial or industrial purposes, such as a co-located biomass energy facility, are less likely to experience significant additional impacts from the plant. Undeveloped sites would experience the largest incremental impact from new facility construction. Usually, zoning regulations in the local area determine whether energy facilities are acceptable uses and, along with local, federal, and state regulations, the mitigation required to reduce adverse impacts. Some resources, such as natural gas, result in the disturbance of land for fuel extraction. Other generation types may have less of an impact. For example, wind turbines are frequently located on agricultural land, and farming activities are able to continue around the generating facilities.

Land use impacts during construction include the possible displacement of existing uses (a long-term impact) and proximity impacts on nearby land uses as a result of noise, dust, traffic, and similar triggers (temporary impacts). The magnitude of these impacts would be greater for large facilities and if development were to occur in rural areas or affect lands designated as sensitive areas such as wetlands. Land use impacts for the alternative portfolios are shown in Table 3-18. Construction impact would be minimal under Portfolio 1 (Rely on the Market - No Action), and the rest of the portfolios would result in up to moderate impacts during construction. Like many of the other elements of the environment differentiating the level of impact between, Portfolio 2, 4, and 5 is difficult because specific development locations of the resources are not known.

Table 3-18. Impacts on Land Use

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	M	M	M
Operation	M	M	M	M

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

Moderate operational impacts could occur for all portfolios due to the potential for most resources to permanently displace existing land uses. Additional impacts may occur from operating noise of the generation facility, vehicle traffic, air emissions, or land-disturbing activities associated with fuel extraction, which would occur for natural gas resources and possibly biomass. The extent of each portfolio's impact cannot be fully determined until specific development sites for all resources are known.

3.8.2 Mitigation

Potential mitigating measures for land use include the following:

- To the extent possible, locate new structures on developed sites to minimize land use impacts.
- Evaluate the project site before construction to make sure it conforms to local planning and zoning requirements and avoids compatibility issues with nearby uses.
- Locate new transmission facilities within or parallel to existing rights-of-way and avoid bisecting existing land uses such as farmland in order to minimize land use conflicts and compatibility issues.
- Develop construction management plans that avoid or minimize disruptions to adjacent existing uses.
- Buffer areas of construction activity from areas frequented by recreationists, if possible.
- Ensure that lease/easement terms and payments to landowners can compensate for any changes/modifications in land use.
- Inform affected landowners of construction schedules.

3.9 Aesthetics and Recreation

3.9.1 Impacts of the Alternatives

Except for energy facilities located in industrial areas, most energy resources and transmission lines would create visual contrasts with the surrounding areas in which they are located. Visual impacts during construction could result from the actual generating facility structure and clearing and grading, which often creates a contrast with the existing environment that can be easily evident to viewers in the area. The visual impact of the actual generating facility structure would also carry on over the long term during operation. The level of impact would depend upon the nature of the site, visibility of the energy facility, and the number of potential viewers. Impacts would likely be reduced if the generating facility is located in an industrial area or building (e.g., landfill gas or biomass cogeneration facility). Fuel extraction sites are also often considered unattractive because of soil disturbance, loss of vegetation, heavy machinery, and potential for noise and dust.

Similar impacts would occur for recreation. Energy facilities in more remote, pristine areas could affect recreation directly because of operating noise and use conflicts, and indirectly through loss of habitat and wildlife compromising the recreation experience.

A summary of impacts on aesthetics and recreation is provided in Table 3-19. None of the portfolios is likely to result in a high level of impacts during construction. At most, all the portfolios except Portfolio 1 (Rely on the Market - No Action) have the potential to cause moderate impacts during construction.

Table 3-19. Impacts on Aesthetics and Recreation

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	M	M	M
Operation	M	M	M	M

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

Although all of the portfolios except Portfolio 1 (Rely on the Market - No Action) include wind resources, which the impact analysis concluded could result in impacts from low up to high depending upon location; these portfolios are rated as moderate. This is due to two factors: one is the commitment of City Light to avoid wind resources with high impacts, and secondly the large quantities of power from resources that have a low impact (conservation, landfill gas, and hydro efficiency) in Portfolios 2 and 4. The aesthetics and recreation impacts of transmission lines are not considered in the evaluation of the portfolios because resource locations are not known.

3.9.2 Mitigation

Potential mitigating measures for aesthetics and recreation include the following:

- If possible, locate facilities in areas with less viewer exposure and away from popular recreation areas.
- Integrate facility design and configuration of structures into the surrounding landscape or otherwise incorporate aesthetic objectives into design.
- Minimize surface disturbance at the project site and access roads; particularly on steep slopes, and control erosion.
- If necessary and effective, provide vegetation screening to obstruct views of the project facilities and fuel extraction sites from surrounding sensitive areas.
- Keep project facilities clean and well maintained throughout project operation.
- Compensate for impacts by aesthetic improvements in other areas such as reclamation of unneeded roads.
- Schedule construction during periods of low recreation use.
- Consider use of aesthetic offsets (mitigation of existing aesthetic impacts from other sources, such as reclamation of unneeded roads) to mitigate unavoidable visual impacts.

3.10 Historic and Cultural Resources

3.10.1 Impacts of the Alternatives

Surface disturbance and excavation during the construction process could adversely affect historic and cultural resources, although most cultural resources can be avoided during the siting process. If existing energy facilities that have historic value or status are removed or modified by new generation facilities, cultural resource impacts would occur. For example, increasing the output of existing generating facilities may require installation of new equipment and modification of existing equipment that displaces structures of historic value. In addition, construction activities and the new facility could be

visible from historic or cultural sites resulting in impacts to the integrity of the site. In the long term, air pollution may degrade historic building materials and character resulting in increased maintenance and/or rehabilitation costs and ultimately compromise preservation of the resource. Air pollutants extending into areas of known cultural importance may be visually intrusive and could affect the spiritual or emotional value associated with the site. Improved access to remote locations that have historic and cultural resources could also lead to greater human presence in the area and possible disturbance. These types of impacts could extend into the period of operation. There might also be additional operation impacts to historic and cultural resources where fuel extraction activities (e.g., natural gas) are involved.

Impacts on historic and cultural resources are summarized in Table 3-20. During construction, it is expected that impacts would be moderate for all portfolios (except Portfolio 1 - Rely on the Market - No Action). Impacts of all portfolios during operation could be moderate. The level of impact is dependent on a number of factors such as the location of the facility and its infrastructure, the scale of the facility, and the type of construction activity. Therefore, differentiating the level of impacts to historic and cultural resources between portfolios is difficult because specific locations of the resources in each portfolio are not known.

Table 3-20. Impacts on Historic and Cultural Resources

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	L	M	M	M
Operation	M	M	M	M

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

3.10.2 Mitigation

Potential mitigating measures for historic and cultural resources include the following:

- Consult during early project planning with the State Historic Preservation Officer, the Advisory Council on Historic Preservation, and Native American tribes with interests in the project area to determine areas of concern and the likelihood of any historic and cultural resources within or near the project area of potential effect, including the proposed route for transmission facilities/infrastructure.
- Conduct historic and cultural resource records and archive searches and field surveys, if necessary, to identify, assess, and evaluate resources that may be present. Records and archive searches and eligibility evaluations should be guided by the standards set forth in The Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.
- Conduct National Historic Preservation Act (NHPA) Section 106 review on individual projects when there is federal involvement (funding, permitting, licensing, or other function).
- Modify the project configuration (e.g., location of the power plant, access roads, substations, transmission lines, and related infrastructure), to the extent possible, to avoid historic and cultural resources identified through the survey and inventory process. Encourage the use of

previously disturbed lands (e.g., existing utility or transportation corridors), rather than pristine lands.

- Develop and implement a mitigation and management plan in consultation with appropriate authorities if historic or cultural resources in development areas cannot be avoided.
- Consult with Native American tribes to determine other issues of concern including but not limited to access rights, disruption of cultural practices, impacts to traditional cultural properties, visual and subsistence resources important to the tribes.
- Halt work immediately if historic or cultural resources are discovered during construction, notify the State Historic Preservation Officer and affected tribes, and develop and implement an appropriate mitigation program. The mitigation program may include conducting shovel probes, monitoring ground disturbance activities and mitigating any identified unavoidable impacts to historic properties or cultural resources.
- Mitigate historic resources receiving energy efficiency measures by retrofitting in a sensitive manner or locating new materials or structures in sites that respect the historic character defining features. Guidance is available from The Secretary of the Interior's Standards for the Treatment of Historic Properties and other National Park Service Preservation Briefs.

3.11 Employment

3.11.1 Impacts of the Alternatives

Employment generally increases during all aspects of the life cycle of electricity generating plants, resulting in usually larger, short-term employment during construction and smaller, permanent employment during operation. This assumes that the generating plant is in addition to, and not replacing, existing generating plants. Different types of energy facilities have different levels of employment impacts.

A report by the Berkeley Energy and Resources Group (Wei, 2010) synthesized data from 15 job studies and calculated the one-time jobs created from construction, installation, and manufacturing and the ongoing jobs created from operation, maintenance, and fuel processing activities. The study concluded "the renewable energy and low carbon sectors generate more jobs per unit of energy delivered than the fossil fuel-based sector" and that "among the common RPS [Renewable Portfolio Standard] technologies, solar creates the most jobs per unit of electricity output." Conservation measures, based on studies done of SCL's programs (SCL, 2008), result in even higher employment levels than shown in the Berkeley Energy Group analysis. Based upon estimates of the total level of funding for these conservation programs, they are estimated to result in over 38 jobs per average megawatt hour, per year. Most of these jobs will be in communities in or around City Light's service area. Appendix C Section 11.2 shows the employment data for solar and the other resources evaluated in the IRP.

Along with employment, local economies accrue gains in personal income due to the wages and salaries paid to workers, spending for facility construction and operation, and the multiplier effects of these economic stimuli. Further, fiscal gains typically accrue to local governmental jurisdictions except in the cases where large-scale development occurs in rural areas without adequate infrastructure (e.g., the "boom-town" phenomenon associated with some past mining activities).

All portfolios would likely have positive impacts during both construction and operation. Employment gains during construction would be likely very low for the No Action (Rely on Market) Alternative because it is unlikely that new plants would be constructed to meet the increased demand for market

transactions. Construction employment gains would likely be moderate for all the alternative portfolios. The moderate impact of the Renewables: Base Conservation and Renewables: Higher Conservation (Portfolio 2 and 4) is primarily due to economic activity associated with conservation program activities, and to the construction of wind farms, utility-scale photovoltaic projects, landfill gas and other renewable resources. The portfolio with wind and gas (Portfolio 5) would have an overall moderate impact during construction because the high employment gains of wind power is diminished by the low employment gains of constructing natural gas combustion turbines.

Employment gains resulting from the operation of the resources all of the portfolios would likely be low. The operation employment gains are due to fuel extraction activities for natural gas and biomass resources along the typically operation and maintenance requirements for all power plants. However, the importance of these employment gains would vary with the size of the local economy in which the facilities are constructed.

Table 3-21 summarizes the impacts of the alternative resource portfolios relative to employment.

Table3-21. Impacts on Employment

	Portfolios			
	1	2	4	5
	Rely on Market	Renewables: Base Conservation	Renewables: Higher Conservation	Wind & Gas
Construction	+L	+M	+M	+M
Operation	+L	+L	+L	+L

L	= Low Impact	M	= Moderate Impact	H	= High Impact	+L, +M	= Positive Impact

3.11.2 Mitigation

No mitigation would be needed, because the impacts are all zero or positive.

4 PUBLIC COMMENT ON THE DRAFT EIS AND RESPONSES

This chapter includes all public comments received on the DEIS. Each specific comment is identified, and a response is given.

Comments were received from:

1. Washington State Department of Ecology SEPA Coordinator
2. Washington State Department of Archaeology and Historic Preservation

DEPARTMENT OF ECOLOGY COMMENTS

If contamination is observed, sampling of the potentially contaminated media must be conducted. If contamination of soil or groundwater is readily visible, or is revealed by sampling, Ecology must be notified. If contamination is encountered in Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, or Yakima counties, contact the Environmental Report Tracking System Coordinator at the Central Regional Office at (509) 575-2490.

City Light Response: Thank you for this comment. While this EIS is not for a specific project or location, if City Light acquires resources to meet load growth in the future it will check that they comply with all applicable regulations regarding toxics contamination.

DEPARTMENT OF ARCHAEOLOGY AND HISTORIC PRESERVATION COMMENTS

1. In section 3.10 at the bottom of page 3-20, I recommend a change to the sentence at the bottom of the page to read: "In addition, construction activities <u>and the new facility</u> could be visible from historic or cultural sites..."

City Light Response: This change has been made.

2. In the first paragraph at the top of page 3-21, I recommend adding another sentence after the first full sentence to read something like the following: "In the long term, air pollution may degrade historic building materials and character resulting in increased maintenance and/or rehabilitation costs and ultimately preservation of the resource."

City Light Response: This change has been made, with a slight modification.

3. In section 3.10.2 on page 3-21-22, I recommend adding potential mitigation measures to include:

"Be proactive in identifying and evaluating for significance and condition of historic and cultural resources presently owned and managed by SCL. Subsequent actions should include developing and implementing policies, plans, procedures, and guidelines for management."

"Continue on-going training of SCL staff on managing cultural and historic properties. Training should be provided for SCL at all levels and having potential impact on management of SCL's cultural and historic properties."

City Light Response: Thank you for these suggestions. Since the IRP considers new resources that SCL might use to supply electricity to customers in the future, the EIS does not address management or mitigation for existing owned or contracted resources. However, while these steps are not listed in the EIS, Seattle City Light has a program for evaluating the significance and condition of the historic and cultural resources that we own and manage. Any decision Seattle City Light makes to purchase energy resources in the future would be made after an evaluation of the impacts of those energy resources on cultural and historic resources and the purchase agreement would include appropriate policies, plans, procedures, and guidelines for managing those historic and cultural resources. SCL recently hired a historic resource specialist in 2011 who provides in-house preservation support including on-going training to SCL staff at all levels regarding to SCL's historic and cultural resources.

4. In Appendix C: Historic and Cultural Resources beginning on page 113, in the 4th sentence in 10.1, I recommend a slight addition to include "landscape" in the sentence.

City Light Response: This change has been made.

5. In section 10.2.3, I recommend deleting "and State". Are there other cultural resource laws that should be listed here? Perhaps there should be a summary of the NHPA here.

City Light Response: These changes have been made.

6. In 10.2.4, see comment (3) above as applicable. Also, I recommend adding to the 5th bullet point the following addition: "Develop and implement a mitigation and management plan (and design guidelines when appropriate) in consultation with appropriate..."

City Light Response: The change to the fifth bullet point has been made.

7. In section 10.8 on Wind, this statement should include the potential to disturb archaeological sites and traditional cultural properties.

City Light Response: This change has been made.

8. Also in section 10.8.2 for operational impacts, I suggest that visual impacts by wind turbines could range to high given the scale and visibility of the structures on the landscape.

City Light Response: This change has been made.

9. In section 10.9 on Solar Energy, the last sentence in 10.9.1 should recognize that solar PV facilities attached to historic buildings or structures could be highly impacted.

City Light Response: This change has been made, added to section 10.9.2.

10. Impacts by solar energy facilities on historic and cultural resources should also acknowledge that installation of solar facilities on private properties (i.e. residences), could have a high visual and physical impact on historic buildings and structures. Mitigation measures should be developed to address these impacts.

City Light Response: These changes have been made.

11. In section 10.13 on Transmission, I suggest that construction of transmission lines and their corridors could have a high impact on the historic character of historic/cultural landscapes and/or traditional cultural properties.

City Light Response: This change has been made.

DISTRIBUTION LIST

INTEGRATED RESOURCES PLAN FINAL EIS

(Includes distribution by electronic link or print copy)

FEDERAL AGENCIES

Bonneville Power Administration
Environmental Protection Agency
National Park Service
NOAA Fisheries
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service

TRIBES

Colville Confederated Tribes
Kalispel Tribe
Lummi Nation
Muckleshoot Indian Tribe
Nisqually Tribe
Puyallup Tribe
Sauk-Suiattle Tribe
Spokane Tribe
Suquamish Tribe
Swinomish Indian Tribe
Tulalip Tribes
Upper Skagit Indian Tribe
Yakama Nation

REGIONAL

Northwest Power Planning Council
Puget Sound Clean Air Agency
Puget Sound Regional Council

WASHINGTON STATE

Office of the Governor
Department of Archaeology and Historic Preservation
Department of Commerce
Department of Community, Trade and Economic Development
Department of Ecology
Department of Fish and Wildlife
Department of Natural Resources
Department of Social and Health Services
Department of Transportation
Washington Energy Facility Site Evaluation Council
Washington State Ferries
Department of Transportation
Washington Utilities and Transportation Committee

Washington Energy Facility Site Evaluation Council
Washington Utilities and Transportation Committee
Washington State Ferries
Washington State University Extension – Energy Program

KING COUNTY

Department of Development and Environmental Services
Department of Health – Seattle and King County
Department of Natural Resources and Parks

FRANCHISE CITIES

City of Burien
City of Lake Forest Park
City of Normandy Park
City of Renton
City of SeaTac
City of Shoreline
City of Tukwila

CITY OF SEATTLE

Office of the Mayor
Budget Office
City Council
Central Library (Downtown)
Department of Law
Department of Neighborhoods
Department of Planning & Development
Economic Development Office
Intergovernmental Relations Office
Office of Sustainability and Environment
Seattle Public Utilities

UTILITIES

British Columbia Hydro
Benton County PUD
Cascade Natural Gas
Chelan County PUD
Clark Public Utilities
Eugene Water and Electric Board
Franklin County PUD
Grant County PUD
Grays Harbor PUD
Idaho Power Company
Mason County PUD No. 3
Portland General Electric
Puget Sound Energy
Snohomish County PUD

Tacoma Public Utilities
Pend Oreille County PUD
Pierce County Utilities
Portland General Electric
Puget Sound Energy
Snohomish County PUD
Tacoma Public Utilities
Umatilla Electric Cooperative
Western Electric Generation and Transmission Cooperative

ORGANIZATIONS and GROUPS

Building Owners and Managers Association of Seattle
Climate Solutions
Energy Northwest
League of Women Voters
Northwest Energy Coalition
Northwest Power and Conservation Council
Pacific Northwest Generating Cooperative
Pacific Northwest Utilities Conference Committee
Port of Seattle
Renewable Northwest Project
Seattle Chamber of Commerce
Seattle Steam Co.
Sustainable Seattle
Washington Environmental Council
Washington Public Interest Research Group
Washington Public Utilities Districts Association
United Indians of All Tribes Foundation

IRP STAKEHOLDERS GROUP

Bonneville Power Association – Stuart Clarke
Envirometrics – Mike Ruby
McKinstry –Mike Locke
Christy Nordstrom
Northwest Council – Tom Eckman
Northwest Energy Coalition – Danielle Dixon, Kim Drury
Nucor – Cameron Cossette
Sabey - Mike Hansen
Seattle Budget Office – Calvin Chow
Seattle Legislative Department – Tony Kilduff
Seattle University – Louie H., Jennifer Sorensen
Sierra Club North Cascades Chapter – Paul Zemtzow
Steven Lafonde
University of Washington – John Chapman, Elise Chayet, Pam Jorgenson, Linda Sandhop

STRATEGIC PLAN (ENVIRONMENT) ATTENDEES

Better Energy LLC – Tracy Farwell
Climate Solutions – Gregg Small, Stephanie Solien
Environmental Works – Roger Tucker
Freehold Group – David Bolin, John Gaines
NBBJ – Energy Code Technical Advisory Committee – Duane Jonlin
North Cascades Conservation Council – Jim Davis
Northwest Energy Coalition – Danielle Dixon
Northwest Sustainable Energy for Economic Development – Linda Irvine
Queen Anne Community Council and Uptown
Urban Center – John Coney
Seattle Parks Foundation – Jessica Shawver
Sierra Club North Cascades Chapter – Paul Zemtzov
Sightline Institute – Eric DePlace
Sustainable Works – Steve Gelb
Washington and Northern Idaho District Council of Laborers – Jermaine Smiley
Washington Environmental Council – Rashad Morris
Paul Higuchi
Brad Meacham

APPENDIX A - GLOSSARY

Biomass
Plant material, vegetation, or agricultural waste used as a fuel or energy source.

Block
A power product offered by the BPA for a fixed amount of power, delivered at a constant rate through the month.

BPA -- Bonneville Power Administration
A power marketing and electric transmission agency of the United States government headquartered in Portland, Oregon.

Capacity
The maximum amount of electrical load that a device can carry at one time. Capacity is also used synonymously with capability.

CCCT – Combined-Cycle Combustion Turbine
A simple cycle combustion turbine with a heat recovery unit added. The heat recovery system recovers waste heat from the combustion turbine and uses it to create steam for additional electricity generation. A combined-cycle turbine operates most efficiently when it is run for long periods of time without being ramped up and down.

EIS -- Environmental Impact Statement
A written analysis of the environmental impacts to be anticipated from a proposed activity (construction of a mine, power plant, or electric transmission). An EIS is required by the National Environmental Policy Act (NEPA) before construction can begin. The Washington State Environmental Policy Act (SEPA) also requires environmental review (which can include an EIS) for proposed activities including approval of plans by governmental agencies.

Electric System
The generation, transmission, distribution and other facilities operated as an electric utility or a portion thereof.

Energy
Electric energy is a measure of the amount of usage over time and is measured in kilowatt-hours or megawatt-hours.

Geothermal
Power generated from heat energy derived from hot rock, hot water or steam below the earth's surface.

IRP -- Integrated Resource Plan
This planning approach provides a process for a utility to evaluate a wide range of power resource alternatives.

Renewables
A resource such as solar energy or wind that is inexhaustible or can be replenished.

Scenario
A possible course of future events. In the IRP, scenarios are used to evaluate portfolios of energy resources under a range of circumstances other than the baseline forecast.

Shaping
Configuring a resource portfolio so that power generation capability and delivery of purchased power closely matches changes in demand over time. Shaping can help to avoid unnecessary costs and the need to sell surplus power.

Slice
A power product offered by the BPA for an amount of power that varies year to year according to the amount of water flowing through the BPA hydroelectric system. In a good water year (above average precipitation), more power is delivered to the same customer than in a poor water year (below average precipitation).

APPENDIX B –
SEATTLE CITY LIGHT'S ENVIRONMENTAL POLICY STATEMENT
and
VISION, MISSION, AND VALUES STATEMENT

Seattle City Light Environmental Policy Statement

Environmental Policy *Our Policy:* Seattle City Light is committed to very high standards of environmental protection. We will operate in a manner that is compatible with the long-term sustainability of the ecosystems that we affect. We believe that sound environmental performance is a key component of sound business performance. Environmental stewardship is a responsibility of all Seattle City Light employees.	*To demonstrate our commitment, we will:* Comply: • Meet or exceed the requirements of all applicable environmental laws, regulations, policies. • Be a model for others in meeting our hydro license requirements. Conserve: • Promote the efficient use of materials and resources, including water and electricity, in all phases of a facility's life. Protect Natural Resources: • Manage our business activities to avoid, minimize, or mitigate impacts to the ecosystems we affect. • Provide resource enhancements when opportunities arise. Prevent Pollution: • Reduce the quantity and toxicity of materials used and waste generated from our facilities and operations through source reduction, reuse, or recycling. Continually Improve: • Set high environmental standards and evaluate our performance against these standards. • Incorporate environmental costs, risks, and impacts when making decisions. • Train all employees on this environmental policy and the key environmental impacts and responsibilities of their work. Lead: • Collaborate with customers, agencies, tribes and other organizations to promote sound science and achieve common objectives. • Be proactive in identifying and addressing emerging environmental issues. • Be a model for others by offsetting our greenhouse gas emissions.

Seattle City Light Vision, Mission, and Values Statement

Our Vision			
TO SET THE STANDARD **To deliver the best customer service experience of any utility in the nation**			
Our Mission			
Seattle City Light is a publicly owned utility dedicated to exceeding our customers' expectations in producing and delivering environmentally responsible, safe, low cost and reliable power			
Customer Service	**Employee Performance & Growth**	**Operational Excellence**	**Financial Strength**
• Being prompt and timely • Improve reliability • Provide solutions	• Reward exceptional performance • Invest in employee development and training • Provide career growth and learning opportunities	• Improve productivity and achieve cost effectiveness • Measure and improve performance • Minimize environmental impact	• Ensure long term financial stability • Preserve and enhance our assets for long term • Manage risks
Our Values			
Excellence	**Accountability**	**Trust**	**Stewardship**
• Safety is our number one concern. • Empowering our employees is essential to providing exceptional customer service. • We anticipate and meet customer needs. • We believe diversity makes us stronger. • We believe that continuous improvement strengthens us. • We are stronger working in teams made up of people from many parts of our business.	• We value ownership of decisions, actions and results. • We measure our success against expectations and accept responsibility. • We encourage sound delegation practices that promote a supportive decision making culture. • We are committed to the highest standards of ethical behavior.	• Our word is our bond. • We are honest, open and respectful in our communications with each other and with customers. • Our customers rely on us to keep our commitments.	• We are entrusted with an irreplaceable hydroelectric legacy. • We work to ensure the success and benefits of public power. • We must enhance, protect and preserve our assets and the environment.

APPENDIX C
TABLE OF CONTENTS

1 INTRODUCTION 7

1.1 RESOURCE DESCRIPTIONS 8

2 SOILS AND GEOLOGY 17

2.1 AFFECTED ENVIRONMENT 17

2.2 GENERAL 17

2.3 CONSERVATION 19

2.4 LANDFILL GAS 19

2.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 19

2.6 GEOTHERMAL 19

2.7 BIOMASS 20

2.8 WIND 21

2.9 SOLAR ENERGY 21

2.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 22

2.11 RENEWABLE ENERGY CREDITS 22

2.12 MARKET TRANSACTIONS 23

2.13 TRANSMISSION 23

3 AIR QUALITY 25

3.1 AFFECTED ENVIRONMENT 25

3.2 GENERAL 25

3.3 CONSERVATION 31

3.4 LANDFILL GAS 32

3.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 33

3.6 GEOTHERMAL 34

3.7 BIOMASS 34

3.8 WIND 37

3.9 SOLAR ENERGY 37

3.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 38

3.11 RENEWABLE ENERGY CREDITS 41

3.12 MARKET TRANSACTIONS 41

3.13 TRANSMISSION 41

4 SURFACE AND GROUNDWATER **44**

4.1 AFFECTED ENVIRONMENT 44

4.2 GENERAL 44

4.3 CONSERVATION 47

4.4 LANDFILL GAS 48

4.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 48

4.6 GEOTHERMAL 49

4.7 BIOMASS 49

4.8 WIND 50

4.9 SOLAR ENERGY 51

4.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 51

4.11 RENEWABLE ENERGY CREDITS 53

4.12 MARKET TRANSACTIONS 54

4.13 TRANSMISSION 54

5 PLANTS AND ANIMALS **57**

5.1 AFFECTED ENVIRONMENT 57

5.2 GENERAL 60

5.3 CONSERVATION 62

5.4 LANDFILL GAS 62

5.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 63

5.6 GEOTHERMAL 63

5.7 BIOMASS 63

5.8 WIND 64

5.9 SOLAR ENERGY 67

5.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 68

5.11 RENEWABLE ENERGY CREDITS 69

5.12 MARKET TRANSACTIONS 69

5.13 TRANSMISSION 69

6 ENERGY AND NATURAL RESOURCES **72**

6.1 AFFECTED ENVIRONMENT 72

6.2 GENERAL 76

6.3 CONSERVATION 77

6.4 LANDFILL GAS 77

6.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 78

6.6 GEOTHERMAL 78
6.7 BIOMASS 78
6.8 WIND 79
6.9 SOLAR ENERGY 79
6.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 79
6.11 RENEWABLE ENERGY CREDITS 80
6.12 MARKET TRANSACTIONS 80
6.13 TRANSMISSION 81
7 ENVIRONMENTAL HEALTH 83
7.1 AFFECTED ENVIRONMENT 83
7.2 GENERAL 83
7.3 CONSERVATION 84
7.4 LANDFILL GAS 85
7.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 85
7.6 GEOTHERMAL 85
7.7 BIOMASS 86
7.8 WIND 86
7.9 SOLAR ENERGY 87
7.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 88
7.11 RENEWABLE ENERGY CREDITS 88
7.12 MARKET TRANSACTIONS 89
7.13 TRANSMISSION 89
8 LAND USE 95
8.1 AFFECTED ENVIRONMENT 95
8.2 GENERAL 95
8.3 CONSERVATION 96
8.4 LANDFILL GAS 96
8.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 97
8.6 GEOTHERMAL 98
8.7 BIOMASS 99
8.8 WIND 99
8.9 SOLAR ENERGY 100
8.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 101
8.11 RENEWABLE ENERGY CREDITS 101

8.12 MARKET TRANSACTIONS 102
8.13 TRANSMISSION 102
9 AESTHETICS AND RECREATION 105
9.1 AFFECTED ENVIRONMENT 105
9.2 GENERAL 105
9.3 CONSERVATION 106
9.4 LANDFILL GAS 106
9.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 107
9.6 GEOTHERMAL 107
9.7 BIOMASS 108
9.8 WIND 108
9.9 SOLAR ENERGY 109
9.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 110
9.11 RENEWABLE ENERGY CREDITS 110
9.12 MARKET TRANSACTIONS 111
9.13 TRANSMISSION 111
10 HISTORIC AND CULTURAL RESOURCES 113
10.1 AFFECTED ENVIRONMENT 113
10.2 GENERAL 113
10.3 CONSERVATION 114
10.4 LANDFILL GAS 115
10.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 115
10.6 GEOTHERMAL 116
10.7 BIOMASS 116
10.8 WIND 116
10.9 SOLAR ENERGY 117
10.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 117
10.11 RENEWABLE ENERGY CREDITS 118
10.12 MARKET TRANSACTIONS 118
10.13 TRANSMISSION 118
11 EMPLOYMENT 121
11.1 AFFECTED ENVIRONMENT 121
11.2 GENERAL 122
11.3 CONSERVATION 124

11.4 LANDFILL GAS 124
11.5 GORGE SECOND TUNNEL (HYDRO EFFICIENCY) 125
11.6 GEOTHERMAL 125
11.7 BIOMASS 125
11.8 WIND 126
11.9 SOLAR ENERGY 126
11.10 NATURAL GAS COMBINED-CYCLE COMBUSTION TURBINES 127
11.11 RENEWABLE ENERGY CREDITS 127
11.12 MARKET TRANSACTIONS 128
11.13 TRANSMISSION 128
12 REFERENCES 130

List of Tables

Table 2-1. Summary of soils and geology impacts 24
Table 3-1. Air emissions per unit of electricity by generation type 28
Table 3-2. Summary of air quality impacts 43
Table 4-1. Water use for combustion turbines (gallons/MWh) 53
Table 4-2. Summary of surface and groundwater impacts 56
Table 5-1. Status of federally-listed animal and plant species in the pacific northwest 58
Table 5-2. Summary of plants and animals impacts 71
Table 6-1. Summary of energy and natural resource impacts 82
Table 7-1. Summary of environmental health impacts 94
Table 8-1. Summary of land use impacts 104
Table 9-1. Summary of aesthetics and recreation impacts 112
Table 10-1. Summary of historic and cultural resource impacts 120
Table 11-1. Summary of employment impacts 129

List of Figures

Figure 1. Representation of Biomass CO2 36
Figure 2. Sources of Northwest natural gas supplies 73
Figure 3. Average employment over the life of a facility from construction, installation, and manufacturing... 123
Figure 4. Average employment over the life of a facility from operation, maintenance and fuel processing..... 123

1 INTRODUCTION

Appendix C begins with a general description of each energy resource and then describes the impacts and mitigation measures for ten elements of the environment:

(1) Soils and Geology,
(2) Air Quality,
(3) Surface and Groundwater,
(4) Plants and Animals,
(5) Energy and Natural Resources,
(6) Environmental Health,
(7) Land Use,
(8) Aesthetics and Recreation,
(9) Historic and Cultural Resources, and
(10) Employment.

Each element of the environment begins with a description of the affected environment and then describes generally how the construction and operation of all the resources considered in the Integrated Resource Plan (IRP) would impact that element. After describing the common environmental impacts that have the potential to occur for nearly every resource, unique impacts and, where appropriate, potential mitigation options are detailed for each of the resources. The section concludes with a table summarizing the level of construction and operation impact assigned to each resource. The assigned impact level is based on a scale of three levels: potential for low, moderate, or high impact. The assigned value reflects a judgment about the severity of an impact, with the level of severity determined by considering the magnitude, extent, duration, and probability of an impact. Although most resources have a negative impact on the environment, occasionally the energy resource may have a positive impact, which is indicated in the summary table with a "+." For example, construction of wind farms, combustion turbines, and all the other resources creates jobs, which results in a positive impact in the Employment section.

The level of impact for each resource is a building block for the analysis of the environmental impacts of the portfolios (combination of resources) described in Chapter 3 of this environmental impact statement (EIS).

There is often a range of environmental impacts that may occur from the construction and operation of energy resources. This is because there is uncertainty about many factors that influence impacts, including the geographic location of the facility, types and effectiveness of mitigation, site conditions, fuel extraction operations, methods of waste disposal, etc. Where a range of potential impacts has been identified, the highest level is depicted in the summary table. This range of impacts may be narrowed by standards that Seattle City Light (SCL) sets and that will be reflected in the analysis.

For example, the level of impact on aesthetics and recreation from transmission towers was determined to range from low to high; the "high" level of impacts is shown in the summary table. For this example, there is a range of aesthetic impacts. This programmatic EIS considers a wide range of impacts. Actual impacts depend on the specific site developed, the surrounding views, and the number and type of exposed viewers and their sensitivity to landscape changes.

City Light will complete a site-specific environmental assessment when specific new resources are acquired.

The description and level of impacts is based upon available information. More is known about mature or well-established technologies (e.g., combustion turbines or wind turbines) than new technologies. Therefore, there

are knowledge gaps in the understanding of construction and operation impacts attributable to new or emerging technologies or for technologies for which fewer plants have been built compared to other types. For example, although operation of the first American geothermal electric power plant began operation in California in 1960, a geothermal electric plant has yet to be constructed in Washington State. As a result, less is known about the local environmental impacts attributable to geothermal development than wind development, which at the end of 2011 had resulted in over 2,500 megawatts (MW) of generating capacity in the state. As a result, the EIS may provide more information about impacts from wind turbines than geothermal plants. This does not necessarily imply that the severity of impacts is greater with wind turbines than geothermal—only that there is a better understanding of the potential impacts.

1.1 Resource Descriptions

1.1.1 Conservation

Conservation resources include a wide range of methods to reduce energy use by residential, commercial, and industrial customers. Individual conservation measures are typically packaged into programs based on target customer groups, delivery methods, and funding sources. This EIS does not address specific conservation programs, but instead describes the general types of conservation measures that could be used in the variety of programs implemented by Seattle City Light (SCL).

1.1.1.1 RESIDENTIAL

Residential conservation includes a wide variety of approaches to promote increased efficiency of electrical use in both new and existing residences. The residential sector includes single-family homes, multiplexes (two- to four-unit dwellings), multifamily apartment buildings, and condominiums. Residential conservation measures can be divided into the following general categories:

- Building envelope
- Lighting
- Water heating
- Space heating (primarily ductless heat pumps)
- Appliances (clothes washers, refrigerators, freezers)

Typical energy efficiency measures installed under a conservation program for existing residences include wall, floor, and ceiling insulation, windows, lighting (bulbs and fixtures), refrigerators, freezers, clothes washers, and ductless heat pumps.

Conservation programs for new residences offer incentives and/or technical assistance to building owners and developers for building to more efficient standards than required by current energy codes and appliance standards. Energy efficiency measures for new residences, including new multifamily buildings, include all the efficient appliances listed above, along with insulation, windows that are more efficient, efficient lighting and lighting controls, and higher efficiency HVAC systems and controls.

1.1.1.2 COMMERCIAL

Commercial sector conservation measures can be applied to both new and existing buildings. Conservation in existing commercial buildings can involve upgrading a single system or more substantial renovations or retrofits where new mechanical, electrical, or structural features are installed. In new commercial buildings, incentives and/or technical assistance are offered to the owner, designer, or developer to build beyond the current energy code. For both existing and new commercial buildings, conservation measures fall into the following end-use categories:

- Lighting – efficient lighting measures includes T-8 fluorescent, T-5 fluorescent, LED, metal halide, high-pressure sodium lamps, and fixtures; exit signs; occupancy sensors; and daylighting controls.
- Heating, Ventilation, and Air Conditioning (HVAC) – HVAC measures focus on increasing the efficiency of energy use in heating and cooling systems and optimizing the air movement in buildings. These measures include more efficient chillers, air conditioners, air-to-air heat pumps, hydronic heat pumps, variable speed drives, and HVAC controls.
- Refrigeration – efficient refrigeration measures include commercial solid-door refrigerators and freezers; pumps, compressors, and chillers; exhaust heat recovery; variable speed drives; and the design and installation of control systems.
- Building Envelope – efficiency measures include insulation and energy-efficient doors and windows.
- Equipment and Appliances – includes more efficient water heaters, data processing equipment, vending machines, and other energy using office equipment.

1.1.1.3 INDUSTRIAL

Energy conservation in the industrial sector is aimed at increasing the efficiency of energy use in industrial processes and systems. Energy-consuming end uses in industrial facilities include motors, pumps, heating, cooling, fluid handling, ventilation, lighting, controls, and space and material heating.

Among the energy efficiency measures applicable to the industrial customer are:

- Efficiency lighting upgrades including daylighting and occupancy controls.
- Compressed air system upgrades including new compressors, humidity controls, variable speed drive compressors, and cycled refrigerated dryers.
- Variable speed drives on cooling tower fans and pumps.
- Ventilation fans and industrial process controls.
- Heat recovery measures.
- Electric furnace upgrades.
- Premium efficiency motors.

1.1.2 Landfill Gas

Landfill gas is a by-product of decomposing organic material produced in the anaerobic conditions of landfills. Typically, landfill gas consists of about 50 percent methane, about 50 percent carbon dioxide (CO_2) and a small amount of non-methane organic compounds (EPA, 2012). In most modern landfills, federal laws require that the gas be captured (usually with a series of collector pipes distributed throughout the landfill) and flared to reduce explosion hazard. In addition to reducing flammable methane, flaring destroys Hazardous Air Pollutants (HAPs) in the landfill gas. Flaring is assumed to destroy 98 percent of the HAPs, but the actual destruction level can be lower (NRDC, 2003).

Alternatively, the gas mixture can be burned to produce electricity using several generation technologies. Methane can be combusted to produce electricity in generators or it can be used in fuel cells to create electricity electrochemically. As of July 2011, there are 558 operational landfill gas energy projects in the United States (EPA, 2012). This analysis assumes that electricity will be generated by combusting the gas in one or more small (approximately 5 MW) combustion turbines or an internal combustion engine rather than using fuel cells.

This analysis assumes that the landfill energy project would be located at an existing landfill in the Northwest, either west or east of the Cascade Mountains. Generally, landfills are already served by the local electrical transmission and distribution network, but upgrades and new infrastructure may be required if the electricity generation exceeds the on-site needs of the landfill, which is likely in the project size category being evaluated.

Additional infrastructure requirements may include transformers or a small substation, and new or larger transmission/distribution lines and poles/towers. The actual upgrade requirements and environmental impacts would be specific to the site.

1.1.3 Gorge Second Tunnel (Hydro Efficiency)

City Light pursues ongoing efficiency improvements to the hydro plants that it owns. This may include upgrades or replacements of turbines, runners, transformers, and other equipment, often on a prescribed schedule. Hydro efficiencies allow incremental increases in generation capabilities, allowing more electricity to be produced from the same hydro resources. The main new hydroelectric resource considered in this analysis is an efficiency improvement at Gorge Dam, part of City Light's Skagit Project.

Gorge Powerhouse is a hydroelectric plant that is part of the Skagit Project owned and operated by SCL. The powerhouse is supplied with water from Gorge Reservoir through a single power tunnel. The project would involve installing a second companion tunnel that would decrease flow velocities, reduce energy lost to turbulence when water flows at high velocity, and reduce the frictional losses that occur between the water and the tunnel wall, thereby increasing the effective hydraulic head. This would result in greater power production for the same amount of water. This efficiency improvement would add 25 MW of capacity and increase annual generation by 57,700 MWh under average water conditions.

The second tunnel would branch off the existing tunnel below the reservoir intake, continue underground and parallel to the existing tunnel, and then reconnect with the existing tunnel above and just north of the powerhouse near the existing surge tank. A new intake would not be required and there would be no change in water diversion amounts, flow, or plant operations. The tunnel would be approximately 11,000 feet long and 22 feet in diameter.

A Federal Energy Regulatory Commission (FERC) license amendment and other permits would be necessary. The project would be completed within about eight years, with the first four years for completing project design and FERC license amendment-related requirements. Construction of the tunnel would be accomplished primarily using a tunnel-boring machine and, to a lesser extent, traditional drilling and blasting methods. The excavated rock would be hauled a distance of 10 miles to an abandoned quarry, where it would be placed. The quarry site would be graded and planted with native species to create six acres of improved wildlife habitat

A detailed assessment of potential effects and mitigation for the second tunnel project construction and operation can be found in the Applicant-Prepared Environmental Assessment, included as Exhibit E in SCL's June 2011 application for amendment of the FERC License for Project 553.[1]

1.1.4 Geothermal

Geothermal energy is a form of renewable energy derived from a natural heat source deep in the earth's crust. The heat is brought near the surface by thermal conduction and by intrusion into the earth's crust of molten magma originating from great depth, heating any nearby groundwater and rock. As the groundwater is heated, geothermal energy may be produced in the form of hot water and steam. This form of renewable energy source can be extracted from the earth and used to produce electricity directly using "flash" geothermal technologies. Alternatively, water or other working fluids may be pumped from the surface and circulated through hot rock formations, then returned to the surface, where the resulting steam is used to generate electricity.

[1]The Applicant-Prepared Environmental Assessment can be accessed on SCL's Gorge 2nd Tunnel FERC Amendment website at http://seattle.gov/light/g2t/lada.asp.

In geothermal power plants, steam produced from geothermal reservoirs provides the force that spins the turbine generators and produces electricity. The geothermal water is then returned down an injection well into the reservoir to maintain pressure, to sustain the reservoir, and eventually to be reheated.

The temperature and pressure of the geothermal resource are the primary factors that determine the generation technology used to convert the geothermal fluid energy to electric energy. Three mature generation technologies that can use geothermal resources to produce electricity are flashed steam, binary cycle, and dry steam. The geothermal generation technology evaluated in this EIS is binary cycle.

Binary cycle technology is used for lower temperature geothermal reservoirs. The geothermal liquid is brought to the surface through wells, and passed through a heat exchanger where the energy is transferred to a low boiling point fluid, usually a hydrocarbon such as isobutane or isopentane. The vaporized low boiling point fluid drives a turbine-generator, condenses, and eventually recycles to the heat exchanger. The cooled geothermal fluid is then injected back into the geothermal reservoir.

Geothermal plants are typically sited in 20- to 50-MW units, but modular systems as small as 5 MW have been developed. Geothermal resources can be operated to vary output up or down to meet changing energy demand, but are normally operated to produce electricity at a constant rate. Geothermal power plants typically produce electricity about 90 percent of the time, though they can be expected to run 95 to 98 percent of the time.

Geothermal development potential in the Pacific Northwest is unclear as only extensive exploratory drilling can demonstrate the presence of a viable geothermal fuel source. The most likely locations for geothermal power plants in the Northwest are the Basin and Range provinces of southeastern Oregon and southern Idaho, and the High Cascades, particularly in southern Oregon. The Cascades represent the greatest potential for geothermal resources, but their development potential is considered the most uncertain. The Western Governor's Association Geothermal Task Force Report identified over 5,000 MW of promising geothermal resources in the West and nearly 1,300 MW of geothermal in the Northwest that is developable in the near term. As of April 2011, geothermal electric power is generated in nine states: Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming (GEA, 2012).

Snohomish County Public Utility District No. 1 has evaluated the feasibility of geothermal energy at several sites in Washington State, including a site at Garland Mineral Springs. In 2012, the utility drilled a 5,000-foot deep well at the Garland Mineral Springs site to establish a temperature gradient profile. However, preliminary results indicate that the temperature and permeability conditions at the site are not favorable for a geothermal facility.

1.1.5 Biomass

The wood biomass generation facility evaluated in the IRP produces electricity by directly combusting waste wood. The heat from combustion turns water into steam; the steam drives a turbine, which turns a generator that produces electricity. This analysis assumes the biomass plant will be a cogeneration facility. Cogeneration or combined heat and power (CHP) generation, is the joint production of electricity and thermal energy using one primary fuel. The thermal energy can be used for a variety of purposes, including steam production, space heat, hot water, drying, and cooling. In wood biomass CHP projects, the steam is often used at a wood processing facility that supplies waste wood as fuel. CHP, therefore, improves the overall energy efficiency of the production process. Conventional steam-electric plants with or without cogeneration are likely to remain the chief technology for electricity generation using wood residue.

For biomass-fueled power plants, reliance on variable supplies of forest and agricultural residues means that a continuous supply of fuel may be uncertain. Generation of electric power requires large quantities of biomass.

Fuel transportation, storage, and handling also have environmental impacts and vary depending on the type of plant and location. For example, logging residue requires more processing and has higher transportation costs than mill residue. Designing the facility to use multiple fuel types can mitigate uncertain fuel supplies.

Fuel competition and transportation costs effectively preclude construction of power plants of greater than 50 MW. Most future biomass plants are likely to be in the range of 15 to 30 MW. There is considerable uncertainty associated with the availability and cost of a firm fuel supply for biomass projects. The biomass plant analyzed was a CHP plant, located near an industrial facility that would need the steam, such as a lumber mill. Therefore, the likely proximity to load (where the electricity is used) reduces those costs and risks because new long transmission lines would not be required as they would for more remote resources.

1.1.6 Wind

Wind was first harnessed to generate electricity approximately 100 years ago. According to the American Wind Energy Association (AWEA), "The American wind industry has added over 35 percent of all new generating capacity over the past four years, second only to natural gas, and more than nuclear and coal combined" (AWEA, 2012a). At the end of 2011, the cumulative installed wind capacity in the United States was 46, 919 MW (AWEA, 20012a). Wind power projects completed in the Pacific Northwest have brought online a production capacity of 2,573 MW in Washington, 2,513 MW in Oregon, 618 MW in Idaho, and 386 MW in Montana by the end of 2011 (AWEA, 2012b).

In 2006, Washington State passed a renewable energy standard through ballot initiative 937. The renewable energy standard requires utilities serving more than 25,000 customers to obtain 15 percent of their electricity from renewable resources by 2020 and invest in energy efficiency. Wind energy is expected to play a key role in meeting this renewable energy standard for energy production and reducing greenhouse gas emissions in Washington.

For this EIS, City Light assumes that acquisition of wind energy resources could involve purchasing electricity generated by an existing or future wind energy project and/or participating in the development of new wind energy facilities. In either case, the wind energy project(s) could be located virtually anywhere within the Northwest, either west or east of the Cascade Mountains where there is a sufficient wind resource. Based on the distribution of existing projects in the Northwest, however, the wind energy facilities would likely be located east of the mountains. Wind farms in the Northwest and elsewhere in the United States tend to be located in rural or remote areas.

Wind energy is converted into electricity and delivered to customers through five basic steps:

(1) Electricity is generated by wind turbines, which typically consist of a tubular steel tower supporting a nacelle (the housing for an enclosed generator that is connected by a gearbox to the rotor) and a three-bladed rotor. Wind blowing against the turbine blades causes them to rotate, which in turn rotates an electrical generator in the nacelle that produces an electrical current.

(2) Cables carry the generated electricity down the tower to a ground-level base panel inside the tower.

(3) The electricity is fed to a pad-mounted transformer located adjacent to the tower that increases (steps up) the power to a higher voltage.

(4) The stepped-up power from the transformer then is fed into a power collection system that connects groups of wind turbines within the project to a project substation.

(5) Substation equipment transforms or again steps up the voltage of the electricity from the project. A transmission line feeds energy from the substation to the regional electrical transmission system, through which it is conveyed to utility distribution systems for delivery to customers.

Modern wind turbines are large structures that usually exceed 350 feet in height. Construction of wind projects involves a number of activities and a variety of heavy construction equipment in the process. Key construction activities typically include:

- Constructing a project access road system;
- Clearing and grading to establish turbine sites and staging and lay-down areas;
- Excavating and installing foundations for the turbine towers;
- Assembling the towers and installing the nacelles and rotors;
- Constructing the substation and operations and maintenance center;
- Installing permanent meteorological (met) towers;
- Connecting the turbines, met towers and substation with power collection and signal cables (typically located underground);
- Constructing the transmission line that connects the substation with the transmission grid; and
- Testing all facilities prior to commercial operation.

Today's utility-scale wind farms typically encompass a total project area of several thousand acres or more, although the permanent facilities use no more than 5 to 10 percent of the total acreage. Construction activities temporarily disturb a considerably larger area than the permanent footprint of the project facilities. The disturbed areas not occupied by permanent facilities are restored following construction.

1.1.7 Solar Energy

Solar energy is generated by two basic technology alternatives: solar thermal and photovoltaic (PV). Solar thermal devices use the heat from the sun to increase the temperature of a working fluid, which is subsequently used to generate electricity. Utility-scale solar thermal technologies, often referred to as concentrating solar power (CSP), include parabolic troughs, power towers, and dish engines.

Both the parabolic trough and the power tower use mirrors that concentrate the sun's energy on a vessel that contains a fluid. The fluid is pumped into a steam generator and, eventually, the steam spins a conventional turbine to generate electricity. In the trough, the mirror is a long parabola with a steel tube running along the focal axis of the mirror, which is usually in a north-south direction. The mirror is rotated from east to west during the day to ensure that energy from the sun is continually focused onto the steel tube. A power tower facility consists of a central tower surrounded by hundreds or thousands of flat-plate collectors that concentrate the sun's energy on a central point at the top of the tower. A cold fluid is pumped up from the ground, heated at the top of the tower, and returned to the ground to a steam generator.

A typical dish system consists of a parabolic concentrator, a receiver, an external heat engine, and a generator. Sunlight is concentrated onto the receiver, which transfers the heat to a gas (usually hydrogen) contained in the heat engine. The heated gas expands and drives a piston, shaft, and drive system similar to those used in combustion engines; however, the gas is not ignited.

Photovoltaic technologies use a semiconductor device, called solar cells, to convert light from the sun to electricity. Energy from the sunlight displaces electrons from their normal atomic orbits; a grid structure on the surface of the semiconductor collects these electrons and makes them available to be used in an external circuit. The semiconductor material can be crystalline or thin film. Crystalline cells are usually made from silicon, cut

into thin slices, processed to optimize collecting efficiency, and laminated into a protective enclosure. Thin film cells are extremely thin layers of semiconducting material that are evaporated onto a substrate. The semiconductor material can be amorphous silicon, copper indium diselenide, or cadmium telluride. Solar photovoltaic cells may be used to build either smaller panels for distributed (rooftop) solar applications or for utility-scale installations. To produce electricity at scale, many individual solar cells are connected as a module; modules are combined to make individual solar panels; and solar panels are grouped into arrays.

Whether photovoltaic or solar thermal technology is used, the amount and timing of solar power production depends on the location of the generation source. The largest amount of solar power can be produced in locations that receive more frequent sunshine, and at latitudes (and times of the year) where the sun shines more directly at the earth. Therefore, this analysis assumes that the solar energy project would be located in sunnier regions of the Pacific Northwest or in the Southwest.

In distributed and small-scale applications, solar power systems generally do not use high-voltage transmission facilities. In large-scale applications, new transmission facilities may be required. For example, new transmission facilities may be needed if a utility-scale solar power system is developed in eastern Washington.

1.1.8 Natural Gas Combined-Cycle Combustion Turbines

A combined-cycle combustion turbine (CCCT) combines or couples a basic gas turbine with a steam turbine, thereby increasing the efficiency of a basic gas turbine. A basic gas turbine mixes fuel (in this analysis, natural gas) with hot compressed air and then burns the mixture in a combustion chamber. The hot exhaust gases expand in a turbine, which then rotates and drives a generator. A CCCT uses the energy of the hot exhaust gases leaving the turbine to operate an additional steam turbine and electric generator.

A CCCT can be started quickly, but the steam cycle takes hours to start up and shut down. Combustion turbines operate at highest efficiency under full load and their efficiencies fall off significantly below 75 percent of output.

A CCCT is a low capital cost, highly efficient generator of electricity. The largest component of the cost of a CCCT is the fuel. Historically, the uncertainty and volatility of the price of natural gas has made other resource alternatives (e.g., coal) look more attractive. However, the lower natural gas prices and the potential for carbon dioxide caps or penalties are encouraging the expansion of natural gas resources.

1.1.9 Renewable Energy Credits

Renewable Energy Credits (RECs) represent the environmental attributes of electricity generated from renewable energy resources. An REC is a tradable certificate that represents at least one hour of generation from a renewable generation facility. It can be sold separately from the generic energy it is associated with. As used in the IRP, RECs comply with Washington's Energy Independence Act of 2006 (I-937). This law specifies that RECs must be from a qualifying facility that is not powered by fresh water except for efficiency improvements to existing hydro facilities. The generation facility must be located in the Pacific Northwest. RECs are verified by a renewable energy credit tracking system selected by the Washington Department of Commerce.

Under current REC market conditions, it is anticipated that SCL will purchase RECs from wind, geothermal, wood biomass, or landfill gas renewable energy projects. While other types of renewable energy technologies qualify under state law, they are not commercially available (such as wave, tidal, or ocean), or are likely to be more expensive (solar, biodiesel or agricultural waste), so are not evaluated at this time. If they are considered in the future, the necessary environmental assessment will be done at that time.

1.1.10 Market Transactions

Market Transactions, are purchases and sales made in the wholesale electricity market directly by City Light. All utilities face periodic mismatches between the production of their generating resources and their retail demand for power. As a practical matter, it is impossible to match the two every hour of every day. When production exceeds demand, utilities typically sell into the wholesale power market and when native production is less than demand, they buy. Annually, City Light is a net seller to the market even under very poor hydro conditions, but will often buy from the market to meet demand on a shorter-term basis or for economic reasons. For example, City Light routinely buys energy from the market during off-peak periods when it is cheap and saves the water that would otherwise be used to meet retail demand during peak periods when power prices are higher.

Assessing the environmental impacts of the wholesale power market as a resource poses a problem because the exact source of the energy is unknown. In practice, the energy is a blend of the energy delivered by all of the generating plants connected to the grid—the interconnected high-voltage transmission system—at the time the energy is consumed. In past planning efforts, City Light constructed a model resource to represent the likely blend of resources running during the periods that City Light was purchasing and used it to estimate the environmental impact. In this plan, City Light is relying on information provided by the U.S. Environmental Protection Agency (EPA) and forecasts of natural gas plants operating in the western US made by energy consultants.

While it is not possible to know exactly what type of power plant will provide the electricity served by market transactions, under current market and regulatory circumstances, City Light has estimated the resources used to supply market purchases over the 20-year planning period. In the near-term planning period, this resource is a natural gas combustion turbine with a small amount of coal power production. The natural gas and coal plants on the margin (i.e., most likely to be turned on or off as the demand for electricity is added or dropped) will in general be older, less efficient plants. Current regulations and low natural gas prices support the assumption that natural gas combustion turbines are likely to be the primary marginal resource.

1.1.11 Transmission

New or upgraded transmission facilities may be required to transmit electricity from new generation facilities to the SCL service area or to deliver it to the regional transmission grid. Also, new transmission facilities may be needed to improve reliability, redundancy, or otherwise increase the capacity of the system in a manner that could reduce or defer the need for new generation facilities. Actual transmission requirements cannot be determined until specific information on the size, location, and operating characteristics of proposed new resources is known. In general, resources farther from load centers (where the electricity is used) and from existing transmission lines would require more new transmission facilities than resources close to load centers and existing transmission lines.

Transmission facility construction could include building new or upgrading existing transmission lines or substations. The transmission lines themselves (i.e., the conductors) move electricity from the generating source to the load centers. Transmission lines are suspended on either lattice steel towers or wood or steel single-pole structures; designs vary, but often towers are a hundred feet or more in height. Transmission lines require access roads for construction and maintenance. New substation facilities would house transformers, breakers, and other electrical equipment.

Transmission line corridors must be kept clear of any vegetation that could contact the lines and cause a power outage. Vegetation is cleared during construction of the lines to allow towers and access roads to be built. The clearance distance between any objects (including trees) and the lines is set by national electrical standards and varies with the voltage and design of the transmission system. Ongoing vegetation management is required

throughout the life of the transmission line to prevent trees from growing into, or falling onto, the lines. Trees and other vegetation requiring removal can be managed through physical removal or with herbicides, or a combination of both techniques. City Light uses an Integrated Vegetation Management approach, which seeks to minimize the use of pesticides. Pesticides used by City Light are evaluated by a toxicologist, and those with the lowest impacts are used. Application targets the plant directly rather than broadcast.

New transmission lines would pass through a variety of jurisdictions and over many types of landscapes to reach areas where the electricity is used. In the Pacific Northwest, over 75 percent of the existing transmission system is owned and operated by the Bonneville Power Administration (BPA), and permitting and construction authority would likely fall to BPA. Other possible permitting and approval authorities include federal land management agencies from which a right-of-way permit might be needed, and/or state and local land use jurisdictions. In Washington, the Energy Facility Siting Council is the transmission siting authority. The appropriate environmental review process would be followed depending upon the federal or state agency with jurisdiction over the transmission facility project.

2 SOILS AND GEOLOGY

2.1 Affected Environment

The Pacific Northwest, the study area for this IRP, spans three physiographic areas: Northern Rocky Mountain, Columbia Plateau, and Pacific Mountain systems. Major features include the Columbia and Snake rivers, the Puget Sound and Willamette Valley plains, and the Coast/Olympic, Cascade, and Rocky Mountain ranges. The Columbia River Basin contains more than 258,000 square miles of drainage including most of Washington, Oregon, and Idaho; Montana west of the Rocky Mountains; small areas of Wyoming, Utah, and Nevada; and southeastern British Columbia. These physiographic features define the climate, vegetation, transportation, and development patterns of the region. The Pacific Northwest includes widely different climatic regions. Elevations range from sea level on the coast to 14,410 feet at Mount Rainier in Washington (BPA, 1993).

There is wide variability in geologic structure, topography, slope, erosion potential, and geologic hazards within this region. The specific conditions at an energy resource site would determine a project's level of impact.

2.2 General

2.2.1 Construction Impacts

Construction of power plants and associated infrastructure such as cooling towers, access roads, transmission lines, and pipelines would result in surface and subsurface disturbances to soil and geologic formations. Disturbances may occur from:

(1) Clearing, grading, and other construction activities that expose soil to erosion by wind and water;
(2) Removing plants and soil and disrupting biological functions that temporarily reduces productivity and could lead to soil erosion;
(3) Operating heavy equipment that compacts native soils, which in turn degrades soil structure, reduces moisture retention, gas exchange and, thus, respiration and other metabolic functions of soil organisms;
(4) Drilling or blasting that could activate geological hazards;
(5) Consuming geologic materials such as sand and gravel for use in concrete, road surfaces and bases, and as backfill; and
(6) Releasing hazardous fluids (fuel and hydraulic oils, etc.) to groundwater during construction.

Disturbances caused by construction staging would be temporary, but soil disturbances caused by roads, the plant, or related facilities would be permanent. The magnitude of the impact will depend on many factors including the existing use of the land. Infrastructure located in an existing structure or on land that has already been disturbed will generally have a smaller impact than projects located on previously undeveloped land. The extent of construction impacts at any one site would also depend upon the quality of soil, the amount of moisture in the soil, the amount of surface water flowing across the site, the steepness of slopes and, for new structures, the type of structure erected. In general, locations west of the Cascades and areas with steeper slopes have greater potential for adverse impact.

Construction impacts on geology and soil can be minimized by careful planning and design, and through use of best management practices (BMPs) in the field. Planning and design measures to reduce impacts include locating project facilities to avoid geologic hazards and erosion-prone areas, conducting site-specific evaluations of geotechnical conditions, and designing project facilities to meet the conditions encountered.

2.2.2 Operation Impacts

Power plant operation would not typically result in significant disturbance of soil and geologic formations. The use of vehicles and equipment during operation and maintenance activities would disturb soil at a low level and there could be vibration from power plant operations. Waste generated by plant operation would require disposal in a landfill, representing a low to moderate soil and geology disturbance depending on the plant location and capacity of the landfill used.

Operation impacts may also occur for energy resources that extract fuel on an ongoing basis. Applicable fuel extraction impacts are discussed in the relevant section.

2.2.3 Laws and Regulations

A number of regulations apply to ground-disturbing activities, including:

- Zoning and grading regulations, which are generally set a the local level (county or city)
- Federal Surface Mining Control and Reclamation Act. The Surface Mining Law created two major programs: a **regulatory program** to establish standards and procedures for approving permits and inspecting *active* surface and underground coal mining and reclamation operations, and a **reclamation program** for *abandoned mine lands* that is funded by fees that operators pay on each ton of coal mined. The fees are used to reclaim land and water resources adversely affected by pre-1977 coal mining. Although the Surface Mining Control and Reclamation Act is a federal law, Congress structured the program in such a way that states would be the primary authorities responsible for enforcing the law, establishing regulations and performance standards, and issuing surface mining permits.
- BMPs to reduce soil erosion and control stormwater runoff. These standards are employed according to specific site and weather conditions, and are often required by local jurisdictions. The required BMPs may include the use of straw, silt fences, and water detention ponds. Clearing and Grading Permits are often required by local jurisdictions for soil and vegetation disturbance and may contain requirements for BMPs.

2.2.4 Mitigation

Measures to mitigate the effects of ground-disturbing activities include:

- Implement planning and design measures to avoid areas of sensitive soil, streams, wetlands, and geologic hazards.
- Retain vegetative buffers where possible to prevent sediment from reaching streams.
- Minimize the footprint of the operations area and the extent of ground disturbance required through careful project planning and by using existing roads to the extent possible. Locate new access roads to follow the local topography, and minimize hillside cuts.
- Identify and avoid unstable slopes and other geologic hazards, and avoid creating excessive slopes during construction; use special construction techniques where applicable.
- Obtain clearing and grading permits required by local jurisdictions for soil and vegetation disturbance and comply with permit requirements.
- Schedule construction during the dry season to the extent possible when stream flow, rainfall, and runoff are low, to minimize erosion, sedimentation, and soil compaction.
- Cover and stabilize exposed areas consistent with applicable standards, salvage removed topsoil and revegetate disturbed areas with native seed as soon as possible.
- Develop and implement a temporary stormwater management system to control runoff, erosion, and sedimentation during construction, including use of a stormwater pollution prevention plan (SWPPP) and BMPs during construction. BMPs may include using straw, silt fences, and water detention ponds.
- Implement a spill prevention control and countermeasure plan (SPCC) that would minimize groundwater impacts.

2.3 Conservation

2.3.1 Construction Impacts

Energy efficiency measures have low potential for adverse impacts on soil and geology.

2.3.2 Operation Impacts

Energy efficiency measures have low potential for adverse impacts on soil and geology.

2.3.3 Mitigation

There is low likelihood that mitigation would be needed.

2.4 Landfill Gas

2.4.1 Construction Impacts

Since the landfill gas energy facility would likely be installed at an existing or permitted landfill, and the electricity generating facilities would not require substantial disturbance to soil or geology outside the existing landfill and gas collection footprint, impacts on soil and geology would be low.

2.4.2 Operation Impacts

See Section 2.2.2. Overall impacts are anticipated to be low.

2.4.3 Mitigation

See Section 2.2.4.

2.5 Gorge Second Tunnel (Hydro Efficiency)

2.5.1 Construction Impacts

The majority of disturbed area would be underground, where approximately 287,700 cubic yards of rock would be removed. At the tunnel portal site, rock scaling would be needed to stabilize the construction site, and soil and vegetation would be disturbed. Excavation staging, rock stockpiling activities, and quarry site redevelopment could result in soil erosion if BMPs were not employed. Overall, it is expected that impacts would be moderate.

2.5.2 Operation Impacts

Operation impacts are anticipated to be low.

2.5.3 Mitigation

See Section 2.2.4.

2.6 Geothermal

2.6.1 Construction Impacts

Before construction, exploratory drilling must be conducted to determine the potential of the geothermal resource. This exploration will require constructing access roads, clearing of the drill site, and drilling and removing soil from the holes. These activities may disturb the soil and geology of the area, depending on the specific activity being conducted. Additional soil disturbance could be caused by building permanent wells to

bring hot water and steam to the surface, foundations for the turbine and generator equipment, and the supporting facilities and buildings required for the operation.

Drilling through geological formations that hold heat and water affects those formations and could permanently alter their hydrological functions. Depending on the types of soils and the extent of the disturbed area, these impacts could be significant. The extent of such impacts would depend on an area's erosion potential, topography, unique geologic features, and mineral resources and the subsequent effects of such hazards on project facilities and personnel. A complete soil and geologic survey of a site would determine if the area could adequately support a geothermal operation while adequately protecting soil and geologic resources of the area. Once a site is determined adequate, the extent and magnitude of the impacts to these resources would be analyzed. Overall, potential impacts are likely to be moderate.

2.6.2 Operation Impacts

The specific operational impacts on an area's soil and geology would relate directly to the conditions on site, and would vary widely depending on a given area. In general, pumping water from underground can cause soil to slide and land to subside if it is not continuously re-injected. There is also the potential for increased seismic activity around geothermal withdrawal areas. The extent of this shifting, and the magnitude of any seismic activity that might result, is difficult to predict without specific site data. Any additional impacts relate to site maintenance and would be limited as long as good erosion control practices are followed and the geothermal wells are adequately controlled.

Depending on the geothermal site, the groundwater may contain solids that must be filtered before the steam is sent to the turbine generators. These solids must be disposed of, either by recovering and selling them as marketable products, or by disposal in a landfill.

There would be no measurable difference between the two types of geothermal processes with respect to the potential impacts on an area's soils or geologic resources in either construction or operation. Overall, impacts are anticipated to be low to moderate.

2.6.3 Mitigation

See Section 2.2.4.

2.7 Biomass

2.7.1 Construction Impacts

See Section 2.2.1. With implementation of appropriate mitigation, impacts are expected to be low.

2.7.2 Operation Impacts

In addition to soil and geology impacts discussed in the General Operation Impacts Section 2.2.2, biomass facilities may have additional impacts associated with the collection of biomass feedstock. This analysis assumes that the feedstock is a waste product that would otherwise be left on site, burned on site, or disposed of at a landfill, and therefore, there would be low potential for incremental impact to soil and geology. If the feedstock is residue from logging operations, there could be a low incremental impact caused by removing the residue from steep fragile soil, which could disturb soil and compact wet soil. Additionally, if too much logging residue is removed, it can interrupt the nutrient cycling.

Additional soil disturbance could occur if the ash from wood combustion has to be disposed of in a landfill, though this is likely to be a small impact relative to other waste sources or, in the case of waste wood, less than

if the waste wood itself was disposed. Overall, operation impacts are likely to be low as City Light intends to use waste wood such as mill waste or logging residue.

2.7.3 Mitigation

See Section 2.2.4.

2.8 Wind

2.8.1 Construction Impacts

In addition to the general construction impacts from building turbine foundations, blasting may be required if rock is encountered at depth. Blasting could activate geologic hazards within the project area. Furthermore, the turbine foundations and access roads may require substantial quantities of sand and gravel. However, these materials are commonly available and project demands are unlikely to affect local supplies.

Based on the required use of erosion and sedimentation control measures, and the application of sound planning and design principles, impacts from construction of wind energy facilities on geologic and soil resources are expected to be moderate.

2.8.2 Operation Impacts

On-site geologic and soil conditions typically stabilize following construction and restoration of the disturbed areas (BLM, 2006). Ongoing disturbance during operation would be limited to occasional vehicle traffic on project roads, and impacts would be low.

2.8.3 Mitigation

See Section 2.2.4.

2.9 Solar Energy

2.9.1 Construction Impacts

Construction impacts to soils occur with the construction of utility-scale solar energy facilities. Construction of a utility-scale solar energy facility will likely involve a variety of the land-disturbing activities discussed in Section 2.2.1 such as clearing and grading to build off-site and on-site access roads, and removing vegetation from the solar field (the location of the mirrors, parabolic troughs or PV panels). Excavating or pile driving may be needed to construct a foundation for a power tower, dish engine, or cooling tower. Due to the large amount of land for utility scale projects, impacts could be high.

2.9.2 Operation Impacts

Ongoing disturbance during operation would mostly be limited to vehicular traffic on project roads. Because of the dry nature of these regions, relatively large amounts of dust suppressants are used because dust can affect the photovoltaic properties of the solar panels. Dust suppressants may contain salts and brines, organic non-petroleum products, synthetic polymers, organic petroleum, electrochemical substances, clay additives, and mulch and fiber mixtures. These constituents can affect runoff and change soil properties (Lovich and Ennen, 2011). Impacts would be low.

2.9.3 Mitigation

See Section 2.2.4.

2.10 Natural Gas Combined-Cycle Combustion Turbines

2.10.1 Construction Impacts

Combined-cycle combustion turbine (CCCT) plants would typically be located on previously undeveloped land, whereas, CHP plants would generally be located in an existing structure or within the footprint of an already planned structure that has already been disturbed, therefore, reducing the incremental construction impacts. Facilities using natural gas as a fuel will also disturb soil and geological formations permanently by building pipelines. The longer the pipeline, the greater in magnitude the disturbances to soil and geology would be. Depending on the size and location of the plant and related structures, disturbances to soil and geologic formations would be low to moderate.

2.10.2 Operation Impacts

Extraction of natural gas could involve continued drilling over the 20-year planning period of the IRP as wells are depleted and new natural gas supplies are sought. Thus, fuel extraction activities are considered an operation impact. Natural gas extraction includes activities such as drilling and operation of large equipment, which would disturb soil and can lead to soil erosion and permanent changes in geologic formations. The drilling activities themselves would also result in changes to geologic formations.

Changes in seismic activity in the form of microearthquakes may be caused by drilling activities, particularly fracking (Nicholson et al., 1990; dePater and Baisch, 2011; Green et al. 2012). The extent of the soil and geologic disturbances would depend on the size of the area over which the extraction-related activities would occur, and the duration and depth of the drilling. Impacts to soil and geology are likely to be moderate to high even if all federal regulations set forth in the Surface Mining Control and Reclamation Act are followed.

2.10.3 Mitigation

See Section 2.2.4. Avoid drilling in areas where potential impacts could be high. Impact and mitigation options will be site specific, depending on local geology and site conditions. Avoid fracking in areas with a high risk of seismic activity. Conduct seimsic and detailed microseismic monitoring before and during natural gas extraction activities. Limit fluid injection during hydraulic fracturing in locations of known seismic activity to reduce the potential for earthquakes.

2.11 Renewable Energy Credits

2.11.1 Construction Impacts

This analysis assumes SCL will purchase renewable energy credits (RECs) from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

2.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

2.11.3 Mitigation

See Section 2.2.3.

2.12 Market Transactions

2.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Construction impacts are expected to be low.

2.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be moderate to high.

2.12.3 Mitigation

See Section 2.2.4.

2.13 Transmission

2.13.1 Construction Impacts

Soils and geology impacts will occur from the general construction activities discussed in Section 2.2.1. Overall, construction impacts are expected to be low to moderate.

2.13.2 Operation Impacts

Maintenance of transmission facilities would require incidental repairs to access roads and management of vegetation, which could cause localized soil disturbance. In most instances, operation and maintenance would have a low direct impact on soil because the affected areas would be small, confined to the area of a particular maintenance action, and dispersed in time and along the length of a corridor.

2.13.3 Mitigation

See Section 2.2.4.

Table 2-1. Summary of soils and geology impacts[2]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		Construction of a new facility is not needed.
		L	Assumes proper disposal of waste.
Landfill Gas	L		Installed at existing disturbed site. Transmission upgrades not necessary.
		L	No impacts associated with fuel extraction.
Gorge Second Tunnel	M		Removal of bedrock to create and an unlined tunnel.
		L	No impacts associated with fuel extraction.
Geothermal	M		Drilling and removal of soil for wells.
		M	Technology and site dependent.
Biomass	L		Assumes reasonable mitigation measures to reduce general soil and geology impacts from construction.
		L	Assumes feedstock is from mill waste or logging residue and not from a dedicated crop.
Wind	M		Large area of land disturbed for construction and excavation required for turbine foundations.
		L	Occasional maintenance and vehicle traffic on project access roads.
Solar Energy	H		Removal of vegetation from solar field and potentially excavating for foundations. Assume adequate nearby transmission lines.
		L	Occasional maintenance and vehicle traffic on project access roads.
Natural Gas/CCCT	M		Involves construction of a pipeline. The plant could be located on undisturbed land or in an existing structure.
		H	Ongoing exploration for new fuel resources. Hydraulic fracturing can open cracks in rock in order to facilitate release of gas.
Renewable Energy Credits	L - H		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L - M	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Assumes existing resources can meet demand. No new construction required.
		H	Ongoing exploration for new fuel resources.
Transmission	M		Potentially large area of land disturbed for construction.
		L	Incidental repairs to access roads and management of vegetation.

[2]Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

3 AIR QUALITY

3.1 Affected Environment

Air quality affects the health of humans, animals, and plants, and the natural and built environment. Potential construction and operation impacts on air quality from energy production relate to the location, size, and type of plant being constructed. The existing air quality of the area, including precipitation, temperature and humidity, wind patterns, and overall climate and meteorology would also determine the specific level of potential impact to an area's overall air quality.

Concern over air quality is greatest in air basins where ambient concentrations of criteria pollutants (including sulfur oxides, SOx; nitrogen oxides, NOx; particulates, PM; and mercury, HG) exceed the federal National Ambient Air Quality Standards (NAAQS) and around certain generating plants in the affected region. Areas where background concentrations are greater than the NAAQS are referred to as nonattainment areas. With the exception of parts of Tacoma and Pierce County, the Puget Sound region is currently in attainment for all regulated pollutants. Part of Pierce County was designated a nonattainment area for fine particulate pollution (PM2.5) in 2009 because fine particle pollution levels too frequently exceeded the national limit (Ecology, 2012). Future regional growth and transportation changes may make it difficult to remain in attainment for particulates in other areas of Puget Sound.

Greenhouse gases are also considered a harmful air emission because of their effect on climate. Theses impacts are global, regardless of the location of the source. There is widespread agreement among climate scientists worldwide that human activity is increasing the greenhouse gases in the earth's atmosphere and accelerating global warming. (IPCC, 2012). Heat-trapping "greenhouse gases" (GHG) in the Earth's atmosphere—primarily water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4)—serve as a "blanket" that keeps the Earth's climate habitable. With industrialization and population growth, greenhouse gas emissions from human activities (like the burning of coal and oil) have significantly increased. As CO_2 and other greenhouse gases increase in the atmosphere, so does their insulating effect, further warming the earth. Climate scientists generally agree that if we continue releasing CO_2 into the atmosphere, global temperatures will continue to rise and our climate will change. But this does not mean a gradual increase in temperature. Climate models predict an increase in violent weather—severe storms, floods, and drought—with potentially devastating impacts on plant and animal populations, and adverse effects on human health. The University of Washington's Climate Impacts Group has reported on possible impacts to the Northwest region. The most likely scenario would be disruption to normal hydrological cycles resulting in less snowpack and more flooding, which would affect hydropower generation, salmon survival, and water resources in general.

This EIS quantifies the emissions for five pollutants: oxides of sulfur (SO_X), oxides of nitrogen (NOx), mercury (HG), particulates (PM), and greenhouse gas, as represented by carbon dioxide (CO_2).

3.2 General

3.2.1 Construction Impacts

Exposed surfaces, including graded land and unpaved roads, and dirt tracked or deposited onto paved roads, can generate fugitive dust. In addition, mobile heavy equipment (such as loaders) would generate fugitive dust during construction. Fugitive dust deposition is generally not considered a health issue; however, excess dust deposition is considered a nuisance because it can soil surfaces. Fugitive dust is not anticipated to produce any measurable effect on the overall ambient air quality in the area surrounding a site.

Operation of heavy construction equipment and vehicles would produce exhaust emissions that increase the quantity of air pollutants including carbon monoxide (CO), carbon dioxide (CO_2), sulfur oxides (SO_2), particulates, oxides of nitrogen (NOx), and volatile organic hydrocarbons (VOCs). These air pollutants would also be produced from vehicles transporting construction materials and workers to the site. Emissions from these sources would be short-term, would likely be low, and are not likely to cause significant air quality impacts or have a measurable effect on ambient air quality near the site.

Minor emissions of air pollutants and greenhouse gases would also occur during equipment manufacturing and fabrication (e.g., fabrication of wind turbines) and with transportation of the components to the project site.

Overall, the air quality impacts related to construction activities would be low for all resources.

3.2.2 Operation Impacts

Operation of energy resources can produce air pollutants that harm human health, the environment and cause property damage.

The following sections describe some of the principal air pollutants of concern and the impact due to emissions from power plant operation.

3.2.2.1 SULFUR OXIDES

The combustion of fuels that contain sulfur results in the emission of sulfur oxides (SOx). The amount of sulfur in a fuel is generally related to the type of fuel. Natural gas emits low levels of SOx. Inhaling oxides of sulfur irritates the lungs, which can lead to coughing, lung damage, and difficulty breathing for both animals and humans. Sensitive populations such as the elderly, children, and people with existing lung and heart problems are particularly at risk, as are people who are outdoors for extended periods or during exercise. SOx also combines with precipitation to form an acid solution, which damages plants and acidifies water bodies, resulting in damage to aquatic life and disruption of aquatic ecosystems. One of the oxides of sulfur is sulfur dioxide, SO_2, which is a criteria pollutant with an annual average Washington State standard of 0.02 parts per million (ppm) and a national standard of 0.03 ppm (Ecology, 2011).

3.2.2.2 NITROGEN OXIDES

Nitrogen oxides (NOx) is a generic term for a group of highly reactive gases that contain varying amounts of nitrogen and oxygen. NOx is a product of combustion that can affect air quality directly and indirectly. The direct effect of inhaling NOx is lung irritation, which can lead to coughing, lung damage, and difficulty breathing for both animals and humans. Indirectly, NOx combines with precipitation to form an acid solution, which damages plants and acidifies water bodies, resulting in damage to aquatic life.

NOx also combines with other chemicals in the air to form ground-level ozone, which is also one of the criteria pollutants. Power plant operation does not emit ozone directly into the air, but ozone is created by chemical reactions. Ground-level ozone is the main component of the smog that sometimes covers the Puget Sound lowlands. In addition to smog, ozone can trigger a variety of health problems including chest pain, coughing, and throat irritation and affect sensitive vegetation and ecosystems.

To protect human health, state and national ambient air quality standards have been established for NOx. The annual average Washington State standard is 0.05 ppm (100 $\mu g/m^3$) and the national standard is 0.053 ppm (Ecology, 2011).

Mercury and Other Hazardous Air Pollutants

Hazardous air pollutants (HAPs) are toxic air pollutants, which are known or suspected to cause cancer or other serious health effects or have adverse environmental effects. Mercury, one of the HAPs, is a very hazardous heavy metal that is gasified when some fuels, particularly coal, are burned. According to the EPA, mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. It is a known neurotoxin. It has been identified as a significant hazard to brain development in babies, both before birth and during infancy and childhood.

Mercury is also a potent toxin in ecological food chains, and affects animals at the top of the food chain through bioaccumulation. The severity and types of health impacts are determined by a number of factors including the form of the mercury (methylmercury, elemental mercury, or other compounds of mercury), the level of exposure (amount and duration), age, and health of the person exposed.

Emissions of other heavy metals including arsenic, chromium, and nickel and acid gases including hydrochloric acid and hydrofluoric acid, are also emitted from power plants. These HAPs are known or suspected to cause cancer and other serious health problems[3].

3.2.2.3 PARTICULATE MATTER

Power plants that combust solid fuels such as biomass emit the largest amounts of particulates per unit of electricity. Federal, state, and local regulations set limits on the concentrations of particles less than or equal to about 10 micrometers in diameter. This particulate matter, called PM10, has potential human health impacts because it can be inhaled deeply into lungs. PM10 is generated by industrial activities and operations, fuel combustion sources, motor vehicle engines and tires, and other sources. The Washington annual average concentration standard for PM10 is 50 $\mu g/m^3$ (Ecology, 2011).

There is also a federal standard for particulate matter less than or equal to 2.5 micrometers in diameter. This fine fraction of particulate, called PM2.5, is a subset of PM10 and is considered to be especially damaging to lung and heart functions. Such small particles can be inhaled deeply into the lungs, and are believed to represent the greatest risk to human health of all types of particulate matter. Particulate matter can cause breathing difficulty, bronchitis, asthma, and damage to heart and lung functions. There is also evidence that supports a link between lung cancer and specific constituents in air pollution including diesel particulate matter[4].Particulates can also reduce visibility. The national annual average standard for PM2.5 is 15.0 $\mu g/m^3$ (Ecology, 2011).

3.2.2.4 GREENHOUSE GASES

Several greenhouse gases are emitted during the extraction, transportation, and combustion of fuel in power plants, as well as during construction and maintenance of power plants. Carbon dioxide is the primary greenhouse gas emitted in producing power, but other greenhouse gases such as methane, nitrous oxide, and soot are also emitted. Industrialization and population growth has increased greenhouse gas emissions into the atmosphere. If greenhouse gas releases continue at a similar rate, global temperatures will continue to rise, disrupting both natural ecosystems and human societies. Violent weather is likely to increase, leading to harmful effects on humans, animals, and plants. In the Northwest, likely results of global warming include disruption to normal hydrological cycles, less snowpack, and more flooding. Global warming will likely affect hydropower generation, salmon survival, and water resources. See section 3.7.2.4 for a description of the framework used to evaluate biomass greenhouse gas emissions.

---

[3] EPA Utility MACT Factsheet, December 16, 2011, http://www.epa.gov/airquality/powerplanttoxics/pdfs/20111221MATSsummaryfs.pdf

[4] EPA, http://www.epa.gov/region1/eco/airtox/diesel.html

Air pollutant impacts from electricity production vary widely among the resource types, the installed pollution control technology, and other site-specific factors. In order to compare the resources and, ultimately, the air quality impacts from different types of power plants, City Light establishes resource-specific emission rates, which quantify the amount of pollutant emitted per unit of electricity produced. The EIS quantifies the emissions for five pollutants: oxides of sulfur (SO_X), oxides of nitrogen (NOx), mercury (HG), particulates (PM), and greenhouse gas as represented by carbon dioxide (CO_2). The assumed emission rates for each resource are shown in Table 3-1.

Table 3-1. Air emissions per unit of electricity by generation type

Resource	SOx lbs/MWh	NOx lbs/MWh	Mercury lbs/MWh	Particulates lbs/MWh	CO_2 lbs/MWh
Conservation	0	0	0	0	0
Landfill Gas[a]	0	0	0	0	0
Gorge Second Tunnel	0	0	0	0	0
Geothermal	0	0	0	0	0
Biomass: Cogen[5]	0.4265	2.2178	0	0.3412	Three emission levels were evaluated: 0, 280, and 640 lbs CO2/MWh See section 3.7.2.4 [6]
Wind	0	0	0	0	0
Solar Energy	0	0	0	0	0
CCCT[a]	0.00432	0.216	0	0.00504	857
Market Transactions[7]	0.0101	0.303	1.9×10^{-6}	0.04	870

a. From the Emissions & Generation Resource Integrated Database for Technical Support document (eGRID2012), April 2012, Year 2009 Data. EPA, www.epa.gov/cleanenergy/energy-resources/egrid/index.html

In addition to the air pollutants associated with fuel combustion, routine operation and maintenance activities create fugitive dust and exhaust emissions. The exhaust emissions are from equipment and repair vehicles traveling to, from, and around the project site. These activities are limited in extent and duration, and the associated emissions from routine operation and maintenance activities would have a low impact on air quality.

3.2.3 Regulations

Regulation of air emissions from power plants is a complex process, in which power plants are subject to laws that are promulgated and administered by multiple jurisdictions. Many laws and regulatory processes can be applied to a single air pollutant and/or power generating facility. Air pollution limits are also based on the existing air quality conditions in the area surrounding the power plant, as well as the types of areas (e.g.,

[5] Emission rates for NOx, SOx, and particulates are based on Northwest Clean Air Agency permit for the Sierra Pacific Burlington biomass plant, June 10, 2010. This plant uses a selective noncatalytic reduction system to reduce emissions of NOx, and a multiclone and electrostatic precipitator (ESP) to control particulate matter emissions. http://www.nwcleanair.org/pdf/aqPrograms/airOperatingPermits/Sierra%20Pacific/AOP_final.pdf

[6] Three carbon dioxide emission rates were evaluated for biomass. See the Biomass Operation Impact section for more details.

[7] Analysis by Energy and Environmental Economics, memo to SCL, June 2011.

proximity to sensitive environments such as wilderness) and affected populations. Therefore, the actual regulations that would apply are very specific to the type of power plant technology, fuel, and location.

The description of regulations below is meant to provide an overview of the major regulations covering power plants. These regulations are currently undergoing significant changes at the federal level and are likely to change over the planning period of the IRP. Details and descriptions of the existing and proposed regulations, their history, and impacts of the regulations can be found at the EPA's website: www.epa.gov.

The environmental analysis in this EIS assumes that the existing laws, and those anticipated to come into effect on the next several years, as announced by the EPA, will be applied to restrict the emissions from new power plants. Emission reductions that may result from laws passed in the future, or from improvements in available control technology, are not included in this analysis.

The Clean Air Act (CAA) of 1970 and the Clean Air Act Amendments (1990) are the primary source of air pollution regulations. The EPA has delegated authority to states to implement many of these regulations. In some states, the limits have been set to be more stringent than those set by the EPA, or limits have been set on emission sources and pollutants that are not covered by the EPA.

The CAA requires EPA to set National Ambient Air Quality Standards (NAAQS) for six common air pollutants: ozone, particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), and lead (Pb). The ambient air quality standards prescribe an allowable concentration of a pollutant and an averaging time over which the concentration is to be measured. Some pollutants have more than one air quality standard to reflect both short- term and long-term effects. Air quality impacts are of relatively greater concern in air basins where ambient concentrations of criteria pollutants exceed NAAQS. Areas where ambient concentrations are greater than the NAAQS are referred to as nonattainment areas.

The NAAQS for sulfur dioxide (SO2) and nitrogen dioxide (NO2) were most recently revised in 2010. New NAAQS for fine particulate matter (PM2.5) were proposed by the EPA in June 2012 and are expected to be finalized in December 2012. New NAAQS for ozone are anticipated in 2013.

Recently, the EPA issued rules that limit the emissions of greenhouse gases. In March of 2012, the EPA proposed a New Source Performance Standard for Greenhouse Gas (GHG) Emissions. This regulation would not apply to existing power plants or newly permitted plants that begin construction by March of 2012, nor to biomass or simple cycle natural gas power plants, nor to power plants smaller than 25 MW of capacity. These limits on power plant emissions cover the six greenhouse gases under the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). In effect, the limit is set at a level that could only be met by certain types of power plants, and would not allow conventional coal plants unless a carbon capture and sequestration (CCS) technology was implemented, and that technology is not currently commercially available.

The NAAQS and GHG standards are applied to specific new power plants (or existing plants that undergo a "major" modification) through the New Source Review (NSR) process.

- If the plant's potential emissions are above the regulatory threshold level, but is to be located in an area that is in attainment with the NAAQS, then it goes through the Prevention of Significant Deterioration (PSD) NSR. PSD Permitting requires that the power plant use the Best Available Control Technology (BACT) and air quality impact analysis of plant's emissions.
- If the potential plant emissions are above the regulatory threshold level, and is to be located in an area that is not in attainment with the NAAQS, the plant must install pollution controls that would result in

the Lowest Achievable Emissions Rate (LEAR) controls, and fund measures that would offset emissions from other sources in the area.

- If the potential emissions are below the regulatory threshold levels, then the power plant is subject to Minor Source requirements under NSR, which are designed by each state, and do not necessarily require emission control equipment.

The EPA issued the Cross State Air Pollution Rule (CSAPR) in July of 2011[8] in order reduce the effects of NOX and SOX that is transported from power plants in any of the states covered by the regulation into neighboring states. This regulation will apply to states in the eastern part of the country, and will not apply to power plants in the western states where City Light purchases electricity. The CSAPR is currently under judicial review, and the United States Court of Appeals issued a ruling to stay the regulation during this review.

The CAA and its Amendments also regulate the emission of other pollutants, through the National Emission Standard for Hazardous Air Pollutants (NESHAPS). Currently there are 188 hazardous air pollutants regulated under these standards, including asbestos, beryllium, mercury, vinyl chloride, benzene, arsenic, radon, and many others. In February of 2012, the EPA issued the final set of NESHAPS covering coal-fired electric utility boilers. These standards limit the allowed emissions of mercury, acid gases, and other hazardous pollutants.

The Acid Rain program is part of Title IV of the CAA, and regulates emissions of SO2 and NOX from power plants.

Many of the regulations described above apply to several pollutants that are emitted by power plants:

- SOx
  - Federal Clean Air Act, National Ambient Air Quality Standards, Cross State Air Pollution Rule
  - Acid Rain Reduction program (SOx trading program) standards
- NOx
  - Federal Clean Air Act, National Ambient Air Quality Standards, Cross State Air Pollution Rule
  - Acid Rain Reduction program (SOx trading program) standards
- Mercury, HAPs, Heavy Metals
  - Mercury and Air Toxics (MATS)/Maximum Achievable Control Technology (MACT)
- Particulates
  - Clean Air Act/MATS/MACT
- Other
  - Clean Air Act
- Greenhouse Gases
  - Oregon, California, and Washington state energy facility siting standards

  EPA New Source Performance Standard for CO_2

3.2.4 Mitigation

To minimize fugitive dust emissions during construction and operation activities:

- Use dust abatement techniques, such as using aggregate materials for roads, watering or application of dust palliatives, on roads and disturbed surfaces during construction.
- Cover stockpiles of soil, construction materials and (if applicable) storage piles at concrete batch plants.
- Minimize the extent of disturbed areas and restore disturbed areas as soon as possible following construction.

[8] EPA, www.epa.gov/crossstaterule

To minimize equipment and vehicle emissions during construction and operation activities:

- Maintain vehicles and equipment in good operating condition to minimize exhaust emissions.
- Use high efficiency or electric hybrid vehicles, where appropriate, to minimize exhaust emissions
- Reduce vehicle idling, where appropriate.

To minimize air pollutants associated with operation of power plants (specific air pollutant control technology, if applicable, is presented for each energy resource in the sections below):

- Use the most efficient power plant technologies to reduce amount of fuel needed and associated air emissions, or for technologies that do not consume a fuel, higher efficiency plants still provide a benefit by avoiding emissions associated with manufacturing plant materials and construction.
- Use the best available control technology.
- Ensure state and federal energy facility siting standards will be met for greenhouse gases.
- Avoid emissions of greenhouse gas to the extent possible, through energy conservation and renewable resource acquisition.
- Purchase high quality greenhouse gas offsets to cover any emissions that result from energy purchased from resources that emit CO_2.

3.3 Conservation

3.3.1 Construction Impacts

There is low potential for fugitive dust emissions associated with installing conservation resources. Vehicle and construction equipment (e.g., crane to lift and install HVAC systems) use would likely be low and air quality impacts are not anticipated.

3.3.2 Operation Impacts

Energy efficiency measures such as insulation, energy efficient windows, caulking, and weatherstripping typically reduce the exchange between indoor and outdoor air. Decreases in air circulation may lead to an accumulation of pollutants that have entered the building from outside or that have been produced indoors. Pollutants affecting indoor air quality include cigarette smoke, radon, formaldehyde, asbestos fibers, disease microorganisms; gases released from construction materials, carpeting, and furniture; as well as pollutants released during normal power plant operations. Decreasing indoor/outdoor air exchange would increase indoor relative humidity and pests such as dust mites. Incidences of allergies and asthma are expected to increase. Increased moisture would encourage the growth of mold and mildew and accelerate wood decay and aging of interior paints.

Unsafe concentrations of radon can be released from urea formaldehyde foam insulation (UFFI) as it ages. UFFI is no longer used to insulate buildings, but indoor air quality may be degraded in older buildings that are insulated with this substance. Microscopic, airborne asbestos fibers are carcinogenic and may affect the respiratory system. If present in existing insulation, ceiling tiles, floor tiles, or other construction materials, asbestos can be released to the atmosphere during building insulation or reconstruction activities. Compact fluorescent lightbulbs (CFLs) contain mercury, which could be released if they are broken, though the amounts of mercury are small. EPA estimates that on average, CFLs contain about four milligrams of mercury sealed within the glass tubing[9].

Chlorofluorocarbons (CFCs) used in refrigeration and air conditioning systems could be released to the atmosphere if these systems are upgraded. CFCs are broken down in the upper atmosphere by ultraviolet

[9] EPA, http://epa.gov/cfl/cfl-hg.html

radiation to produce, among other compounds, atoms of chlorine or bromine. The latter chemically destroys ozone in a layer of the upper atmosphere, increasing ultraviolet radiation from the sun. Thus, atmospheric releases of CFCs could result in increases in ultraviolet radiation.

However, since the air emissions from any of these sources would be very small, the overall potential impacts would be low.

3.3.3 Mitigation

The following measures can reduce harmful effects of indoor air pollution:

- Provide adequate ventilation or filter indoor air to avoid an accumulation of pollutants that negatively affect indoor air quality.
- Monitor radon in the lower floors of buildings.
- Practice safe asbestos removal techniques.
- Recover and recycle CFCs.
- Properly handle and dispose of CFLs to reduce breakage, and properly clean up and dispose of broken CFLs.

3.4 Landfill Gas

3.4.1 Construction Impacts

As described in the General Construction Impacts section 3.2.1, there would be small amounts of fugitive dust, air pollutants, and greenhouse gases released from typical construction activities and equipment. Emission levels would likely be low and, assuming reasonable mitigation to control dust emissions, are not likely to cause significant air quality impacts or have a measurable effect on ambient air quality near a site.

Overall, impacts would be low during construction.

3.4.2 Operation Impacts

3.4.2.1 SULFUR OXIDES

Landfill gas contains sulfur, and energy generation could result in sulfur dioxide (SO_2) emissions. Combustion turbines of the size used in landfills do not use SO_2 control equipment, but often the landfill gas is "cleaned" and sulfur removed to avoid damaging the generation equipment (NRDC, 2003). The amount of sulfur in landfill gas varies with landfill. However, SO_2 emissions are assumed to be the same as the emissions from flaring landfill gas and, therefore, no additional impact would occur with a landfill gas combustion turbine project (eGRID 2012) and, therefore, the incremental increase in emission rate for SO_2 is assumed to be zero. (eGRID2012 Plant File, Year 2009 Data)

3.4.2.2 NITROGEN OXIDES

Since, in most cases, the landfill gas must be flared if it is not consumed as useful energy, this analysis only accounts for the incremental nitrogen oxide (NOx) emissions attributable to using the gas to generate electricity. The analysis assumes a NOx emission rate of zero.

3.4.2.3 MERCURY AND OTHER HAZARDOUS AIR POLLUTANTS

Emissions of mercury and other hazardous air pollutants from burning landfill methane will vary widely depending on the mercury contained in the landfill waste. The use of landfill methane for electricity should not increase the amount of mercury released into the environment compared to flaring the methane. Burning landfill gas reduces most hazardous air pollutants in the gas, but produces small amounts of dioxins, another

hazardous pollutant (NRDC, 2003). Overall, it is expected that impacts associated with hazardous air pollutants would be less than with flaring the landfill gas.

3.4.2.4 PARTICULATES

Emissions of particulate matter would vary widely depending on material in the landfill (NRDC, 2003). Overall, emission offsets from flaring landfill gas would likely result in little to no additional emissions of particulates; impacts would be low.

3.4.2.5 GREENHOUSE GASES

While burning landfill gas to produce electricity produces CO_2 emissions, the net impact on greenhouse gas emissions is considered zero because anaerobic decomposition of organic materials in the landfill would otherwise release methane, a more potent greenhouse gas than CO_2, or if the methane is flared, an equivalent amount of CO_2 would have been released without generating electricity. While large landfills are usually required to capture and flare landfill gas, smaller and older landfills are not. These may be significant sources of methane releases to the atmosphere. Since methane is 25 times more potent as a greenhouse gas than CO_2, capturing methane that would otherwise be released offers a significant benefit in reducing greenhouse gas emissions. Accordingly, electricity produced at smaller landfills that captures the methane and reduces greenhouse gas emissions would result in positive environmental effects.

Overall, incremental air quality impacts compared to flaring during operation is expected to be low.

3.4.3 Mitigation

Impacts from landfill gas generation plants can be reduced by:

- Operate generators in "lean burn" mode (less oxygen than needed to combust fuel), which reduces NOx formation. However, it also results in more unburned fuel (VOCs and HAPs).
- Install additional flares, as described above, to destroy VOCs and other HAPs. Although efforts are underway to reduce the amount of mercury in consumer products and the amount of mercury that goes into landfills, it is likely that buried mercury from past decades will gasify and be emitted.
- Minimize fugitive dust and vehicle emissions according to the General Mitigation section 3.2.3.

3.5 Gorge Second Tunnel (Hydro Efficiency)

3.5.1 Construction Impacts

As described in the General Construction Impacts section 3.2.1, there would be small amounts of fugitive dust, air pollutants and greenhouse gases released during construction, from drilling, excavation, and vehicles used to build the tunnel. Impacts would be low.

3.5.2 Operation Impacts

During operation of the new tunnel, no air emissions are expected other than very small amounts emitted by vehicles used during maintenance. Impacts would be low.

3.5.3 Mitigation

Minimize fugitive dust and vehicle emissions according to the General Mitigation section 3.2.3. No mitigation is required for other pollutants since they are not emitted.

3.6 Geothermal

3.6.1 Construction Impacts

As described in the General Construction Impacts section 3.2.1, there would be small amounts of fugitive dust, air pollutants and greenhouse gases released during construction, from drilling, excavation, and vehicles used to build the plant. Impacts would be low.

3.6.2 Operation Impacts

Although some geothermal plants have air emissions, the technology used in the model is binary geothermal, which is assumed to have zero emissions. With binary technology, steam is contained and not released to the atmosphere.

Geothermal steam can also contain hydrogen sulfide gas (H_2S), which has a distinctive rotten-egg smell, but usually it is below the level that most people would be able to detect (at high concentrations, H_2S can be lethal). Emissions would vary by site, and adequate control technologies are available for reducing hydrogen sulfide emissions. Geothermal plants emit most particulates directly, and emit small amounts of SOx (GEA, 2012).

Overall, impacts to an area's air quality from the operation of a geothermal plant would be low, as they would emit mostly water vapor.

3.6.3 Mitigation

See the Air Quality General Mitigation section 3.2.3, and:

- Implement processes to separate H_2S gas into elemental sulfur and hydrogen.
- Inject gases into original reservoirs.

3.7 Biomass

3.7.1 Construction Impacts

As described in the General Construction Impacts section 3.2.1, there would be small amounts of fugitive dust, air pollutants, and greenhouse gases released from typical construction activities and equipment. Emissions from these sources would be short-term, would likely be low, and are not likely to cause significant air quality impacts or have a measurable effect on ambient air quality near a site. Overall, impacts would be low.

3.7.2 Operation Impacts

3.7.2.1 SULFUR OXIDES

While the sulfur oxides (SOx) content of wood biomass fuel is expected to be low, this pollutant is included in air permits for recently constructed biomass plants. This is, in part, because the wide range of fuel sources that could result in changes in sulfur content of those fuels over time. Based on recent permit limits for a biomass plant in Washington State, the SOx emission rate is assumed to be 0.4265 pounds per MWh. For wood biomass plants, installing pollution control equipment or taking other actions to reduce these emissions is generally not required in permits. The permit levels are likely to be higher than actual emissions.

3.7.2.2 NITROGEN OXIDES

The principal air pollutants of concern from burning wood are oxides of nitrogen (NOx) and particulates. Some biomass power plants have a relatively high NOx emission rate compared to other combustion technologies (PECC, 2005), and rates vary widely with plant design and operational conditions. The estimated NOx emission rate for a biomass cogeneration facility is NOx is 2.2178 pounds per MWh. Available technologies for controlling

NOx emissions from biomass fuel boilers include combustion process modifications and post combustion exhaust gas treatment systems. Available combustion process modifications include staged combustion using overfire air (OFA), natural gas reburn (NGR), and flue gas recirculation (FGR). Available post-combustion controls include selective noncatalytic reduction and selective catalytic reduction.

3.7.2.3 PARTICULATES

Without controls, particulate emissions would be substantial for a wood-burning facility. However, control technology would be used to substantially reduce emissions of large particulates, which make up most of the particulate emissions. The particulates emission rate depends on the type of control technology used and its efficiency. In this EIS, it is assumed that the emission rate for PM is 0.3412 pounds per MWh. Available PM control technologies include centrifugal collectors, wet or dry electrostatic precipitators, fabric filters or baghouses and wet scrubbers. Further, if logging residue is the fuel source, an overall reduction in particulate emissions would occur if the residue would otherwise have been slash burned.

3.7.2.4 GREENHOUSE GASES

Historically, greenhouse gas emissions from biomass plants have been considered to be part of a closed cycle—while burning the wood fuel produces CO_2 emissions, the CO_2 is sequestered in growing wood and other plants in a relatively short time. Recently, the assumption that biomass is carbon neutral has been questioned. Concerns raised include the time period over which biomass fuel regrows and captures carbon to offset emissions, impacts to forest health and soil, and alternative fates of wood biomass if it is not used for fuel. The EPA is reevaluating this issue and is expected to issue its results in 2014.

In the EIS, SCL will use a framework to consider a range of potential emissions based on varying two components that are important in assessing the net CO2 emissions from a biomass plant: (1) the time value of CO_2 emissions and sequestration and (2) the alternative fates of waste wood not used for fuel. Until recently, it was assumed that the time for sequestration to take place, i.e., the difference in time between when CO_2 is emitted from the plant until the time it is taken up by tree growth was not significant in terms of climate impacts. This assumption is now being questioned. To better understand the potential impacts of this time lag, SCL looked at the sequestration rate for tree growth in the western part of the Pacific Northwest (see Figure 1). We then applied either a 0 percent or a 3 percent discount rate to account for differing views of the time value of the lag of CO_2 uptake.

The alternative fate of the waste wood would be either burning or decomposition on site or in landfill. Three cases were considered in the analysis. The first assumed the time frame for sequestration was not significant (0 percent discount rate) and resulted in 0 pounds of CO_2 per MWh. The second assumed a 3 percent discount rate for sequestration and that 20 percent of the fuel would have been burned, the rest would decompose. This results in 280 pounds per MWh. The third assumes a 3 percent discount rate for sequestration and that all of the fuel would have decomposed. This results in 640 pounds per MWh.

Figure 1 shows CO_2 from forest wood waste, and is based on information provided in "Greenhouse gas and air pollutant emissions of alternatives for woody biomass residues" study by the Stockholm Environment Institute (SEI, 2010)[10] and Technical Guidelines for Reporting of Greenhouse Gas[11] by the USDA.

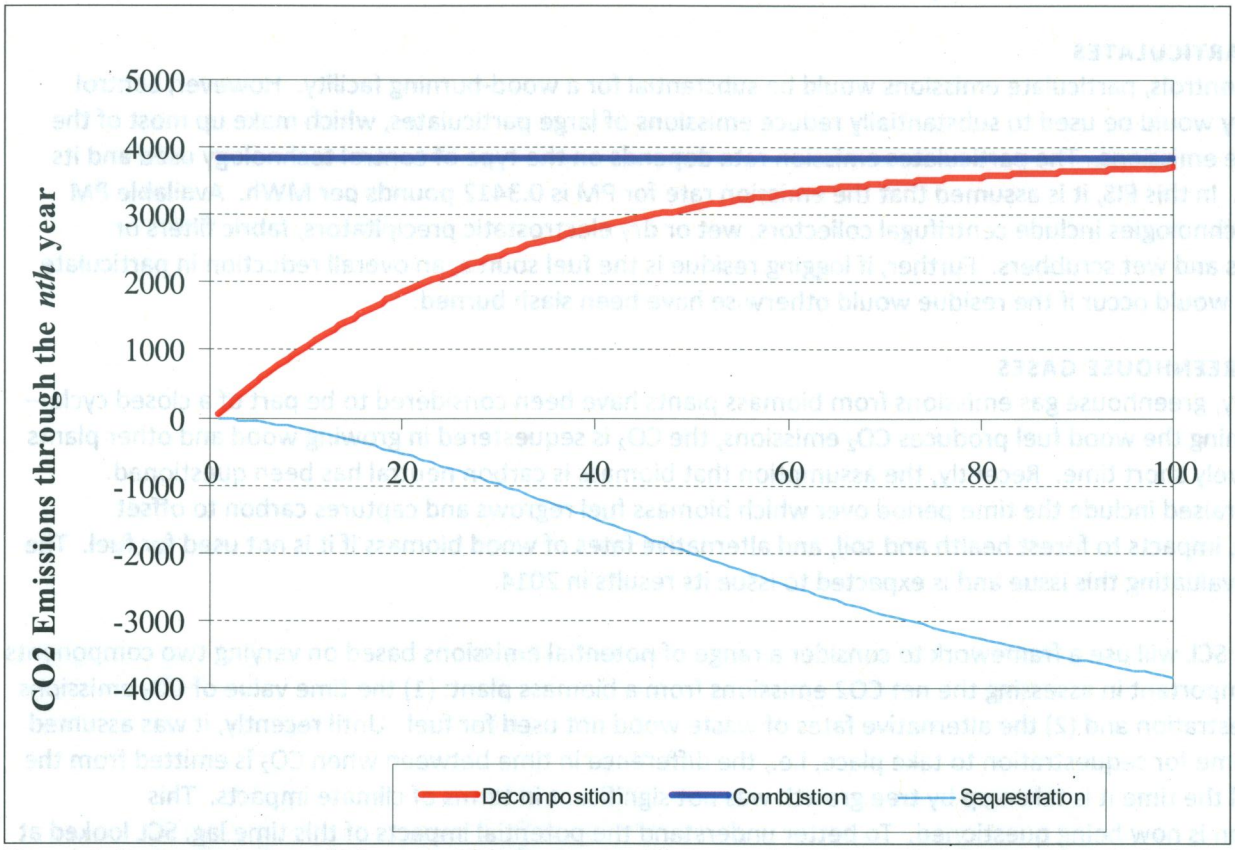

Figure 1. Representation of Biomass CO2: Decomposition, Combustion, and Sequestration Emissions from Forest Wood Waste

The actual rate that carbon is sequestered in a forest depends on the size of the forest plot, site productivity (a term used to combine many other factors such as soil, drainage, rainfall, temperature, altitude and slope that are difficult to quantify individually), geographic location and type of tree. This analysis assumed the geographic location was the western Pacific Northwest, reference tree species (composed of alder-maple, Douglas fir, fir-spruce-mountain hemlock and hemlock-Sitka-spruce), average site productivity and tree restocking area that is equivalent in size to the amount of land disturbed from harvest of 100-year-old trees.

The assumed decay rate for the biomass is 0.033, which corresponds to a half-life of about 27.8 years. This is an average decay rate for the Pacific Northwest region. Actual decay rates will depend on factors such as geographic location, tree species, and size of downed biomass material.

Overall, based on the current understanding of sequestration potential for biomass compared to fossil fuels, and the likely alternative fate of wood biomass fuel (combustion),for a biomass power plant, air impacts due to NOx, SOx, mercury and particulates would be moderate, and emissions of greenhouse gas would be low during operation.

[10] http://data.orcaa.org/reports/all-reports-entries/woody-biomass-emissions-study/
[11] http://www.usda.gov/oce/global_change/gg_reporting.htm

3.7.3 Mitigation

See the Air Quality General Mitigation section 3.2.3, and:

- Use dust abatement techniques described in the General Mitigations section 3.2.3.
- Use best available control technology to reduce particulate emissions.
- Use selective noncatalytic reduction to control NOx emissions.
- Purchase offsets for any CO2 emissions.

3.8 Wind

3.8.1 Construction Impacts

Equipment exhaust and fugitive dust generation would be the principal potential sources of air pollutants during construction of a wind energy project. The emissions are described in the General Construction Impacts, Section 3.2.1.

In addition, because wind farms are often installed in rural areas, temporary concrete batch plants may be established at the project site to supply concrete for project facilities. Batch plant emissions (particulates and combustion emissions) represent an additional source of air pollutants, although these are offset to some degree by reduced transportation of concrete and/or concrete inputs.

Emissions from these sources would be short-term; emission levels would likely be low and they would occur on an exposed, windy site where good dispersion could be expected. Therefore, exhaust emissions from construction equipment are not likely to cause significant air quality impacts or have a measurable effect on ambient air quality near a site.

Overall, impacts during construction would likely be low.

3.8.2 Operation Impacts

Air emissions during operation of wind energy facilities are anticipated to be low. The wind turbines themselves do not produce emissions in operation. Minor emissions of Volatile Organic Compounds (VOC) can occur during routine maintenance, such as changing lubricating and cooling fluids or painting equipment (BLM, 2006). Routine operation and maintenance activities create fugitive dust and exhaust emissions from equipment and vehicles traveling across the wind farm site, or from periodic brush clearing. These activities are limited in extent and duration, and the associated emissions are anticipated to have low impact on air quality.

3.8.3 Mitigation

See the Air Quality General Mitigation section 3.2.3.

3.9 Solar Energy

3.9.1 Construction Impacts

As described in the General Construction Impacts section 3.2.1, for utility-scale solar facilities, there would be small amount of fugitive dust emissions from the disturbance of ground surfaces, removal of vegetation cover, material handling or vehicle traffic. There would also be minor emissions of air pollutants and greenhouse gases released from the fabrication of solar equipment, transportation of components to the project site and construction equipment. Emissions from these sources would be short-term, would likely be low, and are not likely to cause significant air quality impacts or have a measurable effect on ambient air quality near a site. Overall, impacts would be low.

3.9.2 Operation Impacts

Air pollutant and greenhouse gas emissions associated with operating a solar facility are not anticipated. Routine operation and maintenance activities from vehicles create fugitive dust and exhaust emissions. Impacts would be low.

3.9.3 Mitigation

Since impacts from solar are expected to be low, the basis mitigation measures described in 3.2.4 are adequate.

3.10 Natural Gas Combined-Cycle Combustion Turbines

3.10.1 Construction Impacts

As described in the General Construction Impacts section 3.2.1, construction of a power plant and related facilities such as gas pipelines would emit small amounts of fugitive dust, air pollutants and greenhouse gases from typical construction activities and equipment. Although these emissions would be temporary and one-time, they would last as long as the construction period, which can range from a few months to a few years depending on the size of the plant or the length of the gas pipeline. The emissions are not likely to cause significant air quality impacts or have a measurable effect on ambient air quality near a site. Overall, impacts would be low.

3.10.2 Operation Impacts

3.10.2.1 SULFUR OXIDES (SOX)

Natural gas contains very little sulfur, and therefore CCCT power plants emit very small amounts sulfur oxides. Emissions from newer, most efficient CCCTs in Washington have reported emissions ranging from 0.0043 to 0.0234 pounds of sulfur dioxide (SO_2) per MWh[12]. Due to low emission rates, generally CCCT plants are not required to install SOx control equipment or take operational actions to reduce emissions of SOx. However, CCCTs are subject to the federal Acid Rain program. The Cross State Air Pollution Rule (CSAPR) regulations on SO2 also applies to CCCT plants, but only in eastern states, so would not be applicable to power plants evaluated in this analysis.

3.10.2.2 NITROGEN OXIDES (NOX)

Nitrogen dioxide emissions from CCCTs are low compared to other fossil fuels and biomass power plants. Emissions from newer, most efficient CCCTs in Washington have reported emissions ranging from 0.08 to 1.06 pounds of nitrogen oxide (NOx) per MWh[13]. Typical control technology for new CCCTs is Selective Catalytic Reduction (SCR), along with operational controls such as modification of burners to reduce thermal NOx creation, and steam injection to reduce NOx post-combustion. These controls require the use of electricity, resulting in small reductions in the efficiency of the CCCT plants. CCCTs are subject to the federal Acid Rain program, including NOx emissions. The Cross State Air Pollution Rule (CSAPR) regulations on NOx also applies to CCCT plants, but only in eastern states, so would not be applicable to power plants evaluated in this analysis.

3.10.2.3 MERCURY (HG), HAZARDOUS AIR POLLUTANTS (HAPS), TOXIC AIR POLLUTANTS (TAPS)

Mercury, hazardous and toxic air pollutant emissions from CCCTs are generally very low. As a result, the recent EPA regulation of mercury and HAPs/TAPs (known as the Electric Utility Mercury and Air Toxics Standard) does not regulate emissions from CCCT plants[14]. However, these plants do emit small amounts of a number of HAP/TAP pollutants, including benzene and formaldehyde. In the SCR process, ammonia is generally used as a

[12] EPA eGRID 2010 v1.1, Frederickson, River Road, and Sumas plants
[13] EPA eGRID 2010 v1.1, Frederickson, River Road, and Sumas plants
[14] EPA, http://www.epa.gov/airquality/powerplanttoxics/

reagent, and this poses risk of release during transport to and storage at the CCCT plant, as well as the release of ammonia ("ammonia slip") during use.

3.10.2.4 PARTICULATES (PM)

The direct combustion byproducts of CCCTs have a low level of particulates compared to other fossil fuels and biomass. Generally, no controls for this category of pollutants are required. However, emissions of NOx can contribute to the secondary formation of particulates. Control of NOx can reduce the overall level of particulate formation resulting from CCCT power plants.

3.10.2.5 GREENHOUSE GASES

Equipment used for extracting natural gas emits carbon dioxide (CO_2) and methane (CH_4). CO_2 and CH_4 are classified as greenhouse gases. Natural gas is primarily CH_4, which has a global warming potential 25 times greater than CO_2. Although estimates of the amount of CH_4 released during drilling vary, an estimate often used is 1 to 4 percent of the amount of CH_4 that is ultimately consumed in an end-use such as producing electricity (NREL, 2001). The magnitude of contribution to the amount of CO_2 and CH_4 in the atmosphere resulting from natural gas extraction would range from low to moderate, depending on the location and size of the activities. However, recently concerns have been raised that techniques for extracting natural gas such as fracking increase the emission of greenhouse gases compared to traditional techniques. Air emissions from fracking may include emissions from diesel- or natural gas-powered equipment such as compressors, drill rigs, and pumps; methane leaks from operation and production activities; and venting or flaring associated with well operation. Fugitive emissions such as leaks from pipe connections and associated equipment may also occur. Potential for explosions or blowbacks also exist and could result in air emissions. The larger the geographic extent of extraction activities or intensity of such activities, the higher the magnitude of the contribution would be.

Operation of a CCCT would emit SO_2, NOx, PM, and CO_2 equivalents at the rates indicated in Table 3-1.
Air emissions associated with extraction and fracking include nitrogen oxide (NOx), volatile organic compounds (VOCs), benzene, toluene, ethylbenzene and xylenes (BTEX), particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO_2), methane (CH_4), and hydrogen sulfide (H_2S). While impacts on air quality caused by NOx, SOx, mercury and particulates is likely to be moderate, climate impacts caused by the release of greenhouse gases are comparatively high.

3.10.3 Mitigation

See the Air Quality General Mitigation section 3.2.3. Leak detection and repair programs, reduced emissions completions, fluid management and minimization, and reduced quantity and toxicity of materials are current practices applied to minimize and mitigate air emissions from fracking operations. Impacts caused by the release of greenhouse gases can be mitigated by the purchase of offsets including offsets to the emissions resulting from extraction.

Use best management practices that include:

- Use appropriate control techniques for diesel and dual-fuel engines;
- Limit sulfur content in the diesel fuel used in operations;
- Avoid operating drilling and fracturing simultaneously at a single well pad;
- Limit the number of wells completed during any consecutive 12-month period at a single pad;
- Limit emissions of benzene at the well pad; and
- Equip tanks at the well pad with vapor recovery systems to minimize fugitive VOC emissions.

During the flowback phase, limit the venting of gas from each well pad during any consecutive 12-month period. During the flowback phase, limit flaring of gas at each well pad during any consecutive 12-month period. Equip wellhead compressors with non-selective catalytic reduction controls.

Do not use uncertified (i.e., EPA Tier 0) drilling or hydraulic fracturing engines for any activity at well sites. Limit the drilling engines and drilling air compressors to EPA Tier 2 or newer equipment. If Tier 1 drilling equipment is used, equip with both particulate traps and SCR controls. During operations, position this equipment as close to the center of the well pad as practicable.

3.11 Renewable Energy Credits

3.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

3.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

3.11.3 Mitigation

See Section 3.2.4.

3.12 Market Transactions

3.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions.

3.12.2 Operation Impacts

On average, impacts would be slightly greater than new natural gas combined-cycle combustion turbines described in this Appendix because of the higher heat rate of existing power plants, including possibly some coal plants that would be used to supply electricity for market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, impacts of NOx, SOx, mercury and particulates would be moderate, and climate impacts is high.

3.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the plants have already been built, and it is unlikely that these plants would install additional mitigating measures in order to meet the incremental demand. See Section 3.10.3 in this Appendix for details on mitigation options. Greenhouse gas emissions could be mitigated by the purchase of offsets.

3.13 Transmission

3.13.1 Construction Impacts

General Construction Impacts described in section 3.2.1. Altogether, construction activities would be expected to have a low impact on air quality.

3.13.2 Operation Impacts

General operation impacts are described in 3.3.2 and, in addition, greenhouse gas emissions may result from electrical equipment used in substations, such as breakers, that may contain sulfur hexafluoride (SF6) gas as an insulator. SF6 gas is very potent, with a global warming potential 22,800 times that of carbon dioxide. In properly functioning equipment, this gas is not released except in very small amounts during equipment testing.

Vehicle and equipment emissions would occur during maintenance activities. Impacts on air quality during operation and maintenance would be expected to be low.

3.13.3 Mitigation

Use dust abatement techniques described in the General Mitigations section 3.2.3, and:

- Use vehicle impact mitigation described in the General Mitigation section.
- To reduce SF6 emissions, new equipment contains much less SF6 than older models, and is it designed to avoid and contain leaks. Proper maintenance and monitoring can prevent and detect leaks, minimizing greenhouse gas emissions.

Table 3-2. Summary of air quality impacts[15]

Resource	Construction (NOx, SOx, PM, Hg)	Operation (NOx, SOx, PM, Hg)	Construction (CO2)	Operation (CO2)	Notes/Assumptions/Summary of unique impacts
Conservation	L		L		No fugitive dust emissions and minimal construction equipment needed to install energy efficiency measures.
		L		L	Assumes reasonable mitigation to protect indoor air quality.
Landfill Gas	L		L		Typical construction emissions from equipment exhaust and fugitive dust.
		L		L	Combustion emissions would be low in comparison to flaring the landfill gas.
Gorge Second Tunnel	L		L		Typical construction emissions from equipment exhaust and fugitive dust.
		L		L	No emissions from the operation of hydro efficiency improvements. Minor vehicle emissions from operation and maintenance.
Geothermal	L		L		Typical construction emissions from equipment exhaust and fugitive dust.
		L		L	Analysis assumes binary geothermal plant, which is assumed to have zero emissions. Minor emissions from operation and maintenance activities.
Biomass	L		L		Typical construction emissions from equipment exhaust and fugitive dust.
		M		L	Assumes best available control technology to reduce particulates. EPA is examining the science associated with CO_2 emissions.
Wind	L		L		Typical construction emissions from equipment exhaust and fugitive dust.
		L		L	No greenhouse gas or air pollutant emissions from wind turbine operation. Vehicle exhaust and dust produced from operation and maintenance activities.
Solar Energy	L		L		Assumes dust mitigation measures will be implemented over a potentially large surface area.
		L		L	No emissions from the operation of solar energy facilities. Minor vehicle and dust emissions from O&M activities.
Natural Gas/CCCT	L		L		Construction of power plant and pipelines would produce equipment exhaust and fugitive dust.
		M		H	High impact because operating CCCT emits significant amounts of greenhouse gases. Fuel extraction activities also emit CO_2 and CH_4.
Renewable Energy Credits	L		L		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-M		L	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		L		Assumes energy will be supplied by existing resources; no new plants will be constructed to meet the demand.
		M		H	Assumes emissions comparable to the combustion of natural gas/CCCT in existing power plants.
Transmission	L		L		Assumes proper maintenance and monitoring to prevent and detect leaks of SF6 from electrical equipment.
		L		L	Vehicle exhaust and dust produced from O&M activities.

[15]Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

4 SURFACE AND GROUNDWATER

4.1 Affected Environment

In general, the Pacific Northwest enjoys excellent water quality, but stringent protection is required to maintain this quality. Nuclear, coal, oil, gas-fired, and some renewable generating plants use water for cooling. Water is taken from rivers, aquifers, coastal waters, or reservoirs, and is recycled within the plant or returned to its source. The Yellowstone River in Montana, the Green River in Wyoming, the Skookumchuck River in Washington, and the Columbia River in Washington and Oregon, supply water to cool existing thermal plants that serve the Pacific Northwest (BPA, 1993).

The Columbia and the Snake rivers are very different now compared to when the region was first settled by non-Native Americans. Over the last 60 years, both rivers have been dammed to produce hydroelectric power, control flooding, provide irrigation and recreation, and improve navigation. The hydroelectric projects are operated to accommodate fish, wildlife, recreation, flood control, irrigation, and other non-power needs as well as to produce power (BPA, 1993). In addition, groundwater has been tapped as a cooling water source for some energy projects, particularly combustion turbine facilities.

Atmospheric conditions and cooling technology are the primary factors in determining water consumption. Therefore, even among power plants using the same generating technology, there are a wide range water consumption rates. A recent study conducted by the National Renewable Energy Laboratory (NREL) concluded "Water withdrawal and consumption factors vary greatly across and within fuel technologies. Water factors show greater agreement when organized according to cooling technologies as opposed to fuel technologies. Once –through cooling technologies withdraw 10 to 100 times more water per unit of electric generation than recirculating cooling technologies; recirculating cooling technologies consume at least twice as much water as once-through cooling technologies." (NREL, 2011)

4.2 General

4.2.1 Construction Impacts

A number of construction processes can affect surface and groundwater. Construction-related impacts to surface and groundwater resources are dependent on the location and size of a specific development. Construction could also affect water resources by:

- Changing surface and groundwater pathways,
- Discharging to existing water sources, and
- Consuming water for various construction activities.

Developing new energy generation facilities and access roads can alter surface water flow and can compact soil and make it less permeable. Rain falling on compacted soil is more likely to flow off the soil's surface, creating erosion and washing soil and sediment into unprotected bodies of water. In addition, excavation and disposal of excavated material could have short-term impacts on surface water quality because of increased turbidity and siltation.

Water required for dust suppression and other construction-related activities (such as fire-suppression) would increase the use of water on-site. The exact type and amount of such use would be determined once a specific site is chosen.

Water is needed for concrete used in structural foundations and pads for transformers, buildings, and substations. Depending on site-specific conditions, construction water supplies are either trucked to the site or obtained from local surface or groundwater. Obtaining a water supply from new sources on or near the project site would be subject to the applicable state and local permit requirements for use of surface or groundwater. Water consumption for project construction is a temporary impact of about one year in duration. Volumes of water withdrawal would be estimated before construction; typical volumes are such that a measurable effect on the availability of local water supplies for existing users would not be expected.

Other construction impacts to consider are:

- Hazardous fluids such as fuel and hydraulic oil used in construction machinery could be released or spilled and potentially contaminate groundwater.
- Minor construction and facility upgrades can generate wastes that contaminate water if they are disposed of improperly.
- Construction would use water for dust suppression, vehicle washing, and potable water for the construction crew.
- Excavations that penetrate a shallow aquifer could adversely affect water quality and productivity of the aquifer.

4.2.2 Operation Impacts

Water needs will depend on the type of electrical generating equipment a facility uses. Certain types of generation machinery, such as steam turbines or turbines with heat capture, would require a water source. If groundwater is a source of water for the facility, withdrawals could lead to water table depression that affect neighboring wells and reduce in-stream flows. In all cases, water rights would need to be obtained.

If wastewater from plant operations, which is usually warmer than when it was withdrawn from its source, is discharged into surface or groundwater bodies, chemical and thermal pollution in the water is transferred to those water bodies.

Long-term effects on surface water quantity and quality would be limited to any permanent changes in drainage patterns and the runoff from impervious surfaces created by the permanent project facilities. Similar to construction, a permanent system that prevents stormwater pollution and uses best management practices would be needed to manage a site's water runoff.

Large quantities of groundwater or surface water are often required for hydraulic fracturing (fracking) and other fuel extraction operations. This consumption may affect surface water or groundwater resources available in an area.

Fracturing or injection fluids, which are typically a combination of water, proppants (usually a sieved sand), and chemical additives, are pumped into fractures to create pressure and facilitate extraction of natural gas. CO_2, nitrogen, and hydrochloric or acetic acid may also be used to facilitate natural gas extraction, clean perforations, or reduce pressure on the surface. Groundwater pollution (turbidity, fluids pumped into or flowing from rock formations penetrated by the well, and natural gas present in the rock formations penetrated by the well) may occur if fracking activities provide subsurface pathways during drilling flowback or production operations (NYSDEC, 2011).

Flowback of the fracturing fluid to the surface following injection produces wastewater. Fracturing fluid may release heavy metals and naturally occurring radioactive materials into the environment as it moves to the

surface during flowback. Therefore, fracking wastewater may contain varying levels of total dissolved solids, fracturing fluid additives, metals, and radioactive materials.

Wastewater handling, storage, processing, and disposal have the potential to affect surface water and groundwater resources if the wastewater is not properly managed. Underground injection of waste fluids is a common method of wastewater disposal. Wastewater may also be discharged to an industrial treatment facility if effluent guidelines are met. Surface water impacts can also occur because of improper handling, storage, or disposal of wastewater and waste material from extraction and operation activities.

Limited quantities of water are needed for functions such as maintenance and cleaning, and to provide potable water for the operations and maintenance facilities and crew.

Changing the flow rate of water can change water quality including turbidity and temperature. Potential effects include dewatering sections of rivers and forming new surface water bodies. The magnitude and extent of impacts would vary widely with the location and size of the plant, the cooling technique employed, the source of the water, and the wastewater disposal technique and location

4.2.3 Regulations

- Federal Clean Water Act
- Cooling Water Intake Structures
    - In April 2012, EPA published final regulations to establish location, design, construction, and capacity standards for cooling water intake structures at new facilities under section 316(b) of the Clean Water Act. Section 316(b) of the Clean Water Act requires EPA to ensure that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.
- Surface Water Discharge
    - National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or manmade ditches. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states.

4.2.4 Mitigation

Using a surface water pollution prevention plan (SWPPP) and associated best management practices (BMPs), and implementing an on-site stormwater management system to control site drainage can reduce construction impacts on water quality and drainage conditions.

Some construction sites require NPDES permits outlining any required development and implementation of a SWPPP and a variety of BMPs to minimize erosion and control runoff and sedimentation. Such construction sites would need to implement a temporary on-site stormwater management system to control site drainage and minimize temporary impacts to water quality.

Before construction, contractors should have a clear understanding of the local hydrology. Areas of groundwater discharge and recharge and their potential relationships with surface water bodies should be identified in order to avoid creating hydrologic conduits (BLM, 2006).

Other mitigation measures include:

- Use a recirculating system for cooling to reduce water requirements.
- Use treated wastewater for cooling where available and appropriate for the type of technology in use.
- Develop temporary and permanent stormwater management systems that incorporate BMPs for pollution prevention.
- Characterize the surface and groundwater hydrology before construction, develop an understanding of discharge and recharge relationships, and avoid creating new hydrologic connections through grading and related activities.
- Monitor water quantity and quality conditions if construction activity is to occur near aquifer recharge areas.
- Implement BMPs for use, handling, and storage of fuels, pesticides, and other hazardous materials during both construction and operation.
- Implement a groundwater-monitoring plan if groundwater withdrawals and discharges are planned.
- Develop and implement a spill prevention control and countermeasure plan. Manage all maintenance/cleaning wash water with appropriate BMPs for pollution prevention.
- Implement water conservation programs and identify conservation measures and water use alternatives.
- Require and apply aquifer-testing protocols.
- Apply drought management practices including water restrictions on use and prioritizing water use.
- Require and adhere to surface water flow release targets for reservoirs, surface water bodies, and other important waterways, and require pass-by flows to protect aquatic resources, competing users, in-stream flow uses, and limit adverse lowering of stream flow levels downstream of the point of withdrawal.
- Use diversion dikes, berms, curbing, grading and other measures to minimize or eliminate run-on into tank filling areas.
- Implement spill response and prevention measures.
- Complete inspections and preventative maintenance for tanks, pumps, piles, and fueling areas.
- Locate additive containers and transport, mixing and pumping equipment as far away from surface waters as possible.
- Use drip pads or pans where additives and fracturing fluid are transferred.

4.3 Conservation

4.3.1 Construction Impacts

Energy conservation measures can degrade water quality if wastes from conservation measures are improperly disposed of. Wastes include discarded light bulbs, fluorescent light ballasts, asbestos, or machinery. Many types of light bulbs contain lead and/or mercury, which can affect human health and degrade the natural environment. In the past, polychlorinated biphenyls (PCBs) and diethylhexyl phthalate (DEHP) were used in fluorescent light ballasts. PCBs are suspected carcinogenic compounds and federally regulated toxic substances. They can bioaccumulate in animal tissues and pollute soil and sediment. Some machinery may also contain PCBs and other toxic compounds. DEHP is an endocrine disruptor and suspected carcinogen. Assuming reasonable mitigation, impacts would be low.

4.3.2 Operation Impacts

Impacts are likely to be low.

4.3.3 Mitigation

Mitigation includes disposal in lined hazardous waste sites per current local, state, and federal laws and regulatory practices for toxic waste removal. Impacts would be low.

4.4 Landfill Gas

4.4.1 Construction Impacts

It is likely that most reclaimed landfills have stormwater runoff management systems in place that would accommodate runoff from the site with little or no modification. If not, a temporary stormwater detention system would need to be developed. Impacts on water resources during construction would likely be low.

4.4.2 Operation Impacts

The analysis for the IRP assumes that the generation technology (e.g., combustion turbine) uses minimal water. Impacts on water quantity and quality are likely to be low.

4.4.3 Mitigation

Please see Section 4.2.4 for mitigation measures to reduce the impact of landfill gas-powered electricity generation facilities.

4.5 Gorge Second Tunnel (Hydro Efficiency)

4.5.1 Construction Impacts

There would be no new intake constructed at the reservoir, since the new tunnel would divert from the existing tunnel below the existing intake. Extensive geotechnical field studies and exploratory borings were completed during the project design phase, allowing detailed evaluation of groundwater near the project and along the proposed tunnel alignment. The tunnel alignment may intersect groundwater fracture flows, in which case the breached seam would release groundwater into the excavation. Where this occurs, the fracture would be permanently sealed, preventing ongoing dewatering of the fracture. Normal precipitation processes would recharge the breached seams.

Although only trace sulfide mineralization has been observed within the project area bedrock during field mapping and core drilling, there is a slight possibility of encountering zones of concentrated sulfide mineralization within the tunnel excavation. Excavated material containing high concentrations of naturally occurring sulfides could introduce heavy metals and acidic water into the Skagit River through site runoff or groundwater infiltration at the Bacon Creek quarry site. Tunnel and quarry development activities could result in turbid runoff or pH contamination to surface or ground water. Overall, construction impacts would be low.

4.5.2 Operation Impacts

Low likelihood of impacts; a new tunnel would not take more water from the existing reservoir.

4.5.3 Mitigation

A rigorous monitoring and containment plan and procedures would be implemented to identify, isolate and properly dispose of contaminated rock spoils to prevent potential leaching of acidic water or heavy metals from sulfide minerals into the Skagit River, groundwater, Bacon Creek, or Bacon Creek quarry site. A water filtration and monitoring system would be implemented to ensure removal of naturally occurring or construction-related contaminants from tunnel water and stormwater before it is discharged for ground infiltration. See Section 4.2.4 for additional mitigation measures to reduce potential impacts to surface and ground water.

4.6 Geothermal

4.6.1 Construction Impacts

Construction of geothermal energy facilities, including associated drilling operations, could affect water resources by:

- Changing surface and groundwater pathways.
- Discharging to existing water sources.
- Consuming water for various construction activities.

Depending on the area of construction, a geothermal plant would require an NPDES permit for discharge of construction stormwater (BLM, 2004). NPDES permit conditions include the required development and implementation of a surface water pollution prevention plan and a variety of BMPs to minimize erosion and control runoff and sedimentation. If these plans and practices are followed, construction impacts on water quality would likely be low.

4.6.2 Operation Impacts

Geothermal plants using binary air-cooled technology, which is assumed in this analysis, use minimal fresh water. However, operation of a geothermal facility can affect ground and surface water, depending on the location of the site relative to surface water bodies and the condition of the aquifer providing the geothermal steam. Geothermal plants extract large amounts of water from underground, and can affect the resource even if that water is pumped back underground. Extracting steam faster than it can be replenished could lead to depletion of the geothermal resource or affect nearby groundwater and/or surface water sources. In addition, if water from the geothermal well is discharged to groundwater or surface water, the temperature and chemical composition of those water bodies could be changed. Overall, impacts during operation are expected to be moderate.

4.6.3 Mitigation

Water quality and/or quantity impacts can be reduced by:

- Preventing geothermal groundwater from being released to land/surface water bodies.
- Injecting geothermal groundwater back into geothermal wells, and use air-cooling where possible.
- Using wastewater from non-geothermal plant sources, such as from municipal water treatment facilities, if the source is within a reasonable piping distance. This can decrease potential impacts from the wastewater potentially being discharged into surface waters, and provides recharge water for the aquifer supplying geothermal energy.

4.7 Biomass

4.7.1 Construction Impacts

Construction of biomass-fueled electrical generation facilities and access roads can alter surface and groundwater flow patterns, cause discharges to existing water sources, and consume water during the construction process. Other construction impacts would be similar to those outlined in Section 4.2.1. No measurable effect on the availability of local water supplies would be expected. Impacts on water quality and drainage conditions during construction would likely be low.

4.7.2 Operation Impacts

A wood-fired plant will require a water source to produce steam. The amount of water required to operate a conventionally cooled wood steam plant per MWh is roughly 20,000 to 50,000 gallons of water per MWh of electricity produced (NREL, 2011).
Long-term effects on surface water quantity and quality would be limited to any permanent changes in drainage patterns and the runoff from the area of impervious surfaces created by the permanent project facilities

Based on the requirements for such a system and the limited runoff volume to be managed, prevailing water quality standards could be met and impacts on surface water quantity and quality are likely to be low to moderate.

4.7.3 Mitigation

See mitigation measures in Section 4.2.4.

4.8 Wind

4.8.1 Construction Impacts

The area of construction disturbance for a wind power project is typically large enough to require an NPDES permit for discharge of construction stormwater (BLM, 2006). While access road systems for large wind farms are rather extensive, long-term changes to local or regional drainage characteristics are typically minor because surface disturbance for project development affects only a small fraction of the total project area. Therefore, impacts on water quality and drainage conditions during construction would likely be low.

Grading and excavation/blasting activities (such as for turbine foundations and underground power collection cables) and extraction of geologic materials for use in construction can change groundwater flow patterns and result in discharges to groundwater (BLM, 2006). Trenching for installation of power collection cables is typically shallow (about 4 feet deep) and at most sites is unlikely to intersect groundwater. Turbine foundations are often up to approximately 40 feet deep and are more likely to encounter groundwater, but subsurface flow patterns would be changed only if the excavation/blasting established a significant hydrologic connection between two aquifers or between groundwater and surface water.

Overall, impacts on water resources during construction would likely be low.

4.8.2 Operation Impacts

Most wind farms use almost no water during operation. Limited quantities of water are needed for maintenance and cleaning, and to provide potable water for operations and maintenance facilities and crew. Based on the requirements for such a system and the limited runoff volume to be managed, prevailing water quality standards would be met and impacts on water quantity and quality are likely to be low.

4.8.3 Mitigation

Water impacts can be reduced by:

- Using readily biodegradable, low volatility lubricating and cooling oils.
- Using durable, high solids, low volatility coatings.
- Managing all maintenance and cleaning wash water with appropriate BMPs for pollution prevention.

4.9 Solar Energy

4.9.1 Construction Impacts

Surface and groundwater impacts during construction of solar projects are typical of those found in the construction industry. This analysis does not include the water consumed during the energy-intensive manufacturing of power plant components because of the limited availability of data on upstream water use for materials manufacturing. Overall, construction impacts would be low.

4.9.2 Operation Impacts

Photovoltaic (PV) systems do not require the use of any water to create electricity. Parabolic trough and power tower facilities may use water resources to cool the steam leaving the generator back to a liquid state. The total water use will depend on the technology for the cooling system. Wet cooling systems are open-circuit systems that use evaporation to cool the heat transfer fluid. Water consumption of a wet-cooled parabolic trough system is estimated to be about 3100 to 3800 L/MWh (Kammen, 2011). Dry cooling systems use ambient air for cooling and require less than one-tenth the amount of water required for wet cooling systems.

Both photovoltaic and solar thermal systems require small volumes of water for panel and mirror washing and other maintenance and sanitary uses to support the workforce. The amount of water needed for mirror washing depends on the fugitive dust conditions, the climate of the region, and the time of the year. Estimates of water use during the operation of a photovoltaic system are low (between 0 and 15 L/MWh) (Kammen, 2011).

Because of the dry nature of regions with utility-scale solar facilities, relatively large amounts of dust suppressants are used because dust can affect the photovoltaic properties of the solar panels. Dust suppressants may contain salts and brines, organic non-petroleum products, synthetic polymers, organic petroleum, electrochemical substances, clay additives, and mulch and fiber mixtures. These constituents can affect runoff and change soil properties (Lovich and Ennen, 2011). Operational impacts for photovoltaic systems would be low. Operational impacts of solar thermal technologies depend upon the cooling system is considered moderate.

4.9.3 Mitigation

Typical mitigation measures are outlined in Section 4.2.4.

4.10 Natural Gas Combined-Cycle Combustion Turbines

4.10.1 Construction Impacts

Construction of natural gas plants and related facilities would use water to control dust and to clean and cool equipment. The amount of water needed would be greater for a longer construction period and a larger construction footprint. Typically, these types of impacts can be mitigated and would be low. See Section 4.2.4 for descriptions of typical construction impacts.

4.10.2 Operation Impacts

The extraction of natural gas could result in depletion or contamination of surface and groundwater sources because underground geological formations are tapped by drilling. Drilling equipment requires water for

cleaning and cooling, and could contaminate surface water resources if fuel or chemicals leak from the equipment.[16]

Both cable tool drilling, which involves raising and dropping a heavy metal bit into the ground to drill shallow, low-pressure formations, and rotary drilling, which involves using a sharp, rotating metal drill bit for deeper wells under higher pressure, require water (NGA, 2006c). Cable tool drilling requires using water in the well hole to combine with all of the drill cuttings. Water is required for rotary drilling as a component of liquid drilling fluid used in the circulating system, the purpose of which is to cool and lubricate the drill bit, control well pressure, remove debris and cuttings, and coat the walls of the well with a mud-type cake. Directional or horizontal drilling can be employed in order to leave a surface water body intact while reaching a source for natural gas underneath that water body (NGA, 2006a).

Hydraulic fracturing pumps water, chemicals, and sand into a well to open cracks (fractures) in rock, which allows the natural gas to flow more easily to a well. The technique requires large amounts of water that may affect the availability of water for other uses. Furthermore, the hydraulic fracturing fluid can spill, leak, or possibly be released during construction and operational activities, which could contaminate the surrounding groundwater and area (EIA, 2012a).

The coal seam methane technique, described in Section 1.1.8.3, often involves removing large amounts of water from shallow aquifers containing trapped methane (natural gas) within the coal seams. Water quality is highly dependent upon the associated aquifer. In some circumstances, water quality can be fairly clean, but often the water contains salts and minerals contributing either to salinity or alkalinity. Depending on the disposal method, wastewater can create environmental damage to surface waters if discharged to streams or rivers, to soil if discharged directly to the ground, or to groundwater if injected, allowed to infiltrate via reservoirs or discharged to the surface. Groundwater aquifers can also be affected by removal of wastewater from the site.

The likelihood and magnitude of potential depletion or contamination of surface and groundwater resources are highly dependent on the location and size of the drilling activity and the presence of surface or groundwater sources at the drilling site. These impacts can range from low to high.

Combustion turbine plants typically use water for process and cooling, and generate wastewater. Ground or surface water is needed for both the water used as a carrier of combustion energy to a turbine for conversion into electricity, and for cooling the plant.

The once-through cooling technique requires more water than recirculation. Recirculating the water reduces the amount of water withdrawn from a surface or groundwater source; however, because more water is lost to evaporation, less water is returned to the source, compared to once-through cooling. In addition, more chemicals such as chlorine and biocides are used in recirculation systems and need to be disposed of when they leave the cooling system. Dry cooling uses very little water, but is not common in existing plants (EF/HF, 2006) because it causes a loss of energy output and does not perform as well as water-cooling in extreme temperatures.

Atmospheric conditions and cooling technology are the primary factors in determining water consumption. Therefore, even among power plants using the same generating technology, there is a wide range water consumption rates.

[16] Underground, in reservoirs that contain oil and gas, the gas is the least dense and is found closest to the surface with the oil beneath it and water typically beneath the oil. (http://www.naturalgas.org/overview/background.asp).

Table 4-1 shows the range of water required for combustion turbine energy plants.

Table 4-1. Water use for combustion turbines (gallons/MWh)

Plant and Cooling Type	NREL (March 2011) (Consumption)	NREL (March 2011) (Withdrawal)
CCCT (once-through)	20-100	7,500 – 20,000
CCCT (recirculate)	130-300	150-283
CCCT (dry)	0-4	0-4

Impacts to surface and groundwater resources caused by operation of combustion turbine plants would range from low to high.

4.10.3 Mitigation

- Reuse cooling water, use dry cooling, or use recycled or reclaimed wastewater to reduce the amount of water required. Wastewater can be treated in many ways, and might be used for industrial or irrigation purposes, depending on location (OEFSC, 2006).
- Use water sources with high quality that would not be compromised by use for power plant cooling, where available and appropriate for the type of technology.
- Implement water conservation programs and identify conservation measures and water use alternatives.
- Require and apply aquifer-testing protocols.
- Apply drought management practices including water restrictions on use and prioritizing water use.
- Require and adhere to surface water flow release targets for reservoirs, surface water bodies, and other important waterways, and require pass-by flows to protect aquatic resources, competing users, in-stream flow uses, and limit adverse lowering of stream flow levels downstream of the point of withdrawal.
- Use diversion dikes, berms, curbing, grading and other measures to minimize or eliminate run-on into tank filling areas.
- Implement spill response and prevention measures.
- Complete inspections and preventative maintenance for tanks, pumps, piles, and fueling areas.
- Locate additive containers and transport, mixing and pumping equipment as far away from surface waters as possible.
- Use drip pads or pans where additives and fracturing fluid are transferred.

4.11 Renewable Energy Credits

4.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

4.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

4.11.3 Mitigation

See Section 4.2.4.

4.12 Market Transactions

4.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions, and impacts would be low.

4.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be high.

4.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the plants have already been built, and it is unlikely that these plants would install additional mitigating measures in order to meet the incremental demand. See Section 4.2.4 in this Appendix for details on mitigation options.

4.13 Transmission

4.13.1 Construction Impacts

Direct surface water impacts from construction of transmission facilities would most likely be caused by erosion and increased runoff where structures or access roads are near water bodies or wetlands. Culvert installation and replacement for access roads could disturb bank soil and shoreline vegetation. Where roads are improved along stream channels, soil could be deposited into the stream channel, increasing turbidity and sedimentation. Vegetation removal and soil disturbance can increase water erosion that deposits sediment directly into stream channels and increases turbidity. Erosion rates would likely return to existing levels once vegetation is reestablished, and turbidity and sedimentation impacts on water resources would be reduced. Impacts would depend on the timing of construction, weather conditions, local topography, the erosion potential of the soil, and the effectiveness of BMPs implemented during construction to minimize soil erosion. Overall, surface water impacts during construction are expected to be low to moderate depending upon location.

Direct impacts on groundwater from construction of transmission facilities are expected to be low to moderate. Groundwater quality could be affected by compaction, which would reduce infiltration capacity and increase surface water runoff to streams. Any impacts would be localized and short term.

4.13.2 Operation Impacts

Maintenance activities such as grading access roads, replacing failed culverts, and controlling vegetation could increase erosion and surface water turbidity. Removing vegetation can reduce shade and cause increased water temperatures if widespread. Use of herbicides for vegetation management could also cause impacts if herbicides reach streams through overspray or transport of herbicide residue. Overall effects on surface water are expected to be low to moderate. An ongoing potential for release of hazardous fluids to groundwater during maintenance activities would require an operational spill response plan. Soil compaction and reduced

infiltration from maintenance activities would also occur. Altogether, impacts on groundwater are expected to be low to moderate.

4.13.3 Mitigation

- Develop temporary and permanent stormwater management systems that incorporate BMPs for pollution prevention.
- Retain vegetative buffers where possible.
- Conduct construction activities during the dry season as much as possible.
- Locate roads and structures to avoid wetlands.
- Develop a spill response plan to minimize the potential for spills of hazardous material.
- Use ecological based ROW vegetation management. Minimize use of pesticides and use only safest pesticides.

Table 4-2. Summary of surface and groundwater impacts[17]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		Low impact assuming proper disposal of waste.
		L	Low impact assuming proper disposal of waste.
Landfill Gas	L		Most landfills have a stormwater runoff management system in place that would accommodate runoff from the site with little modification.
		L	The generation technology used frequently for landfill gas energy projects use little water during operation.
Gorge Second Tunnel	L		Low possibility of introducing naturally occurring heavy metals and acidic water into ground or surface waters. In the absence of BMPs, turbidity, pH, or other contaminants could be introduced to ground or surface waters.
		L	New tunnel will not take more water from the existing reservoir.
Geothermal	L		Drilling could potentially change surface and groundwater pathways. Proper mitigation is needed to control runoff and sedimentation.
		M	Some plants may extract water from underground and not replenish the water source. Discharging water may affect surface water temperature.
Biomass	L		Assumes biomass plant constructed in an existing industrial facility site.
		M	Technology likely requires a water source to produce. Potential water quality impacts at the forest harvest site.
Wind	L		With reasonable mitigations, three is a low potential for water quality impacts resulting from surface disturbance.
		L	Wind farms use almost no water during operation. Maintenance facilities and crews may use minimal water.
Solar Energy	L		Typical construction related impacts (e.g., water used to control dust, surface runoff) that can be mitigated.
		M	Small amount of water used for cleaning PV panels has moderate impact in arid environments. Operational impacts of solar thermal technologies depend upon the cooling system and are considered moderate.
Natural Gas/CCCT	L		Typical construction related impacts (e.g., water used to control dust, surface runoff) that can be mitigated.
		H	Fuel extraction methods could include hydraulic fracturing, which uses large amounts of water and could contaminate aquifers.
Renewable Energy Credits	L		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-M	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Assumes energy will be supplied by existing resources; no new plants will be constructed to meet the demand.
		H	Assumes emissions comparable to the combustion of natural gas/CCCT in existing power plants.
Transmission	M		Typical construction related impacts but greater potential to be located near water bodies or wetlands.
		M	Vegetation maintenance efforts could increase erosion and surface water turbidity.

[17] Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

5 PLANTS AND ANIMALS

5.1 Affected Environment

The Pacific Northwest is among the more geographically diverse regions of North America. This region includes wet coastal and dry interior mountain ranges, coastline, interior valleys, basins, and high desert plateaus. Moisture, temperature, and substrate vary greatly (BPA, 1993). Vegetation has evolved to thrive in the many types of ecosystems and, consequently, habitats are quite diverse. Accordingly, diverse fish, wildlife, and plant species inhabit Pacific Northwest environments. These species vary in size and distribution and include larger animals such as bear, elk, and deer, and smaller animals such as butterflies, snails, and birds. All are ecologically important but some are of special concern due to dwindling populations, ecological function, or cultural or recreational value. Some species are listed for protection by state and/or federal governmental agencies. The following section focuses primarily on species that have received such designations.

5.1.1 Fish

The Pacific Northwest supports many anadromous (migratory) fish, species that migrate downriver to the ocean where they reside from one to five years, after which they return to their natal river to spawn. The principal anadromous fish runs in the Pacific Northwest are Chinook, coho, pink, chum, and sockeye salmon, steelhead, and Pacific lamprey. These species are important resources to the Pacific Northwest for their economic value to the sport and commercial fisheries, for cultural and religious value to the region's Native American tribes, and for their role in both marine and freshwater ecosystems. Several distinct populations of Chinook, chum, coho, and sockeye salmon and steelhead in the Pacific Northwest are listed as threatened or endangered under the federal Endangered Species Act (ESA) (Table 5-1). These listings occurred following substantial declines in abundance and population productivity that were observed since the 1980s. Puget Sound steelhead, listed as threatened in 2007, are the most recent anadromous fish listing to the ESA in the Pacific Northwest.

Resident fish are freshwater fish that live and migrate within the rivers, streams, and lakes of the Pacific Northwest. Many of these fish, including rainbow trout, cutthroat trout, bull trout, and white sturgeon are important in terms of economic and recreational value. Bull trout and cutthroat trout in particular are of important cultural value to tribes in the Pacific Northwest. Bull trout, cutthroat trout, and white sturgeon in many areas of the Pacific Northwest have an amphidromous life history, meaning that they migrate from freshwater to estuary and marine nearshore waters for several months before returning to freshwater to spawn. A number of resident fish species are listed as threatened or endangered under the ESA, including bull trout, Lahontan cutthroat trout, white sturgeon, Lost River suckers, shortnose suckers, Modoc suckers, Warner suckers, Foskett speckled dace, Borax Lake chub, Hutton tui chub, and Oregon chub.

Large habitat losses have occurred in the Columbia River Basin due to the construction of hydroelectric dams on Pacific Northwest rivers. In addition, past mitigation has not fully compensated for the effects of hydropower or other development (BPA, 1993). A number of major dams such as those in the upper Columbia River have blocked the upstream access to large areas that were historically used by salmon and steelhead for spawning. To improve this situation, the Northwest Power Act directs the Northwest Power Planning Council to develop a program to protect, mitigate, and enhance fish and wildlife including related spawning grounds and habitat on the Columbia River and its tributaries [U.S.C. Section 839b(h)(1)(A)].

Table 5-1. Status of federally listed animal and plant species in the Pacific Northwest

Status	Listed Species in the Pacific Northwest (WA, OR, ID) Including Those That May Not Occur in the Region E = Endangered T = Threatened
	Animals
E	Albatross, short-tailed (*Phoebastria (=Diomedea) albatrus*)
T	Bear, grizzly lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)
E	Butterfly, Fender's blue (*Icaricia icarioides fenderi*)
T	Butterfly, Oregon silverspot (*Speyeria zerene hippolyta*)
E	Caribou, woodland Selkirk Mountain Population (*Rangifer tarandus caribou*)
E	Chub, Borax Lake (*Gila boraxobius*)
T	Chub, Hutton tui Hutton (*Gila bicolor ssp.*)
T	Chub, Oregon (*Oregonichthys crameri*)
E	Condor, California U.S.A. only (*Gymnogyps californianus*)
T	Dace, Foskett speckled Foskett (*Rhinichthys osculus ssp.*)
E	Deer, Columbian white-tailed Columbia River DPS (*Odocoileus virginianus leucurus*)
T	Fairy shrimp, vernal pool (*Branchinecta lynchi*)
E	Limpet, Banbury Springs (*Lanx sp.*)
T	Lynx, Canada lower 48 States DPS (*Lynx canadensis*)
T	Murrelet, marbled CA, OR, WA (*Brachyramphus marmoratus marmoratus*)
T	Otter, southern sea except where EXPN (*Enhydra lutris nereis*)
T	Owl, northern spotted (*Strix occidentalis caurina*)
T	Plover, western snowy Pacific coastal pop. (*Charadrius alexandrinus nivosus*)
E	Rabbit, pygmy Columbia Basin DPS (*Brachylagus idahoensis*)
T	Salmon, chinook Puget Sound (*Oncorhynchus (=Salmo) tshawytscha*)
T	Salmon, chinook fall Snake R. (*Oncorhynchus (=Salmo) tshawytscha*)
T	Salmon, chinook lower Columbia R. (*Oncorhynchus (=Salmo) tshawytscha*)
E	Salmon, chinook spring upper Columbia R. (*Oncorhynchus (=Salmo) tshawytscha*)
T	Salmon, chinook spring/summer Snake R. (*Oncorhynchus (=Salmo) tshawytscha*)
T	Salmon, chinook upper Willamette R. (*Oncorhynchus (=Salmo) tshawytscha*)
T	Salmon, chum Columbia R. (*Oncorhynchus (=Salmo) keta*)
T	Salmon, chum summer-run Hood Canal (*Oncorhynchus (=Salmo) keta*)
T	Salmon, coho Oregon Coast (*Oncorhynchus (=Salmo) kisutch*)
T	Salmon, coho Lower Columbia River (*Oncorhynchus (=Salmo) kisutch*)
T	Salmon, coho Southern Oregon-Northern California Coast (*Oncorhynchus (=Salmo) kisutch*)
T	Salmon, sockeye U.S.A. (Ozette Lake, WA) (*Oncorhynchus (=Salmo) nerka*)
E	Salmon, sockeye U.S.A. (Snake River, ID stock wherever found.) (*Oncorhynchus (=Salmo) nerka*)
T	Sea turtle, green except where endangered (*Chelonia mydas*)
E	Sea turtle, leatherback (*Dermochelys coriacea*)
T	Sea turtle, loggerhead (*Caretta caretta*)
T	Sea lion, Steller eastern pop. (*Eumetopias jubatus*)
E	Sea lion, Steller western pop. (*Eumetopias jubatus*)
T	Snail, Bliss Rapids (*Taylorconcha serpenticola*)
E	Snail, Snake River physa (*Physa natricina*)
E	Spring snail, Bruneau Hot (*Pyrgulopsis bruneauensis*)
T	Squirrel, northern Idaho ground (*Spermophilus brunneus brunneus*)
T	Steelhead Puget Sound (*Oncorhynchus (=Salmo) mykiss*)
T	Steelhead Snake R. Basin (*Oncorhynchus (=Salmo) mykiss*)

T	Steelhead lower Columbia R. (*Oncorhynchus (=Salmo) mykiss*)
T	Steelhead middle Columbia R. (*Oncorhynchus (=Salmo) mykiss*)
T	Steelhead upper Columbia R. Basin (*Oncorhynchus (=Salmo) mykiss*)
T	Steelhead upper Willamette R. (*Oncorhynchus (=Salmo) mykiss*)
E	Sturgeon, white U.S.A. (ID, MT), Canada (B.C.), Kootenai R. system (*Acipenser transmontanus*)
E	Sucker, Lost River (*Deltistes luxatus*)
E	Sucker, Modoc (*Catostomus microps*)
E	Sucker, shortnose (*Chasmistes brevirostris*)
T	Sucker, Warner (*Catostomus warnerensis*)
T	Trout, bull U.S.A., conterminous, lower 48 states (*Salvelinus confluentus*)
T	Trout, Lahontan cutthroat (*Oncorhynchus clarki henshawi*)
E	Whale, humpback (*Megaptera novaeangliae*)
E	Whale, killer Southern Resident (*Orcinus orca*)
E	Wolf, gray lower 48 States, except MN and where XN; Mexico (*Canis lupus*)
	Plants
T	Catchfly, Spalding's (*Silene spaldingii*)
T	Checker-mallow, Nelson's (*Sidalcea nelsoniana*)
E	Checkermallow, Wenatchee Mountains (*Sidalcea oregana var. calva*)
E	Daisy, Willamette (*Erigeron decumbens var. decumbens*)
E	Desert-parsley, Bradshaw's (*Lomatium bradshawii*)
T	Four-o'clock, MacFarlane's (*Mirabilis macfarlanei*)
E	Fritillary, Gentner's (*Fritillaria gentneri*)
T	Howellia, water (*Howellia aquatilis*)
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)
E	Lily, Western (*Lilium occidentale*)
E	Lomatium, Cook's (*Lomatium cookii*)
T	Lupine, Kincaid's (*Lupinus sulphureus (=oreganus) ssp. kincaidii (=var. kincaidii)*)
E	Meadowfoam, large-flowered woolly (*Limnanthes floccosa ssp. grandiflora*)
E	Milk-vetch, Applegate's (*Astragalus applegatei*)
T	Paintbrush, golden (*Castilleja levisecta*)
T	Peppergrass, Slickspot (*Lepidium papilliferum*)
E	Popcornflower, rough (*Plagiobothrys hirtus*)
E	Stickseed, showy (*Hackelia venusta*)
T	Thelypody, Howell's spectacular (*Thelypodium howellii spectabilis*)
E	Wire-lettuce, Malheur (*Stephanomeria malheurensis*)

Source: U.S. Fish and Wildlife Service web site.

5.1.2 Plants and Animals

Vegetation within the region is a diverse mix of species found in varying complexes of topography, climate, and soil. The vegetation may be classified as (BPA, 2000):

- Grasslands—naturally-growing grasses found in the southern Puget Lowlands, Willamette Valley, and the extensive rangelands of eastern Washington, Oregon, southern Idaho, and the intermountain valleys of Montana.

- Shrublands—shrubby areas located on mountains and in low-lying areas, rangeland, and shrub-steppe vegetation that typically have few trees and where herbaceous vegetation ranges from none to densely abundant.

- Forested areas—extensive areas of coniferous, deciduous, and mixed tree species that occur generally where precipitation is highest: Coast Range, Willamette and Puget Sound valleys, Cascade Mountains, Blue Mountains of northeastern Oregon, and Rocky Mountains of Idaho and western Montana.

In addition, riparian areas, where vegetation may be taller and lusher than surrounding vegetation because more water is available, occur within these major vegetation zones. Likewise, wetlands are special plant communities influenced by the presence of water. Wetlands also occur throughout these vegetation zones and provide water quality and hydrologic benefits; they are important habitats for a wide variety of plant and animal species. Wetlands are accorded special protection at the federal, state, and local levels with restrictions on land use related to the quality, function, and location of the wetlands.

There are fewer federally listed plant species than fish species (Table 5-1), but the threatened and/or endangered status is widespread in the region for several of the species. For example, Spalding's catchfly and water howellia are listed species in all three states.

Wildlife in the region is also diverse, ranging from large mammals to birds, insects, and reptiles (BPA, 2000). The presence of wildlife species is determined by the type and amount of food, cover, water, and other habitat conditions. Some species are of special interest due to economic or recreational value, or are protected by state or federal government regulations. Some well-known species that are either threatened or endangered include the grizzly bear, gray wolf, spotted owl, and marbled murrelet (Table 5-1).

In addition to the federally listed species shown in Table 5-1, many additional plant and wildlife species have state status in one or more of the Pacific Northwestern states. The regulations regarding these species vary amount the states but generally, each state has programs with goals to maintain viable, self-sustaining populations of all native wildlife and plants to prevent species from becoming endangered.

5.2 General

5.2.1 Construction Impacts

Construction of new electricity generating facilities could have potentially significant effects on the plants and animals at a proposed site. One direct construction impact is removing vegetation and the habitat it provides for wildlife. Vegetation and habitat could be removed in previously undeveloped areas and along roads to or around a new facility. Habitat would be disturbed by both site clearing and construction activities.

Another direct construction impact is mortality or injury to animal species that inhabit the site at the time of construction. Mobile wildlife or aquatic species on a project site are likely to be displaced during construction, while those that are less mobile can be killed or injured by construction activity.

Other direct impacts include the loss of food and prey species; disruption to breeding, nesting, and rearing; altered movement and migration; and habitat fragmentation. The severity of these impacts depends on the specific location of a facility. Other potential impacts could include:

- Introduction of noxious weeds
- Potential impact on special status plant and animal species
- Effects on plants and animals from artificial lighting and noise
- Temporary modification (or permanent displacement) of plant and animal habitat
- Extirpation of animal species without migration/dispersal routes

- Impacts on aquatic species from changes in water quantity or quality, erosion or landslides, and other alterations of the hydrologic regime

Potential Indirect effects include interference with normal animal behaviors or introduction of adverse changes to their habitat. Both air and water impacts could adversely affect plants and wildlife health. For example, remaining vegetation and habitat quality for wildlife can be diminished indirectly through dust generated by construction, erosion and runoff, and increased opportunities for invasive species. Construction can increase fugitive dust emissions that reduce the photosynthesis process in plants.

Similarly, aquatic habitat can be degraded by runoff, dust, and exposure to contaminants through spills. Air emissions from equipment used at construction sites could contribute to degraded water quality. Increased turbidity (suspended particles in the water) and sedimentation could occur in streams, rivers, and lakes, which could lead to fish mortality during spawning and incubation periods. Increased turbidity affects fish by abrasion, gill clogging, decreased feeding success due to reduced visibility, degradation of spawning gravel, increased egg and fry mortality, and reduced fry growth rates.

Noise, the presence of humans and vehicles, and other aspects of construction activity can modify the behavior of wildlife remaining on the site and nearby.

Overall, construction impacts would likely be moderate depending upon the site location and the quality and sensitivity of habitat. Some construction impacts would be unavoidable, but mitigating measures would be implemented to limit the extent and magnitude of such impacts.

Impacts could also occur during development of transmission facilities depending on the quality of habitat and species that are present along transmission routes.

5.2.2 Operation Impacts

Operation of some electricity generating facilities would affect plants and animals by creating waste, noise, and air emissions. Some facilities would use or reroute water; most facilities would require clearing vegetation from the site. If groundwater or surface water is withdrawn or discharged during plant operation, streams, wetlands, and the aquatic species they support could be affected by changes in water quality and flow. Wind facilities can result in bird and bat mortality. Transmission lines can also result in bird collisions and electrocution. The extent and magnitude of these impacts would depend on the specific site, scale of operation, and other project-level factors.

5.2.3 Regulations

- Endangered Species Act, Migratory Bird Treaty Act, Clean Water Act, Coastal Zone Management Act, Tribal treaties regulations by Federal (U.S. Fish and Wildlife, NOAA Fisheries, U.S. Army Corps of Engineers), State and local government, Tribes
- Northwest Power Act regulations by the Northwest Power and Conservation Council and NOAA National Marine Fisheries Service

5.2.4 Mitigation

The effects of some construction and operations on plants and animals would be unavoidable, but mitigating measures could include avoiding areas that are high quality habitat or home to sensitive, threatened, or endangered plant and animal species. Additional measures include:

- Coordinate with USFWS and state agencies during the siting, design, construction, and operational stages.

- Where possible, use existing roads and disturbed areas for project development and minimize the area disturbed for project construction.
- Avoid areas that support unique or sensitive plants or important wildlife habitat.
- Develop and implement a restoration plan to restore disturbed plant and animal habitat.
- Implement measures to minimize invasive species.
- Landscape site buffer areas with native plant species.
- Conduct pre- and post-development studies of plant and animal resources.
- Implement hydrologic and species monitoring programs if aquatic resources are adversely affected.
- Time construction to avoid sensitive periods for species of concern.
- Design necessary stream crossings to minimize disturbance and maintain aquatic habitat conditions.
- Implement a water quality and quantity monitoring program.
- Purchase or set aside land to replace habitat lost through project development.
- Monitor project impacts on wildlife during construction and operation, and report the results of the monitoring effort.
- Avoid and minimize adverse effects, and when appropriate, compensate for adverse effects.
- Maintain low-growing vegetation in transmission line rights-of-way.
- Properly manage garbage and waste disposal on project sites.
- Minimize lighting and avoid steadily burning lights.

5.3 Conservation

5.3.1 Construction Impacts

No direct adverse construction effects on plants and animals are caused by conservation. However, some plants and animals, especially amphibians, could be indirectly harmed by increased ultraviolet radiation resulting from atmospheric releases of CFCs when people upgrade to energy-efficient refrigeration or air conditioning systems. Impacts are low.

5.3.2 Operation Impacts

Impacts are low.

5.3.3 Mitigation

Mitigation measures are not required for conservation. Equipment containing greenhouse gases (e.g., refrigerators) and hazardous material (e.g., fluorescent light bulbs containing mercury) should be properly handled and disposed of.

5.4 Landfill Gas

5.4.1 Construction Impacts

Power plants that use landfill gas would be installed at existing or permitted landfills, and would not require significant land outside the landfill footprint. Construction of these facilities would cause little habitat disturbance, but would require removal of any plants within the facility's footprint. The quality of the habitat would likely be low and impacts on plants and animals would be correspondingly low. Threatened and endangered species would not likely be affected.

5.4.2 Operation Impacts

There would be no direct impacts during operation because additional disturbance would not occur. Depending on the location of the facility on the landfill site, noise from operations could disturb nearby wildlife. Overall, impacts would be low.

5.4.3 Mitigation

See Section 5.2.4.

5.5 Gorge Second Tunnel (Hydro Efficiency)

5.5.1 Construction Impacts

There would be no impacts on plants and animals other than those associated with typical construction (noise, vehicle traffic) since most of the work would be done below ground and there would be no change in the way water is removed from the reservoir. Construction activities that affect surface water could have temporary effects on avian or aquatic species. Overall, minor habitat disturbance and human activity in the project area would result in low impacts. Other potential direct and indirect impacts on plants and animals are described in section 5.2.1. Impacts would be low.

5.5.2 Operation Impacts

Impacts would be low.

5.5.3 Mitigation

See Section 5.2.4.

5.6 Geothermal

5.6.1 Construction Impacts

Construction of a geothermal operation could have potentially significant impacts on plants and animals near the development. Habitat for animals would be disturbed by vegetation removal, drilling, and pipeline and plant construction. The severity of the impacts would depend on the drilling site, pipeline routes, and the specific facility location. Impacts could be high.

5.6.2 Operation Impacts

Overall, impacts would be low unless water resources and aquatic species are adversely affected.

5.6.3 Mitigation

See Section 5.2.4.

5.7 Biomass

5.7.1 Construction Impacts

Construction of biomass-fueled energy facilities can have a variety of direct and indirect consequences for plants and animals. For example, a 40-MW wood-fired plant can occupy about 30 acres for the plant itself plus fuel storage. Construction requires clearing existing vegetation in areas to be occupied by roads, a boiler and generator, fuel storage, substations, and other project facilities. This area may represent a permanent loss of vegetation and habitat on a previously undeveloped site.

Other potential direct and indirect construction impacts are described in section 5.2.1.

Most plants are likely to be built on previously disturbed sites, so overall construction impacts would most likely be low.

5.7.2 Operation Impacts

There would be minimal impact to plants and animals at a biomass-fueled power plant site during operation.

There would be no incremental operation impacts to plants and animals if the fuel were mill residue, agricultural waste such as orchard cuttings, or urban wood waste. If the fuel is logging residue, the effects on plants and animals may be positive, negative, or a mix of both.

Possible impacts include some loss of soil nutrients. Benefits might include reduction of on-site burning and clearing out of some areas for more understory or even tree growth. Species of plants and animals that might have used waste wood biomass for habitat could be negatively affected by its removal.

Noise during operation could affect some sensitive wildlife species. Overall, potential incremental impacts on plants and wildlife from operation would be low.

5.7.3 Mitigation

Mitigation measures for plants and animals from the construction and operation of biomass-fueled facilities would be similar to those identified for other energy facilities in Section 6.2.4, as well as:

- Minimize disturbance caused by collecting logging residue.
- Design necessary stream crossings to minimize disturbance and maintain aquatic habitat.
- Provide a cooling system that does not release water with elevated temperatures.
- Ensure that sufficient biomass remains on site to meet critical habitat needs and maintain ecosystem processes.

5.8 Wind

5.8.1 Construction Impacts

Construction for wind farms requires clearing vegetation around areas to be occupied by roads, turbines, substations, and other project facilities. Because construction activity affects a larger area than the permanent facilities occupy, much of the area of temporary disturbance is revegetated following construction. Consequently, much of the disturbance area represents a temporary loss of vegetation and the habitat that it provides.

Productivity in the temporary disturbance area can also be reduced over the long term through soil compaction and loss of topsoil, unless these effects are carefully addressed during the restoration process. A permanent wind farm occupies a small fraction of the total project area (typically no more than 5 to 10 percent, and often less), although this area may represent a permanent loss of vegetation and habitat on a previously undeveloped site.

Overall, the impacts of wind project construction on plants and animals are expected to be low to moderate. Impacts to protected or sensitive plants, animals, and their habitat can usually be avoided or minimized through careful planning, design, and construction measures (NWCC, 2002, 2010; USFWS, 2012; WDFW, 2009). Most of the construction impacts are temporary or do not occur at the same level once construction is completed, and

most of the habitat affected during construction can be replaced through site restoration. The extent of permanent habitat loss is small relative to the size of the project area, and replacement habitat is commonly provided on site or nearby.

Other potential impacts on plants and animals from construction of wind energy facilities are described in section 5.2.1.

5.8.2 Operation Impacts

Several types of potential long-term effects on plants and animals are associated with wind farm operation. These can include collision hazards for birds and bats, electrocution hazards, interference with migratory behavior, and a variety of disturbance factors that can result from project operation (BLM, 2006; NWCC, 2010). Collision is probably the greatest operational hazard to wildlife, and is the most controversial biological factor in the siting and development of wind power projects (BLM, 2004; NWCC, 2002, 2010).

Predevelopment studies of bird resources and use patterns are standard components of wind farm siting, and there continues to be extensive comparative research on both projected (pre-development) and observed (post-development) bird mortality from collisions with wind turbines, meteorological (weather) towers, and transmission lines. In addition to determining absolute numbers of bird fatalities, these studies estimate mortality rates on a per-turbine basis and in relation to the rotor-swept area (RSA) of the turbines at individual facilities. The history of bird mortality at the Altamont Pass Wind Resource Area in California, and extensive publicity associated with that mortality, has raised concern among resource agencies, conservation groups, and the public about the hazards of wind farms to birds.

In general, experience at other operating wind farms throughout the U.S. has been that birds and bat fatalities due to collisions are highly variable between facilities and regions of the country, and are if properly sited, relatively small (NWCC, 2002, 2011). Even though the relationship of current fatalities to the demographics of bird and bat populations is poorly understood, it is unlikely that current fatalities are causing populations to decline (NWCC, 2011). Although only general estimates are available, the number of birds killed in wind farms is substantially lower relative to estimated annual bird casualty rates from a variety of other manmade factors, such as vehicles, buildings, and windows (NWCC, 2011).

Comparative studies have indicated that bird mortality at Altamont Pass has been substantially higher on a per-turbine and/or per-RSA basis than the mortality at other operating wind projects, and these studies have identified a variety of potential reasons for the differences in mortality (BLM, 2006). Altamont Pass is the first large-scale wind energy development in the U.S. Most of the turbines were installed in the 1980s, and it was a test site for many different turbine designs installed by many different developers. Unfortunately, the area was not studied extensively to determine bird use before development, and the pass is now known to be a major migration route and use area for birds. Key bird species at Altamont Pass that are reflected in the mortality statistics include a number of species with a high public profile, primarily raptors such as golden eagles, kestrels, and red-tailed hawks. Researchers have concluded that unusually high raptor densities, regional topography, and the older turbine technology may be factors contributing to the higher bird mortality results for Altamont Pass, compared to other U.S. wind projects.

Bat mortality at wind farms has been the subject of increased research. There is still great uncertainty about geographic distribution and the cause of bat fatalities (NWCC, 2010). All recent studies of bat collisions have demonstrated that fatalities peak at wind facilities during late summer and early fall migration (NWCC, 2011). Generally, bat fatalities are linked to collisions with wind turbines, although barotrauma is also known to be a factor. Tree-roosting bats appear to be affected more heavily than cave-roosting bats. Studies indicate that bats may be attracted to wind turbines, either because of noise generated from wind turbines, because insects may

accumulate near the blades, or because turbines may appear to provide roosting potential. There have been incidents of unexpectedly large bat mortality, particularly during migration season. Studies show that weather patterns may also influence the number of bat fatalities at a facility. The USFWS Draft Land-Based Wind Guidelines provide wind project developers with a process for planning, operating, and monitoring wind energy facilities that minimize negative effects on birds, bats, and other wildlife (2012), as does the WDFW Wind Power Guidelines (2009).

Large birds can be electrocuted when they touch two electrical conductors or a conductor and a grounded wire, and electrocution fatalities on transmission and distribution lines have been documented for some time. Transmission lines associated with wind farms can be an electrocution hazard, although these hazards can be effectively mitigated by appropriate design standards (NWCC, 2002).

Noise produced by wind turbines and other wind farm equipment (typically vehicles), and the occasional presence of humans represent potential operational sources of disturbance impact for wildlife.

Given the overall industry experience, and assuming the use of appropriate pre-development studies and planning measures, it would be reasonable to expect the operation impacts of a new wind project at a typical location in the Northwest to be no worse than moderate. Because bird and bat use and mortality could be substantially above average at certain locations, however, conclusions about long-term impacts on plants and animals would need to be made on a case-by-case basis.

5.8.3 Mitigation

On March 23, 2012, the U.S. Fish and Wildlife Service (USFWS, 2012) issued their Final Land-Based Wind Guidelines addressing the siting, construction, operation, and decommissioning of wind farms to help the wind energy industry avoid or minimize impacts on wildlife and their habitats. Specific actions recommended by the current USFWS guidelines represent appropriate mitigation measures for the plant and animal impacts of wind farms.

In 2009, the Washington Department of Fish and Wildlife (WDFW) issued similar guidance for wind energy development in Washington (Wind Power Guidelines). This is to be accomplished through:

- Proper evaluation of potential wind resource areas.
- Proper location and design of turbines and associated structures within wind resource areas selected for development.
- Pre- and post-construction research and monitoring to identify and/or assess impacts to wildlife.

These guidelines are based on current science and will be updated as new information becomes available; they are intended to assist wind power development and minimize impacts on wildlife. Specific measures directly identified in the USFWS guidelines and/or in other sources include:

- Avoid siting wind projects in areas that are heavily used by migrating birds and/or bats, and/or that have frequent fog and mist.
- Avoid siting wind projects in areas that support unique or sensitive plants or wildlife habitat.
- Use facility designs such as modern, slow-moving wind turbines on tall monopole structures, freestanding permanent meteorological towers, and underground electrical lines that discourage birds from perching or nesting to minimize the risk of collision or electrocution.
- Employ standard aviation protection measures when aboveground power lines are used.
- Configure turbines to avoid landscape features known to attract raptors.

- Landscape site buffer areas with native plant species, but ensure that areas around project structures do not have vegetation that would support wildlife use.

Please see Section 5.2.4 for other possible mitigation measures.

5.9 Solar Energy

5.9.1 Construction Impacts

Construction of a utility-scale solar facility could adversely affect plants and animals. Solar energy fields require large tracts of land that remove a substantial amount of vegetation and wildlife habitat. Because solar developments occur in dry areas, the amount of dust that is generated can be substantial and can have high adverse impacts on wildlife, vegetation, and nearby habitat. These dry regions are often inhabited by many more species that are less mobile or are subterranean, which can result in high numbers of direct wildlife mortalities. Other potential direct and indirect construction impacts on plants and animals are described in section 5.2.1. Overall, the impact for utility-scale solar facilities could be moderate. Distributed solar facilities are expected to have low impact on plants and animals, since they are mounted on existing building structures.

5.9.2 Operation Impacts

Because harnessing utility-scale solar energy is a relatively new technology, little is known about the impacts of this technology on wildlife. What is known, though, is that solar farms require large tracts of land that permanently remove habitat, fragment remaining habitat, and could create barriers to gene flow between populations. Solar panel movement and noise from pumps and fans used in the cooling systems could disturb and displace wildlife. Roads necessary to maintain the facilities can also lead to habitat fragmentation, cause vehicular disturbance, and generate dust.

A variety of chemicals is used for the cooling systems, which presents the possibility of spills (Lovich and Ennen, 2011). Dry-cooling solar systems that are gaining popularity require less water, but consume much more habitat because they require a larger footprint.

Light pollution can be produced at solar farms in the form of polarized and reflected light. Reflected light can adversely affect the physiology, behavior, and population ecology of wildlife, which could include the alteration of predation, competition, and reproduction. Polarized light could affect the orientation and navigation of some wildlife species. Studies also suggest that the heat produced by central-tower solar facilities can burn or incinerate birds and flying insects flying through concentrated beams of reflected light.

Because of the dry nature of these regions, relatively large amounts of dust suppressants are used because dust can affect the photovoltaic properties of the solar panels. Dust suppressants may contain salts and brines, organic non-petroleum products, synthetic polymers, organic petroleum, electrochemical substances, clay additives, and mulch and fiber mixtures. These constituents can affect runoff and change soil properties that can further affect habitat (Lovich and Ennen, 2011).

Operational impacts could be low to moderate depending on the species and habitat in a project area, as well as the location and size of the project. Solar projects should be reevaluated often as more studies are conducted regarding the effects on plants and wildlife.

5.9.3 Mitigation

- Avoid siting solar projects in areas that are heavily used by wildlife or that support unique or sensitive plants or wildlife habitat.
- Minimize lighting and avoid steadily burning lights.

5.10 Natural Gas Combined-Cycle Combustion Turbines

5.10.1 Construction Impacts

If present, vegetation and wildlife habitat would be removed or disturbed at the plant site and along the path of the gas pipelines during construction. The magnitude, extent, and likelihood of impacts depend on the location and length of the pipeline routes and location of the plant site. Overall, impacts may be moderate. Other potential impacts on plants and animals are outlined in Section 5.2.1.

5.10.2 Operation Impacts

If present, vegetation and wildlife habitat could be removed or disturbed at the drilling site. Extraction typically occurs in non-urban areas, suggesting that impacts upon plants and animals would be relatively higher when compared to a plant in a suburban or urban area. Impacts to plants and animals due to plant operation would be moderate.

5.10.3 Mitigation

- Avoid siting natural gas projects in areas that support unique or sensitive plants or wildlife habitat.
- Require multiple wells on single pads whenever possible.
- Design well pads to fit available landscape and minimize tree removal.
- Limit mowing to one cutting per year and do not allow mowing during nesting season for grassland birds.
- Limit or minimize activities during active nesting seasons for birds.
- Limit the total area of disturbed ground, well pads, and roads where practicable.
- Restrict lighting during bird migration periods.
- Revegetate areas whenever possible.
- Conduct pre- and post-construction monitoring of wildlife species and vegetation to evaluate impacts over time. Apply appropriate mitigation measures or adapative management approaches, as necessary, for plants and animals.
- Wash all equipment and machinery used in the construction process to reduce and eliminate the spread of invasive and noxious weed and plant species.
- All fill and/or construction material including straw bales should be obtained from a certified weed free source.
- Implement water conservation programs and identify conservation measures and water use alternatives.
- Require and apply aquifer-testing protocols.
- Apply drought management practices including water restrictions on use and prioritizing water use.
- Require and adhere to surface water flow release targets for reservoirs, surface water bodies, and other important waterways, and require pass-by flows to protect aquatic resources, competing users, in-stream flow uses, and limit adverse lowering of stream flow levels downstream of the point of withdrawal.
- Use diversion dikes, berms, curbing, grading and other measures to minimize or eliminate run-on into tank filling areas.

- Implement spill response and prevention measures.
- Complete inspections and preventative maintenance for tanks, pumps, piles, and fueling areas.
- Locate additive containers and transport, mixing and pumping equipment as far away from surface waters as possible.
- Use drip pads or pans where additives and fracturing fluid are transferred.

Please see Section 5.2.4 for other possible mitigation measures.

5.11 Renewable Energy Credits

5.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

5.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

5.11.3 Mitigation

See Section 5.2.4.

5.12 Market Transactions

5.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Overall, construction impacts would be low.

5.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be moderate.

5.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the power plants have already been built. It is unlikely that these plants would install additional mitigation measures in order to meet the incremental demand. See Section 5.2.4 for more information on possible mitigation measures.

5.13 Transmission

5.13.1 Construction Impacts

Construction of transmission facilities would likely result in clearing and crushing of vegetation and damage to plant roots from soil compaction within the transmission line right-of-way, access roads, and at structure and substation sites. The level of impact would depend on the quality of vegetation and soil, site topography, and

the type of stream crossing used (bridges or culverts). Overall, impacts on vegetation would be low to moderate.

Depending upon the type of vegetation that is cleared and the species using the area, wildlife could experience low to moderate impacts because of losses in habitat; such losses are likely to be small compared to habitat in surrounding areas. Increased noise during the breeding season could result in moderate impacts on wildlife if the noise reduces the foraging effectiveness of adults or causes adults to abandon nest sites. Overall impacts on wildlife are expected to be moderate.

Other potential direct and indirect construction impacts are described in Section 5.2.1.

5.13.2 Operation Impacts

Maintenance of transmission line corridors requires vegetation management including periodic trimming, cutting, or clearing of trees and shrubs to allow access to transmission facilities, and removal of dangerous trees. Impacts on vegetation are expected to be low, while impacts on fish may be low to moderate depending on the type of activity and proximity to streams.

Animals, particularly birds, can interact with transmission lines. Many bird species use transmission lines as perches, and some bird species, including large birds of prey, use transmission towers as nesting sites. Some level of bird mortality would be expected because of collisions with conductors and structures. Migratory waterfowl have the highest incidence of mortality from collisions with transmission lines, particularly near wetlands, feeding areas, or open water. Perching on the lines presents little risk of electrocution for small birds. However, for larger birds whose wings and nests can span the transmission lines, there is the potential for electrocution. Small climbing mammals can contact electrical lines and be electrocuted.

Developing transmission line routes increases human access to areas that are currently difficult to reach. This easier access can increase human intrusion (e.g., hunting, poaching and fishing) and adversely affect fish and wildlife. Impacts on birds and other wildlife are expected to be low to moderate.

5.13.3 Mitigation

- Limit vegetation clearing to only what is necessary to prevent interference with transmission lines or to create access roads.
- Develop an ecologically based vegetation management plan and revegetate disturbed areas with native seed.
- Minimize the use of herbicides and use those that have the least impact to the surrounding environment.
- Ensure that there is adequate separation between conductors and places that birds would perch in order to avoid electrocution.
- Install bird flight diverters on lines

Table 5-2. Summary of plant and animal impacts[18]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		No impacts anticipated.
		L	No impacts anticipated.
Landfill Gas	L		Little habitat disturbance due to use of existing site.
		L	Noise from operations could disturb nearby wildlife.
Gorge Second Tunnel	L		Typical construction noise and vehicle traffic. Assume mitigation measures protect water quality and do not affect aquatic species.
		L	No impacts are anticipated.
Geothermal	H		Removal of habitat and vegetation could impacts species in sensitive and protected areas.
		L	Assume aquatic species are not adversely affected.
Biomass	L		Assume biomass plant is built in an existing industrial facility.
		L	Incremental increase in clearing of vegetation may represent permanent loss of habitat. Operation noise could affect sensitive species.
Wind	M		Clearing of vegetation may represent permanent loss of habitat.
		M	Impacts could include hazards for birds and bats and interference with migratory behavior.
Solar Energy	M		Requires large tracts of land that remove vegetation and wildlife habitat.
		M	Little known about the potential impacts but it could fragment remaining habitat.
Natural Gas/CCCT	M		Could require clearing of vegetation.
		M	Air emissions could contribute to degraded water quality. Ongoing fuel extraction would also cause clearing of vegetation.
Renewable Energy Credits	L-H		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-M	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Assumes energy will be supplied by existing resources; no new plants will be constructed to meet the demand.
		M	Assumes use of a fossil fuel to generate market transaction energy.
Transmission	M		Clearing of vegetation may represent permanent loss of habitat.
		M	Many bird species use transmission lines as perches. Vegetation management removes habitat permanently.

[18] Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

6 ENERGY AND NATURAL RESOURCES

6.1 Affected Environment

Generating electricity often involves the consumption of energy and natural resources. This is the case in electricity sources that combust fossil fuels, such as natural gas, but is also the case in some renewable electricity technologies, such as those that combust or gasify solid biomass for fuel. In this analysis, Energy and Natural Resources are considered to be fuel or other natural elements (water, minerals, etc.) that are consumed in the production of electricity. While there is a relationship between the impacts from consumption of certain Natural Resources and the impacts on other Elements of the Environment that are evaluated in this EIS (for example the consumption of water does impact surface and groundwater), the discussion in this section is focused on the magnitude of the natural resource consumed and whether that consumption has an impact on the sustainability of the resource itself.

According to the Northwest Power and Conservation Council data[19], in year 2010, 24,612 average megawatts (aMW) were generated in the northwest. Of that total, the majority (54 percent) was hydropower. The remaining generation was coal (22 percent), natural gas (13 percent), wind (5 percent), nuclear (4 percent), and biomass (2 percent). The use of non-renewable fuel resources to produce electricity contributes to depletion of known fuel reserves. In contrast, conservation measures and increased use of renewable resources such as hydropower, wind power, and geothermal energy would have less potential adverse impacts to fossil fuel resources. In the case of biomass, while wood can be regrown, the timing of the regrowth of trees as well as the potential loss of nutrients from removing harvest residue could be considered to have an affect.

6.1.1 Natural Gas

6.1.1.1 FUEL BACKGROUND

Natural gas is located in underground geological formations across North America. It is extracted through wells and transported to generation facilities through pipelines that are hundreds or thousands of miles long. While the Northwest does not have significant natural gas supplies, the region has good pipeline access to important western North American natural gas-producing areas. Natural gas prices are subject to significant volatility, ranging from very low prices such as was seen in the early 1990s, to very high prices during the energy crisis of 2000 and 2001. Absent changes in the structure of natural gas marketing, this pattern of volatility is likely to continue.

Recently, natural gas prices have generally been decreasing because the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that was previously uneconomical to produce. Hydraulic fracturing is a technique in which water, chemicals, and sand are pumped into a well to unlock the hydrocarbons trapped in shale formations by opening cracks or fractures in the rock and allowing natural gas to flow from the shale into the well (EIA, 2012a). Liquefied natural gas imports may also play an important role in determining marginal gas prices. Additional new supplies may come from the Alaskan North Slope and the McKenzie Delta, coal bed methane and tar sands, and American and Canadian offshore fields.

The primary fuel used for combustion turbine generation is natural gas. Distillate fuel oil is typically used as a backup fuel if natural gas supplies are disrupted. Gasified fuels such as syngas derived from coal may also be used in integrated gasification combined cycle plants.

---

[19] Northwest Power and Conservation Council Energy Generating Files (Existing and new/proposed power plants, "Historical Energy Production in the Northwest" graph, February 2012), http://www.nwcouncil.org/energy/powersupply/Default.asp

Natural gas-fired combined-cycle plants have been the bulk power generation resource of choice since the early 1990s due to long periods of low natural gas prices, reliable and efficient equipment, low capital costs, short lead-time, operating flexibility, and relatively low air emissions compared to coal. Natural gas power plants represent about 16 percent (9,100 MW) of Northwest generating capacity. Of this, 6,960 MW are combined-cycle units, 1,830 MW are peaking units, and 350 MW are industrial cogeneration units (NWPCC, 2010). Natural gas will likely be a competitive long-term resource that helps set marginal market energy prices because of the low natural gas price, the development of shale gas resources, the low cost of combined-cycle power plants, and the ability to site plants near the load and have access to both the natural gas pipeline and transmission at locations where water is available.

The best locations for natural gas CCCTs provide access to natural gas pipelines and are at lower elevations, where combustion turbines produce more usable power. One of the Northwest's three interstate gas pipelines that transport natural gas from British Columbia (Northwest Pipeline) intersects City Light's Skagit generation project transmission line (Figure 1). Numerous turbines are located along this pipeline. The other two interstate gas pipelines transport gas from Alberta, Canada, from the Rocky Mountains, converge in northeastern Oregon, and then proceed through Portland and south into California.

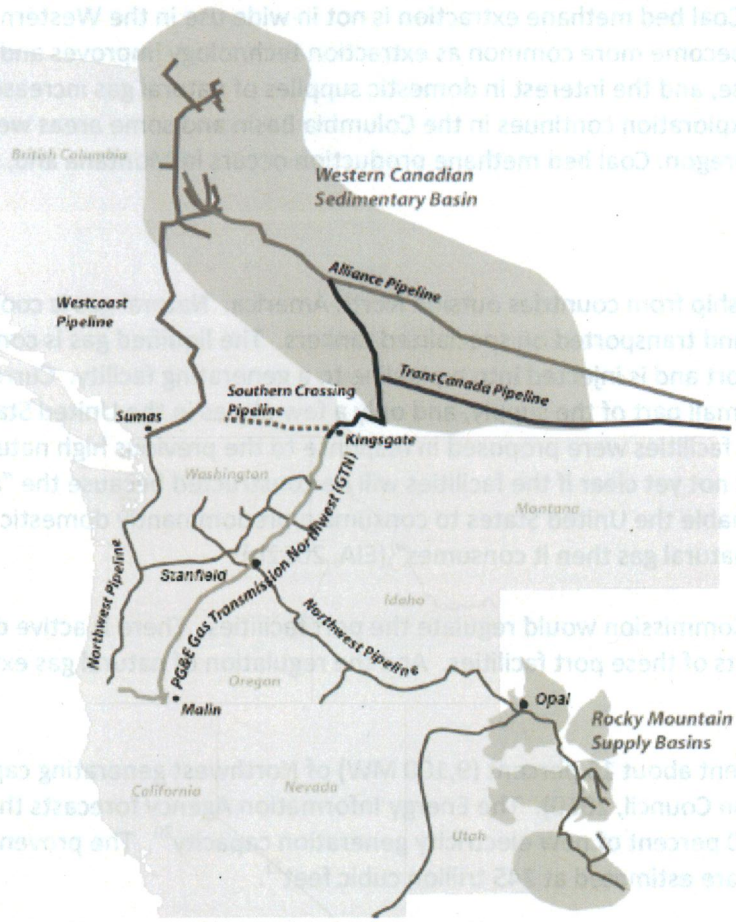

Figure 2. Sources of Northwest natural gas supplies

Source: Natural Gas Study by the Washington State Department of Community, Trade, and Economic Development 2004

6.1.1.2 FUEL SUPPLY

Conventional Drilling

Conventional drilling, construction, and maintenance of pipelines result in disruption to soil and geology. Also, conventional gas requires processing before use, and by-products such as sulfur, ethane, natural gas liquids, propane, butanes, natural gasoline, and wastewater are generated. These by-products can affect air quality and, depending upon wastewater treatment and disposal methods, can affect surface and groundwater. Natural gas from conventional drilling is supplied by sources in the United States and by pipeline from Canada and Mexico.

Shale Gas

Shale gas refers to natural gas that is trapped within fine-grained sedimentary rocks that can be a source of petroleum and natural gas. Technological advances from the combination of horizontal drilling and hydraulic fracturing or "fracking" have allowed access to large volumes of gas that was previously uneconomical to produce. Recently, concerns have been raised about the process of hydraulic fracturing and the potential to pollute deep aquifers as well as potential impacts to public health.

Coal Bed Methane

Natural gas can be released from coal seams and then remain trapped near the seam by a layer of water. This configuration is called coal bed methane (also referred to as coal bed natural gas or coal seam methane). Coal bed methane only occurs in areas where geological processes contribute to its development, and extraction technology is currently limited. Coal bed methane extraction is not in wide use in the Western United States (EIA, 2006). This resource may become more common as extraction technology improves and as natural gas supplies decrease, prices increase, and the interest in domestic supplies of natural gas increases. In the Northwest, coal bed methane exploration continues in the Columbia Basin and some areas west of the Cascade Mountains in Washington and Oregon. Coal bed methane production occurs in Montana and, predominantly, in Wyoming.

Liquified Natural Gas

Natural gas can be imported by ship from countries outside North America. Natural gas is cooled and pressurized into its liquid state and transported on specialized tankers. The liquified gas is converted back into gaseous form when it reaches port and is injected into a pipeline to a generating facility. Currently, this source of natural gas makes up only a small part of the supply, and only a few places in the United States receive liquified natural gas. Many new facilities were proposed in response to the previous high natural gas price and supply shortages. However, it is not yet clear if the facilities will be constructed because the "availability of large quantities of shale gas should enable the United States to consume a predominantly domestic supply of gas for many years and produce more natural gas then it consumes" (EIA, 2012b).

The Federal Energy Regulatory Commission would regulate the port facilities. There is active debate about the safety and environmental impacts of these port facilities. And the regulation of natural gas extraction in the source countries is unknown.

Natural gas power plants represent about 16 percent (9,100 MW) of Northwest generating capacity (Northwest Power Planning and Conservation Council, 2010). The Energy Information Agency forecasts that between 2009 and 2035, natural gas will fuel 60 percent of new electricity generation capacity[20]. The proven reserves of natural gas in the United States are estimated at 245 trillion cubic feet[21].

---

[20] Energy Information Agency (United States Department of Energy) presentation, page 21, http://www.eia.gov/pressroom/presentations/newell_06212011.pdf

[21] Energy Information Agency (United States Department of Energy) presentation, page 13, http://www.eia.gov/pressroom/presentations/newell_06212011.pdf

Currently, shale gas makes up 25 percent of the US natural gas production[22]. Over the planning period from 2012 through 2031, natural gas consumption in the United States is forecast to vary between 24 and 27 trillion cubic feet per year[23]. In addition, Canada has vast reserves of natural gas. Liquified natural gas (LNG) imports are predicted to decrease over the planning period[24].

Generally, gas-fired power plants are sited close to natural gas pipelines. However, electric transmission lines may need to be constructed to connect the power plant and the existing electric transmission grid. If new LNG terminals are built along the Pacific coast, new gas pipelines would be built to transport the fuel, creating new potential locations for gas-fired power plants.

6.1.2 Fuel Oil

Fuel oil in the Northwest region is primarily used as backup fuel for natural gas-fired generating plants. In 2010, only just over 45 aMW were produced in the northwest using fuel oil or petroleum coke. In case of natural gas curtailment, a sufficient supply of oil is normally stored in tanks at the plant site, refilled as necessary by tank trucks. Crude oil pipelines run alongside major highways in the region. Northwest supplies are delivered via the Trans-Mountain Pipeline from Canadian oil fields and the Olympic Pipeline Company transmission system, which transports oil to the region from Montana, Wyoming, and Utah. These resources are anticipated to be sufficient to supply fuel oil to existing and planned generation facilities in the Northwest region during the planning period.

6.1.1 Biomass

Wood fuel sources under consideration by SCL include logging residue, mill residue, agricultural waste products such as orchard cuttings, and clean woody municipal solid waste (urban wood waste and construction debris). SCL is committed to using only waste wood. This analysis assumes that dedicated wood crops would not be used as the fuel source.

In 2010, nearly 4.4 million tons of wood biomass was produced as a by-product of Washington State forest operations. About 0.6 million tons was sold for either electricity production or other purposes such as compost (DNR, 2012). The remaining wood biomass by-product was left either scattered in the woods or in piles at landings or burned. Though timber production and logging and mill residue has declined in the Northwest over the past two decades, stabilization and possible expansion of the timber supply and logging and mill residues can be expected as forest recovery occurs. In addition, the supply of forest thinnings could increase from more intensive commercial forest management, forest health restoration efforts, and wildfire control. Clean woody municipal solid waste is expected to increase with economic and population growth.

To summarize, natural gas is estimated to be available to the Northwest region, and the existing reserves in the western United States and Canada would be sufficient to meet the forecast demand in the region for the next 20 years. Fuel oil, for backup generation, is widely available and is easily transported by trucks to power generating facilities in the northwest region. However, supply of these fuels, and their costs, have been volatile in the past, and it is difficult to forecast precisely what their availability will be in the future.

---

[22] Energy Information Agency (United States Department of Energy) presentation, page 11, http://www.eia.gov/pressroom/presentations/newell_06212011.pdf

[23] Energy Information Agency (United States Department of Energy) presentation, page 14, http://www.eia.gov/pressroom/presentations/newell_06212011.pdf

[24] Energy Information Agency (United States Department of Energy) presentation, page 14, http://www.eia.gov/pressroom/presentations/newell_06212011.pdf

6.2 General

6.2.1 Construction Impacts

The construction, manufacturing, and installation of a power plant and its related infrastructure would require a range of energy and natural resources including fossil fuels, electricity, water, and mineral resources.

Fossil fuels would be used for on-site construction equipment such as cranes, trucks, or drilling equipment. The types of fuel consumed during construction activities include diesel, gasoline, and electricity. Fossil fuels would also be used to transport workforce and material (e.g., facility components, sand and gravel, steel parts) to the project site, which could be extensive depending on a given site's location in relation to the required construction components. In addition, geologic materials such as sand and gravel would be used in road construction, as fill materials and for making concrete. Water may also be required for concrete and for dust suppression. Generally, the construction impacts on energy and natural resources would be temporary and would represent a low impact on total energy resources.

Note that some aspects of the construction impacts associated with fuels such as natural gas and wood biomass are also discussed in sections on other Elements of the Environment, such as Soils and Geology and Surface and Groundwater.

6.2.2 Operation Impacts

Operation and maintenance of facilities requires small supplies of fuel, water for domestic use, and electricity for support facility operation. Fuel is used for operating vehicles, transporting workers to the site and, with some resources, transporting fuel to the power plant. Minor quantities of gravel and other materials may also be needed for periodic road maintenance or similar activities. The largest potential impact would be from extraction, processing, delivery, and burning of fuel to a power plant. Generating electricity from renewable energy sources such as wind and solar reduces the use of other forms of energy such as fossil fuel, and may reduce impacts on energy and natural resources. As a result, there may be a beneficial operational impact from some energy resources.

Note that some aspects of the operational impacts associated with fuels such as natural gas and wood biomass are also discussed in sections on other Elements of the Environment, such as Soils and Geology and Surface and Groundwater.

6.2.3 Regulations

- Limited regulation; some states have Renewable Portfolio Standards, which require electric utilities to supply a percentage of energy from renewable sources. For example, voters in Washington State approved I-937, also known as the Energy Independence Act, which mandates certain utilities in Washington State, including City Light, to acquire renewable resources to meet demand for electricity. The renewable resource portfolio requirements in the initiative will increase over time: at least three percent of a utility's load by January 1, 2012; 9 percent by 2016; and 15 percent by 2020. This requirement could also be met by using renewable energy credits.
- Certain regulations that limit greenhouse gas emissions from power plants, such as those in the states of Oregon and Washington, and the federal New Source Performance Standard for Greenhouse Gas (see Air Quality section of this Appendix for more information), would indirectly require that new power plants achieve a minimum efficiency in order to comply with the limits.

6.2.4 Mitigation

- Use conservation to reduce the need for new resources.
- Use renewable generating resources.
- Increase the overall efficiency of power plants that use fossil fuel in order to use less of the resource.
- For facilities that require transmission improvements, design new lines for higher voltages to reduce energy loss.

6.3 Conservation

6.3.1 Construction Impacts

Conservation equipment and measures indirectly require some expenditure of energy resources in manufacturing. Otherwise, no direct adverse impacts to energy resources would result from the installation of energy efficiency measures.

6.3.2 Operation Impacts

As conservation measures are designed to reduce energy use, the use of conservation measures reduces l impacts to energy and natural resources. Ongoing conservation measures would have a low beneficial impact.

6.3.3 Mitigation

No mitigation would be needed.

6.4 Landfill Gas

6.4.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.4.2 Operation Impacts

Using methane from landfills to produce electricity avoids the use of other forms of energy such as fossil fuel. While there is debate as to whether landfill gas is renewable because it is based on waste material from consumed products, it is a resource that is expected to be available well into the foreseeable future. Many states including Washington that have a Renewable Portfolio Standard requiring utilities to provide a certain percentage of electricity from renewable sources do consider landfill gas to be a renewable fuel. The amount of electricity generated per unit of landfill gas will vary by generator technology. The technology assumed in this analysis is roughly 25 to 30 percent efficient at converting landfill gas energy into electricity, and does not include heat recovery. Heat recovery is used in some landfill gas-to-energy applications, which does increase the overall efficiency of fuel use resulting in less use of other generating fuels. Overall landfill gas power plants would have low beneficial impact.

6.4.3 Mitigation

No mitigation would be needed.

6.5 Gorge Second Tunnel (Hydro Efficiency)

6.5.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.5.2 Operation Impacts

Project operation would not use fossil fuel and would not increase the amount of water consumed to produce electricity. The increased output of electricity would reduce the need for other electricity sources to meet City Light's load growth, thus having a low beneficial impact.

6.5.3 Mitigation

No mitigation would be needed.

6.6 Geothermal

6.6.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.6.2 Operation Impacts

Transportation of a fuel resource is not necessary to operate a geothermal plant, as the resource is acquired directly at the project site. Furthermore, geothermal energy is typically considered a renewable resource and does not consume significant amounts of fossil fuel. Some water may be consumed depending on the technology that is used to cool the heat transfer fluid. Overall, it would result in a low beneficial impact.

6.6.3 Mitigation

Based on the anticipated level of impacts to energy and natural resources, no mitigating measures are necessary or proposed.

6.7 Biomass

6.7.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.7.2 Operation Impacts

Whether from mill or logging residue, waste wood is generally considered a renewable energy resource, if the ultimate source of the wood fuel is properly replanted, maintained, and harvested. Proper management will be needed to ensure that wood waste can be sustained as a source of fuel, and that the source does not involve old-growth forests, wetlands, wilderness areas, or other scarce natural resource areas.

Energy and natural resources would be consumed in transporting and processing wood fuels and in other aspects of the operation; impacts would be low. Overall, operation would have a low beneficial impact.

6.7.3 Mitigation

No mitigation would be required as long as a wood waste product is being used as the source of fuel. City Light would use waste wood and residue. Locating the power plant close to the source of fuel would minimize transportation distance and use of fossil fuels.

6.8 Wind

6.8.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.8.2 Operation Impacts

See Section 6.2.2. Operation would have a low beneficial impact.

6.8.3 Mitigation

No mitigation would be needed.

6.9 Solar Energy

6.9.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.9.2 Operation Impacts

See Section 6.2.2. Operation would have a low beneficial impact.

6.9.3 Mitigation

No mitigation would be needed.

6.10 Natural Gas Combined-Cycle Combustion Turbines

6.10.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.10.2 Operation Impacts

As described in Section 6.2.2, fossil fuels are used by construction and operation equipment to transport equipment to the site, extract natural gas (diesel or natural gas powered equipment such as compressors, drill rigs, and pumps), dispose of wastewater and waste materials, and transport extracted natural gas to plants for processing and consumption. Large volumes of water are also necessary to support fracking operations. The amount of water generally needed to drill and fracture a gas well generally ranges from approximately 2 to 4 million gallons depending on the basin and geologic characteristics. Water use can affect surface water and groundwater availability and increase competition among users. Natural gas extraction sites are typically located on large tracts of land, which have the potential to eliminate habitat or fragment habitat used by wildlife. Additionally, pipelines extend long distances to transport gas over land. However, with the exception of energy used for pipeline maintenance, no energy would be consumed transporting the natural gas in the pipeline to the plant.

Natural gas is the primary fuel used for combustion turbine plants, and is a non-renewable fuel. Natural gas power plants represent about 16 percent of the Northwest generating capacity (NWPCC, 2010). The use of these non-renewable fuel resources to produce electricity contributes to depletion of known fuel reserves. In contrast, conservation measures and increased use of renewable resources such as hydropower, wind power, and geothermal energy would result in less depletion of fossil fuel resources.

The existing reserves of natural gas in the western United States and Canada would likely be sufficient to meet the forecast demand in the region for the next 20 years. However, supply and costs of these fuels have been volatile in the past, and it is difficult to forecast precisely what the supply situation will be in the future.

The amount of natural gas used to produce a unit of electricity depends on the efficiency of the combustion turbine. This analysis assumes the heat rate for a gas CCCT ranges from 6,790 million Btu per megawatt hour (mmBtu/MWh) to 7,050 mmBtu/MWh. Differences in efficiency and fuel use are based on how much heat in the natural gas stream is captured for producing more electricity or other useful energy, such as steam or space and water heating. Increase in demand for natural gas over the next 20 years will increase pressure to produce natural gas from domestic sources and to increase imports. Overall, impact would be high.

6.10.3 Mitigation

- Use highest efficiency plant available
- Minimize fugitive emissions from extraction and transport from natural gas wells.

6.11 Renewable Energy Credits

6.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

6.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

6.11.3 Mitigation

No mitigation would be needed.

6.12 Market Transactions

6.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Impacts would be low

6.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion turbines described in this Appendix because the existing power plants used to supply electricity for market transactions are less efficient and they require more fuel to produce an equivalent amount of electricity. Overall, these impacts could be high.

6.12.3 Mitigation

Mitigation options are limited, since the plants are already built. It is possible that these existing plants could be made more efficient, thus reducing fuel use slightly, but it is unlikely that efficiency projects would be undertaken to meet demand for incremental energy.

6.13 Transmission

6.13.1 Construction Impacts

See Section 6.2.1. Impacts would be low.

6.13.2 Operation Impacts

Transmission systems do, in a sense, consume energy. Some of the electricity that is transported over the lines is lost to resistive heating of the conducting materials and in the transformers. These losses vary with the voltage of the transmission system, whether the system is operated with direct or alternating current, the amount of electricity transmitted over the lines at any given time, and the ambient temperature. Generally, it is assumed that 4 to 8 percent of the electricity originally put into the transmission system at a generation site is lost by the time the electricity is received at the location of end use. Impacts would be low to moderate.

6.13.3 Mitigation

Design new lines for higher voltages to reduce energy loss.

Table 6-1. Summary of energy and natural resource impacts[25]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		Minimal energy expenditure in the installation and manufacturing of energy conservation equipment.
		+L	Reduced energy use in comparison to original conditions.
Landfill Gas	L		Typical quantities of resources used in the construction process.
		+L	Considered a renewable source of fuel, which avoids the need to generate electricity from fossil fuels.
Gorge Second Tunnel	L		Typical quantities of resources used in the construction process.
		+L	Operation does not use fossil fuel and would not increase the amount of water consumed to produce electricity.
Geothermal	L		Typical quantities of resources used in the construction process.
		+L	Does not require transportation of a fuel resource to operate. May also avoid the need to generate electricity from fossil fuels.
Biomass	L		Typical quantities of resources used in the construction process.
		+L	Assumes City Light uses wood waste as the fuel source and reasonable transportation distances between the forest and plant.
Wind	L		Typical quantities of resources used in the construction process.
		+L	Does not require transportation of a fuel resource to operate. May also avoid the need to generate electricity from fossil fuels.
Solar Energy	L		Typical quantities of resources used in the construction process.
		+L	Does not require transportation of a fuel resource to operate. May also avoid the need to generate electricity from fossil fuels.
Natural Gas/CCCT	L		Typical quantities of resources used in the construction process.
		H	Requires the consumption of a fossil fuel to generate electricity.
Renewable Energy Credits	L		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		+L	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		It is unlikely that new plants would be constructed to meet the demand for market energy transactions.
		H	Assumes use of a fossil fuel to generate market transaction energy.
Transmission	L		Typical quantities of resources used in the construction process.
		M	Transmission losses consume between 4% and 8% of the electricity originally put into the transmission system at a generation site.

[25] Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

7 ENVIRONMENTAL HEALTH

7.1 Affected Environment

In addition to possible air quality health impacts covered in Section 2 of this Appendix, other health issues associated with energy facilities are noise and electric and magnetic fields.

Audible noise occurs during the construction and operation of energy facilities, and may be present near electricity generating plants and high-voltage transmission lines. Noise impacts are evaluated with respect to adjacent and surrounding land uses, especially sensitive noise receptors like schools. Many governmental jurisdictions have regulations governing permissible noise levels at adjacent properties that vary with the type of land use that would apply to the operation of energy facilities. Construction activities are generally exempt from noise regulations except for provisions regarding permissible hours of construction activity.

Electric and magnetic fields: Power lines, appliances, and wiring—and anything else that generates, transmits, or uses electricity—all produce electric and magnetic fields (EMFs). Electric fields are the result of voltages applied to electrical conductors and equipment, and magnetic fields are produced by the flow of electric currents. The strength of both electric and magnetic fields decreases as you get farther away from the source of the field.

Since electricity is used ubiquitously, EMFs are found in nearly all locations people spend time—homes, workplaces, cars, the supermarket, etc. A person's average exposure depends upon the sources they encounter, how close they are to them, and the amount of time they spend there. In most homes, background magnetic field levels average about 1 milligauss (mG), resulting from wiring within the home, electrical appliances, and power lines outside the home (Zaffanella, 1993). The intensity of magnetic fields diminishes quickly with distance from the source.

Questions have been raised as to whether exposure to electric or magnetic fields causes adverse health effects. This concern is evaluated in the Transmission Section 7.13.

7.2 General

7.2.1 Construction Impacts

Construction of energy facilities would affect environmental health concerns regarding the occupational safety for workers. Additional concerns would include general safety issues regarding the use of heavy construction and the electric power industry. Adherence to occupational health and safety regulations, in addition to health and safety plans used by contractors, would reduce the level of such impacts.

Most construction activities, including construction of energy facilities would produce audible noise. Noise sources may include heavy equipment operation, construction of the structures and ancillary facilities, blasting and truck traffic. Because of their short-term duration, construction activities are generally exempt from noise regulations established in state and local regulatory standards, though they are usually confined to normal daytime hours.

Workers' health could also be impacted by handling materials that require solid or hazardous waste disposal, such as diesel fuel, gasoline, lubricants, cleaning solvents, paint, used oil, spent antifreeze, unused adhesives, chemicals, batteries, empty containers, scrap wood, metal and trash. Assuming mitigation measures are in place for waste handling the impacts would be low.

7.2.2 Operation Impacts

In addition to possible air quality health impacts, other environmental health issues associated with energy facilities are operating noise, exposure to EMFs and occupational safety hazards that workers are exposed to by routine maintenance of turbines, generators, electric systems, and other energy resource infrastructure. The source of noise is discussed in the relevant resource section and the risks associated with exposure to EMFs are detailed in the transmission section.

7.2.3 Regulations

- Noise regulations are set by State and Local jurisdictions
- Federal Mine Safety and Health Administration
- OSHA and state regulations

7.2.4 Mitigation

- Restrict construction activities to daylight hours if there are potential receptors nearby.
- Lay out plant facilities so that noise standards are not exceeded at the site boundary. If necessary, construct noise barriers, insulate buildings that house turbines and generators, install and use noise control devices in the stacks, or implement other mitigation measures to comply with state and local noise regulations.
- Ensure adherence to all applicable occupational safety regulations and standards and develop and implement health and safety plans for construction and operation.
- Establish safety zones and setbacks to prevent public exposure to potential safety hazards during both construction and operation.
- Secure construction sites at night.
- Analyze and evaluate operating noise conditions during project planning and design to ensure compliance with applicable community noise standards.
- Consider implementing a noise complaint and investigation program for the project duration period.
- Use up-to-date low field designs to minimize EMFs and induced currents.
- Transfer construction and operation wastes to appropriate facilities for recycling, treatment, processing, or disposal.
- Restrict nighttime operation of the power plant if sensitive land uses are nearby.

7.3 Conservation

7.3.1 Construction Impacts

Installation of energy efficient equipment may expose workers to potentially hazardous environments. For instance, installing lighting products may expose workers to ladders, which if used improperly, may be dangerous. However, impacts would be low if mitigation measures are followed and occupational health and safety regulations are followed.

7.3.2 Operation Impacts

As summarized in the Air Quality Operation Impact Section 3.3.2, some energy conservation measures may pose health risks if they decrease indoor/outdoor air exchange rates leading to excessive concentrations of indoor air pollutants. PCBs found in old fluorescent light ballasts are suspected carcinogens and federally regulated toxic substances.

Impacts would be low assuming appropriate disposal of waste products and no degradation of indoor air quality.

7.3.3 Mitigation

- Transfer construction and operation wastes to appropriate facilities for recycling, treatment, processing, or disposal.
- Use products that will not contribute to indoor air quality problems and/or provide adequate ventilation or filter indoor air to avoid an accumulation of pollutants that negatively affects indoor air quality.
- Follow proper installation and maintenance procedures.

7.4 Landfill Gas

7.4.1 Construction Impacts

See Section 7.2.1. Construction impacts are not anticipated or would be low.

7.4.2 Operation Impacts

See Section 7.2.2 and the Landfill Gas Air Quality Section 4.3. Overall, operation impacts would be low.

7.4.3 Mitigation

See Section 7.2.4.

7.5 Gorge Second Tunnel (Hydro Efficiency)

7.5.1 Construction Impacts

See Section 7.2.1. The hydro efficiency project includes the use of boring equipment and drill-and-blast procedures, which present unique occupational hazards not anticipated for the other energy resources. No additional corona or EMF effects are anticipated during construction. Construction impacts would be low.

7.5.2 Operation Impacts

See Section 7.2.2. During operation, no additional noise, or EMF impacts are anticipated. Overall, operation impacts would be low.

7.5.3 Mitigation

See Section 7.2.4.

7.6 Geothermal

7.6.1 Construction Impacts

See Section 7.2.1. Geothermal facility development includes several occupational hazards unique to construction of well drilling and geothermal support facilities, as well as hazards found in dealing with high-temperature water and steam. Impacts could be moderate.

7.6.2 Operation Impacts

Typical geothermal power plant operations produce little noise, as most of the operation is inside structures and is limited to production of steam and electricity. Noise levels of typical plants are commonly compared to "rustling leaves," according to common sound level standards (GEA, 2012). As the primary emission from geothermal plants is water vapor, no significant impacts on surrounding populations from emission pollution would occur. H_2S emissions could affect the health and comfort of workers if not properly handled through treatment processes (e.g., gas separation and reinjection). Overall, impacts to environmental health from

geothermal facilities are anticipated to be moderate; however, more detailed analysis would be needed once more information is known about a specific site and type of facility being proposed.

7.6.3 Mitigation

- See Section 7.2.4.
- Muffle steam wells, if necessary, to comply with state and local noise regulations.
- Implement treatment processes to handle H_2S gas.

7.7 Biomass

7.7.1 Construction Impacts

See Section 7.2.1. Impacts could be low to moderate.

7.7.2 Operation Impacts

Principal noise-producing sources would be operation of the boiler and generator, handling of wood fuels in the storage area, and fuel conveyance. Depending upon site location, noise could be incompatible with surrounding land uses. The facility can likely be planned and laid out so that noise levels at the site boundary do not exceed local noise codes. If dedicated crops or logging residue is used as fuel, there would be noise associated with harvesting, collecting/yarding, and hauling fuel. Such noise would likely be typical for the areas in which these activities would occur (e.g., noise from yarding of forest residue would be similar to noise associated with logging). Overall, noise impacts would be low to moderate.

7.7.3 Mitigation

See Section 7.2.4.

7.8 Wind

7.8.1 Construction Impacts

See Section 7.2.1. Noise sources would include heavy construction equipment and, potentially, blasting during the construction of wind projects. Impacts would be low to moderate.

7.8.2 Operation Impacts

Wind farm operation and maintenance workers are also exposed to occupational safety hazards associated with maintenance of tall, complex structures (wind turbines) and electrical systems. Occupational health and safety regulations and project health and safety plans apply to these hazards.

Risks associated with exposure to electrical and magnetic fields (EMF) and the occurrence of electromagnetic interference (EMI) are common concerns related to the generation and transmission of electricity. The electrical and magnetic fields associated with wind turbines and wind farm power collection systems, substations, and transmission lines are weaker than the fields associated with extra-high-voltage transmission lines where EMF and EMI have typically been raised as issues. In addition, access controls on wind farms generally prevent public exposure to any EMFs.

The history of wind farm siting and operation includes numerous cases of public concern over safety hazards unique to wind energy. These issues include the risks of several types of mechanical failure, such as wind turbine collapse, blade throw, and ice throw, and the risks of fire or explosion created by wind farm equipment. While the unique hazards associated with wind energy have received considerable media attention, the

documented incidents and problems have generally been sparse and related to old wind turbine technology. With current wind turbine technology and design, wind farm public access controls and adequate setback requirements are sufficient to address these types of safety risks (NWCC, 2002).

Wind turbines and meteorological towers create a nominal potential for aviation safety hazards because they are tall structures that conceivably could interfere with navigable airspace. Federal Aviation Administration (FAA) regulations require that the agency be notified of the proposed construction of any features that could be obstructions to aircraft, including any structures over 200 feet tall. The FAA evaluates air navigation hazards associated with such construction proposals. The FAA also administers regulations that require marking (paint and/or safety lighting) potential obstructions including wind farms. These regulatory provisions are considered sufficient to address the aviation safety hazards of wind farms.

Shadows created by wind turbines can be greatly elongated during times of the day and year when the sun is at a low angle. When such shadowing occurs with operating wind turbines, the result can be a strobe effect that is called shadow flicker. While shadow flicker is an intermittent occurrence of short duration, it can be annoying to people outdoors or in their homes. Shadow flicker would only occur within a certain distance of a wind turbine, and a setback distance of approximately 10 rotor diameters is likely to be sufficient to avoid shadow flicker.

Wind turbines are the primary source of noise from wind energy facilities. Wind farms are located in windy areas, and the background noise produced by the wind is often sufficient to mask the operating noise of wind turbines. Wind farms are also typically located in rural areas where ambient noise levels are low, however, and even a modest increase in noise levels can be a concern if residents are located near a wind farm. Modern wind turbines are relatively quiet under normal operating conditions and primarily produce broadband noise, which is considered less intrusive than impulsive, low frequency, or tonal noise (NWCC, 2002). Potential noise issues are typically addressed through detailed noise analysis and the application of setbacks in project siting and development.

The cumulative international and national experience with wind energy has produced ample documented evidence that the environmental health hazards (or nuisance hazards, such as shadow flicker) associated with wind farms can be reasonably managed through careful site selection, project design, and operation measures. Nevertheless, there has been sufficient public interest and concern in some siting cases to indicate that wind farm hazards can be perceived as a significant risk, and these risks can be important issues in the permitting of wind farms. Evaluation of the significance of these potential operation impacts would require a site-specific analysis of population and proximity factors for any individual wind farm proposal. Overall, it is expected that impacts would be low to moderate.

7.8.3 Mitigation

See Section 7.2.4, and:

- Locate project facilities to minimize exposure of receptors to shadow flicker and noise.
- Plan and design projects to comply with FAA requirements for notification and marking of tall structures to ensure aviation safety.

7.9 Solar Energy

7.9.1 Construction Impacts

See Section 7.2.1. Solar thermal facility development includes the hazards associated with heavy construction and the electric power industry. Impacts would be low with appropriate mitigation measures.

7.9.2 Operation Impacts

See Section 7.2.2. Solar thermal facilities involve hazardous associated with high temperature water and steam Impacts would be low with safe operational practices.

7.9.3 Mitigation

See Section 7.2.4.

7.10 Natural Gas Combined-Cycle Combustion Turbines

7.10.1 Construction Impacts

See Section 7.2.1. With mitigating measures in place, these impacts would likely be moderate.

7.10.2 Operation Impacts

Health impacts associated with air emissions are discussed in Section 2 of this Appendix. Noise generated during extraction could lead to adverse impacts on the health of the workers. Workers' health could also be impacted by handling materials that require solid or hazardous waste disposal. Other impacts to workers may include inhalation of proppants or other chemicals, exposure to methane releases and chemicals used in fracking operations, and potential for unintended explosions or blowbacks from fracking operations. With appropriate protective equipment and mitigating measures in place, these impacts would be low to moderate.

Combustion turbine plant operation can produce increased noise levels due to equipment and gas venting through the stacks. With mitigation, noise impacts would be low to moderate, depending in part on the proximity of sensitive noise receptors.

7.10.3 Mitigation

See Section 7.2.4, and:

- Manage and minimize solid and hazardous wastes produced during extraction and construction in accordance with applicable federal, state, and local laws and regulations.
- Leak detection and repair programs.
- Use of personal protective equipment (PPE).
- Air Quality Monitoring.
- Spill Response and Containment Plans.
- Separate enclosures for major noise sources such as turbines, pumps, and generators.

7.11 Renewable Energy Credits

7.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

7.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

7.11.3 Mitigation

See Section 7.2.4.

7.12 Market Transactions

7.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Construction impacts would be low.

7.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be moderate.

7.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the plants have already been built, and it is unlikely that these plants would install additional mitigation measures in order to meet the incremental demand. See Section 7.2.4 in this Appendix for details on mitigation options.

7.13 Transmission

7.13.1 Construction Impacts

Environmental health concerns during construction are principally related to occupation safety. Clearing rights-of-way, erecting structures, and stringing conductors all pose potential safety hazards. Helicopters are sometimes used to string conductors. There would also be a risk of fire. Occupational health and safety regulations apply to these hazards, as do health and safety plans used by contractors.

Overall, impacts from an environmental health perspective could be high.

7.13.2 Operation Impacts

Serious or even fatal electric shocks could occur if an individual contacts a conductor. However, the National Electric Safety Code specifies minimum allowable distances between conductors and the ground or other objects. Thus, the probability of electric shocks is low, and overall impacts would be moderate.

7.13.2.1 ELECTRIC AND MAGNETIC FIELDS - BACKGROUND

Power lines, appliances, and wiring – and anything else that generates, transmits or uses electricity – produce electric and magnetic fields (EMF). Electric and magnetic fields are properties of the space near their electrical source and describe the forces that would be experienced by an object that is capable of interacting with these fields. *Electric fields* are the result of voltages applied to electrical conductors and equipment, and *magnetic fields* are produced by the flow of electric currents. The strength of both electric and magnetic fields decreases as you get farther away from the source of the field.

Since electricity is being used nearly on a constant basis, EMF can be found in nearly all locations people spend time – homes, workplaces, cars, the supermarket, etc. A person's average exposure depends upon the sources they encounter, how close they are to them, and the amount of time they spend there. In most homes,

background magnetic field levels average slightly below 1 milligauss (mG), resulting from wiring within the home, electrical appliances, and power lines outside the home (Zaffanella, 1993). Since the intensity of magnetic fields diminishes markedly with distance from the source, distance from a power line reduces the effect on the magnetic field level within the home. In fact, the strongest sources of magnetic fields that are encountered indoors are electrical appliances.

Questions have been raised as to whether exposure to electric or magnetic fields causes adverse health effects. Hundreds of studies have been conducted over more than 30 years to address this question. In addition to laboratory experiments, observational studies conducted using the techniques of epidemiology[26] have looked for relationships between EMF exposures in homes and workplaces and cancer or other adverse health outcomes. Some of the epidemiology studies have reported associations[27] between EMF exposure and adverse health outcomes, while others have not. Most of the attention has focused on the possible association between childhood leukemia and magnetic field exposure, following epidemiology studies that suggested a possible association.

The following sections address how scientists have evaluated this body of research, the conclusions they have drawn, and standards or guidelines that set limits on exposure to EMF.

7.13.2.2 SCIENTIFIC PROCESS FOR EVALUATING RISK

The scientific process of risk analysis entails looking at *all* the evidence on a particular issue in a systematic and thorough manner. Each study is evaluated to determine its strengths and weaknesses, and then the entire body of research is evaluated together, giving more weight to studies of higher quality and greater relevance to a specific disease in humans. When there are a sufficient number of studies with similar objectives, conclusions can be drawn from the entire body of evidence based on the overall weight of evidence. Such reviews generally include three sources of information: epidemiology studies in humans, experimental studies in animals (*in vivo*), and experimental studies in isolated cells and tissues (*in vitro*). The overall pattern of consistency among results from epidemiology and experimental studies is important in drawing conclusions on the likelihood of risk at specific exposure levels. Epidemiology is observational, relying on data from people going about their ordinary lives over long spans of time, but without the control over exposures that occurs in laboratory science. Consequently, good knowledge about exposure is a frequent weakness in epidemiology. In contrast, laboratory scientists can tightly control all aspects of exposure to animals, tissues and cells, thereby allowing greater certainty about the possibility that an exposure does or does not cause a particular effect.

Numerous multidisciplinary international and national scientific agencies have assembled scientific panels to conduct weight-of-evidence reviews of the research literature on EMF and possible adverse health effects. These scientific panels include the International Commission for Non-Ionizing Radiation Protection (ICNIRP, 2010), International Agency for Research on Cancer (IARC, 2002), and National Institute for Environmental Health Sciences (NIEHS, 1998), National Radiological Protection Board (NRPB, McKinlay et al. 2004) and World Health Organization (2007). It is valuable to look to these agencies for conclusions because they have the expertise to make decisions about health using balanced, objective, scientific methods that are applicable to many environmental health questions.

[26] Epidemiology is the study of the frequency and distribution of disease and good health in human populations together with factors that might be associated with, and possibly be causes of, disease and good health.

[27] Epidemiology studies estimate associations, which are quantitative measures of how often an exposure and a disease occur together. If a study reports a statistical association between an exposure and a disease, it means that the disease and the exposure occur together more often than one would expect as a result of chance. A statistical association between an exposure and a disease does not mean that the exposure causes the disease, just as an observed association between baldness and wearing a hat would not be proof that hats cause baldness.

7.13.2.3 CONCLUSIONS OF WEIGHT-OF-EVIDENCE REVIEWS

The conclusions from the IARC, ICNIRP, NRPB (now the Health Protection Agency, HPA) and NIEHS and similar organizations are generally consistent.[28] The assessments agree that the weight of evidence supports the conclusion that EMF is not established as a cause of adverse health effects, including adult and childhood cancer, Alzheimer's disease, amyotrophic lateral sclerosis, and reproductive effects. However, epidemiologic studies of EMF and childhood leukemia (the most common childhood cancer) have been problematic for over three decades. Despite numerous studies and analyses of the body of evidence, it has not been possible to achieve scientific consensus concerning the possibility that the risk of childhood leukemia is greater among the most highly exposed children, who form a small proportion of the total. To date, it has not been possible to determine if the apparent increase in risk is valid or mistaken. Epidemiology studies of EMF and other diseases do not have the level of consistency and strength of association that would be convincing evidence of an increased risk, and animal studies failed to show consistent increases in cancer even at high field strengths over lengthy periods.[29] Furthermore, no mechanism has been discovered in laboratory studies or theoretical analyses that explains how electric or magnetic fields at levels found in the environment could cause disease. Given these weaknesses and uncertainties, particularly those derived from epidemiological studies, and because laboratory studies did not support a causal relationship, IARC and NIEHS assigned EMF to the lowest category of cancer risk as a "possible carcinogen."

The only studies that confirm a relationship between electric and magnetic fields and an adverse biological or health effect are those in which very high levels of exposure to these fields produce currents and fields in the body at levels approaching a very weak electric shock. These short-term effects occur only with very high field strengths that exceed exposure guidelines designed to protect against their occurrence. Fields at these high intensities are not found in residential environments and elsewhere where the public has access.

7.13.2.4 RECENT RESEARCH

PubMed and EMF-Portal are large databases that include EMF research. Recent research publications were identified from these databases in order to provide a current picture of scientific research on EMF. Since the time of the last weight-of-evidence review by the ICNIRP in 2010, hundreds of laboratory studies, review articles, and at least 25 epidemiology studies with relevant risk estimates have been published. In addition, other epidemiology papers treated exposure assessment and methodological concerns or reviewed existing data. The recent epidemiology research contributes new data on associations of various disease endpoints and power frequency exposures with a major focus in existing areas with unresolved controversies, principally, leukemia and other blood cancers in children and adults, benign and malignant brain tumors, pregnancy outcomes, amyotrophic lateral sclerosis (ALS), and dementia (including Alzheimer's Disease). The studies varied in quality and statistical power. The recently published papers, which include some meta-analyses, do not change the problematic nature of the literature. Observed risks magnitudes and patterns of association continued to give some support for the hypothesis that relatively stronger magnetic field exposures in a range a few times greater than 1 mG are associated with greater risk for leukemia in adults and children, brain cancer in

[28] Both the IARC and the NIEHS have an established method for classifying the possible carcinogenicity (capability of causing cancer) of exposures to any agent. IARC categories are ordered according to the strength of evidence for cancer risk: carcinogenic to humans, probably carcinogenic to humans, possibly carcinogenic to humans, not classifiable as to carcinogenicity to humans, and probably not carcinogenic to humans. The categorization "possible carcinogen" does not mean that magnetic fields cause cancer, and does not suggest that this possibility is likely.

[29] Three scientists from the California EMF program also conducted a review of the research on EMF and health effects that was reported in 2002. This review used a unique methodology in which each reviewer ranked risks probabilistically. The reviewers concluded there were elevated probabilities for a causal association between EMF exposure and a number of diseases (including childhood leukemia). The review was conducted for the State of California Public Utilities Commission, and in absence of a definitive determination on whether magnetic fields are a cause of adverse health effects (http://www.ehib.org/emf/) the state continued existing policies for electric power facilities.

children and adults, and dementia in adults and the elderly. Exposures at the levels where associations appear (for example, greater than 3 – 4 mG), involve relatively few people, contributing to the difficulty in getting definitive conclusions. Data that point against any increased risks are similarly not robust enough to dismiss the possibility of increased risk. However, there was stronger evidence, and less conflict, among a few studies that indicated maternal magnetic field exposure was not a factor in birth defects, stillbirth, and other adverse conditions acquired before birth. In summary, based on existing and recent epidemiologic research, certain long-standing questions about potential adverse health effects due to residential and occupational EMF exposure remain unresolved. Biophysical considerations that dismiss the possibility of effects of any type because EMF energies are too low remain unchanged.

Overall, in addition to the recent epidemiology studies noted above, entries for power-frequency EMF studies published since 2009 in PubMed and the efm-portal database through June 2012 include about 200 additional papers from in vitro research, animal studies, and reviews that ranged widely over a variety of experimental models and exposures methods. None of the laboratory or epidemiology research makes a breakthrough in understanding or sharply changes the weight of evidence obtained from the research reviewed in the past and more recently by ICNIRP (2010).

7.13.2.5 STANDARDS AND GUIDELINES

No scientific organization has recommended limiting exposure to members of the public to the levels of EMF typically encountered on a daily basis. Several international scientific organizations have published guidelines or standards for exposure to EMF based on *acute* (short-term) biological effects (e.g., the stimulation of nerves and muscles, comparable to a mild shock-like effect) that can occur at very high field levels. The ICNIRP recommends 2,000 mG as a guideline to limit general public exposure under nearly all circumstances and 10,000 mG for occupational exposures (ICNIRP, 2010). The International Committee on Electromagnetic Safety (ICES) also recommends limiting exposures at high levels because of the risk of acute biological effects, although their limits are higher than ICNIRP's guidelines (ICES, 2002). The public rarely, if ever, encounters magnetic field strengths of several thousand milligauss, the levels at which guidelines are set. Electric power transmission lines do not expose the public to magnetic fields comparable to the limits of guidelines or standards.

In addition to scientific organizations, government bodies can also issue standards or guidelines, although these recommendations are not always based on health effects. For example, six states have standards or guidelines for electric fields on or at the edge of the right-of-way (ROW) to minimize the perception of shocks. Two states, Florida and New York, have enacted standards to limit magnetic fields at the edge of transmission line ROWs (150 mG and 200 mG, respectively). The basis for limiting magnetic fields from transmission lines in these two states was to maintain the "status quo" so that fields from new transmission lines would not be higher than those produced by existing transmission lines.

7.13.2.6 CONCLUSION

The scientific agencies that have considered EMF health and safety concluded that the extensive body of current research shows that EMF from electric power transmission and substation equipment are not an established cause of any long-term adverse health effects. There remains some uncertainty concerning epidemiologic associations of childhood leukemia with magnetic field exposure that has not proven easy to resolve as either a true or false indication. Risk assessments recognize the possibility of biological effects that do not affect health adversely. Such biological effects can occur with acute exposures at very high field strength levels sometimes found in occupational settings but rarely encountered by the public. The only studies that show a causal relationship between power-frequency EMF and a potentially adverse biological effect are those in which very high levels of exposure produce short-term, shock-like effects. The levels at which these short-term effects occur are very high and are rarely encountered by the public. Although recent research does not provide any new conclusive evidence to alter the forgoing conclusions, the continuation of research shows the need for

monitoring future developments. In summary, risk analysis derived from the scientific research literature provides no conclusive evidence for adverse health effects to the public because of the electric and magnetic fields from transmission lines and substations.

7.13.3 Mitigation

EMF surrounding substations and overhead transmission lines, including areas outside the property line or right-of-way, can be reduced by design techniques available to power transmission engineers. Transmission systems are often built using methods that reduce fields by configuration of conductor phasing, conductor placement, line and tower height, and the location and design of substation equipment on the site. Application of these methods is project-specific because of the need to develop an engineering model that may need to consider existing power lines and equipment and any site-specific constraints in topography, available land, and land use. EMF of underground transmission lines can also be reduced by engineering methods.

In respect to EMF, Seattle City Light policy and procedures for review of new energy delivery infrastructure requires evaluation of design techniques to minimize EMF and induced currents.

Table 7-1. Summary of environmental health impacts[30]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		May require workers to work from heights but impacts are not anticipated assuming OSHA requirements are followed.
		L	Assume proper disposal of waste products and indoor air quality is not degraded.
Landfill Gas	L		Typical construction related concerns but impacts are not anticipated assuming OSHA requirements are followed.
		L	Potential positive impact attributable to the reduction in air pollutants and greenhouse gas emission in comparison to flaring landfill gas.
Gorge Second Tunnel	L		Environmental health concerns related to heavy construction, electric power industry and those unique to boring equipment.
		L	No additional noise or EMF impacts are anticipated.
Geothermal	M		Environmental health concerns related to well drilling and dealing with high temperature water and steam.
		M	Hydrogen sulfide emissions and low noise levels of plants (compared to "rustling leaves").
Biomass	M		Typical construction related environmental health concerns.
		M	Noise and work hazards associated with collecting and hauling fuels.
Wind	M		Typical construction related environmental health concerns. Blasting may be needed.
		M	Sufficient public concern over shadow flicker, blade throw, etc. Also, concern about working from heights.
Solar Energy	L		Environmental health concerns related to heavy construction, electric power industry and potentially high-temperature fluid.
		L	Environmental health concerns related to heavy construction, electric power industry and potentially high-temperature fluid.
Natural Gas/CCCT	M		Environmental health concerns related to heavy construction, electric power industry.
		M	Noise from fuel extraction activities and CCCT operation. Assume proper handling of waste.
Renewable Energy Credits	L-M		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-M	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Unlikely that new plants would be constructed to meet demand for Market Transactions.
		M	Fuel extraction impacts, which are similar to the Natural Gas/CCCT resource.
Transmission	H		Dangers include high voltage lines. Installing transmission lines may also involve working from helicopters.
		M	**The scientific agencies that have considered EMF health and safety concluded that the extensive body of current research shows that EMFs from electric power transmission and substation equipment are not an established cause of any long-term adverse health effects. Inherent danger in working with high voltage.**

[30]Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

8 LAND USE

8.1 Affected Environment

Forest, rangeland, and agricultural lands are the predominant land cover types in the Pacific Northwest. About two-thirds of the land is publicly or tribally owned. Managers of public lands include the U.S. Forest Service, Bureau of Land Management, Department of Energy, Department of Defense, state and local governments, and National Park Service. The rest of the land is privately owned (BPA, 1993).

The most intensively developed areas are in the Puget Trough and Willamette Lowlands areas of western Washington and Oregon, which is where the greatest demands for electricity are centered. Population in the Pacific Northwest centers on the Seattle metropolitan area, greater Portland, and smaller urban areas in Washington, Oregon, Idaho, and Montana. The population of these states in 2010 was 6.72 million, 3.83 million, 1.57 million, and 989,000, respectively.

Washington and Oregon have land use planning laws that regulate where various land uses may be developed. In Washington, each jurisdiction must have a process for administering the siting of essential public facilities, which includes energy facilities proposed by public utilities. Both states have siting councils that oversee the permitting of energy facilities above designated capacities.

8.2 General

8.2.1 Construction Impacts

Construction of power plants often requires the long-term displacement of existing land uses. Impacts from the facility on existing land uses would be highly dependent on the project location, size of the facility, and the amount of land it displaces.

Construction periods can last a few months to a few years, but are temporary. Although plants are generally located away from population centers, some are located near or in urban areas. Air emissions, noise, and vehicle traffic can increase and cause proximity impacts to nearby properties during construction. The increased construction traffic can delay traffic flow or limit access to certain areas, thus limiting land use for other purposes. The level of these impacts will depend on the mitigating measures employed, the length of the construction period, and the types of neighboring land uses.

8.2.2 Operation Impacts

Direct impacts could include permanent withdrawal of land from existing uses and interference with adjacent land uses on an ongoing basis.

Many electricity-generating facilities are single-use facilities that preclude any other use of the site. For safety of the public and security of the plant, the area is often fenced in and access would be limited to facility personnel. The extent and magnitude of potential impacts during operation of a power plant on existing land uses would be directly related to the type of area in which the facility is located. It is likely that direct and indirect land use impacts would be less in undeveloped, rural areas, as compared to more developed sites, but the extent of such impacts could not be determined until a specific site is chosen for development.

In addition, operation of electricity generation facilities may result in some proximity-related impacts associated with noise, traffic, and the physical presence of the facilities. The severity of the specific operation impact will be affected by its compatibility with existing land use.

8.2.3 Regulations

Regulations related to land use impacts include the Growth Management Act (GMA) and zoning and land use regulations. Zoning and land use regulations, which are subject to the GMA, are generally set at the local level (county or city).

8.2.4 Mitigation

- To the extent possible, locate new structures on developed sites to minimize land use impacts.
- Evaluate the project site before construction to make sure it conforms to local planning and zoning requirements and avoids compatibility issues with nearby uses.
- Locate new transmission facilities within or parallel to existing rights-of-way and avoid bisecting existing land uses such as farmland in order to minimize land use conflicts and compatibility issues.
- Develop construction management plans that avoid or minimize disruptions to adjacent existing uses.
- Buffer construction areas activity from areas frequented by recreationists, if possible.
- Ensure that lease/easement terms and payments to landowners can compensate for any changes/modifications in land use.
- Inform affected landowners of construction schedules.

8.3 Conservation

8.3.1 Construction Impacts

Energy efficiency measures are expected to have low impacts.

8.3.2 Operation Impacts

Energy efficiency measures are expected to have low impacts.

8.3.3 Mitigation

See Section 8.2.4.

8.4 Landfill Gas

8.4.1 Construction Impacts

The landfill gas combustion turbine would likely be sited within the boundaries of an existing landfill site. Because a site would already be developed for landfill use, there would be no additional land use impacts from the installation of electricity production equipment—no displacement of other existing land uses would occur. Many landfills already have piping for capturing and flaring methane gas and, typically, the electricity generating equipment (regardless of whether the technology is a gas turbine, internal combustion engine, or fuel cell) would easily be accommodated on the land used for the landfill. Some new structures may be required, such as foundations or buildings to house the generating equipment, but it should be possible to accommodate them within the existing landfill footprint. Depending on the existing electricity transmission infrastructure available at the site, new transmission and distribution facilities may be required, including poles/towers, conductors, transformers and substations. Some of these facilities would be located off site and could result in the displacement of existing land uses. Overall, impacts would be low during construction.

8.4.2 Operation Impacts

The proximity-related impacts described in Section 8.2.2 would be low because the landfill gas site likely would already be used for an industrial purpose and a precedent would have been established. Therefore, land use compatibility impacts would be low.

8.4.3 Mitigation

See Section 8.2.4.

8.5 Gorge Second Tunnel (Hydro Efficiency)

8.5.1 Construction Impacts

The primary land uses in the area are hydropower facility operations, transportation, and recreation. Land use impacts during construction would be associated with staging for construction and increased vehicle traffic for various construction activities. SR20 is the only highway that traverses the North Cascades National Park complex from east to west through Newhalem. The tunnel project will require development of one to two temporary structures that would need to cross SR20: a below-grade temporary water conveyance pipe and, depending on site layout, an overhead conveyor belt to transport tunnel spoils to a temporary stockpile area. Traffic on SR20 would be temporarily disrupted during construction of these facilities. A small visitor parking area with interpretive signage would be removed and parking for recreational vehicles would be altered. Depending on how the construction site was designed, access to a historic site, Ross Crypt, could be temporarily disrupted. Another option would temporarily disrupt use of an open lawn that is used for picnicking.

During the tunneling phase of the project, haul truck operators would use ten miles of SR20 between the tunnel portal and an old quarry site near Bacon Creek for transporting large quantities of excavated tunnel rock. According to a project traffic analysis, these impacts would likely be low because the existing speed limit posted along SR20 through Newhalem is low (20 to 30 miles per hour) and through traffic would continue to have the right of way on SR20. Construction traffic would be required to yield to through traffic. In addition, if a stockpile option is selected that could cause haul trucks to queue along SR20 while waiting to enter the site, pullouts would be developed to move them out of the flow of traffic.

8.5.2 Operation Impacts

Project operation would be compatible with the site's existing use as a hydroelectric project and would not permanently change the use of surface land. See section 10.5.2, Historical and Cultural Resources, for related information. The area is within the Ross Lake National Recreation Area; however, there would be no incremental changes or potential impacts on recreation compared to the present. The project operates under a federal license that includes requirements for minimizing and mitigating impacts of the hydroelectric plant operations on the National Recreation Area. City Light works closely with the National Park Service in implementing license requirements. Overall, operation impacts would be low.

8.5.3 Mitigation

See Section 8.2.4 and implement the following mitigation measures during construction, as needed:

- Provide continued access to areas frequented by recreationists, where safe to do so.
- Provide interpretive materials and signage and updated project information to inform and educate recreationalists passing through the area during construction.
- Develop temporary parking areas for recreational vehicles if existing parking areas cannot be accessed during construction.

- Develop temporary pullouts along SR20 for haul trucks waiting to enter the stockpile area.
- Have the Washington State Department of Transportation (WSDOT) review Gorge Second Tunnel project traffic plans. If WSDOT determines that flaggers or signage are needed at the intersection of the Gorge Railroad Bridge and Highway 20 or at the spoils stockpile area or the Bacon Creek quarry site, direct the construction contractor to implement WSDOT-recommended measures.
- Implement a signaling system to manage one-way travel across the Gorge Railroad Bridge for haul trucks entering and exiting the staging area, if the rock stockpile is located in the staging area.
- Suspend trucking when driving conditions are unsafe.
- Use trenchless methods to construct the Highway 20 crossing for the temporary tunnel water conveyance pipe. The pipe likely would be jacked under the highway.
- Have WSDOT review conveyor layout plans if conveyor system would cross Highway 20.

8.6 Geothermal

8.6.1 Construction Impacts

Development of a geothermal facility would require long-term displacement and conversion of the existing uses within a given area for geothermal energy production. Potential impacts from the facility on existing land uses would be highly dependent on the project location, and would vary considerably from site to site. Geothermal sites are often located in natural areas and forests, though they may also be found in agricultural areas. The industrial nature of geothermal plants would conflict with the standard land use in natural and forested areas. On some federal land, the facilities could be considered part of the multiple use mandate intended for public resources. Transmission lines would need to be constructed that would cause additional land use impacts.

A typical geothermal field uses 1 to 8 acres per megawatt (MW) versus 5 to 10 acres per MW for nuclear operations, and 19 acres per MW for coal power plants. Geothermal energy production would, therefore, create less direct and indirect land use impacts in comparison with other energy facilities. In addition, the nature of geothermal energy production, in comparison with other facilities such as coal mining, would generally create less impact on adjacent land uses. Overall, construction impacts would be moderate.

8.6.2 Operation Impacts [Comment: Farming surrounds geothermal plants in Iceland]

According to the U.S. Department of Energy, geothermal energy uses less land than other energy sources, both fossil fuel and renewable (GEA, 2012). In addition, no transportation of geothermal resources would be necessary, as the resource is acquired directly at its source. During the 30-year period commonly used to compare the life cycle impacts from different power sources, a geothermal facility uses 404 square meters of land per gigawatt hour, while a coal facility uses 3,632 square meters per gigawatt hour (GEA, 2012). Overall, impacts could be moderate depending on the specific size and location in which the facility would be located.

8.6.3 Mitigation

See Section 8.2.4, and:

- Use slant drilling to access geothermal steam with less use of surface land for drilling pads, access roads, and piping.
- Use slimhole-drilling techniques to reduce the amount of well drilling.
- Inject withdrawn water back into the ground to reduce chance of subsidence.
- Avoid areas with high conflict with existing uses.

8.7 Biomass

8.7.1 Construction Impacts

Development of a wood-burning facility would require long-term displacement and conversion of the existing uses within the site. A plant site, including fuel storage, would require about 30 acres for a 40 MW plant. If the fuel source is wood waste and the plant is co-located with the waste generator (e.g., sawmill), land area requirements would likely be smaller. Also, compatibility with surrounding land uses would be greater with co-location. For other fuel sources, potential impacts would be highly dependent on the project location, and would vary considerably from site to site. It is plausible that sites could be in either developed industrial areas (low impact) or rural areas (greater impact). Location decisions would need to consider the cost trade-offs between fuel transport and need for transmission lines. Transmission lines would cause additional land use impacts. Overall, impacts would likely range from low to moderate.

8.7.2 Operation Impacts

Operation of a wood-fired biomass project could result in some proximity-related impacts associated with noise, traffic, and the physical presence of the facilities, which would vary with site location. City Light intends to use previously unused forest waste products, which includes materials from mill residuals, forest residue and other non-merchantable debris that is removed for timber management or ecological restoration efforts (e.g., invasive species removal, wildfire mitigation). Since it is assumed that the fuel source is from an already disturbed site with existing access roads, land use impact will likely be low.

8.7.3 Mitigation

See Section 8.2.4.

8.8 Wind

Land use impacts from wind energy development could include conversion of existing uses on the project site, conflicts with applicable land use plans and regulations, and conflicts with existing uses in adjacent or nearby areas. Wind project impacts on land use are highly dependent on the project location; most often, project sites are in agricultural or rural areas where issues of compatibility with adjacent uses are minor. In some cases, wind projects can provide financial benefits that allow continued ranch or farm operation on the host properties and avoid conversion of land to other uses.

8.8.1 Construction Impacts

Development of a wind farm requires the temporary displacement of existing uses within the area of project construction, and the long-term conversion of some land to wind energy production. The amount of land used for a wind farm is primarily limited to turbine foundations and pads, access roads, substations, and operations and maintenance facilities. The permanent footprint of these facilities typically represents a small portion of the total project area. For example, the average utility-scale wind turbine takes up one-quarter acre of land (Fleischmann, 2006), while a mile of access road would likely occupy 3 to 4 acres. The project substation and transmission line connection can be located off site and require acquisition of land or easements outside the wind farm boundary. Displacement or loss of existing uses is typically compensated through lease agreements with participating landowners, and through purchase or easement agreements for off-site facilities.

In addition to displacement of existing uses, construction activities for wind farms can cause access disruptions for adjacent uses. In such cases, construction management plans would typically include provisions for alternate access or other means to minimize the disruptions. Based on the limited extent and intensity of wind farm construction impacts on land use, these impacts are likely to be low to moderate in any given project context.

8.8.2 Operation Impacts

In the Northwest, wind farms are typically located in rangeland, pasture, or cropland that continues to be used for farming, with little ongoing impact to farm operations. If there are residential or recreational uses on nearby lands, wind farm operation could result in some proximity-related impacts associated with noise, potential project hazards, and/or the physical and visual presence of the facilities. Specific issues of this type are addressed under the headings for Environmental Health and Aesthetics and Recreation. With respect specifically to land use compatibility, approval of a wind farm would require a determination by state and/or local land use authorities that the new use would be consistent with local comprehensive plans (if applicable) and zoning designations for the project site. For development of wind farms on BLM-administered public lands in 11 western states (including Washington, Oregon, and Idaho), these projects must follow the policies and BMPs established in the BLM's PEIS-Wind Energy Development Program (BLM, 2006). The evaluation of land use compatibility would depend on the applicable conditions in a given jurisdiction, and cannot be predicted on a general basis.

Operation of a wind farm is not expected to change the underlying use of the host properties, and is generally considered a beneficial factor in maintaining the current use(s). Industry experience has also not indicated that the long-term presence of a wind farm is likely to promote changes of use on adjacent properties, although it may inhibit conversion of nearby rural lands to developed uses. Consequently, the long-term impacts of a wind farm on land use are likely to be low to moderate. In cases where local residents have concerns over environmental health hazards and/or visual impacts, however, these concerns are likely to be represented as a significant issue of land use compatibility.

8.8.3 Mitigation

See Section 8.2.4.

8.9 Solar Energy

8.9.1 Construction Impacts

Solar technologies may require a significant amount of land depending upon the specific technology used and the scale of the facility.

The amount of electricity produced by a photovoltaic (PV) source varies with the amount of surface area that it uses to collect sunlight. As a result, smaller, distributed PV systems, which can be ground-mounted or mounted above ground on the top of buildings or other structures, will have a small impact on land use. Utility-scale PV project installations with bigger surface areas are often ground-mounted and, thus, are likely to have a larger land use impact.

The amount of land required for utility-scale solar technologies are difficult to project because there are few operational facilities in the United States. Estimates of the land area required for parabolic trough, power tower, and dish engine facilities are approximately 5, 9, and 9 acres per MW, respectively (BLM, 2010). Land area requirements for PV facilities are approximately 10 acres per MW. The estimates are based on land use requirements for the few existing facilities in the United States and anticipated needs of proposed facilities that are in the preliminary stages of evaluation.

Utility-scale solar energy development would preclude other land uses within the project footprint. Development of the supporting structure (e.g., new transmission line and roads) would also locally impact land use (BLM, 2010). Overall, impacts could be moderate.

8.9.2 Operation Impacts

The development of utility-scale solar projects requires the permanent displacement of existing uses within the area of project construction. Therefore, the operational impact of solar facilities differs from wind farms because wind farms, which are typically located in agricultural areas, do not often change the underlying use of the property. Overall, impacts could be moderate.

8.9.3 Mitigation

See Section 8.2.4. Mount new solar energy systems, to the extent possible, on top of an existing structure such as a building rooftop to avoid disturbing new land.

8.10 Natural Gas Combined-Cycle Combustion Turbines

8.10.1 Construction Impacts

Construction periods can last a few months to a few years, but are temporary. Although plants are generally located away from population centers, some are located near or in urban areas, particularly CHP plants. Air emissions, noise, and vehicle traffic can increase and cause proximity impacts to nearby properties during construction. These impacts can be low to moderate, depending on the mitigating measures employed, the length of the construction period, and the types of neighboring lands uses. Facility development would result in the displacement of existing land uses on the site.

8.10.2 Operation Impacts

Typical land uses in areas of gas extraction include rural residential, rural industrial, recreational, mining, forestry, and other resource-related commercial activity. These activities tend to be low in density and confined to certain contained spaces. Overall operation impacts would be moderate.

If a new plant is located in an urban industrial area, or a plant is an addition to or an expansion of an existing plant, land uses impacts would be low because the plant would be consistent with existing land uses and consistent with current zoning. CHP plants are often built next to or as part of existing plants. Facilities, including plants and pipelines, built on raw or greenfield sites (as is typical with CCCT plants) would result in the largest incremental impact because the proposed use would be different from the existing use.

Local zoning regulations would apply to any new facility to ensure consistency with current standards. Although plants are generally located away from population centers, some are located near or in urban areas, particularly CHP plants. Air emissions, noise, and vehicle traffic to and from the plant can increase and cause disturbances to nearby properties. These impacts can be low to moderate, depending on the mitigation measures employed and the location of the site among land use types. Vehicle traffic and noise during operation is typically lower than during construction.

8.10.3 Mitigation

See Section 8.2.4.

8.11 Renewable Energy Credits

8.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

8.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

8.11.3 Mitigation

See Section 8.2.4.

8.12 Market Transactions

8.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Construction impacts would be low.

8.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be moderate.

8.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the plants have already been built, and it is unlikely that these plants would modify the facilities or uses in order to meet the incremental demand with reduced impacts to land use. See Section 8.2.4 in this Appendix for details on mitigation options.

8.13 Transmission

8.13.1 Construction Impacts

New transmission lines would require dedicated corridors where existing uses would be precluded in most cases. While transmission lines are sited to minimize land use conflicts, this is not always possible. Therefore, there are likely to be direct land use impacts in development of new transmission lines and, in some cases, upgrading of existing lines. Direct impacts could include permanent withdrawals of land from existing uses, interference with adjacent land uses on an ongoing basis, and temporary disturbance of existing uses. The magnitude and extent of the impact would depend on the type of structure (towers vs. single poles) and the land use in question.

In general, transmission lines suspended on lattice-steel towers require wider rights-of-way (up to 100 feet or more for double-circuit lines) than do single-pole structures and, thus, would have a greater impact. Transmission lines extending through rural areas where the land use is agriculture or rangeland would cause mostly temporary impacts during construction since these uses are often allowed to continue within the right-of-way after construction is completed (although the presence of towers would continue to interfere with farming operations). On the other hand, where lines extend through forest lands, the timber resource is permanently withdrawn from production. Likewise, transmission lines through built-up areas could displace many residential, commercial, or industrial uses. From a land use compatibility standpoint, transmission lines generally would be more compatible with commercial and industrial uses than with residential uses. Also,

during construction, temporary interference with traffic could occur when conductors are strung over roadways. Overall, land use impacts could range from low to moderate.

Consistency with land use plans and policies would be variable. Some jurisdictions provide for transmission lines as a conditional use, and some do not address the use at all. In some cases, transmission lines may not be consistent with local jurisdictions' plans and policies. As noted previously, in addition to possible local land use approval, there are several agencies at the federal and state levels that may assert permitting and approval authority.

8.13.2 Operation Impacts

Operation impacts are similar to construction impacts although over a longer time. Overall operation impacts would be moderate to high.

8.13.3 Mitigation

See Section 8.2.4.

Table 8-1. Summary of land use impacts[31]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		No adverse impacts are anticipated.
		L	No adverse impacts are anticipated.
Landfill Gas	L		Project and its infrastructure would likely be sited within the boundaries of an existing landfill.
		L	Existing site likely used for industrial purposes and, therefore, minimal proximity-related impacts.
Gorge Second Tunnel	L		Minimal impacts from construction vehicle traffic and intermittent delay of traffic flow.
		L	City Light works closely with the National Park Service to minimize and mitigate impacts on recreation.
Geothermal	M		Facility requires long-term displacement and conversion of the existing uses most likely in undeveloped areas.
		M	Project precludes the site from being used for other purposes. No fuel delivery required.
Biomass	M		Long-term displacement and conversion of the existing uses within the plant site.
		L	Assume the use of mill waste or unused forest by-products.
Wind	M		Temporary displacement of existing uses, and turbines spread over large areas.
		M	Not expected to change the underlying use of the host property, but will affect potential land uses of adjacent parcels.
Solar Energy	M		Large-scale projects require a significant amount of land.
		M	Project precludes the site from being used for other purposes. No fuel delivery required.
Natural Gas/CCCT	M		These are industrial facilities and as such will have the potential for moderate impact to adjacent property.
		M	The operation of the plant will have ongoing impacts. Extracting fuel and transporting it in pipelines will affect land use during operation.
Renewable Energy Credits	L-M		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-M	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Unlikely that new plants would be constructed to meet demand for Market Transactions.
		M	Similar to those for natural gas.
Transmission	M		Could include permanent withdrawals of land from existing uses.
		H	Similar to construction impacts but over a longer time.

[31] Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

9 AESTHETICS AND RECREATION

9.1 Affected Environment

The diverse landscape and abundance of natural settings and scenic vistas in the Pacific Northwest provide a wide range of aesthetic and recreational opportunities. The rivers, lakes, and adjacent land areas offer many water-based recreational activities such as fishing, water-skiing, rafting, boating, windsurfing, and swimming. Land-based activities such as picnicking, camping, hiking, and bird watching do not require water access, but many users prefer sites that are enhanced by scenic lakes and rivers.

A variety of government agencies, private organizations, and individuals has developed hundreds of recreational sites that offer a full range of water and land-based activities. Scenic drives also are popular recreational activities. Roads and highways parallel to rivers, lakes, and ocean shores provide access to majestic vistas and natural scenes. Many of these recreation activities occur year-round; however, peak use occurs during the summer months. These recreational resources are important components of the Pacific Northwest's regional economy and lifestyle.

In addition to diverse designated recreational areas and magnificent scenic vistas, the Pacific Northwest contains designated wilderness areas and scenic rivers. Some noteworthy areas are located at Mount Rainier, Mount Hood, Mount Baker, Strawberry Cap, Hells Canyon, and sites on the Olympic Peninsula and in the Cascade Mountains. These wilderness areas are sensitive to any development, including development associated with the production and transmission of electrical power. These areas are particularly sensitive to airborne pollutants that may originate from fossil-fuel burning power plants. For instance, the aesthetic visibility in some wilderness areas (e.g., Mount Rainier) can be adversely affected by airborne oxides of nitrogen. In addition, the deposition in alpine lakes of nitrates and sulfates from rainfall can have adverse effects on fisheries.

9.2 General

9.2.1 Construction Impacts

Recreational users could be subject to visual impacts and noise during the construction of generating facilities, transmission lines or fuel extraction activities. Visual impacts may occur because the construction activities, such as clearing and grading, create a contrast with the existing environment that can be easily evident to viewers in the area. Depending on proximity and access relationships, it is also conceivable that travel routes to recreation sites could be disrupted by construction activities.

The significance of aesthetic impacts during construction would depend primarily on the specific site chosen for development, in addition to the type of the surrounding views and the number and type of exposed viewers and their sensitivity to landscape changes.

9.2.2 Operation Impacts

In general, power plants are not considered aesthetically pleasing. The completed project and its related infrastructure can introduce strong contrasts in forms, lines, colors, and textures compared to the existing landscape, which may be perceived as a negative visual impact (BLM, 2010). The visual impacts from operation would be similar to those experienced during construction, although over a longer time.

Power plants are generally closed to the public and do not create any recreational opportunities and could, depending on location, restrict recreational activities or be visible from recreational areas. Energy facilities in

more remote, pristine areas could affect recreation directly because of operating noise, use conflicts and loss of habitat and wildlife and indirectly through compromising the recreation experience. The significance of such impacts would be dependent on the specific scenery of the area and the number and type of exposed viewers and their sensitivity to landscape change.

9.2.3 Regulations

- Regulations related to mitigating aesthetics and recreation impacts include land use and zoning regulations. The regulations vary widely as they are generally set at the local level (county or city).

9.2.4 Mitigation

- If possible, locate facilities in areas with less viewer exposure and away from popular recreation areas.
- Integrate facility design and configuration of structures into the surrounding landscape or otherwise incorporate aesthetic objectives into design.
- Minimize surface disturbance at the project site and access roads; particularly on steep slopes, and control erosion.
- If necessary and effective, provide vegetation screening to obstruct views of the project facilities and fuel extraction sites from surrounding sensitive areas.
- Keep project facilities clean and well maintained throughout project operation.
- Compensate for impacts by aesthetic improvements in other areas such as reclamation of unneeded roads.
- Schedule construction during periods of low recreation use.
- Consider use of aesthetic offsets (mitigation of existing aesthetic impacts from other sources, such as reclamation of unneeded roads) to mitigate unavoidable visual impacts.

9.3 Conservation

9.3.1 Construction Impacts

Energy efficiency measures would not result in any direct or indirect adverse impacts except insofar as the physical appearance of structures could be altered by the measures in a manner than would be aesthetically unappealing. Construction impacts would be low.

9.3.2 Operation Impacts

Potential impacts from operation would be similar to those experienced during construction, although over a longer time. Operation impacts would be low.

9.3.3 Mitigation

See Section 9.2.4.

9.4 Landfill Gas

9.4.1 Construction Impacts

As described in the General Construction Impacts Section 9.2.1, construction activities would create minor changes in the visual quality of the setting during construction. No recreational impacts would occur since the site would not have been available for recreational purposes; landfills are not generally located in or near recreational areas. Impacts would be low.

9.4.2 Operation Impacts

As described in the General Operations Section 9.2.2, there is a potential for energy facilities to affect the visual quality of the setting. However, landfills are often screened from public view or located far from population centers; therefore, the likelihood of long-term visual impacts is low. However, to the extent that new structures and activities contrast with the existing visual setting, and there is a viewing population, there could be low aesthetic impacts.

A landfill gas energy facility would be installed at an existing or permitted landfill that meets or is likely compatible with existing zoning requirements, and the electricity generating facilities would not require land outside the landfill footprint. Consequently, the facility is not likely to conflict with existing recreational activities in the area. The facility may beneficially reduce odors by collecting and combusting landfill gas. However, in landfills where gas is already captured and flared there may be little improvement attributable to the energy facility. Overall, impacts would be low.

9.4.3 Mitigation

See Section 9.2.4.

9.5 Gorge Second Tunnel (Hydro Efficiency)

9.5.1 Construction Impacts

Construction activity including vehicle and equipment use and ground disturbance could create contrasts with the existing visual environment and adversely affect the visual experience of motorists. As noted in the Land Use Section, work will take place in the Ross Lake National Recreation Area, which is part of the North Cascades National Park Complex. The project would be in close proximity to State Route 20, the highway used by all travelers through the area. The area is used for recreation, and increased construction activity and noise could adversely affect the recreation experience of hikers and others. These impacts would be temporary. Overall, impacts would be low to moderate.

9.5.2 Operation Impacts

Operation would have no impacts on aesthetics and recreation, since the new tunnel facilities would be underground and require little routine maintenance. Operation impacts would be low.

9.5.3 Mitigation

See Section 9.2.4.

9.6 Geothermal

9.6.1 Construction Impacts

As described in the General Construction Impacts Section 9.2.1, construction activities including clearing and grading to accommodate project structures and construction of access road may be evident to viewers in the area and affect the visual quality of the setting. Since geothermal sites typically would be located in natural or forested areas, where views of industrial facilities would be in sharp contrast to the immediate surroundings the impacts could be moderate.

9.6.2 Operation Impacts

As described in the General Operations Section 9.2.2, there is a potential for energy facilities to affect the visual quality of the setting. The significance of such impacts would be dependent on the specific scenery of the area

and the number and type of exposed viewers and their sensitivity to landscape change. Overall, impacts could be low to moderate.

9.6.3 Mitigation

See Section 9.2.4.

9.7 Biomass

9.7.1 Construction Impacts

As described in the General Construction Impacts Section 9.2.1, construction may be evident to viewers in the area and affect the visual quality of the setting. It is assumed that a biomass cogeneration facility can be located to avoid recreational conflicts. Overall impacts would likely be low to moderate.

9.7.2 Operation Impacts

As described in the General Operations Section 9.2.2, there is a potential for energy facilities to affect the visual quality of the setting. Visual and noise impacts for biomass facilities may include tall smokestacks that emit water vapor and air pollutants, fuel processing activity and fugitive dust emissions, and daily truck traffic transporting fuel to the power plant. The significance of such impacts would be dependent on the specific scenery of the area and the number and type of exposed viewers and their sensitivity to landscape change. Plant facilities co-located with a mill would produce only minor impacts. As City Light intends to use only wood waste, there would not be incremental impacts above the level that results from timber harvesting activities. Since City Light does not intend to use biomass fuel from a dedicated crop, there will be no aesthetic impacts and recreational conflicts caused by clearing native vegetation, planting, and harvesting the crop. Overall, impacts could be low to moderate.

9.7.3 Mitigation

See Section 9.2.4.

9.8 Wind

Visual impacts are generally recognized are likely impacts of wind energy facilities. This is primarily because of the large size (over 350 feet in height) and high visibility of modern, utility-scale wind turbines. While project construction activities can produce landscape changes that are regarded as aesthetic impacts, the primary focus has been on the long-term presence of wind energy facilities during their operation period.

9.8.1 Construction Impacts

As described in the General Construction Impacts Section 9.2.1, construction of wind farms would create visual impacts and noise. While the disturbance created from clearing and grading and construction of access roads generally occupies a relatively small portion of the project area it is, nevertheless, rather extensive because project areas for wind farms tend to be large. In addition, transporting and installing turbine components involves large vehicles and cranes that can be visible from relatively long distances. The visual impacts would temporary, although restoration of surface scars could require several years.

Unless a wind farm site is near a heavily used recreation resource, construction impacts on recreation would likely be no worse than moderate.

9.8.2 Operation Impacts

Wind energy facilities tend to be visible from considerable distance because of the size of the wind turbines and because they are often situated on ridges or in wide-open spaces, where wind is more reliable. In addition to the size of the structures, noticeable aspects of wind farms include safety lighting required by the Federal Aviation Administration on tall structures, color contrast of turbines with their background, configuration and design of turbines, silhouetting on ridgelines, glare or glint from reflective surfaces, and the potential for shadowing effects at low sun angles.

The significance of the long-term visual impacts of wind farms varies by site and the degree of visibility to the public. Assessment of visual impacts is highly subjective and opinions about the aesthetic character of wind turbines vary—some people view the appearance of turbines favorably, while others consider them a visual blight. Accordingly, impacts could range from low to high.

In general, existing and proposed wind farms in the Northwest are not located in areas of high recreation use, but they may be visible from major highways or residential sites. Operation impacts of wind farms on recreationists would primarily occur through views of the wind energy facilities. Recreational uses located close to wind farms could also experience operational noise from the turbines.

9.8.3 Mitigation

See Section 9.2.4, and to integrate the facility design into the surrounding landscape consider providing visual order and unity in the turbine arrays; employing uniform size, shape, and color in the turbine towers, nacelles and rotors; using non-reflective paints and coatings; burying power collection cables; and locating substations and operations buildings where they would not be visible from sensitive viewpoints.

9.9 Solar Energy

9.9.1 Construction Impacts

As described in the General Construction Impacts Section 9.2.1, construction activities for utility-scale solar may disrupt travel routes to recreation areas, create noise and visual contrast that can be easily evident to viewers in the area. Unless the solar energy facility is near a heavily used recreation resource, construction impacts would likely be no worse than moderate. The impacts of distributed solar PV are expected to be low, as these systems are often mounted on roofs or other existing structures.

9.9.2 Operation Impacts

Utility-scale solar energy facilities can occupy hundreds of acres of land resulting in substantial change to the visual quality of the setting. These facilities are generally closed to the public and do not create any recreational opportunities and could, depending on location, restrict recreational activities or be visible from recreational areas. Impacts could be moderate to high. Since distributed solar facilities are often located in urban areas and are not highly visible, they are expected to have low visual and recreational impacts.

9.9.3 Mitigation

See Section 9.2.4.

9.10 Natural Gas Combined-Cycle Combustion Turbines

9.10.1 Construction Impacts

See General Construction Impacts Section 9.2.1. Construction is not typically viewed as an aesthetically pleasing activity, and could decrease view quality temporarily. These impacts would typically be no more than moderate because of their temporary nature.

9.10.2 Operation Impacts

As described in the General Operations Section 9.2.2, there is a potential for energy facilities to affect the visual quality of the setting and impact recreational activities or experiences. For the operation of natural gas facilities, the impacts are primarily due to fuel extraction activities. Although, the activities would likely occur in rural areas away from population centers, some activities could be visible from transportation corridors, resulting in an adverse impact to views of natural areas from the highway. Extraction activities and the presence of pipelines could also affect views from wilderness areas and recreational hiking trails. The extraction sites are often considered unattractive due to the soil disturbance, heavy machinery, and potential for noise and dust. Extraction locations are typically contained, even though they may still be visible from afar. Pipelines in Washington are generally buried or close to the ground and would have a low impact on views in rural, forested areas.

Wilderness areas are sensitive to any development, including development related to the production and transmission of electrical power. These areas are also sensitive to airborne pollutants that may originate from combustion turbine plants. For example, the aesthetic visibility in some wilderness areas (e.g., Mount Rainier) could be adversely affected by airborne oxides of nitrogen. Also, the deposition in alpine lakes of nitrates and sulfates from rainfall could have adverse effects on fisheries, which can affect recreation activities. The significance of such impacts would be dependent on the specific scenery of the area and the number and type of exposed viewers and their sensitivity to landscape change. Overall, these impacts would likely be low to moderate.

9.10.3 Mitigation

See Section 9.2.4.

9.11 Renewable Energy Credits

9.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

9.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

9.11.3 Mitigation

See Section 9.2.4.

9.12 Market Transactions

9.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Overall impacts would be low.

9.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion Turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be moderate.

9.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the plants have already been built, and it is unlikely that these plants would modify the facilities or uses in order to meet the incremental demand with reduced impacts to aesthetics and recreation. See Section 9.2.4.

9.13 Transmission

9.13.1 Construction Impacts

Construction activities related to clearing of rights-of-way and structure sites, grading of access roads, erection of structures and their components, and pulling and tensioning sites for the conductors would cause short-term impacts on the visual environment. If construction occurs in areas near recreation facilities, they could adversely affect the recreational experience of users. Overall, construction-related impacts are likely to be low to moderate.

9.13.2 Operation Impacts

Potential long-term impacts would result from changes in the visual appearance of transmission line corridors. Transmission towers are often more than 100 feet tall and the corridors can extend for hundreds of miles. Visual impacts vary depending upon the location and distance from sensitive viewing places and the number of potential viewers. Different landforms and vegetation influence visual impact; topography and forest cover may screen transmission line features at many locations. Because transmission lines are often considered visually unappealing, many people perceive that they negatively influence property values. Visual impacts are greatest where the transmission line is clearly visible to many people from sensitive viewing locations such as along transportation corridors or in public places. Overall, visual impacts could be low to high.

Transmission lines often cross recreational areas such as state and national forests. In most cases, there would be no direct interference or impacts on recreationists. However, the quality of recreation experience could be diminished by the presence of the lines. On the other hand, in many areas transmission and recreation can coexist, as long as the recreation activity does not require permanent infrastructure or allow people unsafe access or proximity to the transmission infrastructure. Walking, horse riding, and skiing trails are often built near or crossing transmission corridors. Overall, impacts on recreation are expected to be low to high.

9.13.3 Mitigation

See Section 9.2.4. To integrate the facility design into the surrounding landscape:

- Use tower steel that has been treated to reduce reflectivity.
- Use non-specular conductors and non-luminous insulators.
- In siting transmission lines, avoid parks and other recreation areas and use existing vegetation and topography whenever possible to limit views of the lines and structures.

Table 9-1. Summary of aesthetics and recreation impacts[32]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		Impacts are not anticipated assuming the building structure does not become aesthetically unappealing.
		L	Impacts are not anticipated assuming the building structure does not become aesthetically unappealing.
Landfill Gas	L		Typical visual impacts from construction activities. Unlikely to affect recreational users.
		L	Unlikely to adversely affect visual quality or conflict with existing recreational activities as plant would be installed at existing landfill.
Gorge Second Tunnel	M		Presence of construction equipment and ground disturbance could adversely affect the visual experience of motorists. Increased construction traffic could affect travelers through the area and construction noise may affect recreation experience.
		L	New tunnel facility is underground and will not have a visual impact.
Geothermal	M		Plant is typically located in natural or forested area where an industrial facility would be in sharp contrast to surrounding area.
		M	Impacts are highly dependent on the scenery of the area and the number and type of exposed viewers.
Biomass	M		Assume biomass facility is constructed in an area that avoids most recreational conflicts.
		M	Daily truck traffic transporting fuel to the power plant.
Wind	M		Visual impacts from construction activities and cranes. Potential impacts to travel routes due to transporting towers and turbines.
		H	Visible because of the height of wind turbines and often situated on ridges. Also potential for shadowing effects at low sun angles.
Solar Energy	M		Visual impacts and noise from construction activities. Potential impacts to travel routes due to transporting facility components.
		H	Can occupy very large areas of land resulting in substantial change to the visual quality of the setting.
Natural Gas/CCCT	M		Typical visual impacts from construction activities. Unlikely to affect recreational users.
		M	Fuel extraction activities are generally considered visually unappealing.
Renewable Energy Credits	L-M		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-H	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Unlikely that new plants would be constructed to meet demand for Market Transactions.
		M	Fuel extraction impacts, which are similar to the Natural Gas/CCCT resource.
Transmission	M		Visual impacts from clearing of project site, grading of access roads and erection of structures and their components.
		H	Transmission towers are tall and considered visually unappealing. Impact is highly dependent on the actual site developed.

[32] Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

10 HISTORIC AND CULTURAL RESOURCES

10.1 Affected Environment

Cultural resources exist throughout the Northwest and in areas where new energy facilities, including transmission, might be built. For the purposes of this section, "cultural resources" refers to archaeological resources and "historic resources" will refer to architectural or the built environment. Cultural resources are the non-renewable evidence of human occupation or activity (BPA, 2002). This evidence may be reflected in a district, site, building, structure, artifact, ruin, object, work of art, architecture, landscape or natural feature. Cultural resources are important in human history and are defined at the national, state, or local level. Cultural resources that could be affected by the construction and/or operation of electric generation plants are located throughout the study area and should be taken into consideration early in the planning process for proposed projects in order to minimize impacts.

10.2 General

10.2.1 Construction Impacts

Construction projects have the potential to directly and/or indirectly affect historic and cultural resources. The impacts or effects are dependent on a number of factors such as the location of the facility and its infrastructure, its scale, the type and frequency of construction activity, access roads and staging areas. Examples can include but are not limited to: erosion of a resource due to changes in hydrological patterns brought on by new construction; vibration impacts to a historic building's foundation; visual changes to a historic ranching landscape or traditional cultural property by the height of smokestacks or towers; or the destruction of archaeological features during excavation for building foundations. It is important to establish an appropriate project area of potential effect in order to adequately consider impacts to the resources in question.

Historic and cultural resource professionals will review the project to ensure compliance with applicable regulations. If historic and cultural resources are present within the project area of potential effect, a range of options will be considered, among them avoidance and/or the redesign/relocation of the project facility, staging areas and related infrastructure in order to minimize project impacts. If unavoidable, mitigation will be negotiated in consultation with appropriate regulatory agencies and Native American tribes.

10.2.2 Operation Impacts

Operation impacts also have the potential directly and/or indirectly affect historic and cultural resources. The impacts or effects are dependent on a number of factors such as the location of the facility and its infrastructure, its scale, the type and frequency of energy generating activities (fuel extraction, processing, and delivery). Power plant or related transmission infrastructure such as wind turbines, monopoles, and towers could be visible from historic or cultural sites, which could affect the integrity of the sites. Integrity is the ability of a property to convey its significance and includes the following qualities: location, design, setting, materials, workmanship, feeling, and association (NPS, 2002 - How to Apply the National Register Criteria for Evaluation). Traditional cultural properties or historic landscapes can be quite expansive, and even distant views of project-related infrastructure from such resources could be considered intrusive. In addition, access roads developed for construction and maintenance could improve access to an area that has historic and cultural resources and indirectly result in a greater human presence in the area, which could result in unauthorized collection of artifacts or vandalism (BLM, 2006).

10.2.3 Regulations

- Federal National Historic Preservation Act
  Enacted in 1966, the NHPA includes several sections guiding the preservation and protection of historic and cultural resources. For additional information please see: http://www.achp.gov/nhpa.html

10.2.4 Mitigation

A range of mitigation activities is possible to address project impacts to historic and cultural resources. They should be guided by the following:

- Consult early during project planning with the State Historic Preservation Officer, the Advisory Council on Historic Preservation, and Native American tribes with interests in the project area to determine areas of concern and the likelihood of any historic and cultural resources within or near the project area of potential effect, including the proposed route for transmission facilities/infrastructure.
- Conduct historic and cultural resource records and archival searches and field surveys, if necessary, to identify, assess and evaluate resources that may be present. Records and archival searches and eligibility evaluations should be guided by the standards set forth in The Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.
- Conduct National Historic Preservation Act (NHPA) Section 106 review on individual projects when there is federal involvement (funding, permitting licensing, or other function).
- Modify the project configuration (e.g., location of the power plant, access roads, substations, transmission lines, and related infrastructure), to the extent possible, to avoid historic and cultural resources identified through the survey and inventory process. Encourage the use of previously disturbed lands (e.g., existing utility or transportation corridors), rather than pristine lands.
- Develop and implement a mitigation and management plan (and design guidelines when appropriate) in consultation with appropriate authorities if historic or cultural resources in development areas cannot be avoided.
- Consult with Native American tribes to determine other issues of concern including but not limited to access rights, disruption of cultural practices, impacts to traditional cultural properties, visual and subsistence resources important to the tribes.
- Halt work immediately if historic or cultural resources are discovered during construction, notify the State Historic Preservation Officer and affected tribes, and develop and implement an appropriate mitigation program. The mitigation program may include conducting shovel probes, monitoring ground disturbance activities and mitigating any identified unavoidable impacts to historic properties or cultural resources.
- Mitigate historic resources receiving energy efficiency measures by retrofitting in a sensitive manner or locating new materials or structures in sites that respect the historic character defining features. Guidance is available from The Secretary of the Interior's Standards for the Treatment of Historic Properties and other National Park Service Preservation Briefs.

10.3 Conservation

10.3.1 Construction Impacts

Energy efficiency measures are not likely to impact cultural (archaeological) resources. However, the potential should be considered when excavation or trenching is needed to install associated facilities such as electrical lines, poles, and vaults, or foundations for related equipment such as heat pumps, streetlights, and solar panels.

Energy efficiency measures have the potential to alter the exterior and/or interior character of historic resources. Character refers to the visual aspects and physical features of a historic building and includes its

overall shape, materials, craftsmanship, decorative details, interior spaces and features, as well as the various aspects of its site and environment. Altering character-defining elements has the potential to severely affect a building's historic significance—its direct association with important events or persons, its importance in design or construction, or its information potential. Overall construction impacts would be low.

10.3.2 Operation Impacts

The selection and installation of energy efficiency measures such as replacement windows, storm windows, light fixtures, heat pumps, ductless heaters, wall and attic insulation, tubular solar skylight fixtures, etc., should consider the character-defining features and the location of new materials in, on, or near the building. In many cases, it may be possible to retain and retrofit historic fixtures while increasing energy efficiency. Overall operation impacts would be low.

10.3.3 Mitigation

See Section 10.2.4.

10.4 Landfill Gas

10.4.1 Construction Impacts

Historic and cultural resources would most likely not be affected since it is assumed that the landfill gas energy facility would be installed at an existing or permitted landfill where major disturbance would have already occurred. Construction impacts would be low, assuming new transmission facilities are not required.

10.4.2 Operation Impacts

See the General Operation Impacts Section 10.2.2. Operation impacts are not anticipated or would be low.

10.4.3 Mitigation

See Section 10.2.4.

10.5 Gorge Second Tunnel (Hydro Efficiency)

10.5.1 Construction Impacts

The proposed Gorge Second Tunnel will be located parallel to the original historic power tunnel which is, along with other buildings, structures, and objects, a contributing resource to the National Register of Historic Places-listed Skagit River and Newhalem Creek Hydroelectric Projects. The project has been designed to avoid impacts to those resources or restore them to pre-construction conditions following construction. Construction limits are identified to eliminate the potential of disturbing known resources during construction activities. It is possible but highly unlikely that additional historic or cultural resources could be discovered during project activities. The project area has been evaluated by cultural resource professionals and an Unanticipated Discovery Plan has been developed to address protection of any resources discovered during construction. Impacts are expected to be low.

10.5.2 Operation Impacts

The project might have an impact on places held sacred by Native American Indian tribes. A portion of the second subterranean tunnel alignment would pass beneath the Stephen Mather Wilderness Area within the existing Skagit Project FERC boundary. While there would be no surface disturbance within the Wilderness Area, the character of the wilderness resource could be symbolically affected by the addition of a permanent subterranean installation within the wilderness. However, this project would not set a precedent for tunneling

beneath wilderness areas because the Skagit Project precedes creation of the Ross Lake National Recreation Area and the Stephen Mather Wilderness Area and SCL has the authority to operate and maintain the Skagit Project within the FERC boundary. Therefore, operation impacts are expected to be low.

10.5.3 Mitigation

See Section 10.2.4.

10.6 Geothermal

10.6.1 Construction Impacts

Construction of geothermal facilities could affect existing historic and cultural resources in and around the construction footprint due to surface disturbance and subsurface excavation of the wells and the aboveground facility and infrastructure (building, pipelines, etc.). Since geothermal facilities are commonly located near geysers, volcanoes, or other geologic formations that may be historically valued or used by Native American tribes or other early peoples, impacts from construction would be moderate.

10.6.2 Operation Impacts

See the General Operation Impacts Section 10.2.2. Assuming facility related infrastructure is not visible from historic or cultural resources, impacts would be low.

10.6.3 Mitigation

See Section 10.2.4.

10.7 Biomass

10.7.1 Construction Impacts

Construction of biomass facilities could affect existing historic and cultural resources. The occurrence and significance of construction impacts on these resources are highly dependent on facility location and its infrastructure, scale and design. However, planning and design would try to avoid historic and cultural resources. Biomass cogeneration plants are more likely to be located in existing or planned structures; therefore, the likelihood that historic and cultural resources would be encountered during construction is less when compared to a stand-alone plant. If unavoidable, consultation would be initiated before project activities following the guidance in Section 10.2.1. Impacts are expected to be low to moderate.

10.7.2 Operation Impacts

See General Operations Impact Section 10.2.2. There would be no incremental impacts if mill waste is used, and probably low impacts if logging residue is used for fuel.

10.7.3 Mitigation

See Section 10.2.4.

10.8 Wind

10.8.1 Construction Impacts

Wind energy projects have the potential to disturb archaeological sites and traditional cultural properties, though they are often situated in farm or rural areas where farming or other activities may have already

disturbed historic and cultural resources. Overall, impacts during construction could range from low to moderate.

10.8.2 Operation Impacts

See General Operations Impact Section 10.2.2. Overall, the potential for visual impacts due to the height of the wind turbines and towers could range from low to high.

10.8.3 Mitigation

See Section 10.2.4.

10.9 Solar Energy

10.9.1 Construction Impacts

The occurrence and significance of utility-scale solar facility construction impacts on cultural resources are highly dependent on facility location. Known cultural resource sites would be avoided in locating a plant site but, like most projects involving subsurface excavation, solar projects have the potential to lead to the discovery of previously unknown archaeological resources. If cultural resources are discovered within the project area because of construction activities, it is possible that disturbance of those sites could be avoided through careful location of project facilities and roads. If cultural resources are present and construction impacts cannot be avoided, a resource inventory and mitigation program would be needed. Overall, depending on the discovery of unknown archaeological resources, impacts during construction could range from low to moderate. Since most distributed solar PV facilities are attached to existing buildings or structures, direct impacts from the distributed solar PV facilities are expected to be low.

10.9.2 Operation Impacts

Operational impacts on cultural resources could occur if the solar project is visible from archaeological or historic sites. Depending upon land use and access conditions, development of the project could improve access to a local area and indirectly result in a greater human presence in the area, which could result in unauthorized collection of artifacts or vandalism. Overall, impacts could range from low to moderate, although if solar PV equipment is attached to or visible from historic buildings or structures, the impacts could be high.

10.9.3 Mitigation

See Section 10.2.4. The applicable local, state, or federal regulations should be followed. Additional analysis and specific mitigation steps should be developed for each project to address unique situations with historic buildings and structures.

10.10 Natural Gas Combined-Cycle Combustion Turbines

10.10.1 Construction Impacts

Depending on location, construction of a plant or pipeline on an undisturbed site could potentially affect historic and/or cultural resources. Impacts could be moderate.

10.10.2 Operation Impacts

As described in the General Operation Impacts Section 10.2.2., historic or cultural resources could be encountered during fuel extraction activities. A records and archive search and/or survey of the project area is typically performed before extraction activities. If cultural resources are anticipated, coordination with regulatory agencies and Native American tribes with interests in the area would be conducted as well as

monitoring during extraction to ensure care is taken if cultural resources are uncovered. Impacts could be low to moderate, depending upon the location and extent of the extraction activities.

10.10.3 Mitigation

See Section 10.2.4.

10.11 Renewable Energy Credits

10.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

10.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

10.11.3 Mitigation

See Section 10.2.4.

10.12 Market Transactions

10.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Construction impacts would be low.

10.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion Turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, these impacts would be low to moderate.

10.12.3 Mitigation

Mitigation options are limited to those that can be applied to the fuel extraction and transportation process, since the plants have already been built, and it is unlikely that these plants would modify the facilities or uses in order to meet the incremental demand with reduced impacts to historic and cultural resources. See Section 10.2.4 of this Appendix for details on mitigation options.

10.13 Transmission

10.13.1 Construction Impacts

Construction of transmission facilities requires surface and subsurface disturbance that could affect historic and cultural resources. The occurrence and significance of construction impacts on these resources are highly dependent on facility location and its infrastructure, scale and design. Additionally, since transmission infrastructure tends to cover large areas and/or are linear in design, they have the potential to cross over or

near historic and cultural resources. In general, historic and cultural resource impacts are likely to be low to moderate since most potential resource sites can either be avoided, follow established transmission corridors, or alter the design (color, footprint, etc.) of the facility.

10.13.2 Operation Impacts

See General Operations Impact Section 10.2.2. Assuming transmission infrastructure is not visible from historic or cultural sites, impacts would be low. However, based upon the height and potential visibility of transmission lines, moderate long-term impacts are assumed.

10.13.3 Mitigation

See Section 10.2.4.

Table 10-1. Summary of historic and cultural resource impacts[33]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	L		Assuming reasonable mitigation measures altered appearances or integrity of historical buildings is unlikely.
		L	Potential to alter appearance of historic buildings.
Landfill Gas	L		Installed at an existing or permitted landfill where disturbance would have already occurred.
		L	Visual disturbance is not anticipated.
Gorge Second Tunnel	L		Project has been evaluated for cultural resources and designed to protect known resources; an Unanticipated Discovery Plan will be implemented.
		L	Small potential to affect the character of the wilderness resource due to the addition of permanent tunnel.
Geothermal	M		Potential for geothermal facility to be located in an area that is historically valued or used by Indian tribes.
		L	Low visual disturbance.
Biomass	M		Plant construction requires surface and subsurface disturbance.
		L	Low incremental impact if mill waste or logging residue is used.
Wind	M		Likely located in rural areas where farming has already disturbed the surface.
		H	Height of turbines increases potential for visual impact.
Solar Energy	M		Potential for disturbance due to large land area required for utility scale solar energy projects.
		H	Potential to be visible from archaeological or historic sites.
Natural Gas/CCCT	M		Potential for disturbance due to sub-surface excavation for pipeline installation.
		M	Resources could be encountered during ongoing fuel extraction activities.
Renewable Energy Credits	L-M		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		L-M	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	L		Unlikely that new plants would be constructed to meet demand for Market Transactions.
		M	Resources could be encountered during ongoing natural gas fuel extraction activities.
Transmission	M		Although transmission lines cover large distances and require subsurface disturbance, most sites can be avoided.
		H	Height of transmission infrastructure increases potential for visual impact from cultural or historical sites.

[33] Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

11 EMPLOYMENT

11.1 Affected Environment

Although not required by SEPA, a general analysis of construction and operation employment, was conducted to identify potential differences among the portfolios. While the following evaluation is not meant to be a detailed economic evaluation of employment impacts, the information may be helpful in discerning the differences among portfolios and the trade-offs between adverse and beneficial characteristics of the portfolios. The approach of this analysis is to show increases in direct employment at the power plants, both during construction or operation, and in fuel extraction, not secondary employment impacts. Increases in employment are designated as being positive. Information about general economic conditions, below, is meant to provide context, not a thorough analysis of the regional and local economic conditions.

The pace and composition of economic growth in SCL's service area and the region are major determinants of future demand for electricity and the amount of new energy that is needed to satisfy the demand. A major factor in the Great Recession of 2008/2009 was the collapse of the housing market bubble. Job loss nationally and the mean duration of unemployment are both the highest on record in more than 30 years. Nationally, it is forecast to be three more years before the recession job loss is made up. The U.S. Gross Domestic Product growth is forecasted to stay below average until 2020. The slow housing market, high oil prices, and sovereign debt crisis all contribute to a slow economic recovery. Regionally, the Great Recession job loss was 7.4 percent and the recovery is forecasted to take 15 quarters. The regional economy continues to improve although it has yet to regain the employment levels of 2007.

Puget Sound population and housing market are slowly starting to rebound from the Great Recession. Net migration to Puget Sound fell 90 percent from the first quarter of 2009 to the first quarter of 2010. Net migration has been slowly growing since the first quarter of 2011. Housing starts fell 85 percent from a 2008 peak, but now are recovering. The housing starts are led by multi-family housing and early signs of life in single-family housing. In the first quarter of 2012, the downtown Seattle commercial vacancy rate reduced to almost the level seen in spring 2009. Amazon.com has grown their footprint in downtown Seattle and the South Lake Union neighborhood in recent years.

The Seattle economy is dependent on the aerospace, hi-tech, and biotech industries. Unlike the recession in 2001-2003, there were not large layoffs at Boeing during the 2008/2009 Great Recession. Boeing is growing and is responsible for about a third of the Puget Sound employment in the manufacturing sector. The professional and business services sector industry added the most Washington State jobs in 2011. Retail trade and leisure hospitality increased jobs in 2011, meaning that discretionary spending is increasing. While private sector jobs in Washington increased in 2011, the amount of public sector jobs decreased. Public employers, like the State of Washington, continued to make job cuts.

Economic conditions in the vicinity of energy resources is likely to be quite variable, ranging from highly developed in the Seattle area to much less developed in rural areas. The structure of the local economies will influence their ability to provide the labor, goods, and services that are needed to build and operate energy facilities and, therefore, to benefit from the economic stimulus that such facilities provide. The local economy in the area the new energy resource is located will benefit from added "direct" employment. This often carries an employment multiplier of two or more additional "indirect" service sector jobs for each direct job created. Some indirect job creation could occur in more urbanized areas if the area where the new energy resource is located has no nearby communities.

11.2 General

11.2.1 Construction Impacts

Construction of energy projects typically provides short-term, positive, direct, indirect, and induced employment and economic effects. Direct refers to the employment and personal income associated with the design, manufacturing, delivery, construction/installation, project management, and operation and maintenance of the different components of the power plant. According to Wei et al. (2010), "Indirect employment refers to the "supplier effect" of upstream and downstream suppliers. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbines is an indirect job. Induced employment accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees." Therefore, in addition to the jobs created from construction projects and the corresponding increase in personal income, there is often a beneficial impact from spending on construction materials and services associated with a project.

In order to compare the quantity of jobs created for different resources, employment data can be presented in units of "jobs/aMW," or one full-time equivalent (FTE) job created per average megawatt (aMW) of power output. One FTE job is defined as full-time employment for one person for a duration of one year. The advantage of normalizing jobs based on average power output is that the method accounts for the scale of the facility and allows comparison of resources with different capacity factors. The method also accounts for the fact that lower capacity technologies have to build more plants than higher capacity technologies to deliver the same power. A report by the Berkeley Energy and Resources Group (Wei, 2010) synthesized data from 15 job studies and calculated the one-time jobs created from construction, installation, and manufacturing and the ongoing jobs created from operation, maintenance, and fuel processing activities. The study concluded that "the renewable energy and low carbon sectors generate more jobs per unit of energy delivered than the fossil fuel-based sector" and that "among the common RPS [Renewable Portfolio Standard] technologies, solar photo voltaic (PV) creates the most jobs per unit of electricity output." Conservation measures, based on studies done of SCL's programs (SCL, 2008), result in even higher employment levels than shown in the Berkeley Energy Group analysis. Based upon estimates of the total level of funding for these conservation programs, they are estimated to result in over 38 jobs per average megawatt hour, per year.

With some resources, particularly solar PV, the data varies greatly. For example, the jobs created during construction, installation, and manufacturing of solar PV projects average about 5.10 jobs/aMW but it could range from 1.4 to 7.4 jobs/aMW (Wei, 2010). Solar PV has the highest average job multiplier of the renewables with a large gap between it and the next highest renewable technology. The job multiplier gap is likely because the study evaluated residential PV projects that have many discrete panel installations as compared to a single location for a wind farm.

Figure 3 shows the average number of jobs created per average MW of power output from construction, installation, and manufacturing.

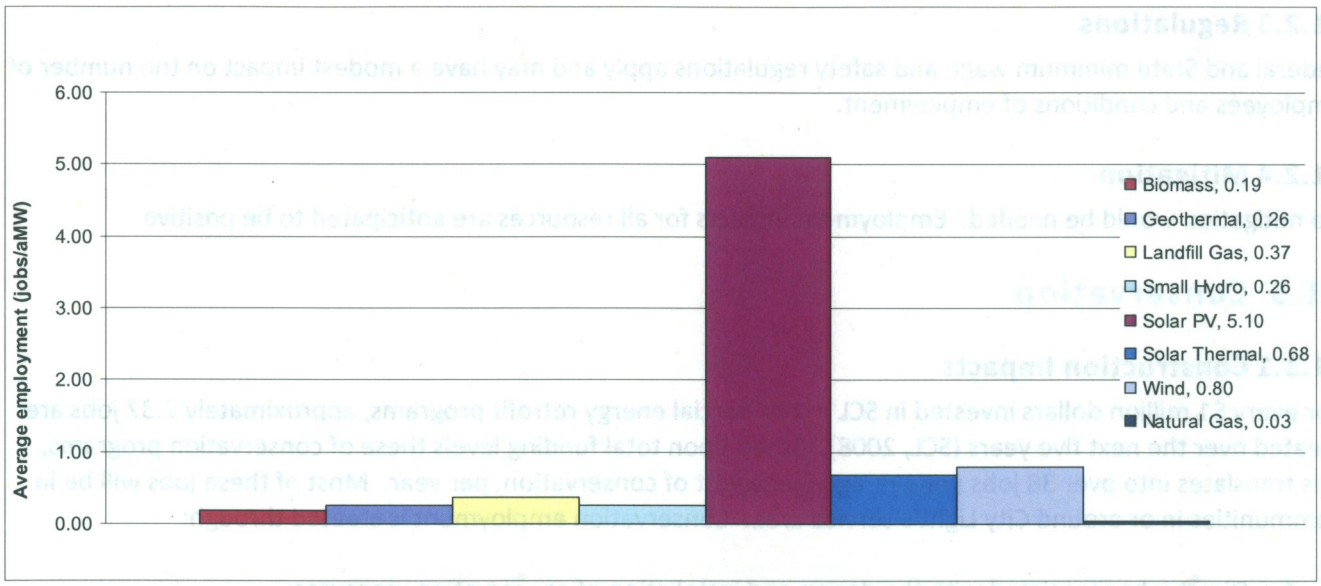

Figure 3. Average employment over the life of a facility from construction, installation, and manufacturing. This figure does not show conservation, which is estimated to be over 38 jobs per aMW, per year (SCL, 2008)

11.2.2 Operation Impacts

There is a permanent increase in employment and personal income associated with operation and maintenance of an energy facility.

Figure 4 shows the number of jobs/aMW of power output from operations, maintenance and fuel processing activities.

The operation of energy facilities can also yield direct income for local jurisdictions through taxes and income for local residents through lease payments.

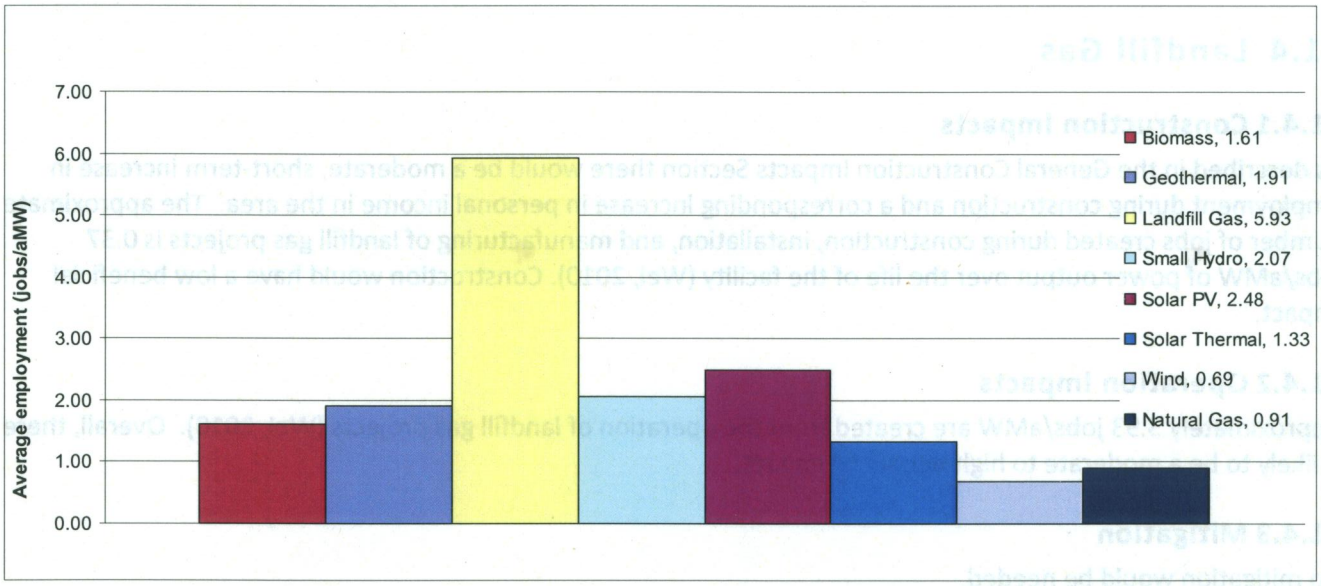

Figure 4. Average employment over the life of a facility from operation, maintenance and fuel processing. This does not show Conservation. See note in Figure 3 for total Conservation employment impacts.

11.2.3 Regulations

Federal and State minimum wage and safety regulations apply and may have a modest impact on the number of employees and conditions of employment.

11.2.4 Mitigation

No mitigation would be needed. Employment impacts for all resources are anticipated to be positive.

11.3 Conservation

11.3.1 Construction Impacts

For every $1 million dollars invested in SCL's commercial energy retrofit programs, approximately 7.37 jobs are created over the next five years (SCL, 2008). Based upon total funding levels these of conservation programs, this translates into over 38 jobs per average megawatt of conservation, per year. Most of these jobs will be in communities in or around City Light's service area. Conservation employment is created through:

1. Direct jobs associated with the design and installation of conservation measures;
2. Indirect jobs via businesses who make or supply conservation materials; and
3. Induced jobs created by wages and salaries spent by the directly and indirectly employed.

This represents a high positive impact. Increased employment and expenditures would result in increased levels of personal income.

11.3.2 Operation Impacts

Induced jobs would be created by spending the additional household savings from energy efficiency measures. A small beneficial impact is anticipated.

11.3.3 Mitigation

No mitigation would be needed.

11.4 Landfill Gas

11.4.1 Construction Impacts

As described in the General Construction Impacts Section there would be a moderate, short-term increase in employment during construction and a corresponding increase in personal income in the area. The approximate number of jobs created during construction, installation, and manufacturing of landfill gas projects is 0.37 jobs/aMW of power output over the life of the facility (Wei, 2010). Construction would have a low beneficial impact.

11.4.2 Operation Impacts

Approximately 5.93 jobs/aMW are created from the operation of landfill gas projects (Wei, 2010). Overall, there is likely to be a moderate to high beneficial impact.

11.4.3 Mitigation

No mitigation would be needed.

11.5 Gorge Second Tunnel (Hydro Efficiency)

11.5.1 Construction Impacts

See General Construction Impacts Section 11.2.1. Overall, there will be a small temporary increase in employment opportunities during construction. There will be a minor increase in local spending by workers for housing and food. Construction would have a low beneficial impact.

11.5.2 Operation Impacts

See the General Operations Impacts Section 11.2.2. There will be a minor increase in employment opportunities during an approximately three-year post-construction period for monitoring and maintaining the successful establishment of revegetated areas. Operation of the new tunnel would not require the creation of new permanent jobs. Operation would have a low beneficial impact.

11.5.3 Mitigation

No mitigation would be needed.

11.6 Geothermal

11.6.1 Construction Impacts

Construction of a geothermal facility would result in a low increase in temporary employment during construction activities as described in the General Construction Impacts Section 11.2.1. The quantity of jobs created over the life of the facility during construction, installation, and manufacturing is about 0.26 jobs/aMW of power output (Wei, 2010).

11.6.2 Operation Impacts

Operation of a geothermal facility would yield a moderate increase (about 1.91 jobs/aMW) in permanent jobs as described in the General Operations Impacts Section 11.2.2.

The operation of a geothermal facility would also yield direct income for local jurisdictions through taxes, as well as savings from the use of the technology over more costly energy sources. No adverse impacts are expected.

11.6.3 Mitigation

No mitigation would be needed.

11.7 Biomass

11.7.1 Construction Impacts

See General Construction Impacts Section 11.2.1. As shown in Figure 2, the number of construction jobs created over the life of a biomass facility is about 0.19/aMW of power output (Wei, 2010). A low beneficial impact is expected.

11.7.2 Operation Impacts

Beneficial impacts during operation would be moderate primarily because of the higher need, relative to other power plants, for fuel processing and handling. If the fuel source is mill waste, there would likely be little additional employment other than the plant operations. If logging residue is the fuel source, there would be some additional employment associated with collecting and transporting the residue. The amount of

employment would vary with site, and may be seasonal, temporary, and low-wage. The number of full-time jobs created from the operation and fuel-processing requirements is approximately 1.6 jobs/aMW of power output.

11.7.3 Mitigation

No mitigation would be needed.

11.8 Wind

11.8.1 Construction Impacts

Economic impacts from construction of wind energy facilities are generally considered positive (NEA, 2003; AWEA, 2012b RNP, 2012). For example, as of February 2012, approximately 3,200 construction jobs have been created by Washington State's wind industry sector (Renewable Northwest Project, 2012). Using the same methods and assumptions as the Berkeley Energy and Resources Group study, the 3,200 construction jobs estimated by the Renewable Northwest Project corresponds to 0.12 jobs/aMW, which is more than the 0.80 jobs/aMW estimated in the Berkeley study.[34] Overall, there would be a low beneficial impact.

11.8.2 Operation Impacts

As of February 2012, the wind industry sector has created about 215 permanent operation and maintenance jobs in Washington State (Renewable Northwest Project, 2012). Because wind farms are typically located in rural areas with small economies, the addition of even a few permanent jobs with good incomes is typically considered positive. As shown in Figure 3, a small permanent increase in employment (0.69 jobs/aMW) is anticipated with the operation and maintenance of a wind energy facility.

Wind energy facilities that are developed and owned by private entities (as opposed to public utilities) are taxed as real and/or personal property and contribute to the tax base of the local jurisdiction. Because wind farms are relatively capital intensive, this contribution can be quite substantial in a small, rural economy.

Furthermore, wind energy developers typically lease the land that the project facilities are built on, and provide annual lease payments to the landowners. Lease payments represent an ongoing stream of increased personal income for the local economy, and a substantial and diversified income source for the landowner. In some cases, the financial benefits of a wind project allow ranches or farms to continue operation on the host properties, and avoid converting the land to other income-producing uses. Overall operation would have a low beneficial impact.

11.8.3 Mitigation

No mitigation would be needed.

11.9 Solar Energy

11.9.1 Construction Impacts

The jobs created during construction, installation, and manufacturing of solar PV projects average about 5.10 jobs/aMW but there is a large variation; employment could range from 1.4 to 7.4 jobs/aMW (Wei, 2010). The jobs created during construction, installation, and manufacturing of solar thermal projects average 0.68 jobs/aMW and vary from about 0.6 to 1.0 jobs/aMW. Solar PV has the highest average job multiplier with a large gap between it and the next highest renewable technology. This gap is likely because the Wei study

[34] Over the lifetime of the facility, 0.12 jobs/aMW = 3,200jobs (2,975 MW installed wind capacity x 25-year equipment lifetime x 35 percent capacity factor).

evaluated some distributed, residential PV projects that have many discrete panel installations, compared to a single location for a wind farm. Thus, utility-scale PV projects would likely have fewer jobs created then the estimated 5.10 jobs/aMW. As described in the General Construction Impacts Section 11.2.1, there would also be an induced positive impact to the economy. Overall, there would be a moderate to high positive impact.

11.9.2 Operation Impacts

Operating and maintaining a solar facility would require varying numbers of on-site personnel, depending on capacity and technology of the facility. Approximately 2.48 jobs/aMW are created from the operation and maintenance of PV systems and about 1.33 jobs/aMW are created from solar thermal facilities (Wei, 2010). Overall, there would be a moderate beneficial impact.

11.9.3 Mitigation

No mitigation would be needed.

11.10 Natural Gas Combined-Cycle Combustion Turbines

11.10.1 Construction Impacts

There would be a small temporary increase in employment and economic benefit associated with the construction, installation, and manufacturing of a natural gas combined-cycle combustion turbine (CCCT). The estimated quantity of jobs created is 0.03 jobs/aMW over the life of the facility (Wei, 2010). Construction would have a low beneficial impact.

11.10.2 Operation Impacts

Typically, economic impacts of natural gas extraction activities are beneficial because they increase economic activity. Extraction activities would result in increased direct spending, employment, and labor income representing economic benefits to the areas where materials and supplies are purchased and areas where workers are hired. Secondary spending, jobs, and related labor income would also increase due to workers' household spending and spending by suppliers. Economic benefits related to extraction would last approximately as long as extraction activities continue.

The average quantity of fuel processing, operation, and maintenance jobs created is about 1.6 jobs/aMW of power output. As described in the General Operations Impacts Section 11.2.2, there is also a direct and induced positive economic effect associated with the employment. Operation would have a low beneficial impact.

11.10.3 Mitigation

No mitigation would be needed.

11.11 Renewable Energy Credits

11.11.1 Construction Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

11.11.2 Operation Impacts

This analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects. The level of potential impact will vary depending on the renewable electricity resource that produces the REC.

11.11.3 Mitigation

No mitigation would be needed.

11.12 Market Transactions

11.12.1 Construction Impacts

Since almost all market transaction energy will be supplied by existing resources, there are minimal incremental impacts. It is unlikely that new plants would be constructed only to meet demand for these market transactions. Construction would have a low beneficial impact on employment.

11.12.2 Operation Impacts

On average, impacts would be slightly greater than new Natural Gas Combined-Cycle Combustion Turbines described in this Appendix because of the higher heat rate of market transactions compared to a new natural gas plant, and the consequent requirement for more fuel extraction. Overall, there would be a low positive impact.

11.12.3 Mitigation

No mitigation would be needed.

11.13 Transmission

11.13.1 Construction Impacts

There would be a small, short-term increase in employment during construction (both local and non-local workers) and a corresponding increase in personal income in the area. Also, as described in the General Construction Impacts Section, there would be a low beneficial impact associated with spending for construction materials and transmission facilities.

11.13.2 Operation Impacts

There would be a small permanent increase in employment and personal income associated with operation and maintenance of the transmission lines. Maintenance employment would be periodic and the size of the maintenance crew would vary with location (e.g., a larger crew would be needed where vegetation maintenance is needed). Operation would have a low beneficial impact on employment.

11.13.3 Mitigation

No mitigation would be needed.

Table 11-1. Summary of employment impacts[35]

Resource	Construction	Operation	Notes/Assumptions/Summary of unique impacts
Conservation	+H		Most of the jobs would be in communities within or surrounding City Light's service territory.
		+L	Household savings results in induced economic effects.
Landfill Gas	+L		Short-term increase in employment.
		+H	Permanent increase in employment.
Gorge Second Tunnel	+L		Short-term increase in employment.
		+L	Operation of the new tunnel would not require the creation of new permanent jobs.
Geothermal	+L		Short-term increase in employment.
		+M	May yield direct income for local jurisdictions through taxes in addition to the O&M jobs.
Biomass	+L		Short-term increase in employment.
		+M	Typical power plant operation and maintenance jobs and a higher need, relative to other power plants, for fuel processing.
Wind	+L		Short-term increase in employment. About 3,200 construction jobs have been created by Washington State's wind industry sector.
		+L	Lease payments to landowners in addition to O&M jobs.
Solar Energy	+H		Large variation depending on solar energy technology.
		+M	Permanent increase in employment.
Natural Gas/CCCT	+L		Short-term increase in employment.
		+L	Typical power plant operation and maintenance jobs and jobs from fuel extraction activities and pipeline construction.
Renewable Energy Credits	+L - +H		Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
		+L - +H	Analysis assumes SCL will purchase RECs from wind, wood biomass, geothermal, or landfill gas renewable energy projects.
Market Transactions	+L		It is unlikely that new plants would be constructed to meet the demand for market transactions.
		+L	Jobs from fuel extraction activities and pipeline construction.
Transmission	+L		Short-term increase in employment.
		+L	Employment would be periodic and depend on transmission line vegetation maintenance needs.

[35]Where a range of potential impacts has been identified, the highest level is depicted in the summary table.

12 REFERENCES

American Wind Energy Association (AWEA), 2012 a. "Industry Statistics." Washington, DC, 2012. www.awea.org/learnabout/industry_stats/index.cfm

AWEA 2012b. "State Fact Sheets." Washington, Idaho, Oregon, and Montana. www.awea.org/learnabout/publications/factsheets/factsheets_state.cfm

AWEA 2012c. "US Industry Consensus Standards Development Activities." www.archive.awea.org/standards/aweastds.html

Bonneville Power Administration (BPA), 1993. *Final Environmental Impact Statement, Resource Programs*, Volume 1: Environmental Analysis. DOE/EIS-0162. Bonneville Power Administration, Portland, Oregon.

Bonneville Power Administration (BPA), 2000. Transmission System Vegetation Management Program. Final Environmental Impact Statement. DOE/EIS-0285 May 2000. efw.bpa.gov/environmental_services/Document_Library/Vegetation_Management/FEIS0285.pdf

Bureau of Land Management (BLM), 2004. *Draft Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States*. US Department of the Interior, Bureau of Land Management. Washington, DC, 2004.

Bureau of Land Management (BLM), 2006. Final Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States. Washington DC, January 11, 2006.

Bureau of Land Management (BLM), 2010. Solar Energy Development Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States. December, 2010. http://solareis.anl.gov/documents/dpeis/index.cfm

California Energy Commission (CEC), 2005. *Environmental Performance Report of California's Electrical Generation System.* Sacramento, California. 2005. www.energy.ca.gov/2005publications/CEC-700-2005-016/CEC/700-2005-016.PDF

DePater, C.J. and Baisch S., 2011. "Geomechanical Study of Bowland Shale Seismicity Synthesis Report." November 2, 2011. www.cuadrillaresources.com/wp-content/uploads/2012/02/Geomechanical-Study-of-Bowland-Shale-Seismicity_02-11-11.pdf

DNR, see Washington State Department of Natural Resources.

Ecology, Washington State Department of, see: Washington State Department of Ecology.

eGRID2012, see: US Environmental Protection Agency.

Fleischmann, Daniel J., 2006. "Global Warming and the Role of Wind Energy." North America Wind Power magazine, February 2006, vol 3, no. 1, page 36.

Geothermal Energy Association (GEA), 2012. http://www.geo-energy.org/

Grantham, John B. and Jack O. Howard. *Logging Residue as an Energy Source*. Seattle, WA: U.S. Forest Service.

Green, Christopher A., Peter Styles, Brian J. Baptie, 2012. Preese Hall Shale Gas Fracturing Review and Recommendations for Induced Seismic Mitigation. GFRAC, Keele University and British Geological Society. April 2012. http://og.decc.gov.uk/en/olgs/cms/explorationpro/onshore/cuadrilla_decc/cuadrilla_decc.aspx

ICNIRP, 2010. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Phys 99(6):818-836.

International Agency for Research on Cancer (IARC), 2002. *Non-ionizing Radiation, Part 1: Static and Extremely Low-Frequency Electric and Magnetic Fields.* IARC Monogr Eval Carcinog Risk Hum. 2002;80

International Committee on Electromagnetic Safety (ICES), 2002. IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz. www.emfs.info/Related+Issues/limits/specific/ICES2002/

Intergovernmental Panel on Climate Change (IPCC), 2012. http:// www.ipcc.ch

Kammen, Daniel, James Nelson, Ana Mileva, and Josiah Johnston, 2011. "An Assessment of the Environmental Impacts of Concentrator Photovoltaics and Modeling of Concentrator Photovoltaic Development using the SWITCH model," Berkeley, California: UC Berkeley Renewable and Appropriate Energy Laboratory, 2011. http://rael.berkeley.edu/node/781

Lovich, Jeffrey E. and Joshua R. Ennen, 2011. "Wildlife Conservation and Solar Energy Development in the Desert Southwest, United States." *BioScience*, Vol. 61, No. 12 (December 2011), pp. 982-992. Published by University of California Press. www.jstor.org/stable/10.1525/bio.2011.61.12.8

McKinlay AF, Allen SG, Cox R, Dimbylow PJ, Mann SM, Muirhead CR, Saunders RD, Sienkiewicz ZJ, Stather JW, Wainwright PR. NRPB. 2004. Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz). Doc NRPB 15(3):i-210. www.hpa.org.uk/Publications/Radiation/NPRBArchive/DocumentsOfTheNRPB/Absd1503/ (accessed 01 June 2012)

Natural Gas Supply Association (NGA), 2006a. "Directional and Horizontal Drilling." www.naturalgas.org/naturalgas/extraction_directional.asp

Natural Gas Supply Association (NGA), 2006b. "Onshore Drilling." 2006. www.naturalgas.org/naturalgas/extraction_onshore.asp

Natural Gas Supply Association (NGA), 2006c. "Rotary Drilling." 2006. www.naturalgas.org/naturalgas/extraction_rotary.asp

National Institute of Environmental Health Science (NIEHS), 1998. Assessment of health effects from exposure to powerline frequency electric and magnetic fields. NIEHS working group report, June 1998. www.niehs.nih.gov/health/assets/docs_a_e/assessment_of_health_effects_from_exposure_to_powerline_frequency_electric_and_magnetic_fields.pdf

National Renewable Energy Laboratory (NREL), 2001. *National Renewable EnergyLab Report: Life Cycle Assessment of Hydrogen Production via Natural Gas Steam Reforming*. February 2001. www.nrel.gov/docs/fy01osti/27637.pdf.

National Renewable Energy Laboratory (NREL), 2006. *Power Technologies Energy Data Book,* fourth edition. Aabakken, Jørn, ed. Report No. NREL/TP-620-39726. Golden, Colorado. http://www.nrel.gov/analysis/power_databook/

National Renewable Energy Laboratory (NREL), 2011. "A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies." J Macknick, R Newmark, G Heath, KC Hallett, March 2011.

National Resources Defense Council (NRDC), 2003. *Is Landfill Gas Green Energy?* by Chen, Cliff and Nathanael Greene. New York, 2003. http://www.nrdc.org/air/energy/lfg/lfg.pdf

National Wind Coordinating Committee (NWCC), 2002. *Permitting of Wind Energy Facilities: A Handbook.* National Wind Coordinating Committee, Siting Subcommittee. Washington, DC, 2002. http://pbadupws.nrc.gov/docs/ML1129/ML11294A539.pdf

National Wind Coordinating Committee (NWCC), 2010. Birds and Bats Fact Sheet. *Wind Turbine Interactions with Birds, Bats, and their Habitats: A Summary of Research Results and Priority Questions.* Washington, DC, 2010. www.nationalwind.org/assets/publications/Birds_and_Bats_Fact_Sheet_.pdf

National Wind Coordinating Committee (NWCC), 2011. Comprehensive Guide to Studying Wind Energy/Wildlife Interactions. Washington, DC, November 2011. www.nationalwind.org//publications/comprehensiveguide.aspx

Nicholson, Craig, and R.L. Wesson, 1990. Earthquake Hazard Associated with Deep Well Injection--A Report to the US Environmental Protection Agency. US Geological Survey Bulletin 1951, 74 p.

Northwest Economic Associates, Inc., (NEA), 2003. *Assessing the Economic Development Impacts of Wind Power; Final Report, January 8, 2003.* Prepared for the National Wind Coordinating Committee, c/o RESOLVE, Washington, DC. Vancouver, Washington. 2003. www.nationalwind.org/assets/past_workgroups/Assessing_the_Econ_Development_Impacts_of_Wind_-_March_2003.pdf

Northwest Power and Conservation Council (NWPCC, 2005). Fifth Power Plan. Portland, Oregon, May 2005. http://www.nwcouncil.org/energy/powerplan/5/Default.htm

Northwest Power and Conservation Council (NWPCC, 2010). Sixth Northwest Conservation and Electric Power Plan. Portland, OR. February 2010. http://www.nwcouncil.org/energy/powerplan/6/default.htm

New York State Department of Environmental Conservation (NYSDEC), 2011. Revised Draft, Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program; Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs. NYSDEC with Assistance from Alpha Environmental, Inc., Ecology and Environment Engineering, P.C., ICF International, URS Corp, NTC Consultants and Sammons/Dutton LLC. September 7, 2011.

Office of Surface Mining (OSM), 2010. "Reclamation and Enforcement." Last modified December 12, 2010. http://www.osmre.gov/

Oregon Department of Forestry (ODF), 2011. *Environmental Effects of Woody Biomass Collection & Conversion, 2011 Report Update.* Salem, OR. November 2011. www.oregon.gov/Biomass/docs/Environmental_effects_of_woody_biomass_collection_and_conversion_102511.pdf

Oregon Energy Facility Siting Council (OEFSC, 2006). "Order in the matter of the 500 Megawatt Exemption from the Demonstration of Showing Need for a Power Plant." 2006. www.oregon.gov/ENERGY/SITING/docs/500mw.pdf

Oregon Toxics Alliance (OTA), 2009. Oregon Toxics Alliance Testimony on Seneca Sustainable Energy (206470) Standard Air Contaminant Discharge Permit (Number 206470). Letter to Merlyn Hough, Director, and Sandra Lopez, Permit Writer, Lane Regional Air Protection Agency, Springfield, OR. (August 20, 2009). http://oregontoxics.org/AQ/Seneca/OTA_TESTIMONY_EXHIBITS_8-20-09_all%20docs.pdf

Pace Energy and Climate Center (PECC), 2005. "Power Scorecard: Electricity from Biomass." Last modified 2005. www.powerscorecard.org/tech_detail.cfm?resource_id=5

Renewable Northwest Project (RNP), 2012. "Washington's Renewable Energy Industry: Economic Benefit Report." 2012. http://rnp.org/sites/default/files/pdfs/WA%20Econ%20Benefits%20Fact%20Sheet%202011%20v12Feb13.pdf

Seattle City Light (SCL). "Global Warming." www.seattle.gov/light/conserve/globalwarming/

Seattle City Light (SCL), 1996. *Integrated Resource Plan: Strategic Resources Assessment Draft Environmental Impact Statement.* 1996.

Seattle City Light (SCL), 2006. *Integrated Resource Plan: Strategic Resources Assessment Draft Environmental Impact Statement.* 2006. www.seattle.gov/light/news/issues/irp/

Seattle City Light Conservation Resources Division (SCL), 2008. *2008–2012 Action Plan. Building a World-Class Conservation Power Plant.* September 16, 2008. www.seattle.gov/light/Conserve/docs/Conservation_5_Year_Action_Plan.pdf

Solar Turbines, A Caterpillar Company. "Gas Turbine Overview." Last modified 2011. http://mysolar.cat.com/cda/layout?m=35442&x=7

Spath, Pamela L., and Margaret K. Mann, 2001. *Life Cycle Assessment of Hydrogen Production via Natural Gas Steam Reforming.* Report No. NREL/TP-570-27637. Golden, CO: National Renewable Energy Laboratory, February 2001. www.nrel.gov/docs/fy01osti/27637.pdf

Stockholm Environment Institute (SEI), 2010. *Greenhouse Gas and Air Pollutant Emissions of Alternatives For Woody Biomass Residues: Final Draft Version 2.0.* Prepared for Olympic Region Clean Air Agency. Olympia, WA. November 2010. http://news.orcaa.org/2010/12/woody-forest-debris-emissions-study-available/

US Department of Energy, 2012. *Sunshot Visions Study.* Prepared by the US Office of Energy Efficiency and Renewable Energy using models from the National Renewable Energy Laboratory. http://www1.eere.energy.gov/solar/sunshot/

US Energy Information Agency (EIA), 2002. *North America: the Energy Picture.* www.eia.doe.gov/emeu/northamerica/engdemd.htm#_VIPID_1

US Energy Information Agency (EIA), 2006. *US Crude Oil, Natural Gas, and Natural Gas Liquids Reserves.* www.eia.doe.gov/emeu/international/reserves.html

US Energy Information Administration (EIA), 2010a. *Table of Cost and Performance Characteristics of New Central Station Electricity Generating Technologies, Annual Energy Outlook.* Washington, DC, 2010. www.eia.gov/oiaf/aeo/assumption/pdf/electricity_tbls.pdf

US Energy Information Administration (EIA), 2010b. *Annual Energy Outlook 2011 with Projections to 2035.* www.eia.doe.gov/oiaf/aeo/gas.html

US Energy Information Administration (EIA), 2012a. "Natural Gas Explained: How Much Natural Gas Is Left." Last modified February 6, 2012. www.eia.doe.gov/neic/infosheets/natgasreserves.html.

US Energy Information Administration (EIA), 2012b. "What is shale gas and why is it important?" Last modified April 11, 2012. www.eia.gov/energy_in_brief/about_shale_gas.cfm

US Department of Energy (US DOE), 2010. Office of Energy Efficiency and Renewable Energy, and US Department of the Interior, Bureau of Land Management. *Solar Energy Development Draft Programmatic Environmental Impact Statement.* 8 vols. Washington, DC, 2010. http://solareis.anl.gov/documents/dpeis/index.cfm#vol1

US Environmental Protection Agency (US EPA), 2011. "Deferral for CO2 emissions from Bioenergy and Other Biogenic Sources under the Prevention of Significant Deterioration (PSD) and Title V Programs." Federal Register 76:139 (July 1, 2011) p 43490. www.gpo.gov/fdsys/pkg/FR-2011-07-20/pdf/2011-17256.pdf

US Environmental Protection Agency (US EPA), 2012. "Landfill Methane Outreach Program." Last modified February 14, 2012. www.epa.gov/lmop/

US Environmental Protection Agency (US EPA), 2008. Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States. (October 2008). Washington, DC, 2008. www.blm.gov/wo/st/en/prog/energy/geothermal/geothermal_nationwide/Documents/Final_PEIS.html

US Environmental Protection Agency (US EPA), 2012. (eGRID2012) "The Emissions & Generation Resource Integrated Database for 2010" technical support document. Prepared for US EPA Office of Atmospheric Programs. Washington, DC, 2010. www.epa.gov/cleanenergy/energy-resources/egrid/index.html

US Department of the Interior, Fish and Wildlife Service (US FWS), 2012. "Final Land-Based Wind Guidelines." (March 23, 2012.) Washington, DC, 2012. www.fws.gov/habitatconservation/wind.pdf

Walker, T., ed., 2010. *Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources.* Natural Capital Initiative Report NCI-2010- 03. Brunswick, ME: Manomet Center for Conservation Sciences, 2010. www.mass.gov/eea/docs/doer/renewables/biomass/manomet-biomass-report-full-hirez.pdf/

Washington Department of Fish and Wildlife (WDFW), 2009. "Wind Power Guidelines." Olympia, Washington. http://wdfw.wa.gov/publications/00294/draft_wind_power_guidelines_2009.pdf

Washington State Department of Ecology (Ecology), 2003. Benedict, Mark. *Techniques for Dust Prevention and Suppression, 2003*. by Mark Benedict. Publication Number 96-433. Olympia, Washington, 2003. www.ecy.wa.gov/biblio/96433.html

Washington State Department of Ecology (Ecology), 2012. Air Quality Nonattianment Areas web page. www.ecy.wa.gov/programs/air/sips/designations/nonattainment_areas.htm

Washington State Department of Ecology (Ecology), 2011. *Ambient Air Quality Standards in Washington State.* Olympia, WA. 2011. www.ecy.wa.gov/programs/air/sips/WA_Stds_August2011.pdf

Washington State Department of Natural Resources (Washington DNR), 2012. *Washington Forest Biomass Assessment Report.* Olympia, WA, 2012. www.dnr.wa.gov/ResearchScience/Topics/OtherConservationInformation/Pages/em_biomass.aspx

Wei, Max, Shana Patadia, and Daniel Kammen, 2010. "Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?" *Energy Policy* 38 (January 2010): 919-931. http://rael.berkeley.edu/node/585

Western Resource Advocates, 2006. www.westernresourceadvocates.org/

World Health Organization, 2007. *Extremely low frequency fields: Environmental Health Criteria 238*. Geneva: WHO Press, World Health Organization, Geneva, Switzerland, 519 p.

Zaffanella, L.E., 1993. *Survey of residential magnetic field sources*. EPRI TR-102759-VI Final Report, 1993. Palo Alto, California.