Energy Life-Cycle Cost Analysis

Guidelines for Public Agencies in Washington State

January 2016

Washington State Department of Enterprise Services

Engineering & Architectural Services

http://des.wa.gov/services/facilities/energy/ELCCA/

Foreword

Public agencies are responsible for ensuring that energy conservation and renewable energy systems are considered in the design phase of major facilities by completing an energy life-cycle cost analysis (ELCCA) as described in Revised Code of Washington (RCW) 39.35.

The Washington State Department of Enterprise Services (DES) is identified in RCW 39.35.050 as having responsibility to develop life-cycle cost analysis guidelines as tools for agencies to use to promote the selection of low life-cycle cost alternatives.

DES Contacts

For questions or assistance in preparing an ELCCA, contact:

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Energy Life-Cycle Cost Analysis guidelines and forms can be obtained online at http://des.wa.gov/services/facilities/energy/ELCCA/

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This booklet can be made available on another format for people with disabilities. Please call (360) 902-7272. TTY users please use relay service.

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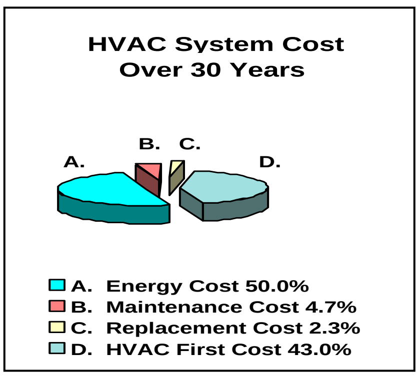
Chapter 1

Introduction

Since 1975, the State of Washington has required that an Energy Life-Cycle Cost Analysis (ELCCA) be performed during the design of all publicly owned or leased facilities. The intent is to help build cost-effective, efficient public facilities.

The ELCCA encourages energy efficiency by evaluating the total cost of ownership of several competing design alternatives. The Washington State Department of Enterprise Services (DES) supports this goal by publishing these guidelines, identifying and encouraging the consideration of cost-effective building technologies, and providing assistance in the development and review of ELCCA reports.

Energy Life Cycle Cost Analysis



The ELCCA is a decision-making tool that compares the owning and operating costs for energy using systems: heating, cooling, lighting, building envelope, and domestic hot water. The analysis accounts for the initial cost of construction or renovating a facility, as well as the cost of owning and operating a facility over its useful life. These costs make up the total cost of ownership for a building.

The ELCCA provides a method for the owner to evaluate different energy using system options and to select the most cost-effective ones. The completed ELCCA report recommends the alternatives that make the most economic sense while providing for the comfort, health, and the productivity of the building occupants.

Legislation

In 1975, the Washington State Legislature enacted “Energy Conservation in Design of Public Facilities” to ensure that energy conservation practices are incorporated into the design of energy using systems of major public facilities, both new construction and extensive renovations. The law applies to state agencies, including colleges and universities, and political subdivisions such as cities, counties, school districts, and other special taxing districts. Requirements pertaining to ELCCA are based on the Revised Code of Washington (RCW) 39.35 and the Washington Administrative Code (WAC) 180-27-075; relevant sections are provided in Appendix B.

In 2001, the Legislature added language requiring that ELCCAs analyze a system “which shall comply at a minimum with the sustainable design guidelines of the U.S. Green Building Council’s LEED NC Silver Standard or similar design standard as may be adopted by rule by the department *RCW 39.35.030(7)(a.).* The LEED NC Checklist can be found at www.usgbc.org.

To meet the legislative intent for energy efficiency and renewables, DES requires that the “High Performance” alternative achieve a minimum 20% reduction in total net energy use compared to a code minimum “Baseline” design. DES also requires analysis of a “Renewable Alternative.” Check the ELCCA web site at http://des.wa.gov/services/facilities/Energy/ELCCA/Pages/default.aspx for spreadsheets, updates, forms and contacts useful to the preparation of ELCCA documents.

Purpose of the ELCCA Guidelines and the Process

These guidelines define the procedures and methods for performing ELCCAs, promote the selection of low life-cycle cost alternatives, provide standard reporting formats, and provide valuable insights about energy efficient design elements that should be incorporated early in the design process.

Other objectives of the guidelines are:

- Identify the timeline for phases of the ELCCA in the design process
- Provide standardized economic assumptions to be used for equipment service life, building life, maintenance costs, and fuel escalation and inflation rates
- Encourage ELCCA Analysts to use renewable resources when feasible and cost-effective

Review and Approval of ELCCAs

DES will review ELCCAs for any public entity. A fee will be charged for this review pursuant to RCW 39.35.060. The review of the ELCCA brings an additional experienced energy engineer into the design process to review the submittals. Public entities wishing to make other arrangements for review of their ELCCAs may do so.

DES has been designated by the Office of the Superintendent of Public Instruction (OSPI) to review all public school projects receiving state construction funds. Only school projects receiving state funding require review by DES.

How Have These Guidelines Changed?

Following are changes from the previous version of these guidelines (December 2005):

- Owner's energy reduction and greenhouse gas emission goals are to be stated in the Work Plan
- Baseline model is defined
- Forms and appendices are updated.
- The prescriptive requirements for lighting and envelope systems are eliminated.
- Need for Report Addendum is deleted
- Building study life extended to 50 years
- Economic factors to be used in the analysis are updated and provided in a new calculation spreadsheet supplied by the Office of Financial Management called the Evaluation Life Cycle Cost Analysis Tool (ELCCAT)

Chapter 2

The ELCCA Process

This chapter defines the projects requiring an ELCCA and identifies the participants and submittals required in preparing the ELCCA.

Projects Requiring an ELCCA

An ELCCA is required in the design of all major publicly owned or leased facilities, i.e. When public funds are used to build and/or operate the new or renovated facility. Projects that require an ELCCA:

1. **New Major Facilities,** having 25,000 square feet or more of usable floor space
2. **Building Renovations/Modernizations,** additions, alterations, or repairs of an existing major facility (25,000 square feet or more) completed within any 12-month period where the project cost is over 50 percent of the replacement value of the facility and the project affects energy-using system(s).

   Example: An agency plans to remodel a 25,000 square foot building for $80 per square foot. The building replacement value is $150 per square foot. The project cost (25,000 x $80 = $2,000,000) divided by the building replacement value (25,000 x $150 = $3,750,000) is equal to 0.53, which is greater than 0.50. Therefore, the project requires an ELCCA.
3. **Combinations (or multiples) of new and renovated facilities** that will be built on the same site during any 12-month period, if the sum of the affected areas is equal to or greater than 25,000 square feet.

   Example: An agency plans to remodel a 15,000 square foot building and add 20,000 square feet in two phases with separate contracts. The addition is to be completed in October and the remodel will be bid the following May. This is considered a single project, and an ELCCA is required because the area is greater than 25,000 square feet (15,000 + 20,000) and the phases will occur within a 12-month period (October to May).

4. **Prototypic Buildings:** Identical buildings built on the same or different sites during any 48-month period shall have a full ELCCA performed for the initial or prototypic building, but subsequent buildings may only need to have an abbreviated report. This applies to buildings less than 100,000 square feet in area. The prototype building must meet current guidelines, and the Reviewer and Analyst must agree that a full analysis will not benefit the project.

Additional Requirements for Public School Projects

For K-12 projects receiving funding from OSPI, the following project categories do not require an ELCCA but do require that a “Public Facility Energy Characteristics” (PFEC) form (see Chapter 5) and a cover letter be submitted to the Reviewer during the design development phase:

- New construction between 5,000 and 25,000 square feet
- Remodels between 5,000 and 25,000 square feet
- Remodels over 25,000 but not meeting the 50% rule above

Participants, Responsibilities, and Qualifications

Figure 2.1 outlines the responsibilities of each ELCCA participant (by project phase and ELCCA submittal). For example:

- The **Owner** (building owner or owner’s representative) will review all the ELCCA deliverables with the design team.

- The **A/E Team** (referred to hereafter as “architect”) is responsible for the design schedule and using the results of the ELCCA to inform early design decisions. The ELCCA Analyst (the “Analyst”) is responsible for preparing and submitting the ELCCA Work Plan, the ELCCA Study Matrix, and the ELCCA Report to the ELCCA Reviewer. The Analyst must either be, or work under the responsible charge of an architect or engineer licensed in the State of Washington. The analyst should have public building design experience and be familiar with energy modeling techniques. Reports shall be signed and stamped by the Analyst or person in responsible charge. The architect shall sign the cover page as having examined the report.

- The ELCCA Reviewer (the “**Reviewer**”) performs a thorough review of each submittal and provides a written response in a timely manner. The Reviewer ensures that the ELCCA meets all requirements as defined in the RCW 39.35 and these guidelines.

- **Utilities** that serve the facility are good resources for the design team. Coordinating the ELCCA process with utilities may identify opportunities for additional efficiency measures, as well as financial incentives and technical assistance the utility can provide to the project.

ELCCA Process/Submittals

A flowchart of the ELCCA process is provided as Figure 2.2. The ELCCA process contains three separate submittals:

1. ELCCA Work Plan, LEED or Washington Sustainable Schools Protocol (WSSP) Checklist (Figure 3.1)
2. ELCCAT Preliminary Results (Figure 4.1)
3. ELCCA Report (Chapter 5)

The schedule for submittals is indicated below.

1. ELCCA Work Plan and LEED or WSSP Checklist (See Chapter 3)

Schedule: Prepared by the Analyst and submitted to the Reviewer early in schematic design. The Reviewer may suggest additional or alternative options to be analyzed. Once the Reviewer approves the Work Plan, the Analyst may begin the ELCCA.

The Work Plan, see Figure 3.1, is an outline of what the Analyst intends to accomplish with the ELCCA report. The Work Plan includes a description of the building and participants, and reflects the planned analysis for each energy system to be addressed in the ELCCA (including building envelope, lighting, domestic hot water, mechanical systems, renewable energy systems, and other energy systems). It identifies envelope and lighting strategies that will be analyzed to help achieve energy goals and the specific Renewable and High Performance Alternatives to be considered. A copy of the LEED (or WSSP) checklist reflecting a silver rating is also to be submitted. Elements identified in the checklist should be reflected in the High Performance Alternative in the Work Plan as a potential means of achieving the Agencies energy goal.

2. ELCCAT Preliminary Results (See Chapter 4)

*Schedule: Prepared by the Analyst and submitted to the Project Team (**not the Reviewer**) at the beginning of Design Development*

The Preliminary results, see Figure 4.1, presents early results of the comparison of multiple HVAC system designs based on preliminary building geometry using the Office of Financial Management (OFM) Evaluation Life Cycle Cost Analysis Tool (ELCCAT). The intent of the modeling at this stage is to inform early design decisions such as siting and orientation, geometry, massing, passive strategies, glazing size and location, shading and daylighting strategies. Alternatives undergo computer simulation to arrive at energy costs. The ELCCAT is used to calculate Life Cycle Costs and Net Present Savings for the different alternative designs.

3. The ELCCA Report (See Chapters 5)

Schedule: Prepared by the Analyst and submitted to the Reviewer during construction documents.

The ELCCA Analyst must submit a report consistent with the analysis guidelines (described in Chapter 4) and the report guidelines (described in chapter 5). The computer model for the baseline and selected system is updated to reflect the final building design. This allows for the final performance and savings estimates to be established.

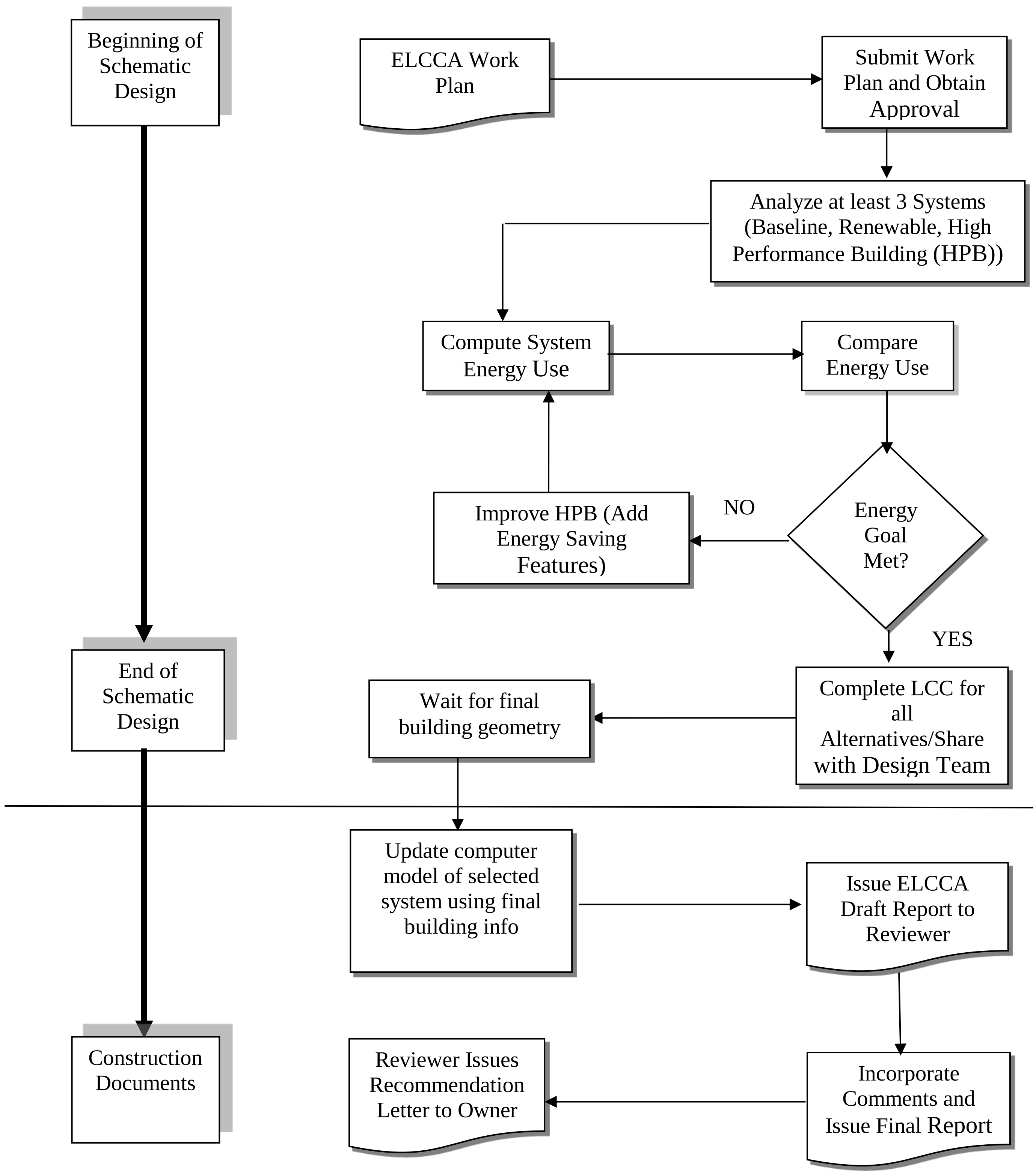
Note: A project undergoing ELCCA need not always choose the lowest life-cycle cost alternative. The requirement is that total life-cycle costs *be considered* in the design of publicly owned facilities. If the selected or recommended design varies from the lowest life-cycle cost by greater than 20%, a letter is required from the owner noting that the owner has been made aware of this situation and describing the reasons for the choice.

Figure 2.1 ELCCA Integration with Building Design Phases

	A/E Selection	***Schematic Design***			***Design Development***			***VE Review***		***Construction Documents***	
Owner	Select A/E and VE Team	Determine whether ELCCA is required; select Analyst	Participate in Work Plan development	Review ELCCA Preliminary Results					Select ELCCA & VE team Suggestion	Verify implementation Letter of justification if lowest Life Cycle Alternative is not implemented	
A/E Team		Determine whether ELCCA is required	Participate in Work Plan development	Review ELCCA Preliminary Results				Present design to VE team		Verify to owner that ELCCA decisions will be incorporated in design Incorporate owner's decisions	
ELCCA Analyst		**Prepare ELCCA Work Plan**		Prepare ELCCA Preliminary Results				Present ELCCA Preliminary Results to VE team		**Prepare & submit ELCCA Report reflecting final building configuration**	**Address comments & make corrections to report**
ELCCA Reviewer		Review & approve Work Plan								Review Report & return comments	Recommend ELCCA to owner
VE Team								Consider Life Cycle Costs in VE report			
Utilities				Participate in Work Plan development to assist with utility programs							

Note: Items in bold denote Submittals to ELCCA Reviewer

Figure 2.2 ELCCA Process Flowchart



Chapter 3

The Work Plan

What is considered in the ELCCA study is as important as how the study is done, so it is the function of the Work Plan to outline the scope of the ELCCA in advance and to have the Analyst and the Reviewer discuss and agree on that plan. The Work Plan should propose to study alternatives that the project team can support and implement, and its development should involve the owner and project architect. The local utility can make a difference if incentives are offered for efficiency measures. Note that a Work Plan is still required for prototypical buildings. The Work Plan is submitted by the ELCCA Analyst in the schematic design phase of a project.

Work Plan Preparation

The Work Plan form is shown as Figure 3.1. This form is also available in electronic format at http://des.wa.gov/services/facilities/Energy/ELCCA/Pages/default.aspx. The following sections provide additional guidance in developing the Work Plan.

Statement of Energy Design Intent
In consultation with the Owner and Design team, the desired energy performance of the building in terms of percentage improvement over the base model and in terms of Energy Use Index (EUI) is stated. The intent is to provide a means to track progress in meeting the organizations energy reduction and greenhouse gas reduction goals.

Building Envelope
Provide details of the planned envelope components and describe any better than code envelope features that will be considered

Lighting Systems
Provide details by functional area of the lighting components that are planned and describe any better than code lighting features that will be considered.

Air Leakage
Provide design and construction strategies to ensure a continuous air barrier and state the infiltration rate assumed for the analysis.

Mechanical Systems
A baseline code compliant and two mechanical system alternatives, at a minimum, shall be analyzed.

Baseline Code Compliant System
The baseline model will be developed and for the purposes of the analysis is defined as the lowest capital cost building that meets state building and energy codes.

Renewable Energy System
One of the analyzed systems must include a renewable energy source. Table 3.1 presents acceptable options; others may be proposed by the Analyst.

Table 3.1 Renewable Examples

Renewable Resource	Acceptable System Options
Waste Heat Recovery	Exhaust gas / Ventilation air heat exchanger not already required by code
Solar Energy	Photovoltaic cells or solar water heater
Wind	Wind generator
Biofuel	Wood chips in heating boiler
Geothermal	Ground source heat pumps

High Performance Building Alternative HPB
The Analyst must include one alternative that is considered equivalent to a U.S. Green Building Council LEED NC Silver Rating. For the purposes of these guidelines, a HPB is defined as having a net energy use that is a minimum of 20% less than the baseline building. The Work Plan should reflect the strategy for the HPB, including what will be analyzed and what enhancements are intended for reaching the minimum 20% improvement or the Owner's energy savings goal whichever is greater. The HPB may consist of:

- An enhancement of an already studied alternative
- A separate system alternative, enhanced as needed, to meet the goal
- An integrated design option with envelope, lighting, and mechanical system variations

Integrated Design
Energy systems behave interactively, and it is possible to analyze the life-cycle costs for an alternative that incorporates changes to more than one energy system at once. This integrated design approach is in contrast to the more traditional "system-by-system" approach where one energy system is analyzed at a time. An example of integrated design is a building designed with daylighting controls, high performance glazing, and natural ventilation, which then reduces the size of the mechanical systems and the associated operating costs. The integrated design approach may be especially useful for the High Performance Building alternative. Information on using building simulation software to calculate life-cycle costs of integrated energy systems can be found in Chapter 4.

Other Energy Systems
Particular building projects may involve energy systems not specifically described previously. Examples may include:

- Cogeneration Equipment
- Photovoltaic Systems
- Emergency Power Systems
- Uninterruptible power systems

Such systems should be noted on the work plan, and described in the report. Work plan discussions should focus on whether these might benefit from doing comparisons of alternatives in the Life Cycle Cost Analysis.

Note: If emergency power systems or uninterruptible power systems are being considered, a fuel cell shall be evaluated as one of the alternatives pursuant to RCW 43.19.651.

Work Plan Review and Approval

The ELCCA Reviewer studies the Work Plan, suggests improvements, and approves the Work Plan with or without comments. The Reviewer will communicate approval of the Work Plan via email. The Analyst forwards a copy of the approved Work Plan to the building owner and the project architect. The Analyst then proceeds with the ELCCA analysis and report.

Figure 3.1 ELCCA Work Plan

1. Project Description

Project Title:	**Date:**
Agency Name:	**City:**
Gross Sq Ft New:	**Gross Sq Ft Remodel:**
Building Only Cost Estimate:	**Site Cost Estimate:**
Function Areas:	
Electric Utility:	**Gas Utility:**
Design Phase:	**Est. Bid Date:**
Energy Modeling Software:	
List organizational energy reduction goals and greenhouse gas emission goals and how the energy use of the is building helps achieve these goals:	

2. Statement of Energy Design Intent

Energy Savings Goal over WSEC or LEED Compliant Building:	
TARGET Energy Use Intensity (kBtu/ft^2/yr):	

3. Team Members

Contact	Name	Organization	Email	Phone
Analyst				
Owner's PM				
Architect				
Other				

4. Building Envelope

Describe any high performance envelope features that will be analyzed/evaluated to achieve stated energy savings goal and that go beyond the minimum code requirements:

TARGET UA improvement over WSEC required: ____________

5. Air Leakage

Describe proposed design and construction strategies to ensure continuous air barrier:

TARGET infiltration rate (cfm/ft2 @ 0.3" wg (75 Pa)): _____________

6. Lighting Systems

Describe any lighting strategies that will be analyzed/evaluated to achieve stated energy savings goal and that go beyond the minimum code requirement:

TARGET interior lighting energy intensity (W/ft2): ____________

7. Mechanical Systems

M1 – Baseline Code Compliant System Description:

M2 – Renewable Alternative1:

M3 – High Performance Building Alternative (This must be equivalent to a building achieving a minimum 40% of the LEED Energy Performance credit. It will provide the target % improvement over WSEC or ASHRAE 90.1 compliant building for new and renovation projects, as appropriate.) :

Other (Consider Net-Zero Energy Ready Alternative) :

1. Renewable is defined as utilizing renewable energy sources including, but not limited to, hydroelectric power, active or passive solar space heating or cooling, domestic solar water heating, windmills, waste heat, biomass and/or refuse-derived fuels, photovoltaic devices, and geothermal energy.

Submit completed Work Plan by email to ELCCA@des.wa.gov

Chapter 4

Energy Use Simulation and Economic Analysis

This chapter provides information and tools needed to perform the energy use simulation and economic analysis required for the ELCCA. The energy consuming systems selected in the Work Plan are analyzed to estimate and document the total cost of ownership of each system over its life.

The annual cost of energy use is calculated through an hourly building simulation model, and along with the annual cost to operate, maintain, repair, and replace equipment is compared on an equal basis for each alternative over the life of the system.

Energy Use Calculation

Calculating annual energy use involves computer modeling of the energy behavior of buildings over time. The computer model simulates the time-based phenomena that affect a building's energy use, e.g., hourly occupancy schedules, thermal mass response, and HVAC control sequences. Items expected to be redundant in all system types modeled (e.g. restroom, kitchen exhaust, etc.) are included in each analysis. Standards for the analyses include:

- The building components and operation shall be in minimum compliance with the Washington State Energy Code (WSEC).
- Each simulation shall be performed by a computer program that is capable of simulating the energy performance of building systems on an hourly basis.
- The annual cost of energy for each alternative shall be calculated using the same simulation program, the same operating conditions, the same weather data and the same purchased energy rates.
- The simulation of the selected alternatives must be complete and consistent with the operating scenarios of systems being studied. If integrated design alternatives are proposed, the alternatives must include all first cost and operation and maintenance (O&M) differences in building configuration, thermal mass, HVAC and lighting controls.

Approved Simulation Models

A computer energy simulation is required for the ELCCA analysis to compare the energy impacts of design alternatives. Approved computer software programs are listed below. These programs have been extensively tested and widely used. Other commercially available software specifically created for building simulations will be considered with prior approval from the ELCCA Reviewer.

- Carrier HAP
- Energy Plus
- DOE-2 & variations
- Trane Trace 700

It is the responsibility of the ELCCA Analyst to select the computer program that best evaluates the alternatives to be studied. The program selected must be one in which the Analyst has sufficient experience to produce accurate results. If modeling assumptions are accurate, a skilled Analyst can make appropriate comparative estimates of the various design alternatives.

Existing software may not be able to accurately model certain complex and innovative measures. In these cases, the ELCCA Analyst and the ELCCA Reviewer should agree on the calculation method and techniques that will be used to evaluate the measure.

Developing the Model

The following are guidelines for selecting the systems and analysis methods to be used.

Building Mechanical Systems: ELCCA guidelines require that a minimum of three systems be analyzed: a baseline code compliant model, a renewable energy systems model and one high-performance building alternative.

Baseline Model: Defined as the lowest capital cost building that meets state building and energy codes.

Renewable Energy System: One renewable energy system alternative is to be analyzed. Table 3.1 lists some renewable energy alternatives; the Analyst may propose others. If the renewable alternative is integrated into the mechanical system, the Analyst should use the simulation model to determine the annual cost of energy wherever appropriate. If the renewable alternative is to stand alone, or not integrated in the mechanical system, the analysis is to be based on an estimate of 50-year life-cycle cost, where approved by the Reviewer.

High Performance Building Alternative: This alternative must be equivalent to a building achieving a minimum 20% improvement in energy use when compared to the baseline model.

First Cost Interactions: Certain alternatives produce benefits beyond simply saving energy costs and improving occupant comfort. For example, alternatives that reduce transmission heat gains or internal heat gains may reduce the *first cost* of mechanical cooling systems as well as save energy dollars. The added cost of increased roof insulation may be at least partially offset by downsized chillers, cooling coils, chilled water piping, pumps, ductwork, and fans.

Integrated Design Alternatives: The Analyst should examine integrated design alternatives by using the computer energy simulation to calculate energy usage for all interactive alternatives.

Include a description of all analyzed systems or combination of systems in the ELCCA report and show details of envelope, lighting, and HVAC systems in their respective sections. Changes in first cost and annual maintenance cost of the various components and system must be fully accounted.

Domestic Hot Water (DHW): The baseline domestic hot water system should be the lowest first-cost system that is acceptable to the building owner. If the baseline system use exceeds 10% of the overall building energy use or if requested by the Owner, alternatives must be analyzed.

Input Assumptions

Envelope U-factors: Calculate effective U-factors for all envelope components to comply with 2013 *ASHRAE Handbook - Fundamentals*. The effects of window frames, stud walls, insulation voids, thermal bridging, sloped roofs, and other losses are to be accounted for in the calculations.

Infiltration: Infiltration losses depend on facility use. The values used in the analysis should be stated clearly and well justified in the report.

Glazing and solar heat gain coefficients: The manufacturer's tested window unit U-factor and shading coefficients should be used if available. If the specific window is unknown, use default U-factors and shading coefficients listed in the WSEC.

Occupant Loads: Latent and sensible heat given off by occupants should be adjusted to reflect activity and actual occupancy levels for each zone.

Lighting: Input the lighting power density for each HVAC zone of the model. Corridors may have less density, while drafting rooms may have more. A global building code default value for lighting power densities can also be used. Include off-hour activities and custodial work in the hours of operation.

System and occupancy schedules: Use the actual occupancy schedules if known or the default occupancy schedules found in the WSEC.

Occupancy Densities, Receptacle Power Densities, and Hot Water Usage: Use the actual building data if available or the default values found in the WSEC.

Miscellaneous equipment loads: Use rated equipment capacities if the simulation offers a load diversity factor or calculates the equipment load using an operating schedule profile that permits fractional amounts. Do not use default values for the entire building.

Critical HVAC parameters: Every input should be realistic using manufacturer's data if available. Important parameters to check are equipment capacities, diversities, percentage of outside air, economizer cooling setpoint, and efficiencies for motors, fans, pumps, and heating and cooling equipment. Part-load efficiencies should be used when available. Design loads output should include “unmet load hours” information for each alternative.

Zoning: Model zoning should be based on the expected HVAC design zoning. However, there may be fewer zones in the model. Use the following basic criteria:

- Usage—similar internal loads
- Controls type—same setpoint and operation schedule
- Solar gains—rooms with greatly differing gains should not be in the same zone
- Perimeter or interior locations—12 to 15 feet from exterior in one zone
- Fan or HVAC system type

Temperature setpoints: Thermostat settings should reflect the buildings expected operation.

High Performance Building Alternative Analysis

The High Performance Building Alternative represents a requirement added in 2001 to RCW 39.35.030 to study a LEED NC Silver rated building. This has been defined in these guidelines as a building that achieves a minimum 20% reduction in total net energy use compared to a code minimum "Baseline" design. In the event the calculated percent savings does not reach the savings goal, the Analyst shall consider additional enhancements to the High Performance Building alternative and re-run the simulation to determine the annual energy usage for the enhanced model, until the percent savings goals are met. Upon reaching the target savings percentage, the Analyst can prepare the final estimated construction and maintenance cost of the High Performance Building alternative, and proceed with completion of the Life Cycle Cost.

Economic Analysis

An excel spreadsheet titled "Evaluation Life Cycle Cost Analysis Tool" (ELCCAT) is available for the economic analysis portion of the report. The spreadsheet is available electronically at http://ofm.wa.gov/budget/forms.asp (under the "Capital budget forms' heading) and a sample input and results report is provided in Figure 4.1. The information needed to complete the spreadsheet includes:

- Construction costs (include utility incentive where applicable)
- Equipment useful life
- Annual maintenance costs
- Annual Energy usage for each fuel type
- Fuel costs
-

The spreadsheet takes this input and uses standardized key assumptions, such as building life, discount rate, and fuel escalation rates to calculate Life Cycle Cost and Net Present Savings. An additional column accounts for Societal Cost in the Net Present Savings. The spreadsheet applies a consistent methodology in calculating how often components need to be replaced and determines residual value at the end of the study life. The hope is that by standardizing the life cycle cost analysis methodology more consistent and comparable results will be achieved.

Figure 4.1 ELCCAT Inputs and Report

Office of Financial Management
Olympia, Washington - Version: 2015-B
Evaluation Life Cycle Cost Analysis Tool
ELCCAT Inputs & Report

Project:	Imaginary Building	
Analysts Firm:	Fake Enterprises	
Electric Rate ($/KWH):	$0.08	Sq.Ft. for EUI Calc
Natural Gas Rate ($/Therm):	$1.00	70,000

ELCCA Results Table	PV of Capital Cost	PV of Maint. Costs	PV of Utility Costs	Total Life Cycle Cost	Net Present Savings	NPS w/SCC	EUI	SIR
Baseline:Primary Building Design	$6,285,056	$1,459,741	$3,216,250	$10,961,046	N/A	N/A	68.2	N/A
Alt 2 Heat Recovery Chiller	$6,594,781	$1,569,221	$2,995,157	$11,159,160	($198,114)	($140,486)	60.3	0.36
Alt 3A Chilled Beams Serving Labs	$6,487,122	$1,505,358	$3,074,219	$11,066,699	($105,653)	($82,247)	62.1	0.48
Alt 3B Chilled Beams Serving Classrooms	$6,230,083	$1,550,975	$2,939,057	$10,720,115	$240,931	$340,295	60.4	No Cost
Renewable - Solar Option	$6,429,135	$1,484,785	$3,150,060	$11,063,980	($102,934)	($69,695)	67.1	0.29
Alt 4 Dueal Core Heat Recovery	$6,587,753	$1,678,702	$3,194,562	$11,461,017	($499,971)	($491,864)	67.7	-0.65
Alt 5 Low Wall Displacement System	$6,524,185	$1,459,741	$3,220,119	$11,204,046	($243,000)	($228,090)	69.6	-0.02
Alt 6 Lab Air Quality Monitoring	$6,430,054	$1,824,676	$3,146,150	$11,400,880	($439,834)	($414,695)	66.3	-2.03
Alt 7 Natural Ventilation in Offices	$6,327,232	$1,528,166	$3,074,893	$10,930,291	$30,755	$88,597	64.8	1.73
High Performance Combination: Alt 3B + Alt 7	$6,302,618	$1,619,400	$2,804,269	$10,726,287	$234,759	$388,262	57.0	14.37

NPS = Net Present Savings, SCC = Social Cost of Carbon Dioxide Pollution, EUI = Energy Use Intensity (kBtu/sq.ft), SIR = Savings to Investment Ratio (Net Present Savings/Incremental PV of Capital Costs)

Page 1

	Primary Building Design				
	Weighted Average and Totals	32.0	$4,063,800	$32,640	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,167,100.00	$32,640.00	1
2	15 Year Components	15	$40,600.00		2
3	20 Year Components	20	$805,800.00		2
4	24 Year Components	24	$191,500.00		2
5	25 Year Components	25	$1,007,800.00		2
6	27 Year Components	27	$70,000.00		2
7	30 Year Components	30	$781,000.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	751,838	Annual Electric Costs	$60,147	
	Annual N.G. Consumption (Therms)	22,116	Annual N.G. Costs	$22,116	

	Alt 2 Heat Recovery Chiller				
	Weighted Average and Totals	31.7	$4,220,200	$35,088	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,175,900.00	$35,088.00	1
2	15 Year Components	15	$41,100.00		2
3	20 Year Components	20	$941,900.00		2
4	24 Year Components	24	$192,500.00		2
5	25 Year Components	25	$1,007,800.00		2
6	27 Year Components	27	$70,000.00		4
7	30 Year Components	30	$791,000.00		4
8					
9					
10					
	Annual Elec Consumption (KWH)	806,025	Annual Electric Costs	$64,482	
	Annual N.G. Consumption (Therms)	14,730	Annual N.G. Costs	$14,730	

	Alt 3A Chilled Beams Serving Labs				
	Weighted Average and Totals	32.2	$4,211,550	$33,660	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,220,710.00	$33,660.00	1
2	15 Year Components	15	$40,600.00		2
3	20 Year Components	20	$810,840.00		2
4	24 Year Components	24	$209,760.00		2
5	25 Year Components	25	$1,007,800.00		5
6	27 Year Components	27	$70,000.00		5
7	30 Year Components	30	$851,840.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	820,638	Annual Electric Costs	$65,651	
	Annual N.G. Consumption (Therms)	15,488	Annual N.G. Costs	$15,488	

	Alt 3B Chilled Beams Serving Classrooms				
	Weighted Average and Totals	32.4	$4,066,255	$34,680	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,186,700.00	$34,680.00	1
2	15 Year Components	15	$22,300.00		2
3	20 Year Components	20	$793,350.00		2
4	24 Year Components	24	$309,905.00		2
5	25 Year Components	25	$765,365.00		6
6	27 Year Components	27	$57,950.00		5
7	30 Year Components	30	$930,685.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	752,088	Annual Electric Costs	$60,167	
	Annual N.G. Consumption (Therms)	16,606	Annual N.G. Costs	$16,606	

	Renewable - Solar Option				
	Weighted Average and Totals	32.0	$4,160,400	$33,200	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,167,100.00	$33,200.00	1
2	15 Year Components	15	$40,600.00		8
3	20 Year Components	20	$805,800.00		2
4	24 Year Components	24	$191,500.00		2
5	25 Year Components	25	$1,007,800.00		9
6	27 Year Components	27	$70,000.00		2
7	30 Year Components	30	$877,600.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	728,150	Annual Electric Costs	$58,252	
	Annual N.G. Consumption (Therms)	22,116	Annual N.G. Costs	$22,116	

	Alt 4 Dueal Core Heat Recovery				
	Weighted Average and Totals	31.7	$4,238,800	$37,536	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,167,100.00	$37,536.00	1
2	15 Year Components	15	$47,000.00		2
3	20 Year Components	20	$805,800.00		2
4	24 Year Components	24	$191,500.00		2
5	25 Year Components	25	$1,168,000.00		2
6	27 Year Components	27	$70,000.00		2
7	30 Year Components	30	$789,400.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	751,025	Annual Electric Costs	$60,082	
	Annual N.G. Consumption (Therms)	21,731	Annual N.G. Costs	$21,731	

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Office of Financial Management
Olympia, Washington - Version: 2015-B
Evaluation Life Cycle Cost Analysis Tool

ELCCAT Inputs & Report

Project:	Imaginary Building	
Analysts Firm:	Fake Enterprises	
Electric Rate ($/KWH):	$0.08	Sq.Ft. for EUI Calc
Natural Gas Rate ($/Therm):	$1.00	70,000

ELCCA Results Table	PV of Capital Cost	PV of Maint. Costs	PV of Utility Costs	Total Life Cycle Cost	Net Present Savings	NPS w/SCC	EUI	SIR
Baseline:Primary Building Design	$6,285,056	$1,459,741	$3,216,250	$10,961,046	N/A	N/A	68.2	N/A
Alt 2 Heat Recovery Chiller	$6,594,781	$1,569,221	$2,995,157	$11,159,160	($198,114)	($140,486)	60.3	0.36
Alt 3A Chilled Beams Serving Labs	$6,487,122	$1,505,358	$3,074,219	$11,066,699	($105,653)	($82,247)	62.1	0.48
Alt 3B Chilled Beams Serving Classrooms	$6,230,083	$1,550,975	$2,939,057	$10,720,115	$240,931	$340,295	60.4	No Cost
Renewable - Solar Option	$6,429,135	$1,484,785	$3,150,060	$11,063,980	($102,934)	($69,695)	67.1	0.29
Alt 4 Dueal Core Heat Recovery	$6,587,753	$1,678,702	$3,194,562	$11,461,017	($499,971)	($491,864)	67.7	-0.65
Alt 5 Low Wall Displacement System	$6,524,185	$1,459,741	$3,220,119	$11,204,046	($243,000)	($228,090)	69.6	-0.02
Alt 6 Lab Air Quality Monitoring	$6,430,054	$1,824,676	$3,146,150	$11,400,880	($439,834)	($414,695)	66.3	-2.03
Alt 7 Natural Ventilation in Offices	$6,327,232	$1,528,166	$3,074,893	$10,930,291	$30,755	$88,597	64.8	1.73
High Performance Combination: Alt 3B + Alt 7	$6,302,618	$1,619,400	$2,804,269	$10,726,287	$234,759	$388,262	57.0	14.37

NPS = Net Present Savings, SCC = Social Cost of Carbon Doxide Pollution, EUI = Energy Use Intensity (kBtu/sq.ft), SIR = Savings to Investment Ratio (Net Present Savings/Incremental PV of Capital Costs)

	Alt 5 Low Wall Displacement System				
	Weighted Average and Totals	31.8	$4,201,400	$32,640	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,171,100.00	$32,640.00	1
2	15 Year Components	15	$40,600.00		2
3	20 Year Components	20	$851,800.00		2
4	24 Year Components	24	$201,100.00		2
5	25 Year Components	25	$1,036,800.00		2
6	27 Year Components	27	$70,000.00		2
7	30 Year Components	30	$830,000.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	711,150	Annual Electric Costs	$56,892	
	Annual N.G. Consumption (Therms)	24,447	Annual N.G. Costs	$24,447	

	Alt 7 Natural Ventilation in Offices				
	Weighted Average and Totals	31.9	$4,056,470	$34,170	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,174,050.00	$34,170.00	1
2	15 Year Components	15	$37,200.00		2
3	20 Year Components	20	$933,830.00		2
4	24 Year Components	24	$207,890.00		2
5	25 Year Components	25	$921,900.00		2
6	27 Year Components	27	$62,500.00		2
7	30 Year Components	30	$719,100.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	734,063	Annual Electric Costs	$58,725	
	Annual N.G. Consumption (Therms)	20,298	Annual N.G. Costs	$20,298	

	Alt 6 Lab Air Quality Monitoring				
	Weighted Average and Totals	31.8	$4,133,400	$40,800	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,166,800.00	$40,800.00	1
2	15 Year Components	15	$40,600.00		2
3	20 Year Components	20	$875,700.00		2
4	24 Year Components	24	$191,500.00		2
5	25 Year Components	25	$1,007,800.00		2
6	27 Year Components	27	$70,000.00		2
7	30 Year Components	30	$781,000.00		3
8					
9					
10					
	Annual Elec Consumption (KWH)	751,875	Annual Electric Costs	$60,150	
	Annual N.G. Consumption (Therms)	20,724	Annual N.G. Costs	$20,724	

	High Performance Combination: Alt 3B + Alt 7				
	Weighted Average and Totals	32.1	$4,058,925	$36,210	Narrative
	Component Description	Useful Life	Installed Cost	Annual Maintenance	REF #
1	Non Re-Occuring Upfront Costs	50	$1,193,650.00	$36,210.00	1
2	15 Year Components	15	$30,300.00		2
3	20 Year Components	20	$988,700.00		2
4	24 Year Components	24	$258,975.00		2
5	25 Year Components	25	$661,450.00		7
6	27 Year Components	27	$50,450.00		2
7	30 Year Components	30	$875,400.00		8
8					
9					
10					
	Annual Elec Consumption (KWH)	737,675	Annual Electric Costs	$59,014	
	Annual N.G. Consumption (Therms)	14,732	Annual N.G. Costs	$14,732	

-

Economic Building Life/Equipment Useful Life
A default of 50 years has been set as the economic life. Equipment useful life is presented in Table 4.4. Deviations from the given values for both buildings and equipment may be used with prior approval by the reviewer. For equipment not found in this table, use published data or an estimate of life based on comparable equipment.

Construction Costs
Provide an itemized system cost estimate (breakdown) for each alternative, analyzed by major equipment items. Costs include labor, materials, overhead and profit, and taxes.

Maintenance Costs
Provide a breakdown of maintenance costs for each mechanical system analyzed. Estimate annual total HVAC maintenance costs for heating and cooling equipment and distribution systems for a building, and compare maintenance costs for various systems to a common baseline, to allow the cost of one system to be compared with that of another.

ELCCA Analysts may use the procedure explained below, or they may calculate annual maintenance costs using their own standard practice or using R.S. MEANS Facilities *Maintenance and Repair Cost Data* and/or *The Whitestone Building Maintenance and Repair Cost Reference*. Estimates based on standard practice must include a line-item breakdown of all costs; the same assumptions, procedures, and summary forms must be used to prepare all of the cost estimates.

Maintenance costs include all labor, materials, and consumable products for the following categories:

- Replacement/servicing (filters, belts, etc.)
- Lubrication
- General housekeeping
- Balancing/Control calibration
- Troubleshooting
- Service contracting (if any)
- Small equipment replacement (an allowance for periodic replacement within the service life of the measure)

Table 4.2 Equipment Service Life

Energy Conservation Measure/ Equipment	Median Life (yrs.)
Air Conditioners	
Window unit	10
Residential single or split package	15
Commercial through-the-wall	15
Water-cooled package	15
Single zone roof top	15
Multi zone rooftop	15
Heat Pumps	
Commercial air to air	15
Commercial water to air	19
Residential air to air	15
Boilers, hot water (steam)	
Steel water tube	24 (30)
Steel fire-tube	25 (25)
Cast iron	35 (30)
Electric	15
Burners	21
Furnaces	
Gas or oil-fired	18
Unit Heaters	
Gas or electric	13
Hot water or steam	20
Radiant Heaters	
Electric or gas	10
Hot water or steam	25
Air Terminals	
Diffuser, grilles, and registers	27
Induction and fan-coil units	20
VAV and double-duct boxes	20
Air Washers	17
Ductwork	30
Dampers	20
Fans	
Centrifugal	25
Axial	20
Propeller	15
Ventilating, roof mounted	20
Coils	
DX, water, or steam	20
Electric	15
Heat Exchangers	
Shell and tube	24
Compressors	20
Chillers	
Absorption	23
Centrifugal	23
Reciprocating	20
Cooling Towers	
Ceramic or FRP	34
Galvanized metal	20
Wood	20
Condensers	
Air-cooled	20
Evaporative	20
Insulation	
Molded	20
Blanket	24
Pumps	
Base mounted	20
Condensate	15
Pipe mounted	10
Sump and well	10
Reciprocating Engines	20
Steam turbines	30
Electric Motors	18
Motor starters	17
Electric transformers	30
Controls	
Electric	16
Electronic	15
Pneumatic	20
Valve actuators	
Hydraulic	15
Pneumatic	20
Self-contained	10

Adapted from: *ASHRAE Handbook 2011 Applications*, Page 37.3, Table 4

Chapter 5

Preparing the Report

Present the information gathered from the energy use simulation and economic analysis as an easy-to-reference report, using these standards:

- 8.5" x 11" paper, bound to lie flat when opened, and printed double-sided
- Include a table of contents and number all pages
- Label each section
- Label each alternative system used in the computer model
- Electronic PDF copy of report is preferred over a mailed hard copy

Report Contents and Instructions

I. Title Page

Date
Project name
Building owner (also list public agency, if different than owner)
Analyst name, firm name and address

II. Table of Contents

List of Participants**:** Contact name, firm name, address, telephone and fax numbers for
Building owner (also public agency and chief executive if different than building owner)
Project architect
Owner's project manager
ELCCA Analyst
ELCCA Reviewer
Natural gas and electric utility representatives
Mechanical engineer
Electrical engineer
Lighting designer

III. Statement of Compliance

Provide a written declaration that the ELCCA report complies with RCW 39.35 and the ELCCA guidelines, signed and stamped by a professional engineer. The project architect signs the statement, indicating that he/she has reviewed the report and discussed it with the owner.

IV. Executive Summary

Describe the overall project including how the building will be operated. Identify the energy systems (envelope, lighting, HVAC, controls, and domestic hot water) that are recommended for inclusion in the building design. If the recommended systems were ***not*** the lowest life-cycle cost, provide an explanation.

A. Complete the Public Facility Energy Characteristics (PFEC) form (See Figure 5.1) with information for each of the recommended energy systems. If the project includes new construction and renovation, provide a separate form for each.

B. For the recommended systems, provide estimates of the building's annual energy costs and maintenance costs (use R.S. *MEANS Facilities Maintenance and Repair Cost Data* and/or *The Whitestone Building Maintenance and Repair Cost Reference*). Break the costs into two categories: dollars per year ($/yr) and dollars per square foot per year ($/sf/yr.).

C. Present two pie charts showing the recommended building's energy usage by “end use” and by “annual expenditure of energy dollars.” Devote individual “slices of the pies” to lighting, heating, cooling, fans, domestic hot water, and miscellaneous loads.

D. Include the ELCCA Results Table output from the ELCCAT spreadsheet.

E. Provide a project timeline through construction.

F. Briefly describe technical or financial assistance to improve the project's energy efficiency that is available from natural gas and electric utilities.

V. Project Description

- Description of the site (elevation, orientation, shading, etc.)
- Basic facility description, especially non-energy systems
- Facility size, number of stories
- How the facility is to be used
- Occupancy schedules, both daily and annually
- Special facility considerations, e.g., noise control, aesthetics, environmental concerns
- Anything out of the ordinary that might affect the facility's energy use (e.g. foundry, pool, kitchen, welding or woodshop, etc.)
- Description of available campus-wide energy sources
- For renovation and addition projects, describe the existing facility and its existing energy systems

VI. Simulation and Economic Assumptions

Energy Simulation (Model) Assumptions
Describe the modeling program and input assumptions. Provide the building occupancy schedule, lighting and HVAC schedules, heating/cooling set points, thermal mass, site shading, and control strategies used as inputs.

Baseline Building Description

Summarize the Baseline building parameters, and establish a baseline building cost opinion. A baseline model will be developed that reflects the lowest first cost building model that meets the applicable building code and owners minimum program and performance requirements.

Enter baseline data into the ELCCAT spreadsheet. Inputs on this and all subsequent ELCCA Spreadsheets in report should have sufficient supporting information to allow reader to follow the logic of each entry. Each entry for first cost, maintenance, and replacement costs should be supported by an estimate sheet or software output showing how these costs and/or intervals are arrived at. Energy Costs should be backed up by load summary from the energy modeling software clearly labeled by alternative.

Economic Assumptions

- Provide the utility rate assumptions and include a copy of the current utility rate schedules. Indicate any qualifications that must be met before the project can be served under this rate schedule.

VII. Building Envelope

- Describe the recommended envelope components (roof, wall, glazing, doors, floors, etc.), indicating materials, insulation values, and variations from baseline levels.
- Describe the baseline envelope, and any other envelope alternatives analyzed.
- Show typical sections and U-factor calculations for all construction types being recommended, (Figures 5.1, 5.2 and 5.3 provide sample formats).
- Describe assumptions used for infiltration and ventilation rates.
- If envelope alternatives are analyzed, for each alternative indicate the initial construction cost, projected annual maintenance costs, and estimated annual energy cost. Include life-cycle cost spreadsheets, energy simulation model with input changes highlighted, and output pages indicating estimated energy use.

VIII. Lighting Systems

- Describe the recommended system for each functional area of the building.
- Describe daylighting zones, daylighting strategies, daylighting controls, and areas covered.
- If lighting alternatives are analyzed, for each alternative indicate the initial construction cost, projected annual maintenance costs, and estimated annual energy cost. Include life-cycle cost spreadsheets and load calculations.

IX. Mechanical Systems

For each alternative system, include system description, single-line diagram, system advantages, input assumptions, energy simulation output, annual energy and maintenance costs, construction costs and the life-cycle cost spreadsheet.

X. Renewable Energy System

Provide a description of the renewable energy system(s) analyzed. Include input assumptions, construction cost, maintenance cost, energy costs/savings, energy simulation output and/or engineering calculations, the life-cycle cost spreadsheets, and description of a base case for comparison.

XI. High Performance Building Alternative

For the High Performance Building alternative include system description, single-line diagram, system advantages, input assumptions, energy simulation output, annual energy and maintenance costs, construction costs, the life-cycle cost spreadsheet, the specific measures implemented to reach the energy savings goal, and a description of building components that affect the energy use.

XII. Control Systems

Describe the recommended building control system. Include systems to be controlled, control features, and monitoring capabilities. Include features intended to facilitate energy conservation such as a direct interface to the utility electrical meter. Describe controls used to ensure adequate and efficient ventilation.

XIII. Domestic Hot Water (DHW)

Describe the recommended DHW system. If alternatives are analyzed, provide a description, predicted energy use and cost estimates (annual energy cost, maintenance cost, material & labor costs).

XIV. Other Energy Systems

Describe other energy systems that impact energy use of this facility as discussed in Chapter 3, Work Plan. If alternatives are analyzed, include energy analysis, cost estimates and ELCCA spreadsheets.

XV. Appendices

Include the following, at a minimum, clearly identified:

A. Approved Work Plan
B. Computer input and output summary reports for the Energy Cost Budget model and for each alternative
C. Scaled floor plan showing the HVAC zones as modeled
D. Site plan including orientation
E. Letter of acknowledgement from Owner (if an alternative is recommended that varies from the lowest life-cycle cost by greater than 20%)

Abbreviated Report for Prototypical Design

If pre-approved at the Work Plan stage, an abbreviated report may be submitted for projects using a previously analyzed prototypical design. A copy of the original report for the prototypical design should be included with the report. An abbreviated report for a prototypical design must use the same format as a full report and contain the following:

- **Title Page**
- **Table of Contents**
- **List of Participants**
- **Statement of Compliance**
- **Executive Summary -** Identify prototype building/design and any changes made to the design. Complete a Public Facilities Energy Characteristics (PFEC) form.
- **Timeline -** Provide a project timeline through construction.
- **Project Description -** Include control system description, mechanical systems, ventilation strategies, etc.
- **Sections Describing Any Energy System Revised from the Prototypical Design** (envelope, lighting, HVAC, controls, or domestic hot water). A new energy use simulation and life-cycle cost analysis may be required as determined at the Work Plan stage.
- **Current Utility Rate Schedules**
- **Appendices**

Report Review

When evaluating the report, the ELCCA Reviewer will check for completeness and accuracy, and compare the analyzed systems to those agreed on in the Work Plan. The Reviewer will check that the report has been submitted prior to the project's scheduled value engineering date (if applicable) and that the report complies with these ELCCA guidelines.

The Reviewer will send an email to the Analyst listing any questions or concerns about the report. The Analyst will have up to 7 days to respond to those questions or concerns in an email. This process may then be repeated until all of the Reviewer’s concerns have been addressed (See Appendix C for “Review Process Checklist”).

Figure 5.4 Public Facilities Energy Characteristics Summary

1. Project Description

Project Title:	Date:
Agency Name:	City:
Gross Sq Ft New:	Gross Sq Ft Remodel:

2. Envelope

Envelope Component Description	U x	A =	UA proposed	% Total	UA Code
Roof Type 1					
Wall Type 1					
Wall Type 2					
Doors					
Window Type 1					
Skylights					
Floors					
Perimeter					
Total					

$(UA_{Code} - UA_{Proposed})/UA_{Code}$ x 100% = ______

% Fenestration Area ______

3. Lighting

Interior Lighting Summary

Lighting Power Density Proposed ____________ **W/ft^2**
Lighting Power Density Allowed ____________ **W/ft^2**

$(LPD_{Allowed} - LPD_{Proposed})/LPD_{Allowed}$ x 100% = ______

Exterior Lighting Summary

Total Allowed Watts ____________ **W**
Total Proposed Watts ____________ **W**

4. Mechanical

System Description:

Energy Use Proposed ______________ $kBtu/ft^2/yr$
Energy Use Baseline ______________ $kBtu/ft^2/yr$

$(EUI_{Baseline} - EUI_{Proposed})/EUI_{Baseline} \times 100\% =$ ______________

Firm Name: ______________________________

ELCCA Analyst: ______________________________

Glossary of Terms

Analyst: The ELCCA analyst is the person responsible for the preparation of the ELCCA.

Annual Fuel Utilization Efficiency (AFUE): An efficiency descriptor of the ratio of annual output energy to annual input energy as developed in accordance with the requirements of U.S. Department of Energy (DOE) 10CFR Part 430.

Base Year: Is a calendar year upon which the analysis is based.

Baseline Model: Is a defined as the lowest capital cost building that meets state building and energy codes.

Building Automation System: Is a control system that uses sensors and actuators within a building that coordinate with various building systems to adjust for varying loads and occupancies.

Building Commissioning: Is a systematic and documented process of ensuring that the owner's operational needs are met, that building systems perform efficiently, and that building operators are properly trained**.**

Building Value: Replacement value of a building as determined by insurance coverage or independent appraisal (often depicted in dollars per square foot). The entire area of the building being remodeled should be considered when determining the building value.

Btu (British thermal unit): Is a unit of heat equal to the amount of heat required to raise one pound of water one degree Fahrenheit at one atmosphere pressure.

Carbon Dioxide Monitor: A device that detects carbon dioxide (CO_2) levels in an occupied zone. It may be used in conjunction with the building automation system to vary and check ventilation system performance.

Coefficient of Performance (COP): Ratio of the rate of heat delivered (heating mode) or heat removed (cooling mode) to the rate of total energy input to the unit, expressed in consistent units and under designated operating conditions.

Commissioning Diagnostics: Using the building automation system to run tests on building systems to identify if they are functioning correctly.

Daylighting: The use of sunlight to supplement electric lighting.

Demand Control Ventilation: The control of outdoor air quantities supplied to a space based on the number of occupants. This is typically done by monitoring carbon dioxide (CO_2) or volatile organic compounds (VOC) in the return air and then modulating the outside air damper to maintain the set level.

Discount Rate: Interest rate used to relate future costs (or benefits, such as salvage) to their equivalent present values. For the ELCCA process, the discount rate reflects the rate at which public institutions borrow money.

Displacement Ventilation: An air distribution system based on introducing cool air into the lower zone of an occupied space at a low velocity, while exhausting air from the upper portion of the occupied zone.

Economic Life: Projected or anticipated useful life span of a facility, used for the life-cycle cost analysis. While a facility may last longer than this period, any costs (or benefits) which may occur after this period need not be considered. When discounting is considered, any such costs (or benefits) are usually negligible.

Energy Efficiency Ratio (EER): A ratio of BTU per hour (/h) produced, divided by the number of watts used to produce the cooling.

Energy Life-Cycle Cost Analysis (ELCCA): Present value evaluation of a system conducted over the economic life of the system. The life-cycle cost includes the initial cost, salvage values, and the annual costs of energy consumption, periodic replacement, operation, and routine maintenance.

Energy Star Compliant Roof: A roof that reflects the sun's heat and prevents it from entering a building, thereby reducing the cooling load. It also reduces the “heat island” effects of the built environment.

Energy Systems: Includes the building envelope, lighting, mechanical, and domestic hot water (DHW) systems, and any other systems or components that account for 10% or more of the overall building energy consumption.

Energy Use Simulation: Calculation of all energy used by a facility (typically for one year), summarized for all energy systems and components by type of energy including the internal energy load imposed on a facility by its occupants, equipment, components, and the external energy load imposed on a facility by the climatic conditions at its location.

Evaporative Cooling: A system or process in which the heat is removed from an object by the evaporation of water.

F-factor: The perimeter heat loss of a slab-on-grade floor expressed in BTU/hr*ft* F.

Fenestration: Any light-transmitting opening in a building envelope, including windows, skylights, clerestories, and glass doors.

Fuel Cell: An electrochemical energy conversion device that converts the elements hydrogen and oxygen into water and, in the process, produces electricity and heat.

Green Building: *Verb:* Environmentally conscious construction method relating to site maintenance, energy usage, and material recycling. *Noun:* An efficient and sustainable structure.

Geothermal Heating/Cooling: A system that uses the earth as either a heat source or heat sink. It may involve a subterranean water source or well for heat and may include pipe loops.

Heat Recovery: The capture and reuse of heat energy that is generated during building operation that would otherwise be wasted.

High Performance Building Alternative (HPB): An alternative developed and studied in the ELCCA that has a net energy use that is a minimum of 20% less than the baseline building

Independent Commissioning Agent: A commissioning agent that works directly for the building owner and is a subcontractor to neither the architect or engineer nor an employee.

Indoor Air Quality (Acceptable) (IAQ): (from ASHRAE 62) Air in which there are no unwanted airborne constituents that may reduce the acceptability of the air as determined by cognizant authorities and with which a substantial majority of the people exposed do not express dissatisfaction.

Initial Cost (first cost or investment): Money required for the capital construction or renovation of a major facility. The initial cost includes the cost of building structures and all equipment, as well as project costs such as professional design fees, permits, tax, etc.

Integrated Design: Is a design in which two or more systems are analyzed as a unit in order to take advantage of positive interactions that are synergistic or greater than the sum of the parts.

LEED ® (Leadership in Energy and Environmental Design): A registered trademark of the U.S. Green Building Council. A program and building rating system for new construction and remodel projects, developed and administered by the U.S. Green Building Council, www.usgbc.org.

Lighting Power Density (LPD): A building's lighting system described in watts per square foot (w/sf) (excludes plug-in task lighting).

Lumen Maintenance Control: An electrical control device designed to vary the light supplied by a lighting system in order to maintain a specified illumination level.

Maintenance Costs: Costs of maintaining HVAC, controls, lighting, DHW, and other building systems in good working order.

Major Facility: Any publicly owned or leased building having 25,000 square feet or more of "usable floor space." See RCW 39.35.030(3) Definitions in Appendix B.

MotorMaster+: U.S. Department of Energy computer software designed to help select efficient electric motors for a given application. The software also features motor inventory management tools, maintenance log tracking, efficiency analysis, savings evaluation, energy accounting, and environmental reporting capabilities. For more information and free software download, go to http://www.oit.doe.gov/bestpractices/software_tools.shtml.

Natural Ventilation: A ventilation system that uses the natural forces of wind and convection to deliver fresh air into buildings.

Net Metering: A simplified method of metering the energy consumed and produced at a home or business that has its own renewable energy generator, such as a wind turbine or solar panel. Under net metering agreements with utilities, excess electricity that is not used in the building will feed into the grid and spin the home or business electricity meter backwards. This provides the customer with full retail value for all the electricity produced.

Net Zero Energy Building: An energy-efficient building where the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

Nominal Price Escalation: Gross price change of annual fuel and maintenance costs, including the effect of general inflation.

Photovoltaic (PV) Modules: Also known as a solar panel, a device that produces an electric current from incident solar radiation.

Project Costs: All costs associated with the building structure with the exceptions of unconditioned outdoor sports facilities, parking or landscaping, and work done to meet safety or health concerns such as seismic bracing, acoustic treatment, or fire sprinklers. Costs of the exceptions may be excluded from the stated project costs if the costs are not included in the building value.

Prototypical design: A building design intended for use on more than one site, resulting in two or more identical structures.

Real Price Escalation: Net price change of annual fuel and maintenance costs after adjusting for general inflation.

Renewable Resource: Non-fossil fuel energy source such as solar (active or passive), wind, biomass, geothermal, "waste" heat, refuse-derived fuels, etc. (See RCW 39.35.030(12) in Appendix B).

Renovation: Any additions, alterations, or repairs within any 12-month period which exceed 50 percent of the value of a major facility, and which will affect any energy systems.

Replacement Costs: One-time or periodic costs to be incurred in the future to maintain the original function of the facility or item.

Report: Energy Life-Cycle Cost Analysis Report, unless otherwise indicated.

Reviewer: Unless otherwise indicated, refers to the ELCCA Reviewer.

R-Value: A measure of a given material's ability to resist the absorption or conduction of heat energy, a characteristic also referred to as thermal resistance.

Salvage Value: The value of equipment at the end of its life-cycle period. (Salvage value is positive if it has residual economic value and negative if removal costs exceed equipment value)
Seasonal Energy Efficiency Ratio (SEER): The total cooling of a central air conditioner (in BTUs) during its normal usage period for cooling (not to exceed 12 months), divided by the total electric energy input in watt-hours during the same period.

Solar Heat Gain Coefficient (SHGC): Measurement of how well a product blocks heat caused by sunlight. The SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed, then subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's SHGC, the less solar heat it transmits.

Solar Hot Water: Generally, a hot water heating system that relies on solar radiation to heat potable water.

Solar Space Heating: A heating system using large windows and heat absorbent materials built into the sunlit floors and walls.

Sustainability: Method of using a resource responsibly so that the resource is not depleted or permanently damaged.

Therm: A unit of heat equal to 100,000 British Thermal Units.

Thermal Storage: The storage of heat or cold for use at another time.

U-Factor: The “Overall Heat Transfer Coefficient” (U) of an assembly of layers of different materials, calculated as the inverse of the overall thermal resistance, and expressed in BTU/hr-ft^2 –F.

Visible Light Transmittance: The ratio of visible light transmitted through a substance to the total visible light incident on its surface.

Wind Power: Electrical energy generated by harnessing the kinetic energy of air in motion (wind).

WSSP (Washington Sustainable Schools Protocol): Standard developed to help school districts achieve high performance.

Enabling Legislation and Administrative Code

Revised Codes of Washington

RCW CHAPTER 39.35 Energy Conservation in Design of Public Facilities

Sections:

RCW 39.35.010 Legislative finding.

The legislature hereby finds:

(1) That major publicly owned or leased facilities have a significant impact on our state's consumption of energy;

(2) That energy conservation practices including energy management systems and renewable energy systems adopted for the design, construction, and utilization of such facilities will have a beneficial effect on our overall supply of energy;

(3) That the cost of the energy consumed by such facilities over the life of the facilities shall be considered in addition to the initial cost of constructing such facilities;

(4) That the cost of energy is significant and major facility designs shall be based on the total life-cycle cost, including the initial construction cost, and the cost, over the economic life of a major facility, of the energy consumed, and of the operation and maintenance of a major facility as they affect energy consumption; and

(5) That the use of energy systems in these facilities which utilize renewable resources such as solar energy, wood or wood waste, or other nonconventional fuels, and which incorporate energy management systems, shall be considered in the design of all publicly owned or leased facilities.
[2001 c 214 § 15; 1982 c 159 § 1; 1975 1st ex.s. c 177 § 1.]

RCW 39.35.020 Legislative declaration.

The legislature declares that it is the public policy of this state to insure that energy conservation practices and renewable energy systems are employed in the design of major publicly owned or leased facilities and that the use of at least one renewable energy system is considered. To this end, the legislature authorizes and directs that public agencies analyze the cost of energy consumption of each major facility to be planned and constructed or renovated after September 8, 1975.
[1982 c 159 § 2; 1975 1st ex.s. c 177 § 2.]

RCW 39.35.030 Definitions.

For the purposes of this chapter, the following words and phrases shall have the following meanings unless the context clearly requires otherwise:

(1) "Cogeneration" means the sequential generation of two or more forms of energy from a common fuel or energy source. Where these forms are electricity and thermal energy, then the operating and efficiency standards established by 18 C.F.R. Sec. 292.205 and the definitions established by 18 C.F.R. 292.202 (c) through (m) as of July 28, 1991, shall apply.

(2) "Department" means the state department of enterprise services.

(3) "Design standards" means the heating, air-conditioning, ventilating, and renewable resource systems identified, analyzed, and recommended by the department as providing an efficient energy system or systems based on the economic life of the selected buildings.

(4) "Economic life" means the projected or anticipated useful life of a major facility as expressed by a term of years.

(5) "Energy management system" means a program, energy efficiency equipment, technology, device, or other measure including, but not limited to, a management, educational, or promotional program, smart appliance, meter reading system that provides energy information capability, computer software or hardware, communications equipment or hardware, thermostat or other control equipment, together with related administrative or operational programs, that allows identification and management of opportunities for improvement in the efficiency of energy use, including but not limited to a measure that allows:

(a) Energy consumers to obtain information about their energy usage and the cost of energy in connection with their usage;

(b) Interactive communication between energy consumers and their energy suppliers;

(c) Energy consumers to respond to energy price signals and to manage their purchase and use of energy; or

(d) For other kinds of dynamic, demand-side energy management.

(6) "Energy systems" means all utilities, including, but not limited to, heating, air-conditioning, ventilating, lighting, and the supplying of domestic hot water.

(7) "Energy-consumption analysis" means the evaluation of all energy systems and components by demand and type of energy including the internal energy load imposed on a major facility by its occupants, equipment, and components, and the external energy load imposed on a major facility by the climatic conditions of its location. An energy-consumption analysis of the operation of energy systems of a major facility shall include, but not be limited to, the following elements:

(a) The comparison of three or more system alternatives, at least one of which shall include renewable energy systems, and one of which shall comply at a minimum with the sustainable design guidelines of the United States green building council leadership in energy and environmental design silver standard or similar design standard as may be adopted by rule by the department;

(b) The simulation of each system over the entire range of operation of such facility for a year's operating period; and

(c) The evaluation of the energy consumption of component equipment in each system considering the operation of such components at other than full or rated outputs.

The energy-consumption analysis shall be prepared by a professional engineer or licensed architect who may use computers or such other methods as are capable of producing predictable results.

(8) "Initial cost," means the moneys required for the capital construction or renovation of a major facility.

(9) "Life-cycle cost" means the initial cost and cost of operation of a major facility over its economic life. This shall be calculated as the initial cost plus the operation, maintenance, and energy costs over its economic life, reflecting anticipated increases in these costs discounted to present value at the current rate for borrowing public funds, as determined by the office of financial management. The energy cost projections used shall be those provided by the department. The department shall update these projections at least every two years.

(10) "Life-cycle cost analysis" includes, but is not limited to, the following elements:

(a) The coordination and positioning of a major facility on its physical site;

(b) The amount and type of fenestration employed in a major facility;

(c) The amount of insulation incorporated into the design of a major facility;

(d) The variable occupancy and operating conditions of a major facility; and

(e) An energy-consumption analysis of a major facility.

(11) "Major facility" means any publicly owned or leased building having twenty-five thousand square feet or more of usable floor space.

(12) "Public agency" means every state office, officer, board, commission, committee, bureau, department, and all political subdivisions of the state.

(13) "Renewable energy systems" means methods of facility design and construction and types of equipment for the utilization of renewable energy sources including, but not limited to, hydroelectric power, active or passive solar space heating or cooling, domestic solar water heating, windmills, waste heat, biomass and/or refuse-derived fuels, photovoltaic devices, and geothermal energy.

(14) "Renovation" means additions, alterations, or repairs within any twelve-month period which exceed fifty percent of the value of a major facility and which will affect any energy system.

(15) "Selected buildings," means educational, office, residential care, and correctional facilities that are designed to comply with the design standards analyzed and recommended by the department.
[2011 1st sp.s. c 43 § 247; 2001 c 214 § 16; 1996 c 186 § 402; 1994 c 242 § 1; 1991 c 201 § 14; 1982 c 159 § 3; 1975 1st ex.s. c 177 § 3.]

RCW 39.35.040 Facility design to include life-cycle cost analysis.

Whenever a public agency determines that any major facility is to be constructed or renovated, such agency shall cause to be included in the design phase of such construction or renovation a provision that requires a life-cycle cost analysis conforming with the guidelines developed in RCW 39.35.050 to be prepared for such facility. Such analysis shall be approved by the agency prior to the commencement of actual construction or renovation. A public agency may accept the facility design if the agency is satisfied that the life-cycle cost analysis provides for an efficient energy system or systems based on the economic life of the major facility.

Nothing in this section prohibits the construction or renovation of major facilities that utilize renewable energy systems.
[1994 c 242 § 2; 1982 c 159 § 4; 1975 1st ex.s. c 177 § 4.]

RCW 39.35.050 Life-cycle cost analysis — Guidelines.

The department, in consultation with affected public agencies, shall develop and issue guidelines for administering this chapter. The purpose of the guidelines is to define a procedure and method for performance of life-cycle cost analysis to promote the selection of low-life-cycle cost alternatives. At a minimum, the guidelines must contain provisions that:

(1) Address energy considerations during the planning phase of the project;

(2) Identify energy components and system alternatives including energy management systems, renewable energy systems, and cogeneration applications prior to commencing the energy consumption analysis;

(3) Identify simplified methods to assure the lowest life-cycle cost alternatives for selected buildings with between twenty-five thousand and one hundred thousand square feet of usable floor area;

(4) Establish times during the design process for preparation, review, and approval or disapproval of the life-cycle cost analysis;

(5) Specify the assumptions to be used for escalation and inflation rates, equipment service lives, economic building lives, and maintenance costs;

(6) Determine life-cycle cost analysis format and submittal requirements to meet the provisions of chapter 201, Laws of 1991;

(7) Provide for review and approval of life-cycle cost analysis.
[2001 c 214 § 17; 1996 c 186 § 403; 1994 c 242 § 3; 1991 c 201 § 15.]

RCW 39.35.060 Life-cycle cost analysis — Review fees.

The department may impose fees upon affected public agencies for the review of life-cycle cost analyses. The fees shall be deposited in the *general administration services account. The purpose of the fees is to recover the costs by the department for review of the analyses. The department shall set fees at a level necessary to recover all of its costs related to increasing the energy efficiency of state-supported new construction. The fees shall not exceed one-tenth of one percent of the total cost of any project or exceed two thousand dollars for any project unless mutually agreed to. The department shall provide detailed calculation ensuring that the energy savings resulting from its review of life-cycle cost analysis justify the costs of performing that review.
[2001 c 292 § 1; 1996 c 186 § 404; 1991 c 201 § 16.]

RCW 39.35.900 Severability — 1975 1st ex.s. c 177.

If any provision of this act, or its application to any person or circumstance is held invalid, the remainder of the act, or the application of the provision to other persons or circumstances is not affected.
[1975 1st ex.s. c 177 § 5.]

Washington Administrative Code

WAC 392-343-075 Energy conservation report

In compliance with the provisions of chapter 39.35 RCW, school districts constructing school facilities shall complete an energy conservation report for any new construction or for additions to and modernization of existing school facilities that will be reviewed by the Washington state department of general administration. One copy of the energy conservation report, approved by the district board of directors, shall be filed with the superintendent of public instruction. The amount of state funding assistance for which a district is eligible for the preparation of the energy conservation report shall be the state funding assistance percentage multiplied by ten thousand dollars. The amount of state funding assistance for which a district is eligible shall be the state funding assistance percentage multiplied by the fee charged.

Review Process Checklist

This checklist is a guide to help verify that the analysis is properly documented and that the owner has the information needed to make viable decisions.

Project Title/Building Name:
____

Agency/Project Owner:
____

Reviewer: ____Date: __________

Work Plan

- ☐ Work Plan complete (envelope, lighting, mechanical, control systems, renewable, and High Performance/Code Baseline)?
- ☐ Are alternatives feasible?.
- ☐ A list developed of potential measures for utility rebates?
- ☐ Renewable and fuel alternatives investigated?
- ☐ Work Plan & LEED/WSSP Checklist sent to Analyst (copies to owner, utility representative, architect, project manager)?

ELCCA Report

- ☐ Check format and content for all necessary items.
- ☐ Check validity of system type comparisons.
- ☐ Compare report to approved Work Plan.
- ☐ Check envelope U-factor spreadsheet comparison to code and prescriptives.
- ☐ Check lighting layouts and calculations.
- ☐ Compare proposed energy management control system to Work Plan checklist.

Verify Modeling Inputs:

- ☐ Building orientation
- ☐ Zone definitions and occupancies
- ☐ U-factors (compare model inputs to PFEC)
- ☐ Lighting and equipment power densities
- ☐ Operating schedules and set points
- ☐ HVAC parameters (fan cfm, fan KW, input power, zones, capacities, and outside air)
- ☐ Plant equipment (system type, efficiencies, and part load efficiencies)
- ☐ Is High Performance Building alternative/code baseline consistent with LEED Protocol?

Check Modeling Outputs:

- ☐ Loads not met (should be a maximum 5% to 7% of output)
- ☐ Ventilation air/economizer operation
- ☐ Simultaneous heating and cooling (how much?)
- ☐ HVAC system COPs or EERs. Calculate output/input for given time period
- ☐ Estimated energy usage (EUI comparable to similar building?)
- ☐ Are hourly and monthly profiles reasonable?

Review Economic Analysis:

- ☐ System cost information is reasonable (each alternative including HPA)
- ☐ Maintenance cost data is reasonable
- ☐ Replacement cost data is reasonable
- ☐ Energy cost matches model results